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Territorial governance for the anticipation and resolution of conflicts in projects of valorization of digestates

Elena Fourcroy

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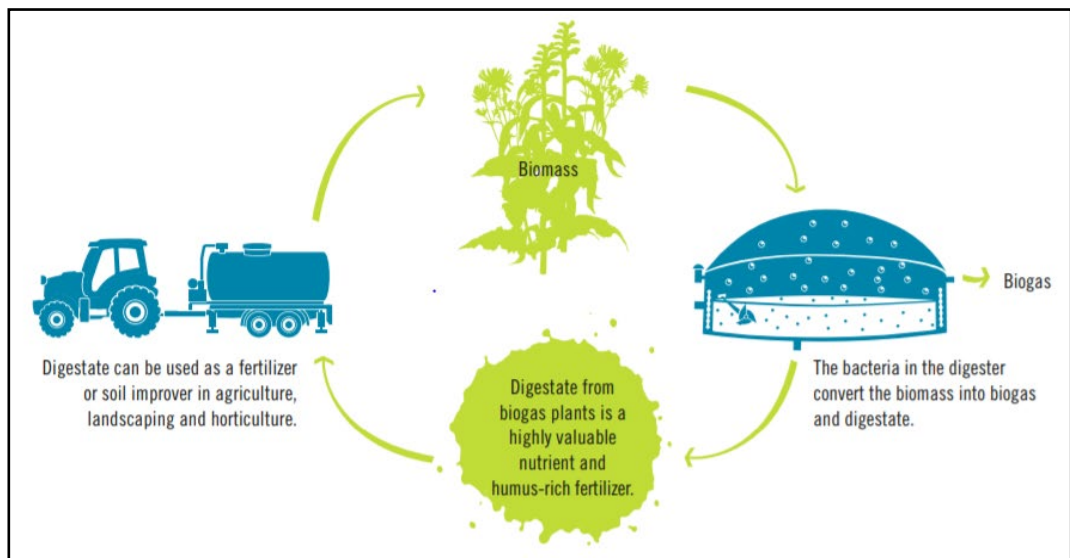
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Par **Elena FOURCROY**

Gouvernance territoriale pour l'anticipation et la résolution des conflits dans les projets de valorisation des digestats de méthanisation

Thèse présentée
pour l'obtention du grade
de Docteur de l'UTC



Soutenue le 12 décembre 2023

Spécialité : Sciences Économiques, Sciences de Gestion et Sociologie des Techniques

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Thèse de Doctorat

Gouvernance territoriale pour l'anticipation et la
résolution des conflits dans les projets de valorisation des
digestats de méthanisation

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Sous la direction de Loïc Sauvée et Lucian Ceapraz

Spécialité :

Sciences Économiques, Sciences de Gestion et Sociologie des Techniques

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Territorial governance for the anticipation and resolution
of conflicts in projects of valorization of digestates

Abstract

The bioeconomy and the circular economy have recently gained a major place in the European Union policies on the ecological, energy and social transition. Supported by these public policies, the biogas sector has experienced a remarkable growth in recent years. Biogas production makes it possible to produce both gas from renewable resources, and digestate, a by-product which amending and fertilizing properties are useful for agriculture. The “return to the soil” of digestate is considered as a key element of the circularity of the biogas sector. However, numerous controversies remain over the environmental and health impacts of returning digestates to the soil, and conflicts related to the actual or supposed negative externalities of digestates negatively impact the development of the sector. We use a qualitative method, centred on the analysis of case studies, to explore this topic, about which the scientific literature remains very scarce. We try to understand, at first, the nature of these conflicts, and secondly, how territorial governance mechanisms can anticipate or solve these conflicts. Our results show that conflicts emerge around certain dimensions of the territorial capital: the preservation of the natural capital, the inadequacy of the infrastructural and equipment capital, and oppositions around the cultural capital. These conflicts often crystallize previous tense situations, at a local or regional scale. The activation of territorial proximity, at different spatial scales, local, regional and sub-regional, with the intervention, sometimes, of one or more public or private intermediaries, allows stakeholders to coordinate in order to: exchange information and better mobilize the territorial capital, produce and acquire new knowledge in the event of uncertainty about the impacts of digestates, and develop common political visions on the development of the sector.

Key-words: biogas production, digestates, conflicts, territorial governance, circular economy, proximity

Résumé

La bioéconomie et l'économie circulaire se sont imposées récemment comme des composantes majeures des politiques de transition écologique, énergétique et sociale de l'Union Européenne. Soutenu par ces politiques publiques, le secteur de la méthanisation connaît, depuis quelques années, un essor remarquable. La méthanisation permet en effet de produire à la fois du gaz issu de sources renouvelables, et du digestat, un co-produit aux propriétés

amendantes et fertilisantes utiles à l'agriculture. Le « retour au sol » du digestat est d'ailleurs considéré comme un élément clé de la circularité de la filière méthanisation. Cependant, de nombreuses controverses demeurent sur les impacts environnementaux et sanitaires du retour au sol des digestats, et des conflits générés par les externalités négatives avérées ou supposées de la valorisation des digestats affectent le développement de la filière. Nous employons une méthode qualitative, centrée sur des analyses de cas, pour explorer ce sujet encore très peu étudié dans la littérature scientifique. Nous tentons de comprendre, tout d'abord, la nature de ces conflits, puis, comment les mécanismes de gouvernance territoriale permettent d'anticiper ou de résoudre ces conflits. Nos résultats montrent que les conflits émergent autour de certaines dimensions du capital territorial : préservation du capital naturel, inadéquation du capital infrastructurel, et oppositions autour du capital culturel. Ces conflits cristallisent souvent des situations antérieures tendues, à l'échelle locale ou régionale. L'activation de la proximité territoriale, à différentes échelles, locale, régionale et sous-régionale, avec l'aide, parfois, d'un ou plusieurs intermédiaires publics ou privés, permet aux acteurs des territoires de se coordonner pour, à la fois, échanger des informations et mieux mobiliser le capital territorial, pour produire et acquérir de nouvelles connaissances en cas d'incertitudes sur les impacts des digestats, et pour élaborer des visions politiques communes autour du développement de la filière.

Mots-clés : méthanisation, digestats, conflits, gouvernance territoriale, économie circulaire, proximité

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This manuscript is dedicated to the memory of Prof. Arjen Y.
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Résumé long en français

Introduction

La méthanisation, un secteur à la croisée des grands défis du 21^{ème} siècle

Notre monde moderne connaît actuellement une crise environnementale sans précédent, qui affecte notamment les secteurs de l'énergie et de l'agriculture, et exige de ces secteurs qu'ils transitionnent vers des modes de production plus durables (FAO, 2023; IPCC, 2023). Le développement de la méthanisation, soutenue par les récentes politiques européennes sur la bioéconomie, les énergies renouvelables, et l'économie circulaire, est souvent présenté comme une des solutions aux problématiques environnementales. En effet, la méthanisation permet, à la fois, le recyclage et la valorisation de la biomasse et des déchets organiques, la production de gaz à partir de sources renouvelables, et la production de digestat, un co-produit aux propriétés amendantes et fertilisantes très utiles en agriculture (French Senate, 2021). La méthanisation est également considérée comme un outil en faveur de l'autonomie et de la résilience économique des exploitations agricoles, et le développement rapide du secteur est pourvoyeur d'emploi dans les zones rurales (French Senate, 2021). Le développement rapide et important du secteur, ces dernières années, a récemment suscité l'intérêt de la communauté scientifique, qui cherche à étudier, observer et comprendre la mise en œuvre de projets issus de la bioéconomie circulaire, au niveau local. Notre recherche s'inscrit donc dans ce nouvel horizon scientifique.

Définition du sujet et objectifs de recherche

Nos recherches se situent dans la continuité des travaux récents dédiés à la compréhension des modes de coordination des acteurs locaux autour des projets de méthaniseurs, de leurs façons de mobiliser les ressources locales, et d'appréhender les défis qui en émergent (Bourdin, Colas, et al., 2019; Bourdin, Nadou, et al., 2019; Bourdin, 2020a; Bourdin, Jeanne, et al., 2020; Bourdin & Nadou, 2020; Depoudent et al., 2020; Niang et al., 2021, 2022; Schumacher et al., 2019; Soland et al., 2013). Ces travaux récents s'intéressent particulièrement aux mécanismes de gouvernance territoriale qui permettent le succès des projets de méthaniseurs. Mais, d'après (Niang et al., 2020, 2021), ces recherches demeurent

encore incomplètes, et le rôle des conflits dans les processus de gouvernance territoriale nécessite d'être encore étudié. Nos recherches ont donc pour objectif de contribuer à la compréhension des mécanismes de gouvernance territoriale à l'œuvre dans le développement de la filière méthanisation, à la compréhension des défis auxquels la filière est confrontée, et à la manière dont les acteurs font face à ces défis. Par extension, nos résultats contribueront à une meilleure compréhension des mécanismes de coordination à l'œuvre dans le développement de la bioéconomie circulaire dans les zones rurales.

Méthode

Nos recherches s'appuient sur un cadre épistémologique relativiste et constructiviste, puisque nous considérons que la gouvernance territoriale est un construit social, et n'existe pas *a priori*. Nous avons choisi d'employer la méthode qualitative, comme une extension logique de ce cadre épistémologique. Nous menons des études de cas multiples et holistiques, telles que définies par (R. Yin, 2003), au travers de cinq cas de méthaniseurs, en France et en Allemagne. Nous utilisons une méthode itérative de collecte des données (Baškarada, 2014; R. Yin, 2003), basées sur des entretiens semi-directifs, une revue de presse, et une analyse de la littérature grise. Nous procédons à la fois à une analyse monographique de nos cas, et à une analyse thématique comparée de nos données, dans la continuité des recherches précédentes (Depoudent et al., 2020).

Chapitre 1 : contexte de développement de la filière méthanisation

Ce premier chapitre a pour objectif de détailler les contextes techniques, économiques, juridiques et politiques du développement de la filière.

Section 1 : contexte technique et organisationnel

Nous abordons, dans cette section, à la fois les processus de production du biogaz et des digestats, et les différents types de méthaniseurs.

La production de biogaz est issue d'une réaction chimique naturelle de dégradation de la matière organique, appelée digestion anaérobie. Cette réaction produit à la fois des gaz, notamment du méthane, du dioxyde de carbone, et de l'ammoniac, et un co-produit plus ou moins solide ou liquide, le digestat. De nombreux procédés de production existent, basés sur

des températures de réaction différentes et sur des fréquences différentes d'introduction de la matière organique (ADEME, 2015). La matière organique utilisée peut également provenir de sources très différentes, incluant, les effluents d'élevage, les déchets alimentaires, et les boues de stations d'épuration (Saveyn & Eder, 2014). La diversité des sources de matières organiques et des process de production génère une grande hétérogénéité de digestats.

A cette diversité technique s'ajoute une diversité de types de méthaniseurs. De nombreuses classifications de méthaniseurs existent, produites par des chercheurs et des organismes professionnels, et basées principalement sur les types de matières organiques utilisées et sur l'identité des actionnaires majoritaires des méthaniseurs (ADEME, 2015b; EBA, 2018; Le Guen & Damiano, 2013). En France, une classification légale existe également, en vertu de la législation ICPE, et distingue les méthaniseurs en fonction du volume des matières organiques digérées.

Enfin, nous présentons les caractéristiques techniques des digestats. Les digestats sont les résidus non digérés de la réaction de méthanisation, et contiennent à la fois du carbone, des nutriments NPK¹, et des oligo-éléments comme le soufre et le calcium (Delfosse, 2010), et ont un pH plutôt basique. Leurs teneurs en matière organique et en éléments nutritifs dépendent de celles des intrants utilisés par les méthaniseurs. De plus, les digestats peuvent aussi contenir des éléments indésirables, tels que des pathogènes, des métaux lourds, des polluants organiques, du verre et du plastique (Nkoa, 2014; Rigby & Smith, 2011; SOLAGRO & IRSTEA, 2015). Plusieurs technologies de *post-traitement* des digestats existent, afin de les raffiner en des produits plus purs chimiquement, et plus facilement utilisables par les agriculteurs notamment, mais ces technologies demeurent encore très peu répandues, principalement à cause de leur prix élevé (Guilayn et al., 2020; Hjort-Gregersen, 2015; Levasseur et al., 2017; Logan & Visvanathan, 2019; Trombin et al., 2017).

Section 2 : contexte politique et économique du développement de la filière méthanisation

Nous présentons, dans cette section, les principales politiques publiques à l'origine du développement du secteur, que nous décrivons par la suite.

Ce sont tout d'abord les politiques publiques européennes de transition énergétique et de promotion des énergies renouvelables, à partir de l'an 2000, qui ont amorcé la croissance du

¹ NPK = azote, phosphore et potassium

secteur. Plusieurs directives et règlements se sont succédés, jusqu'en 2022, où la guerre en Ukraine a encore plus fortement encouragé le développement de la méthanisation, afin de réduire la dépendance aux importations de gaz russe (Messad, 2022). Ces politiques européennes se déclinent en politiques nationales, dans les Etats membres. En France, c'est principalement depuis 2013 que la croissance du secteur est réellement encouragée, suite au plan « Energie, méthanisation, autonomie, azote » (Bourdin & Nadou, 2020; French Senate, 2021). En Allemagne, de nombreux bonus et subventions ont permis, depuis 2004, au travers des lois « EEG » régulièrement révisées, une croissance rapide du secteur (Thrän et al., 2020).

Puis, ce sont les récentes stratégies européennes de développement de la bioéconomie, depuis 2008, et de l'économie circulaire, depuis 2015, qui ont encouragé le développement de la méthanisation, avec pour objectif le bouclage des flux de biomasse et de nutriments (Pappalardo et al., 2018; Selvaggi et al., 2018). Ces stratégies ont également été déclinées en France, et en Allemagne, et ce sont principalement des lois promouvant le recyclage des déchets organiques qui soutiennent le développement de la méthanisation.

Grâce à ce contexte législatif très favorable au développement de la méthanisation, le secteur a connu un boom, à l'échelle européenne, entre 2009 et 2014, où plus de 10 000 méthaniseurs ont été installés, pour un total de presque 17 000 méthaniseurs. La croissance du secteur s'est poursuivie, bien que plus lentement, pour atteindre environ 20 000 méthaniseurs en 2020 (EBA, 2020; EBA, 2021). L'Allemagne est de très loin le leader mondial du secteur, avec 10 000 méthaniseurs en fonctionnement sur son sol, mais le pays cherche actuellement à stopper la croissance du secteur, pour faire face, notamment, aux conflits que ce développement suscite (Brémond et al., 2021). La France, quant à elle, compte près de 1700 méthaniseurs en fonctionnement en 2023, contre 900 en 2020 (ATEE, 2021). L'accroissement du secteur entraîne naturellement une production croissante de digestats, et on estime qu'entre 222 et 258 Mt de digestats auraient été produites en 2021 dans l'UE (EBA, 2022d), dont environ la moitié en Allemagne, et un peu plus de 10 Mt en France (European Commission, 2019).

Section 3 : contexte économique et légal de l'usage des digestats

Dans cette section, nous détaillons le contexte légal de l'usage des digestats, et le contexte économique actuel de la valorisation des digestats.

Nous rappelons tout d'abord que l'Union Européenne a adopté, depuis juillet 2022, le règlement 2019/1009 sur les matières fertilisantes d'origine organique, qui permet aux

digestats, dans la mesure où ils respectent un ensemble de critères de qualité et d'innocuité, d'être commercialisés avec un statut de produit dans tout le marché européen unique. En dehors de ces critères, ce sont les états membres qui fixent les règles quant au statut légal des digestats.

En France, les digestats ont un statut, *a priori*, de déchets, et doivent être épandus sur des sols agricoles suivant un plan d'épandage autorisé par la préfecture (CPE, 2020). Cependant, si les digestats respectent certains critères de qualité et d'innocuité supplémentaires, ils peuvent être commercialisés en tant que produits, suivant, soit, les critères établis par le Cahier des Charges entré en vigueur en octobre 2020, les critères des normes NF U 44-051, NF U 44-071, NF U44-95, NF U 44-551 et NF U42-001/A12 (ADEME, 2015b), ou la délivrance d'une autorisation de mise sur le marché.

En Allemagne, au contraire, les digestats ont un statut de produit, et leur usage suit les règles d'utilisation des autres fertilisants organiques, établies notamment par les règlements sur la fertilisation et l'ordonnance sur les biodéchets (Dollhofer & Zettl, 2017; Trombin et al., 2017).

On estime que 95 % des digestats, en Europe, sont épandus sur les sols agricoles en tant que matière fertilisante et amendante (Dahlin et al., 2015). Ces épandages ont souvent lieu dans un rayon de 15 à 30 km autour du méthaniseur, pour éviter des coûts de transport et de stockage trop élevés (WRAP, 2013). De nombreuses autres possibilités de valorisation des digestats sont explorées, ou théorisées : usage sur des marchés agricoles de niche comme la vermiculture, la culture de champignon, l'horticulture ou culture des algues, mais aussi comme matière première pour le secteur du textile ou de la construction. Mais pour l'instant aucune commercialisation réelle à grande échelle (Rigby and Smith, 2011; Monlau et al., 2015; Plana & Noche, 2016; Dahlin et al., 2017; Trombin et al., 2017; Fruhner-Weiß, 2018; Logan & Visvanathan, 2019; Theuerl et al., 2019; Guilayn et al., 2020).

Chapitre 2 : problématique de recherche

Dans ce chapitre, nous présentons les questions de recherche qui ont émergé dans la littérature scientifique, à propos de la valorisation des digestats, et qui demeurent encore sans réponse. Nous précisons ensuite les questions auxquelles nos travaux cherchent à répondre.

La question de la territorialisation du secteur

Parmi les questions de recherche qui ont émergé, ces dernières années, dans la littérature scientifique, il y a celle de la territorialisation de l'économie circulaire, c'est-à-dire, de son déploiement dans les territoires, et de son adaptation aux spécificités territoriales (Gallaud and Laperche, 2016; Carrière, 2018; Niang et al., 2020). La méthanisation, conçue comme un modèle de bioéconomie circulaire, fait également face au défi de l'intégration de la dimension territorial et spatiale dans son déploiement à grande échelle. Cette dimension spatiale et territoriale des projets de méthanisation, et son impact dans la réussite ou l'échec des projets, se doit d'être encore étudiée et analysée (Bourdin, 2020a; Bourdin & Nadou, 2020).

Les controverses autour de la filière

La littérature scientifique souligne également les controverses sociales, environnementales et sanitaires qui émergent autour des externalités négatives potentielles entourant le développement de la méthanisation (Bourdin & Nadou, 2020; Chodkowska-Miszczuk et al., 2019; Koszel & Lorencowicz, 2015; Monlau et al., 2015; Niang et al., 2022; Schumacher & Schultmann, 2017; Theuerl et al., 2019; Zemo et al., 2019). Tout d'abord, il existe des controverses sur le bilan carbone réel de la méthanisation, impacté notamment par la gestion des digestats (Dornburg et al., 2010; Guilayn et al., 2020). Sont également mentionnées des controverses sur la pollution des eaux aux nitrates et aux phosphates, par des fuites et par le lessivage des digestats (Plana & Noche, 2016; Trombin et al., 2017), mais aussi la contamination des eaux par des pathogènes et des polluants contenus dans les digestats (Dabert et al., 2013; Guilayn et al., 2020; Nkoa, 2014; Plana & Noche, 2016; Rigby & Smith, 2011; Theuerl et al., 2019), et l'usage de cultures dédiées comme le maïs (Dornburg et al., 2010; Yang et al., 2021). De nombreuses incertitudes scientifiques demeurent également sur les impacts à long terme des digestats, notamment sur les sols et la biodiversité (Theuerl et al., 2019; Trombin et al., 2017). Enfin, des controverses existent aussi sur l'impact des méthaniseurs sur les paysages, la congestion des routes et l'émission d'odeurs déplaisantes (Bourdin & Nadou, 2020; Chodkowska-Miszczuk et al., 2019; Giuliano et al., 2018; Soland et al., 2013).

Des oppositions locales à la méthanisation

Les controverses et les inquiétudes détaillées précédemment ne sont pas sans conséquences sur l'acceptation des méthaniseurs au niveau local. Elles génèrent des « résistances », du « rejet », des « oppositions » et des « conflits » qui sont qualifiés de

« fréquents » en France (Bourdin, 2020a; Bourdin, Jeanne, et al., 2020; Depoudent et al., 2020; Giuliano et al., 2018; Niang et al., 2021, 2022; Schumacher et al., 2019). Ces oppositions et ces conflits menacent sérieusement le développement de la filière, causant l'annulation d'environ 30% des projets, ou des retards conséquents dans leur développement (Bourdin, 2020a; Bourdin, Jeanne, et al., 2020; Bourdin & Nadou, 2020; Chodkowska-Miszczuk et al., 2019; Niang et al., 2021, 2022). Plusieurs études évoquent l'importance de la valorisation des digestats dans l'émergence de ces conflits, et suggèrent que ce sujet devrait être étudié de manière plus approfondie (Chodkowska-Miszczuk et al., 2019; Depoudent et al., 2020).

La littérature scientifique demeure peu développée

Malgré l'identification de nombreux conflits autour des méthaniseurs, et de la valorisation des digestats, la littérature sur le sujet demeure peu développée (Bourdin, 2020a). Les recherches en sciences humaines et sociales sur les digestats se concentrent principalement sur des aspects de marketing et de consentement à payer des agriculteurs (Dahlin et al., 2015, 2017; Guilayn et al., 2020; Pappalardo et al., 2018; Rigby & Smith, 2011; Selvaggi et al., 2018, 2021; WRAP, 2012). En parallèle, la recherche en SHS sur la filière méthanisation s'est récemment développée autour des questions de coordination des acteurs locaux, souvent au travers d'études de cas, d'entretiens semi-directifs et d'analyse de la presse (Bourdin, Colas, et al., 2019; Bourdin, Nadou, et al., 2019; Bourdin, 2020a; Bourdin & Nadou, 2020; Niang et al., 2021, 2022; Schumacher et al., 2019; Soland et al., 2013). Cependant, la plupart de ces études, soit, se concentrent sur la coordination en amont de la construction du méthaniseur, soit ne se penchent pas de manière approfondie sur les conflits et les modes de coordination autour de la valorisation des digestats. Ce sujet reste donc à explorer. Enfin, la littérature récente autour des méthaniseurs souligne l'intérêt d'étudier l'impact de la gouvernance territoriale dans l'émergence et la résolution des conflits, tout en considérant que ce sujet reste trop peu exploré (Niang et al., 2021, 2022).

Questions de recherche

Suite aux différents constats exposés précédemment, nos recherches s'articulent autour d'une problématique centrale :

Comment les mécanismes de gouvernance territoriale peuvent-ils impacter l'émergence et la résolution des conflits locaux autour de la gestion et de l'usage des digestats ?

Nous détaillons cette problématique en plusieurs questions de recherche :

-Quelle est la nature de ces conflits et quelles dimensions des territoires ils affectent ? Peut-on identifier des conflits spécifiques à certains contextes territoriaux, et observer des conflits qui émergent indépendamment du contexte local ?

-Comment les acteurs locaux se coordonnent-ils autour de la gestion et de l'usage des digestats, et comment cette coordination impacte-t-elle l'émergence et la résolution des conflits ?

-Comment les problématiques d'incertitude et de manque d'information et de connaissances sur les digestats et leurs impacts impactent-elles les mécanismes de coordination locale des acteurs ?

Chapitre 3 : cadre d'analyse

Dans ce troisième chapitre, nous présentons notre cadre d'analyse, qui nous permet de proposer une première réponse à nos questions de recherche, et à formuler des hypothèses que nous testons par la suite de manière empirique.

Section 1 : la mobilisation du capital territorial

Nous évoquons, tout d'abord, l'importance de la « variable territoriale » (Pecqueur, 1989), dans le développement des activités économiques à l'échelle locale. Nous nous inscrivons dans le champ scientifique de l'économie des territoires, où les territoires sont des construits sociaux et des systèmes dynamiques, aux frontières mouvantes, faits à la fois de ressources et d'agents, qui eux-mêmes mobilisent et créent ces ressources (Chevalier & Pola, 2014; Dermine-Brullot & Torre, 2020; Leloup, 2010; Leloup et al., 2005; Zimmermann, 2008). Nous faisons donc l'hypothèse que l'activité de valorisation des digestats participe à la définition de nouveaux territoires.

La territorialisation des activités de valorisation des digestats, c'est-à-dire, leur adaptation aux contextes territoriaux, peut correspondre à deux appréciations différentes de ce concept. Tout d'abord, une définition francophone, basée sur la mobilisation adéquate des ressources du territoire pour valoriser aux mieux les digestats et éviter ainsi les conflits (Fleuret, 2015; Ginelli et al., 2020), et de l'autre, une définition anglophone, qui postule le rôle d'une autorité territoriale qui contrôle, contraint et accompagne le développement des activités économiques afin qu'elle corresponde aux spécificités locales (Bassett & Gautier, 2014). Nous

faisons l'hypothèse de la nécessité des deux approches pour assurer l'anticipation et la résolution des conflits autour des digestats.

L'ensemble des ressources matérielles et immatérielles des territoires est appelé capital territorial, ou parfois encore capital rural. (Gobert & Brullot, 2018) définissent six dimensions du capital territorial : le capital naturel, le capital organisationnel, le capital culturel, le capital institutionnel, le capital infrastructurel et le capital cognitif et technique. (Gkartzios et al., 2022) y ajoutent le capital financier, et (Chevalier & Pola, 2014) insistent sur la nature duelle du capital territorial, pouvant être à la fois un atout ou un obstacle au développement d'une activité économique.

La littérature sur la méthanisation insiste sur la nécessité d'une mobilisation adéquate des ressources matérielle et immatérielle des territoires, afin de garantir le succès des projets de méthaniseurs (Bourdin & Nadou, 2020; Chodkowska-Miszczuk et al., 2019; Depoudent et al., 2020). Nous faisons donc l'hypothèse que la gestion et l'usage des digestats nécessite la mobilisation adéquate des sept dimensions du capital territorial mentionnées précédemment. Cependant, la mobilisation de ces ressources nécessite que les acteurs locaux se coordonnent (Niang et al., 2021, 2022; Soland et al., 2013).

Section 2 : Les proximités et la coordination des acteurs locaux

La coordination des acteurs locaux est facilitée, voire permise, par l'activation des *proximités* (Boschma, 2005; Bourdeau-Lepage & Huriot, 2009; Gallaud, 2018; Zimmermann, 2008). Les travaux précédents sur la méthanisation mobilisent le concept de proximité tel que défini par l'école française de la proximité (Bourdin, Colas, et al., 2019; Bourdin, Nadou, et al., 2019; Bourdin & Nadou, 2020; Niang et al., 2021, 2022), qui admet deux grands types de proximité : la proximité géographique et la proximité organisée (Torre, 2014; Torre & Zuindeau, 2009). Nous avons souhaité, pour notre étude, mobiliser les cinq types de proximités définies par (Boschma, 2005) : la proximité géographique, et la proximité organisée divisée en proximité organisationnelle, proximité sociale, proximité cognitive et proximité institutionnelle, afin d'analyser de manière plus fine les relations entre acteurs locaux.

Il est admis que c'est par la combinaison de ces différentes proximités que la coordination peut réellement avoir lieu, et qu'un territoire peut « émerger » (Zimmermann, 2008). Cependant, tout comme le capital territorial, les proximités ont un caractère duel, et des proximités imposées sont sources de conflits (Gallaud, 2018). Ces conflits semblent être une partie intégrante du processus de développement de nouvelles activités économiques dans les

territoires (Gallaud, 2018; Torre, 2011, 2014; Torre et al., 2006) ; ils permettent aux processus de gouvernance d'évoluer et aux projets de se réadapter à leurs territoires (Bourdin, Colas, et al., 2019; Niang et al., 2021). Mais les conflits sont aussi parfois considérés comme des échecs des processus de gouvernance territoriale (Bourdin, Jeanne, et al., 2020), et la gouvernance territoriale se doit de diminuer ces conflits (Niang et al., 2021).

La gouvernance territoriale permet de réunir des acteurs locaux très divers, aux objectifs très différents, pour qu'ils se coordonnent autour d'objectifs communs (Bourdin, Colas, et al., 2019; Leloup et al., 2005; Niang et al., 2021). Le rôle d'intermédiaire territorial est souvent nécessaire pour rassembler ces différents acteurs, et ce rôle est souvent incarné par un acteur public local. L'intermédiaire territorial active la proximité territoriale, c'est-à-dire la combinaison des différentes proximités (Bourdin & Nadou, 2020; Carrière, 2018; Niang et al., 2022). Nous faisons l'hypothèse de la nécessaire activation de la proximité territoriale, parfois grâce à l'intercession d'un acteur intermédiaire, afin de permettre la mobilisation adéquate du capital territorial, pour prévenir l'émergence de conflits liés à des modes de valorisation des digestats non adaptés aux territoires, ou de résoudre ces conflits, lorsqu'ils n'ont pas pu être anticipés.

Section 3 : Acquisition et transfert d'information en situation d'incertitude partagée

Afin de pouvoir se coordonner efficacement et ainsi éviter l'émergence de conflits, la littérature insiste sur l'importance de l'échange d'information entre les différents acteurs des territoires, plus ou moins impliqués dans la vie du méthaniseur (Bourdin, Colas, et al., 2019; Bourdin, Nadou, et al., 2019; Bourdin, Jeanne, et al., 2020; Bourdin & Nadou, 2020; Chodkowska-Miszczuk et al., 2019). Cependant, dans les travaux de recherche précédents, l'information est considérée comme existante, et détenue par certains agents qui peuvent faire l'effort d'améliorer leur communication. Or, au vu des incertitudes que nous avons exposées au chapitre 2, sur l'impact de l'usage des digestats, nous postulons qu'il existe des situations d'incertitude partagée sur les propriétés des digestats, c'est-à-dire, des situations où aucun agent du territoire ne possède l'information parfaite sur les digestats. Nous faisons l'hypothèse qu'il existe donc à la fois des situations d'asymétrie d'information nécessitant une amélioration des échanges d'information, et des situations d'incertitude partagée nécessitant de nouvelles formes de coordination des acteurs afin d'acquérir et de produire cette information manquante.

Chapitre 4 : matériel et méthode

Ce chapitre expose la méthode employée pour confronter les hypothèses formulées au chapitre 3 avec des explorations de terrain.

Section 1 : la méthode qualitative de l'étude de cas

Tout d'abord, nous choisissons un positionnement épistémologique constructiviste et relativiste, car nous considérons notre objet d'étude, la gouvernance territoriale, comme un construit social qui n'a pas d'existence propre *a priori*. La méthode qualitative est un prolongement logique de ce positionnement épistémologique. Elle permet d'étudier de manière holistique et approfondie un sujet complexe et encore peu étudié, et d'en étudier le contexte de manière détaillée et précise (Baškarada, 2014; Livian, 2018; Njie & Asimiran, 2014).

Au sein de la méthode qualitative, nous avons choisi de mobiliser la méthode de l'étude de cas holistique et multiple, telle que décrite par (R. Yin, 2003). La méthode de l'étude de cas permet d'étudier particulièrement l'impact du contexte dans un sujet donné, et nous cherchons précisément à comprendre l'impact du contexte territorial dans la valorisation des digestats et l'émergence des conflits. La méthode de l'étude de cas ne permet, non pas d'obtenir des résultats généralisables de manière statistiques, mais permet de formuler des propositions théoriques sur le phénomène étudié, propositions qui peuvent être ensuite testées avec d'autres investigations (R. Yin, 2003). Nous menons nos investigations de terrain en suivant une approche itérative, c'est-à-dire en adaptant constamment notre collecte de données avec la littérature théorique (Baškarada, 2014).

Section 2 : sélection et description des cas étudiés

Nous avons choisi d'étudier cinq cas d'études, comme préconisé par (Marshall et al., 2013). Nous avons sélectionné quatre cas français de méthaniseurs industriels et centralisés, dans quatre régions différentes, en faisant l'hypothèse que cela nous permettrait d'étudier des contextes différents. Après nos investigations des cas français, nous avons sélectionné un cas allemand, qui nous permet de confirmer ou de questionner les observations de nos cas français, à la manière du cas critique décrit par (R. Yin, 2003). Nous avons délimité nos cas d'étude par leur activité, la gestion et la valorisation des digestats, par l'espace où ces activités ont lieu, et par le temps, du début des activités jusqu'en 2022, fin de nos investigations de terrain.

Section 3 : collecte et analyse des données

Nous mobilisons plusieurs sources de données pour accroître la fiabilité et la pertinence de nos observations, et nous mobilisons des sources déjà utilisées par les précédentes recherches en SHS sur le sujet (Baškarada, 2014; Bourdin, Colas, et al., 2019; Bourdin, Nadou, et al., 2019; Bourdin & Nadou, 2020; Depoudent et al., 2020; Niang et al., 2021, 2022). Nous avons conduit 69 entretiens semi-directifs, nous avons analysé 60 articles de la presse locale, nationale et spécialisée, et nous avons analysé 77 documents issus de la littérature grise. Nous avons analysé nos données par thèmes, de manière à la fois monographique et transversale, en nous aidant du logiciel Nvivo®.

Chapitre 5 : organisation et conflits autour de la valorisation des digestats

Dans ce chapitre, nous exposons la première partie de nos résultats issus de nos études de cas, puis nous discutons ces résultats dans la dernière section du chapitre.

Section 1 : la valorisation des digestats s'intègre dans des contextes territoriaux ambivalents

Nous présentons, dans cette section, les différentes dimensions du capital territorial déjà plus ou moins mobilisées par les acteurs locaux et régionaux, autour des questions d'épandage, des activités agricoles et de la protection de l'environnement, en amont de la valorisation des digestats. Nous présentons également les différentes proximités déjà activées pour mobiliser ces ressources territoriales. Nous exposons et comparons tout d'abord les contextes naturels et agricoles de nos cas d'étude, puis nous comparons les contextes économiques et institutionnels, et enfin nous détaillons les contextes culturels et cognitifs. Nous montrons que ces différents contextes peuvent être à la fois des freins et des atouts pour la valorisation des digestats.

Section 2 : de ces contextes ambivalents émergent des opportunités et des conflits

Nous détaillons de manière plus précise, dans cette section, comment les différents contextes territoriaux de nos cas d'études créent des opportunités pour la valorisation des digestats, mais également comment ils peuvent contenir les germes de conflits autour des

digestats. Nous montrons que les principales sources de conflits proviennent d'un capital infrastructuel et d'équipements inadapté à la gestion et à l'usage des digestats, provoquant des dommages sur le capital naturel, de l'émission d'odeurs nauséabondes aux différentes étapes de la valorisation des digestats (production, transport, stockage, épandage), et de visions politiques et culturelles divergentes du développement agricole et de la transition écologique.

Section 3 : des peurs et des tensions émergent de l'asymétrie d'information et de l'incertitude partagée

Nous exposons, dans cette section, nos observations de situations d'asymétrie d'information et d'incertitude partagée autour des impacts des digestats, qui s'ajoutent aux conflits décrits dans la section précédente. Nous décrivons les situations qui ont révélé que les digestats avaient à la fois des caractéristiques de biens de recherche, de croyance, d'expérience, et que ce sont également des biens incertains voire controversés. Ces situations d'asymétrie d'information et d'incertitude partagée créent parfois des « guerres de la vérité », où différents groupes d'acteurs s'opposent de manière plus ou moins virulente, dans les territoires, autour de ce qu'ils pensent être la vérité sur les caractéristiques et les impacts des digestats.

Section 4 : la valorisation des digestats est modelée par, et modèle, en retour, les territoires

Nous discutons, dans cette section, les résultats présentés dans les sections précédentes. Tout d'abord, nous montrons que la valorisation des digestats, et les conflits locaux qui en émergent, contribuent à définir et à redéfinir des espaces et des territoires, par l'action et la coordination des différents acteurs de la filière, et par la mobilisation des ressources matérielles et immatérielles à différentes échelles spatiales. Nous complétons également le cadre théorique du capital territorial en mettant en valeur de nouvelles dimensions du capital que nous avons identifiées, et qui contribuent à la valorisation des digestats. Nous confirmons la nature duelle du capital territorial. Nous proposons également une séquence explicative de l'émergence des conflits : une faible activation des proximités organisationnelles et sociales entraîne une faible activation des proximités institutionnelles et cognitives, l'ensemble entraînant une mobilisation inadéquate du capital territorial. Le tout combiné à une proximité géographique imposée génère

les conflits. Enfin, nous confirmons l'importance de considérer des situations d'incertitude partagée dans l'étude de la coordination des acteurs autour des méthaniseurs.

Chapitre 6 : anticiper et résoudre les conflits : une analyse dynamique et multi-acteurs de la gouvernance territoriale

Dans ce chapitre, nous exposons la seconde partie de nos résultats et nous les discutons.

Section 1 : la coordination des acteurs à l'échelle locale

Dans cette section, nous nous penchons en détail sur les mécanismes de coordination des acteurs à l'échelle locale. Par échelle locale, nous entendons l'échelle spatiale de réalisation effective des activités de valorisation des digestats : échelle des chantiers d'épandage, échelle du méthaniseur, échelle des stockages... Nous rendons compte, en premier lieu, d'un manque global de coordination et d'anticipation de la valorisation des digestats, dans les territoires. En second lieu, nous détaillons les mécanismes de coordination permettant une anticipation des conflits. Nous soulignons le rôle des interactions directes entre les acteurs, mais aussi la place d'un intermédiaire pour faciliter les échanges d'information. Nous exposons ensuite les mécanismes de coordination permettant une résolution des conflits locaux. Nous soulignons à nouveau le rôle des interactions directes et des intermédiaires, pluriels, pour résoudre les conflits. La coordination des acteurs aboutit bien souvent à un enrichissement du capital infrastructurel.

Section 2 : la coordination des acteurs à l'échelle régionale

Dans cette section, nous explorons les mécanismes de coordination des acteurs à l'échelle régionale. Par échelle régionale, nous entendons toutes les échelles spatiales supra-locales que nous avons identifiées dans nos études de cas, c'est-à-dire, la région administrative, le bassin versant, le département, le parc naturel régional... Nous détaillons, d'une part, les mécanismes de coordination observés pour anticiper les conflits, et d'autre part, ceux observés pour résoudre les conflits. Nous identifions, dans les deux cas, le rôle inévitable d'un intermédiaire régional capable d'activer la proximité territoriale. L'activation des proximités à l'échelle régionale permet l'acquisition et la production d'information et de connaissances

nouvelles, apportant ainsi une solution aux situations d'incertitude partagée. Cette activation régionale permet également de développer des visions communes du développement de la méthanisation, et plus largement, de la transition écologique et énergétique. Enfin, nous soulignons à la fois la grande diversité d'identité des intermédiaires régionaux, mais nous insistons aussi sur le rôle quasi indispensable de l'Etat dans l'activation des proximités, dû à la fois à son autorité légale, et à sa responsabilité dans le développement de la filière.

Section 3 : une gouvernance territoriale aux caractéristiques et aux dynamiques multiples

Dans cette section, nous discutons les résultats présentés dans les deux sections précédentes. Nous confirmons, tout d'abord, l'hypothèse selon laquelle la territorialisation de la filière nécessite à la fois une mobilisation adéquate des ressources territoriales par les acteurs locaux, et un contrôle et un encadrement par l'Etat des activités de valorisation des digestats. Nous revenons également sur l'existence de conflits quel que soit le contexte territorial, ce qui confirme l'idée que les conflits sont des parties intégrantes des processus de gouvernance territoriale, et qu'ils contribuent à les faire évoluer, afin d'anticiper l'émergence, de nouveau, de conflits similaires. Nous insistons également sur la nécessité d'appréhender la très grande diversité d'acteurs participant ou souhaitant participer aux processus de gouvernance territoriale, et nous rappelons la diversité des intermédiaires territoriaux possibles, tant des acteurs publics que privés. Enfin, nous soulignons l'importance tant des interactions directes entre acteurs, que des interactions facilitées par un intermédiaire territorial, pour résoudre les situations d'asymétrie d'information et d'incertitude partagée.

Chapitre 7 : recommandations de gouvernance à l'attention des acteurs de la filière méthanisation

Ce chapitre est volontairement bref et concis. Il contient les recommandations que nous souhaitons transmettre aux acteurs de la filière. Il est utilisable par quiconque indépendamment du reste du présent manuscrit.

Conclusion

Nous commençons, tout d'abord, par rappeler nos résultats au regard de nos questions de recherche. Nous évoquons à la fois le rôle de l'Etat dans la territorialisation de la

méthanisation, ainsi que l'importance de la mobilisation adéquate du capital territorial, par l'activation de la proximité territoriale, pour anticiper et résoudre les conflits autour de la valorisation des digestats. L'activation de la proximité territoriale est facilitée par des intermédiaires multiples aux identités diverses, à des échelles spatiales différentes, et elle permet à la fois la production et l'acquisition d'information et de connaissances nouvelles, la transformation du capital territorial, et le développement de visions partagées autour des digestats et de la méthanisation. Nous exposons ensuite des limites à nos travaux, notamment des limites méthodologiques liées à l'emploi de la méthode qualitative, entraînant de possibles biais dans nos résultats. Enfin, nous proposons des perspectives de recherches futures, notamment à propos de l'importance de l'incertitude partagée et de la dimension politique et culturelle dans les projets de bioéconomie circulaire, et de transition énergétique et écologique. Nous évoquons également la possibilité de mobiliser des méthodes quantitatives et qualitatives pour compléter nos présents résultats.

Territorial governance for the anticipation and resolution of conflicts in projects of valorization of digestates

Introduction

1. Context: biogas production at the crossroad of major challenges

Our modern world currently faces a global unprecedented environmental crisis, which is a source of multiple challenges, among which: the global warming of temperatures, the desertification of agricultural soils, increasing droughts, biodiversity loss, and the depletion of natural resources, in particular, of water resources (IPCC, 2023). These challenges seriously threaten the agricultural sector, and our capacity to produce food for an ever-increasing human population (FAO 2023). In parallel, agricultural activities are considered as one of the major causes of global warming, notably because of the important Green House Gas (GHG) emissions of the sector (IPCC, 2023). Therefore, the mitigation of carbon emissions, and even the will to reach carbon neutrality, in the agricultural sector and in other economic sectors, are among the most important goals of the 21st century (United Nations, 2015). Achieving this goal notably goes through the shift from the use of fossil fuels to renewable sources of energy (IPCC, 2023). To this environmental crisis add economic and political challenges, including the economic and demographic decline of rural areas, and the abandonment of land use (Fourcroy & Drejerska, 2019). More recently, the COVID crisis and the 2022-war in Ukraine induced a rise in energy and food prices, and highlighted the necessity of food and energy sovereignty in the European Union (European Commission, 2022a).

However, according to the new European Green Deal launched by the European Commission (2023), rural territories have a full potential to overcome these environmental, economic, political and social challenges (European Commission, 2023). The mobilization and the valorization of rural biological resources, and in the first place, of agricultural resources, can highly contribute to the EU bioeconomy strategy, whose implementation in rural areas is supposed to boost local economy, protect the environment and improve the well-being of rural inhabitants by providing jobs and opportunities (European Commission, 2018). The EU bioeconomy strategy has recently been connected to the EU circular economy strategy, and the development of a circular bioeconomy in rural areas, i.e., the circular use of biological resources, is supposed to help mitigating GHG emissions and to protect natural resources

(European Commission, 2022b).

The development of the biogas sector in the rural territories of the EU has recently been promoted as a model of the circular bioeconomy. The circular use of biomass, including agricultural biomass, as a local renewable source of energy, is supposed to improve the management of natural resources and of biowastes, to increase the energy autonomy of farms and rural territories, and to contribute to a decrease in GHG emissions. In addition, the use of digestates, the by-product of biogas production, as cheap local fertilizers, should also support the economic resilience and the autonomy of the agricultural sector (French Senate, 2021). The development of the biogas sector should therefore bring solutions to the main environmental, socio-economic and political challenges affecting agricultural and rural areas. The fast and important development of the biogas sector in rural territories has recently raised the interest of the scientific community, which seeks to study, observe and understand the implementation of the circular bioeconomy at the local level. Our research is therefore embedded in this new scientific and economic horizon.

2. Definition of the topic and research objectives

Our work is in the continuity of recent research that have focused on understanding the organization of the biogas sector in rural territories, and especially, on understanding the coordination of local agents around biogas projects, how they mobilize material and immaterial resources, what challenges they face and how they overcome them (Bourdin, Colas, et al., 2019; Bourdin, Nadou, et al., 2019; Bourdin, 2020a; Bourdin, Jeanne, et al., 2020; Bourdin & Nadou, 2020; Depoudent et al., 2020; Niang et al., 2021, 2022; Schumacher et al., 2019; Soland et al., 2013). Based on previous results, Niang et al. (2021) argued that “market coordination is not sufficient in the case of local circular economy experiments and that local agreements need to rely on the cooperation between local actors”. In this perspective, recent research chose to investigate the territorial governance mechanisms that allow for a successful implementation of circular bioeconomy projects, and especially, of biogas projects (Bourdin, Colas, et al., 2019; Bourdin, Nadou, et al., 2019; Bourdin, 2020a; Bourdin & Nadou, 2020; Niang et al., 2021, 2021, 2022). According to (Leloup et al., 2005), territorial governance corresponds to new modes of local organization, and, in an economic framework, it is the process of coordination of local agents in the perspective of organizing economic activity. Territorial governance implies the creation of new places, techniques and processes of coordination to develop

projects. In this perspective, territories contribute to reduce transaction costs, and are therefore the adequate spatial level to implement collective action. In addition, non-economic institutions are considered as capable of facilitating local coordination, and therefore hold an important place in territorial governance processes (Leloup et al., 2005).

However, according to (Niang et al., 2020, 2021), only little attention has yet been paid, by the scientific community, to territorial governance mechanisms around biogas projects, and more attention should be paid to the nature and role of conflicts in governance processes.

Therefore, the objective of our research is to contribute to the understanding of the territorial governance mechanisms at work in the development of the biogas sector, to the understanding of the challenges that the sector faces, and particularly, the conflicts, and to how stakeholders deal with these challenges. By extension, our results will contribute to a better understanding of the coordination mechanisms at work in the development of the circular bioeconomy in rural areas.

In the continuity of previous research on our topic, our work is embedded in the field of geographical economics, and especially, economics of territories. Geographical economics is a field of research that aims at understanding the role of space in the development of economic activities (Thisse, 2011). Economics of territories go even further by focusing on the role of *territories*, and not just “space”, in the development of economic activities (Leloup, 2010). The mobilization of these fields of research allows us to study and analyze the determinants and modes of coordination of local agents, within their territories, where the projects of biogas plants are actually designed and conceived. To complement this approach, we also mobilize some elements of the Economics of Quality, to capture the impacts of imperfect information in the coordination of agents (Lupton, 2002, 2005).

The originality of our work therefore lies in our contribution to bridge the knowledge gap about the mechanisms and processes of coordination within the biogas sector. Moreover, our research puts a particular emphasize on the conflicts and the coordination mechanisms to anticipate and solve these conflicts. And, additionally, our research targets the downstream stages of the sector, i.e., the valorization of digestates, because previous research focused more on the upstream stages and the launch of projects, while we focus on the operations of biogas plants and the management of digestates.

We conducted applied research, within the Institut Polytechnique UniLaSalle (France), in the team InTerACT, and co-funded by the French Agency for the Ecological Transition (ADEME) and the Avril Group. The ADEME is a public institution in charge of implementing public policies on the ecological transition throughout the French territory. It supports the

development of the biogas sector through studies, experiments and subsidies. The Avril Group is a world leader of the agri-food sector. The group notably valorizes agricultural co-products, hence its interests in the valorization of digestates, and it shows interest in the biogas sector as a lever for the resilience of the agri-food sector. We aim, through our applied research, to deliver recommendations of governance to the stakeholders of the biogas sector in France.

3. Method of the research

We follow an epistemological approach that is essentially relativist, as our main research topic, territorial governance, is a socially constructed object and does not exist *a priori*. Our research is therefore based on a constructivist paradigm, based on relativist assumptions about the nature of reality. We chose the qualitative method as a logical extension of our constructivist paradigm. The choice of the qualitative method, which makes us belong to heterodox economics, allows us to investigate and understand the complex phenomena that underlie the interactions between economic and non-economic agents, and their process of coordination (Livian, 2018). Within the qualitative approach, we chose the direction of the holistic multiple-case study method, as defined by (R. Yin, 2003). We selected five case studies of biogas plants, four in France and one in Germany. We focus on the development of the biogas sector in France, but the German case was selected to benefit from a comparison with a country that developed its biogas sector ten years before France, and has ten times more biogas plants. We followed an iterative approach to conduct our investigation, i.e., we constantly went back and forth between our field investigations and theory (Baškarada, 2014; R. Yin, 2003). We used the main tools of data collection associated to the qualitative case study method: we conducted semi-structured interviews with experts and stakeholders of the sector, we collected and analyzed documents from various sources of the grey literature, and we reviewed the press. We analyzed our data using both a monographic approach and a cross-cutting thematic analysis, in the same way as previous research on our topic (Depoucent et al., 2020).

4. Contents of the manuscript

The present manuscript is divided into 7 chapters. In the first chapter, we present the context and the perspectives of development of the biogas sector, in its various aspects, including the technical, economic and regulatory aspects. In the second chapter, we expose the

research questions that have been left unanswered by previous research, and based on these, we detail our research objectives. In the third chapter, we present our analytical framework, and our research assumptions, that we wish to confront to our field investigations. In the fourth chapter, we expose the method we followed for our field investigations. The fifth and the sixth chapters contain the results of our field investigations, and a discussion of these results. Finally, chapter 7, redacted both in French and in English to be easily available to the stakeholders of the biogas sector, displays recommendations of governance.

In the first chapter entitled “*Context of development of the biogas sector*”, we first present the technical and organizational context of development of the sector, and we show the variety and heterogeneity of biogas plants and of their production processes. We also expose the characteristics of digestates, and again, we highlight the variety and heterogeneity of digestates (section 1). We then detail the political and economic context of development of the sector, in the EU, in France and in Germany. We detail the role of energy, bioeconomy and Circular Economy policies in the development of the biogas sector, and the forecasts for future development (section 2). We then focus on digestates, and we expose the regulatory context of the use of digestates, and its impacts on the various modes of valorisation of digestates, that we also detail (section 3).

In the second chapter, entitled “*Research problem*”, we present the research questions that have emerged from the dynamic and complex development of the biogas sector that we exposed in Chapter 1. We first expose the claims made in the literature about the necessity to pay much more attention to the spatial and territorial dimensions of the development of the biogas sector, and, more generally, of circular bioeconomy projects (section 1). We then review the controversies around the biogas sector, presented in the scientific literature, and often associated to the lack of consideration for the territorial dimension, and / or to the lack of scientific knowledge (section 2). Then, we explain how these controversies lead to oppositions, rejections and conflicts around biogas plants (section 3). However, we show that the social sciences literature that addresses these issues remains rather scarce, and that there is almost no literature dedicated to the issues around the valorization of digestates. We then explain that the recent literature claims for the necessity to study and analyze the role of territorial governance in the anticipation and resolution of challenges and conflicts around biogas projects (section 4). In section 5, we formulate the research problem that has emerged from the literature review, which is about the role of territorial governance in the anticipation and resolution of conflicts around the valorization of digestates. We also detail the research questions that arise from our

research problem, and we present the epistemological approach we take to answer these questions.

In the third chapter, entitled “*Analytical framework*”, we present the theoretical corpus we review and mobilize to answer our research questions, and to formulate assumptions that we test through our field investigations. In the first section, we mobilize the framework of the economics of territories, and in particular, the concept of territorial capital, to understand and formulate assumptions on how territories and their inner resources shape the development of the biogas sector and the emergence of conflicts. In the second section, we mobilize the framework of proximities and of territorial governance to understand how agents coordinate to mobilize the territorial capital, and to formulate assumptions on how it affects the emergence or the resolution of conflicts. In section 3, we mobilize the framework of the Economics of Quality to show that information about digestates is often imperfect, and we formulate assumptions about the impact it has on the coordination of agents.

In the fourth chapter, entitled “*materials and method*”, we present the method we used to conduct our field investigations. We first expose the arguments in favor of the qualitative holistic multiple-case study method combined with an iterative approach (section 1). In the second section, we explain how and why we selected our case studies, then we present how we bounded our cases, and we provide general information about the cases. In the third section, we detail how we collected the data and which sources of data we mobilized, and how we analyzed the data collected.

In the fifth chapter, entitled “*Organization and conflicts over the valorization of digestates*”, we present the first part of the results of our field investigations, and we discuss them in the light of the literature we reviewed in chapter 3. We first describe the ambivalent territorial contexts into which our case studies are embedded, and how these contexts create unique sets of the territorial capital (section 1). Then, we explain how these contexts create both opportunities and challenges for the valorization of digestates. We describe the issues and conflicts we observed around the valorization of digestates (section 2). Then, we expose the situations of imperfect information we witnessed and their impacts on the relationships between local agents (section 3). In section 4, we discussed our results in light of the literature on the territorial capital, proximities and imperfect information.

In the sixth chapter, entitled “*The anticipation and resolution of conflicts: a dynamic and multi-actor analysis of territorial governance*”, we present the second part of our results,

and we also discuss them in light of chapter 3. We first present the mechanisms and processes of coordination of stakeholders at the local scale, both to anticipate and to solve the conflicts we described in chapter 5 (section 1). We then describe the mechanisms and processes of coordination of stakeholders at the regional scale, and again, both to anticipate and to solve the conflicts exposed in chapter 5 (section 2). In section 3, we discussed these results in light of the literature on territorial governance and imperfect information we mobilized in chapter 3.

The seventh and last chapter, entitled “*Recommendations of governance to the stakeholders of the biogas sector*”, is a brief and concise chapter that contains the main recommendations of governance we wish to address to the stakeholders of the biogas sector, based on the research and results we expose in the six previous chapters of this manuscript.

Chapter 1: Context of development of the biogas sector

Introduction

The aim of this chapter is to present the context of development of the biogas sector in the European Union, with a particular focus on the specificities encountered in France and in Germany. We also make a focus on the management and the use of digestates. We first present the technical and organizational context of biogas and digestates production, to provide the reader with a global understanding of the organization of this production (Section 1). We then present the political and economic context that supports the deployment of the sector, in the EU, as well as in France and in Germany (Section 2). We show how the development of the sector was initiated, what policies sustain its development, and we detail the dynamics of growth of the sector. We then move to our focus on digestates, by presenting the regulatory and economic contexts into which the use of digestates is embedded (Section 3). We focus on the legal status of digestates, and its impacts on the opportunities of valorization, and we present these economic opportunities. We conclude this chapter with a general conclusion and a transition to the next chapter.

Section 1: Technical and organizational context

Introduction of Section 1

Section 1 is divided into four sub-sections. In the first sub-section, we present the processes of production of biogas and digestates from a biochemical perspective, and the different stages of production at the scale of a biogas plant. In the second sub-section, we detail the types of feedstocks used in the production processes and their impacts on the qualities of digestates. In the third sub-section, we present the different categories of biogas plants that result from the combination of different parameters, including the processes of production and the types of feedstocks. In the fourth and last sub-section, we focus on biochemical and agronomic properties of digestates, and we present post-treatment technologies and their outcomes.

1. The process of biogas production

Biogas production, also called “méthanisation” in French, is originally the result of a *natural* chemical reaction called “anaerobic digestion”, which literally means a digestion that occurs in conditions where oxygen is absent². The French Agency for the Ecological Transition (ADEME), one of the main supporters of biogas production in France, defines methanation as “a *technology* based on the degradation by micro-organisms of organic matter, under controlled conditions and in the absence of oxygen” (ADEME, 2015b, 2016). The initial natural reaction is therefore turned into a technological process in order to satisfy human needs. This biochemical reaction of “anaerobic digestion” transforms complex organic matter into simpler elements: it produces methane (CH₄), which is the biogas that gives its name to the reaction, and is the most desired outcome of the process, but the reaction also produces gaseous by-products, mainly carbon dioxide (CO₂), ammonia (NH₃) and hydrogen sulphide (H₂S), and a solid or liquid by-product, called digestate (Delfosse, 2010). An important characteristic of this reaction is that although biogas is the expected outcome of the process, up to 70-90% of the volume of the organic matter digested in the reaction can actually become *digestates* (Martel & Desmeules, 2013; Turley et al., 2016), which makes the management of digestates a key element for the development of the biogas sector.

The reaction of anaerobic digestion is complex and involves a whole community of micro-organisms that have to be maintained in the adequate conditions to produce the expected volume of biogas. The reaction, described by Figure 1, starts with the hydrolysis of complex organic matter (carbohydrates, lipids and proteins) by hydrolytic bacteria. The simpler organic components (fatty acids, amino acids and simple carbohydrates) obtained are then turned into alcohols and volatile fatty acids by acidogenic bacteria. These components are then turned into acetate, dihydrogen (H₂) and CO₂ by acetogenic bacteria. Finally, acetoclastic and hydrogenotrophic methanogenic bacteria turn part of these gases into biomethane. The organic matter that has not been digested, and the wastes from these successive reactions produce the *digestates* (Delfosse, 2010).

² The opposite reaction, the digestion of organic matter under conditions where oxygen is present, creates compost.

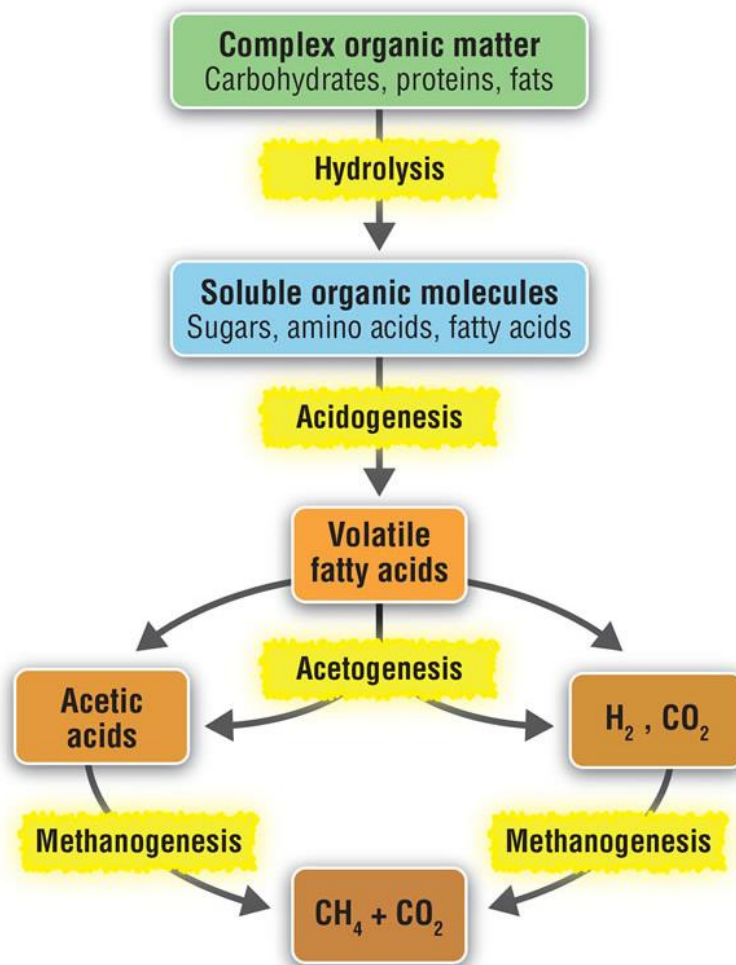


Figure 1: “Biological process of anaerobic digestion” (source: Greene, 2016)

In addition to this delicate chain of reactions, the process itself can be held in several different conditions that produce variations in the outcomes. The first distinction in the production process is the choice of wet or dry conditions to carry out the reaction of anaerobic digestion, and this choice depends on the types of feedstocks used. The main differences of outcomes between dry and wet conditions are biogas production efficiency, volumes of liquid by-products produced and the more or less liquid physical state of digestates (ADEME, 2015). The anaerobic digestion reaction can also be carried out under different temperatures. If the reaction is carried out under 40°C, the process is called “mesophilic” whereas if the temperature exceeds 50°C, the process is called “thermophilic”. The important difference here is that thermophilic processes are supposed to provide a better hygienisation of the feedstocks, which should lead to a reduced number of pathogens and sprouts in the digestates (the presence of

undesired components in digestates, and the resulting controversies, are discussed in Section 4). Conversely, mesophilic processes are supposed to keep the reaction easier to handle for biogas plants managers (ADEME, 2015). Finally, there can be also different ways to introduce feedstocks in the digester, depending on the physical state of the feedstocks. These different ways are called: “continuous”, “semi-continuous” and “discontinuous”, and imply different frequencies of introduction of feedstocks, that then affect the frequencies of collection of digestates, and the physical state of digestates (more or less liquid), which in turn can impact the modes of transportation and storage of digestates (ADEME, 2015; Moletta et al., 2015).

The anaerobic digestion reaction brought up at the scale of a biogas plant involves several steps described in Figure 2. The first step consists in the collection of the various feedstocks, usually around the biogas plants, but distances of collection can vary a lot depending on the types of biogas plants and the objectives of the plant owner. The feedstocks can then be pre-treated for hygienisation or to reduce odors, or directly digested to produce raw biogas and digestates, and a post-digestion phase is sometimes added to the process. Once biogas is produced, different options of valorization and post-treatment exist. A widespread valorization mode is the “cogeneration” of electricity, and biogas can also be refined into biomethane and injected in the gas networks, or used as a heat source, or even as a fuel for transportation vehicles (ADEME, 2015). We will not dive deeper into this part as it does not have any impact on the management of digestates, and therefore it has no interest for our research. Post-treatment and management options of digestates are addressed in sub-section 4 of Section 1, and in Section 3.

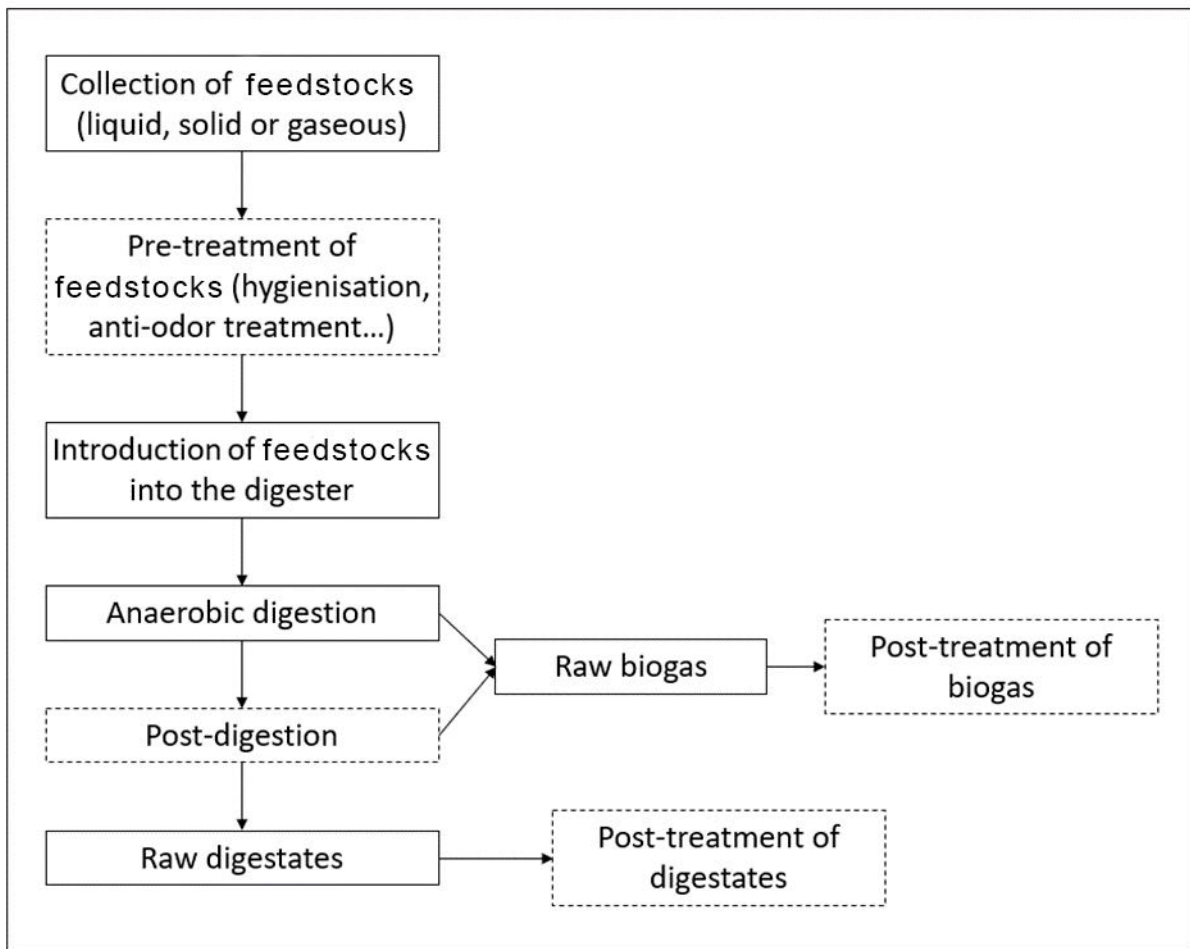


Figure 2: the main steps of biogas production (Source: own graph).

Legend: the steps represented with dotted lines are not compulsory



2. The feedstocks

In addition to the variety of processing conditions, the feedstocks used to feed the anaerobic digestion reaction are very diverse and heterogeneous, as nearly every type of organic matter can be used as feedstocks, except from lignin that requires a specific pre-treatment (Saveyn & Eder, 2014).

The feedstocks used by the sector therefore include (Saveyn & Eder, 2014):

-The biodegradable fraction of municipal solid waste (food waste, green wastes from parks, other wastes made from fibre...), that we call “biowastes” and “green wastes” in the rest of the manuscript,

- Other food waste that in some cases may not be collected by municipalities (such as commercial food waste), that we include in the “biowastes” category,
- Forestry wastes,
- Sewage sludge,
- Wastes and residues from agriculture (manure, slurry, straw residues, haulms, other types of crop residues...), which represent a very diverse category of feedstocks,
- Energy crops (such as maize),
- Wastes from the food and beverage industry, that we call “industrial wastes” in this manuscript.

These feedstocks have different constituents that impact the qualities of digestates, especially in terms of nutrients contents, organic material, toxic elements and contaminants (Dahlin et al., 2015; Guilayn et al., 2020; SOLAGRO & IRSTEA, 2015; WRAP, 2012). As an example, according to some studies that have tried to categorise digestates based on their composition, digestates made from pig and poultry manure, and animal by-products, have higher nitrogen contents than digestates made from cow manure, from green wastes and from municipal solid wastes (Dabert et al., 2013; Jimenez et al., 2020; SOLAGRO & IRSTEA, 2015). To the contrary, the latter usually have a higher rate of organic matter and will be used as soil amendments rather than fertilizers³. Other types of digestates can have either a higher phosphorous content, such as digestates from sewage sludge, or a higher potassium content, such as digestates from silage (Jimenez et al., 2020), and digestates made from urban wastes are said to contain more impurities, such as plastics, undesirable trace minerals and trace organics, than digestates made from agricultural residues (ADEME, 2015). Important variation in digestates qualities also exist within the same categories too, especially when multiple feedstocks are mixed together, such as feedstocks from the food industry (SOLAGRO & IRSTEA, 2015). More details about the qualities and contents of digestates are provided in subsection 4 of Section 1.

³ “A soil amendment is any material which, upon addition to the soil, would improve or maintain its physical, chemical or biological properties” (Nkoa, 2014), whereas fertilizers bring nutrients to the crops and are supposed to enhance yields (Nkoa, 2014).

3. The different types of biogas plants

The types of feedstocks used by biogas plants not only affect the qualities of digestates produced, but they also influence the typologies of biogas plants (Berthe et al., 2020). There are several typologies of biogas plants, based on many different characteristics, such as technological aspects, legal aspects, status of the plant owner or, indeed, the nature of the feedstocks (Berthe et al., 2020). For the need of our research, and the selection of our case studies, we will focus in this part on two kinds of typologies: an “owner and feedstock-centred” typology, and the legal typology.

3.1. *The owner and feedstock-centred typology*

Several owner and feedstock-centred typologies have been released by official bodies, companies or researchers, but due to the high diversity of biogas plants, we argue that none of these typologies fully capture this diversity, and many plants can combine several characteristics of the different categories that constitute these typologies. We present and compare below some of the most common typologies, and we sum up this comparison in table n°1.

The European Biogas Association, in its 2018 report, used a very simple typology, only based on feedstocks: “agricultural”, “sewage”, “landfill”, “others”, “unknown” (EBA, 2018). We believe that this typology is too simple as many biogas plants are fed by a more complex mix of feedstocks. The French Agency for the Ecological Transition created a typology also based on the types of feedstocks, which contains eight categories of biogas plants: “on-farm” (farm wastes only), “collective” (farm wastes + other wastes), “centralized” (mix of different feedstocks), “wastewater treatment plant” (sewage sludge only), “food industry” (industrial wastes), “biowastes” (municipal wastes collected separately), “biowastes not collected separately” and “non-hazardous wastes storage facilities” (ADEME, 2015). GRDF (Gas Network and Distribution France)⁴ issued another typology by crossing the types of feedstocks and the types of owners. It results in five categories of biogas plants: “agricultural” (farmers are the majority shareholders and feedstocks are mainly composed of agricultural residues), “wastewater treatment plant” (same as in ADEME), “non-hazardous wastes storage facilities”

⁴ GRDF is the main gas distributor in France and in Europe, and is therefore naturally implied in the development of the biogas sector.

(same as in ADEME), “industrial” (one or several industrialists are owners + a mix of different feedstocks), “territorial” (the owner is a public authority or an industrialist, and the feedstocks are composed of municipal wastes). Similarly, (Le Guen & Damiano, 2013) partially crossed owners and feedstocks characteristics and created four main categories of plants: “centralized-industrial” (the owner is an industrialist), “collective” (the owner is a public authority and the feedstocks are the municipal wastes), “centralized-agricultural” (owned by a group of farmers only or associated to other shareholders), and “on-farm” (only farm residues).

The high diversity of plants and the many parameters that can be selected to create typologies make it difficult to capture the heterogeneity of the biogas plants that can exist across territories (Berthe et al., 2020). Moreover, the types of feedstocks and the types of owners will also affect the management strategies of the biogas plant (Berthe et al., 2020), and therefore, the management strategies of the digestates. Due to this heterogeneity, the biogas plants we selected for our case studies⁵ can correspond to different categories across these typologies. They could correspond to “industrial” biogas plants in some typologies, or to “collective / territorial / biowastes” biogas plants in other typologies, and even to “centralized” biogas plants (see the semantic grouping we created in table n°1).

Consequently, to synthesize and help the readers in their further investigation, the plants we study in this manuscript will mostly fall into the categories “industrial” “centralized” and “territorial” of many typologies, whether in France or in Germany, although these terms can sometimes hide the importance of agricultural feedstocks used by these plants, and the involvement of farmers in their capital and in the management of the plant. For instance, Guilayn et al. (2020), defined “centralized” plants as “those receiving mostly urban or industrial inputs”, and this does not correspond to our case studies, as our plants all use a diversity of feedstocks among which agricultural residues sometimes constitute a significant part⁶. We would therefore agree more with the definition given by Depoucent et al. (2020) to “territorial biogas plants”, that is, a category of biogas plants that corresponds to a diverse reality, in terms of feedstocks, digestates management and identity of biogas plant owners.

⁵ These biogas plants are presented in detail in Chapter 3.

⁶ The reasons for studying these industrial / centralized / territorial plants are described in Chapter 3.

Semantic grouping	Typology	Name	Feedstocks	Majority shareholders
"Agricultural"	EBA (2018)	Agricultural	Agricultural substrates	-
	GRDF	Agricultural	Agricultural substrates	Farmers
"Sewage sludge"	Le Guen & Damiano (2013)	On-farm	Agricultural substrates	-
	ADEME (2015)	On-farm	Agricultural substrates	-
	EBA (2018)	Sewage	Sewage sludge	-
	ADEME (2015)	Wastewater treatment plant	Sewage sludge	-
	GRDF	Wastewater treatment plant	Sewage sludge	-
	ADEME (2015)	Non-hazardous waste storage facilities	Non-hazardous wastes	-
"Landfill"	GRDF	Non-hazardous waste storage facilities	Non-hazardous wastes	-
	EBA (2018)	Landfill	Landfill wastes	-
"Industrial"	ADEME (2015)	Food industry	Food industry wastes	-
	GRDF	Industrial	Mix of various substrates	Industrialists
"Collective / territorial / biowastes"	ADEME (2015)	Biowastes	Municipal wastes	-
	ADEME (2015)	Biowastes not collected separately	Biowastes	-
	GRDF	Territorial	Municipal wastes	Industrials or/and local public powers
	Le Guen & Damiano (2013)	Collective	Municipal wastes	Local public powers
	ADEME (2015)	Collective	Mostly agricultural substrates + mix of various substrates	-
	Le Guen & Damiano (2013)	Centralized-industrial	-	Industrialists
"Centralized"	Le Guen & Damiano (2013)	Centralized-agricultural	-	Farmers + other local shareholders
	Guylain et al. (2020)	Centralized	Municipal and industrial wastes	-
"Others"	ADEME (2015)	Centralized	Mix of various substrates	-
	EBA (2018)	Others	-	-
	EBA (2018)	Unknown	-	-

Figure 3: Comparison of four different typologies of biogas plants. (Source: own table).

3.2. *The legal typology*

National State services usually issue legal typologies of biogas plants, that specify the regulations that apply to the plants, and we focus in this part on the typologies in force in French and Germany. We chose to dive into this typology to complement the previous owner and feedstock-centred typologies in the selection of case studies. In France, biogas plants are legally categorised depending on the threats they supposedly represent to their environment. They fall under the categories 2781-1 and 2781-2 of the typology called “ICPE”, i.e., facilities classified for the protection of the environment (“Installations classées pour la protection de l’environnement”), with the « décret 2018-458 du 6 juin 2018 » being the more recent decree that applies to biogas plants. Based on the nature and the volumes of the feedstocks used, these two categories are divided into three different “regimes”, called *declaration*, *registration*, and *authorisation* (Figure 3).

These three regimes correspond to different legal requirements about feedstocks and digestates management, the declaration regime being the less demanding, and the authorisation regime being the more demanding (CPE, 2020). These regimes regulate the nature and amount of information that feedstocks producers and biogas plant managers have to provide to State authorities, the types and frequency of controls of the feedstocks’ biophysical parameters, the digestates biochemical, agronomic and environmental analysis that must be carried out, and specify the environmental rules that must be respected for the management and use of digestates. This important amount of information must be kept available for State services and technical consular bodies⁷. The biogas plants that fall under the authorisation regimes also have to provide information to State services about all the incidents happened on site, as well as to provide all information about anything considered relevant that happened during the year, as well as all information requested by the public, and all additional analysis required by State services, if any. As a consequence of these different legal requirements, the flows and exchange of information between economic and non-economic agents is made denser for the biogas plants that are submitted to the authorisation regime, than for those that fall under the declaration and registration regimes. The agents that can request and receive information are very diverse, as they can be State representatives, consular bodies representatives, or any agents living around the biogas plant.

⁷ In France, these technical consular bodies, such as the “SATEGE” and “MUAD” in the North of the country, occupy various roles such as advising digestates producers and users, and providing technical support to State services.

All the biogas plants we selected in France for our case studies fall under the authorisation regime, as do many industrial / centralized / territorial plants, because they often treat higher volumes of feedstocks than agricultural plants.

Types of feedstocks	Volumes of feedstocks	Legal regimes
(1) Raw plant material Industrial plant wastes Manure Faecal matter Whey	Less than 10 950 t/year	Declaration
	Between 10 950 and 36 500 t/year	Registration
	More than 36 500 t/year	Authorisation
(2) Other non-hazardous wastes	Less than 36 500 t/year	Registration
	More than 36 500 t/year	Authorisation

Figure 4: the French legal regimes of biogas plants according to the ICPE regulation. Source: author, adapted from (CPE, 2020).

In Germany, there is no specific legal typology for biogas plants, whose approval of operation by States services depends on the “Construction” or “Building Law” (BauGB) and on the “Federal Emission Protection Law” (BImSchG) (Große, 2014; Hofmeier, 2022; Trombin et al., 2017). The Construction Law focuses on the deliverance of the permit for the construction of the biogas plant although the Federal Emission Protection Law targets both the construction and the operation of the biogas plants. The Construction Law has only general requirements and there are no specific rules concerning biogas plants, whereas the Federal Emission Protection Law provides requirements in terms of waste management and environmental protection, but they mainly concern noise and air pollution issues (Große, 2014). As we can see in Figure 4, the focus of the German legal typology is less on the types of feedstock than those of the French typology, the two first criteria being on biogas production. The feedstock criteria only concern the volume and the storage capacities, added to a criterion on the storage capacities for digestates.

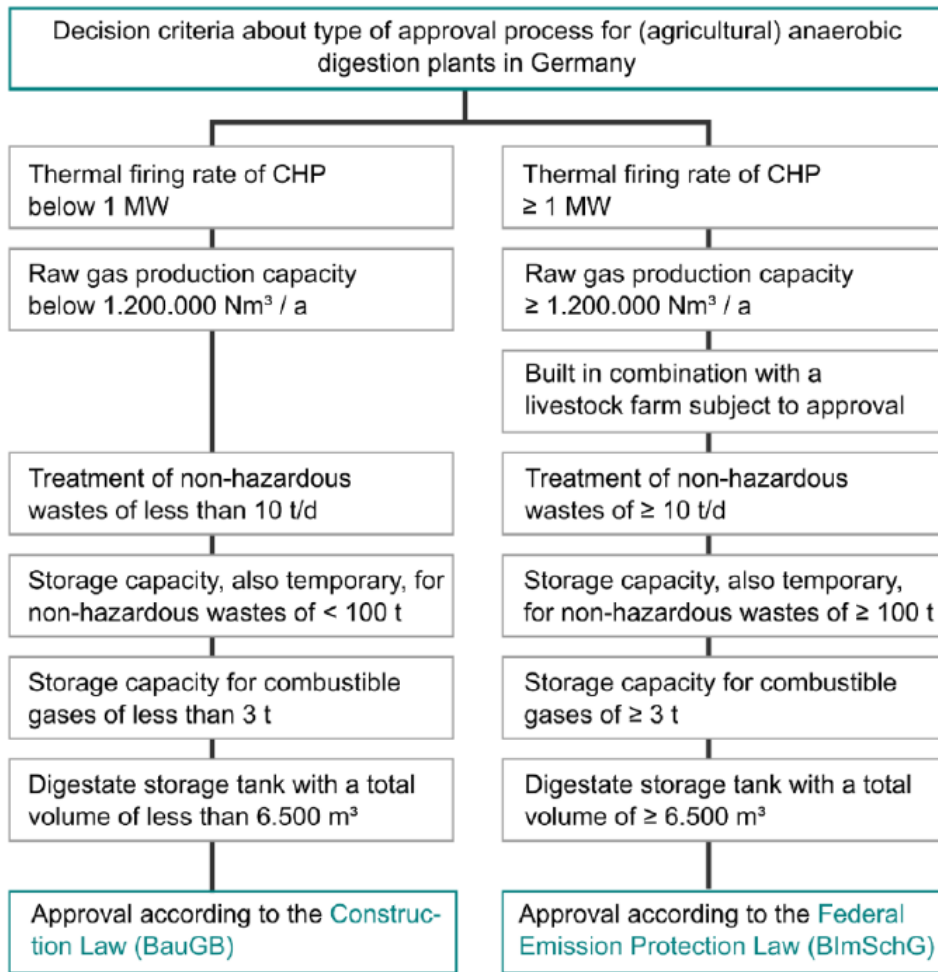


Figure 5: Biogas plants in Germany can fall under the Construction Law or the Federal Emission Protection law. Source: (Trombin et al., 2017) Original title: “Decision criteria for selecting the permitting procedure for biogas plants in Germany.”

4. Technical presentation of digestates

4.1. Biochemical properties of digestates

Official reports and scientific literature have issued more or less complex definitions of digestates. Simple definitions often describe digestates as “undigested organic matter that contains nitrogen, phosphorous and potassium” (Delfosse, 2010) and as a “moist product rich in a partially stabilized organic matter”, with an emphasis put on the high diversity and variability of digestates, as mentioned in sub-section 1 (ADEME, 2015b, 2016; SOLAGRO & IRSTEA, 2015). In a more comprehensive definition, the EU regulation 2019/1691⁸ describes digestates as “a residual semisolid or liquid material that has been sanitised and stabilised by a biological treatment process, of which the last step is an anaerobic digestion step, and where the inputs used in that process are biodegradable materials originating only from non-hazardous source segregated materials, such as food waste, manure and energy crops”. This definition mentions two different physical states for digestates, semi-solid and liquid, mainly due to the diversity of feedstocks and production processes we described in sub-section 1. The resulting diversity of digestates has been studied quite extensively in the scientific literature.

(Rigby & Smith, 2011) compared, for a WRAP⁹ report, digestates from livestock slurry and from food waste. They revealed variations in the dry solids' contents going from 2.7% to 9.3% of the fresh weight, an alkaline pH (between 7.6 and 8.8) and a volatile solids content ranging between 68.3 and 73.2%. Their analysis also reported a large proportion of immediately bioavailable nitrogen in both categories of digestates, with however a greater C:N ratio for slurry-based digestates. Another WRAP report from 2012 highlighted the heterogeneity in nitrogen content between several food-waste based digestates, with a content ranging from 3.5 kg/t and 7.9 kg/t, which shows that variation also exists within digestates produced on similar categories of feedstocks (WRAP, 2012). (Nkoa, 2014) also reported “considerable” heterogeneity in the “biochemical properties” of digestates depending on the feedstocks and the production processes, with organic matter contents ranging from 38 to 75% and the C:N ratio¹⁰ varying from 6.2 to 24.8. The literature also reports some variation in the phosphorous (P) and

⁸ This regulation is part of the « REACH » regulation on the impacts of chemicals on health and the environment.

⁹ Waste and Resources Action Program (registered as a UK charity).

¹⁰ The C:N ratio (or C/N ratio) corresponds to the ratio between the mass of carbon and the mass of nitrogen in organic matter (Khanal et al., 2019)

potassium (K) contents of digestates, and on the proportion of water-soluble P and K (Dabert et al., 2013; Nkoa, 2014; Rigby & Smith, 2011; SOLAGRO & IRSTEA, 2015). In addition to being a source of NPK, digestates also contain sodium, chlorine, sulphur, calcium and magnesium, again at varying concentrations, as well as heavy metals¹¹ (Nkoa, 2014; Rigby & Smith, 2011; SOLAGRO & IRSTEA, 2015). To summarize, digestates are heterogeneous and variable liquid or semi-solid by-products whose qualities depend on the feedstocks and the biogas production process. They have in common an alkaline pH (varying between 7 and less than 9), and an interesting nutrients content, but they can also be polluted by pathogens and micro-organisms, and impurities such as glass and plastics (Figure 6). Appendix ... presents some analysis of digestates contents.

¹¹ Heavy metals found in digestates: copper, zinc, lead, cadmium, mercury, nickel, chromium, molybdenum, fluorine, aluminium, selenium, iron and arsenic.

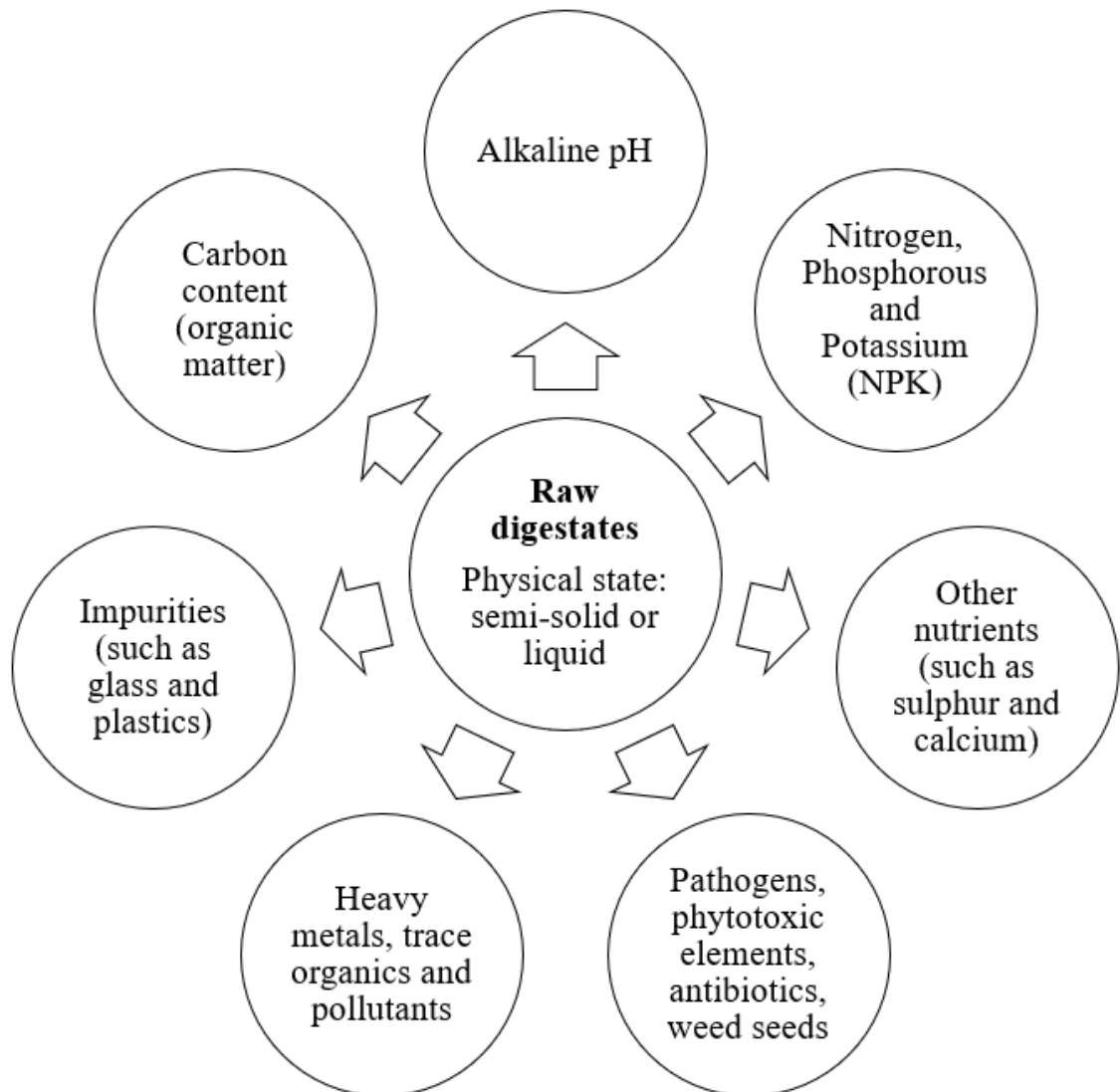


Figure 6: synthetic representation of the main characteristics of digestates. All characteristics are not always found (such as impurities) (source: author).

4.2. Post-treatment options

The process of anaerobic digestion produces, at first digestates, in a raw form, called raw digestates. Raw digestates can be directly valorized by farmers as soil amendments and fertilizers but many different technologies have been developed or adapted from other sectors to transform and upgrade digestates. These transformations aim at a better valorization of digestates through different means such as the reduction of land application and storage costs, the improvement of transportation, the exportation of nutrients to areas that are deficient in nutrients, and the production of marketable digestate-based products (see Section 3 for the detailed explanation of the valorization options of digestates) (AILE, 2015; Hjort-Gregersen, 2015; MAAF, 2014; Plana & Noche, 2016; SOLAGRO & IRSTEA, 2015; Trombin et al., 2017). However, the high costs of these technologies do not make them affordable for every biogas plant but only to a minority, although the price surge of mineral fertilizers could boost the interests for these technologies (Levasseur et al., 2017; Plana & Noche, 2016; Trombin et al., 2017). The post-treatments usually reduce the volume of digestates, and concentrate or separate the nutrients and the pollutants (ADEME, 2015; Plana & Noche, 2016; Trombin et al., 2017), but they also create a lot of by-products that need to be stored, transported and valorized too (Levasseur et al., 2010)

The most common transformation is the solid-liquid phase separation (Hjort-Gregersen, 2015; MAAF, 2014), which separates the raw digestates into a solid phase mostly used as a soil amendment, and a liquid phase, used as a fertilizer. The solid phase usually concentrates the organic matter, the phosphorus and the calcium, while the liquid phase concentrates the nitrogen, the potassium and the magnesium, and is poor in organic matter (ADEME, 2015b; AILE, 2015; SOLAGRO & IRSTEA, 2015). Different technologies exist, such as the decanter centrifuge, the screw press and the filter press, and the efficiency of these technologies vary a lot depending on the types of raw digestates (Hjort-Gregersen, 2015; MAAF, 2014; SOLAGRO & IRSTEA, 2015).

Liquid digestates can also be dried, but through technologies that are often costly and energy-consuming. Drying creates a solid phase, that can be more easily transported, spread, and further pelletized or composted with other wastes, such as manure and green wastes, and more easily marketed, and it produces a liquid phase rich in ammonium sulphate¹² (ADEME, 2015b; AILE, 2015; Hjort-Gregersen, 2015; Levasseur et al., 2010, 2017; Logan &

¹² Ammonium sulphate is used as a nitrogen and sulphur fertiliser in agriculture (Levasseur et al., 2017).

Visvanathan, 2019; MAAF, 2014; Trombin et al., 2017). The liquid phase of digestates can also be dehydrated through evaporative-concentration and condensation, but many by-products remain, such as waste water, ammonium sulphate and concentrates, depending on the technology used and the types of digestates. This technology is also very costly and only affordable for the biggest biogas plants (Hjort-Gregersen, 2015; Levasseur et al., 2017; Logan & Visvanathan, 2019; Trombin et al., 2017). Therefore, the liquid fraction of digestates are very often still applied on agricultural lands or recirculated in the digester if the feedstocks are mainly composed of dry matter (Trombin et al., 2017).

Digestates can also be treated through membrane filtration technologies, such as centrifugal decanter, ultrafiltration and reverse osmosis, to improve the transportation and the spreading of the concentrated nutrients, but the outcomes of the treatment again vary depending on the technology. Biological treatment of digestates is also used for a better management of nitrogen in nitrogen-vulnerable zones. Other treatment technologies such as nitrogen stripping (that creates ammonium sulphate) and struvite (also called magnesium-ammonium-phosphate) precipitation (through a chemical reaction) exist but are very costly (struvite precipitation requires costly additive such as flocculants and phosphoric acid) (Hjort-Gregersen, 2015; Levasseur et al., 2017; Logan & Visvanathan, 2019; Trombin et al., 2017). Figure 7 provides an overview of these post-treatment technologies and of some of their outcomes.

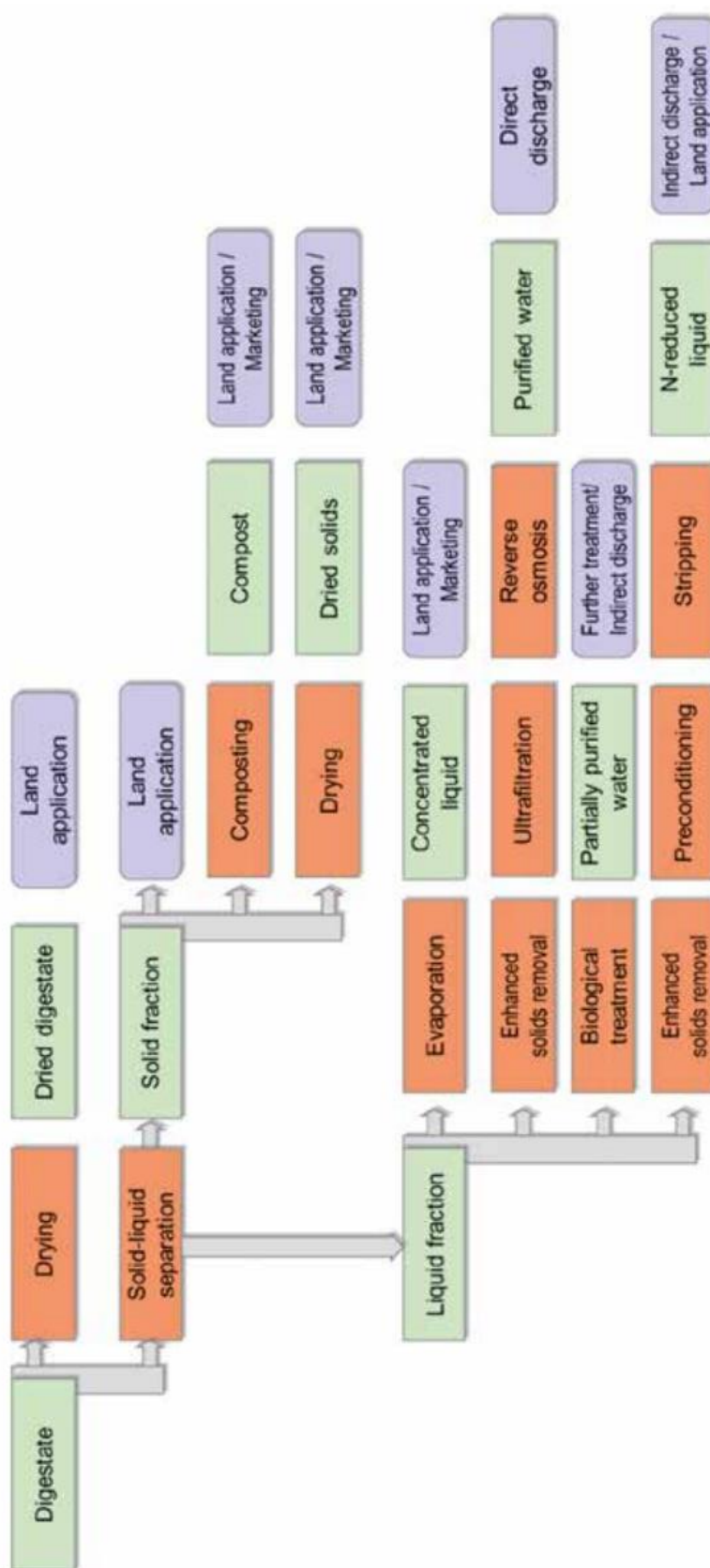


Figure 7: overview of post-treatment options. Source: (Fuchs & Drosig, 2013)

Conclusion of section 1

Biogas production is a complex and delicate process that results in many by-products, the main one being digestates. Behind the single term of “biogas production” or “méthanisation” used to name the sector, lies, in fact, a diversity of processing conditions that lead to different outcomes. First of all, the primary material used to produce biogas and digestates is very heterogenous and have an important impact on the qualities of digestates. We understand *quality / qualities* based on the definition used by (Lupton, 2002), and initially formulated by (Lancaster, 1966), which is, the constituent characteristics of a good, that become an economic variable per se, in markets where products are not considered homogeneous. Therefore, these qualities will depend on the various resources available, across the different territories, to the biogas plants. Secondly, there exists an important diversity of post-treatment technologies of digestates, that themselves produce various products and by-products, that require different management options. Therefore, across the different territories of production, there is not a single digestate produced but a “panel” of digestates that are “highly non-uniform” (Dahlin et al., 2015; Depoucent et al., 2020). The environmental regulation, particularly in France, also emphasizes this diversity by imposing to the producers of digestates different frequency and intensity of information acquisition and transfer destined to a variety of agents. We assume these heterogeneous expectations can lead to different networks of exchanges and different connections between agents across territories. The biogas sector therefore gathers a variety of situations that result from a combination of particular feedstocks, production processes and post-treatment technologies, and different administrative requirements.

Section 2: Political and economic context of the development of the biogas sector

Introduction of Section 2

Section 2 is divided into four sub-sections. In the two first sub-sections, we present the political context that supports the deployment of the sector. We first present the European renewable energy policies that initially launched the development of the sector, and we show how these policies have been incorporated in French and German renewable energy policies. We then present the more recent EU Circular Economy and Bioeconomy policies that complemented the support to the development of the sector, and how they introduced more interest for digestates, while renewable energy policies focused merely on biogas. We also present again the declination of these policies in France and in Germany. In the third and last sub-section, we provide the reader with an overview of the past and current development of the sector in the EU, with a focus on the French and German sectors, and we evoke some future perspectives of development.

1. Biogas production in European energy policies and their applications in France and in Germany

European and national authorities have largely supported and promoted the rapid development of the biogas sector through their legislations on renewable energy sources (RES), and through incentives and subsidies (Kanellakis et al., 2013; Scarlat et al., 2015, 2018; Theuerl et al., 2019; Torrijos, 2016); the main objectives of RES legislation being the fight against climate change and GHG emissions, and the reduction of energy importations (da Graça Carvalho, 2012; Kanellakis et al., 2013; Scarlat et al., 2015, 2018; Torrijos, 2016). In 2001, the Renewable Electricity Directive paved the way to the large-scaled development of RES with a goal of 22% of electricity consumption from RES by 2010 (DIRECTIVE 2001/77/EC, 2001). The production of energy was the unique target of the Directive, as energy, in its different forms, such as electricity and gas, was the desired output of the RES production processes. By-products and wastes, i.e. undesired and unplanned outputs of energy production, were not addressed in these energy policies. Wastes were only mentioned in the case they would serve as an input of energy production (DIRECTIVE 2001/77/EC, 2001), namely, when they would acquire a value in the process. The 2001 Directive were followed by many other directives and

packages on RES (Scarlat et al., 2015; 2018). The policy scheme remained consistent: GHG emissions from energy production were the only negative externalities addressed with either no mention of wastes or the sole mention of wastes as a potential factor in the GHG emissions calculation (DIRECTIVE 2009/28/EC, 2009; DIRECTIVE 2018/2001, 2018; European Commission, 2012b, 2012a, 2019a).

The 2009 Renewable Energy Directive introduced some sustainability criteria for RES production process (Scarlat et al., 2015), but these criteria only applied to upstream stages of production (i.e. land use change, competition between food and non-food use of crops...) and did not address externalities linked to downstream stages, such as by-products and waste management. New targets were regularly set to encourage the fast development of RES markets and they positively influenced the growth of the biogas sector. The European Union aimed at achieving 20% of gross final consumption of energy from RES in 2020 (DIRECTIVE 2009/28/EC, 2009), 32% in 2030 (DIRECTIVE 2018/2001, 2018) and maybe to reach a carbon-neutral economy in 2050 (European Commission, 2012a). The European renewable energy policy also insisted on social cohesion and public acceptance of RES, therefore recognizing that RES deployment could potentially have unwanted negative effects on local communities (DIRECTIVE 2001/77/EC, 2001; European Commission, 2012a, 2012b, 2019a).

More recently, as part of the European Green Deal launched at the end of 2019, and due to the war in Ukraine that started in 2022, the EU increased again its targets of RES and among that, of biogas production. In May 2022, the European Commission revealed its REPowerEU plan, that includes a Biomethane¹³ Action Plan to specifically promote and implement a faster deployment of the biogas sector (EBA, 2022a). The REPowerEU plan aims at “a massive scaling-up and speeding-up of renewable energy”, to reduce the EU’s “dependence on Russian fossil fuels” and “strengthen economic growth, security, and climate action” (European Commission, 2022b). As a result, the European Parliament approved in September 2022 the increase to 45% of the share of RES in energy consumption in 2030 (Messad, 2022). Concerning biogas, REPowerEU forecasts a necessary increase of production to replace 20% of Russian gas imports by 2030, with a targeted production of 35 billion cubic metres of biomethane in 2030, for approximately 70-80 billion euros of investment (EBA, 2022b). To achieve these targets, a Biomethane Industrial Partnership “was launched between European Commission and industry leaders” in September 2022. REPowerEU also asks EU Member

¹³ “Biomethane is the purified form of raw biogas and can be used as a natural gas substitute.” (EBA, 2022c)

States to “Develop national strategies on sustainable biogas and biomethane production and use or integrate a biogas and biomethane component in the National Energy and Climate Plans (NECPs)” and claims to support the implementation of European cross-borders projects (European Commission, 2022a). However again, none of these official documents mention and anticipate digestates management.

To apply the European strategy, the French government has been pushing for the national deployment of the biogas sector through several laws passed in the last decade, and several subsidies and public investment schemes (Bourdin & Nadou, 2020; French Senate, 2021). In 2013, the French ministries for Agriculture and for Energy released a joint plan called “Energy, methanation, autonomy, nitrogen”¹⁴ that forecast the deployment of a thousand additional agricultural biogas plants before 2020 (MEDE & MAAF, 2013). In 2015, the law 2015-992 of Energy Transition for a Green Growth planned 32% of final national energy consumption from RES, in direct application of the EU strategy. The law specifically supported the deployment of biogas production by allowing the use of food crops, crop residue and energy crops as feedstocks. The 2016-1442 decree for the Pluriannual Energy Planification set objectives of 137 MW in 2018 and between 237 and 300 MW in 2023 of electricity produced by biogas plants while the 2020-456 decree set objectives of 14 TWh in 2023 and 24-32 TWh in 2028 of total biogas production¹⁵. In addition, the law 2021-1104 “Energy and Resilience” asked for the valorization of at least 70% of wastes, especially through biogas production. At the sub-national level, the SRADDET (Regional Schemes for planification, sustainable development and territorial equity) promote the production of biogas at the regional level, with a cumulated objective of 60 TWh in 2030, all regional objectives summed up (French Senate, 2021).

In Germany, the expansion of biogas production was strongly supported through the EEG laws at the Federal level from 2000 to 2014 through a variety of tools such as a “nationwide unified remuneration scheme” to guarantee electricity prices over 20 years, “advantageous conditions for the access of biogas to electricity markets and grids” and investments supports (Appel et al., 2016; Thrän et al., 2020; Yang et al., 2021). From 2004 to 2012, new bonuses were implemented to boost the sector, such as the bonus for energy crops cultivation (2004) and the bonus for the use of manure (2009), and between 2004 and 2008 the Federal State Building Law was revised to favour the establishment of biogas plants, making

¹⁴ « Energie, méthanisation, autonomie, azote » in French.

¹⁵ As a comparison, total electricity production in France was of 510 TWh in 2021 and total energy production was of 1423 TWh in 2020 (MTE, 2021).

biogas production an interesting investment sector (Appel et al., 2016; GBA, 2018; Hofmeier, 2022; Thrän et al., 2020). However, from 2014, a reduction in subsidies and the removal of the bonus for energy crops aimed at slowing the fast growth of the sector and ensuring that only competitive biogas plants were built (Appel et al., 2016; Brémond et al., 2021; EBA, 2014; Thrän et al., 2020). In 2017, the new EEG law targeted a yearly expansion of a capacity of 150MW from 2017 to 2019 and 200MW from 2020 to 2022 (Brémond et al., 2021; Thrän et al., 2020) and in 2021, the new EEG law required that the 2030 installed capacity remained equal to the 2021 capacity with an openly admitted goal to “reduce bioenergy conflicts” (Hofmeier, 2022). In the same line, the revised 2022 EEG law was criticized by biogas supporters for not supporting the biogas sector enough anymore, and for restraining its expansion, in the aim of addressing the multiple concerns raised by opponents, and therefore going against the new REPowerEU strategy (Bioenergy Insight, 2022).

Law / Regulation / Plan / Events	Objectives
European Union	
Directive 2001/77/EC (2001)	22% of electricity consumption from RES by 2010
Directive 2009/28/EC (2009)	20% of gross final consumption of energy from RES in 2020
Directive 2018/2001/EU (2018)	30% of gross final consumption of energy from RES in 2020
European Green Deal (2019)	To keep increasing the targets for RES
Beginning of the War in Ukraine (2022)	Lead to the will to reduce EU's dependency on Russian gas
REPowerEU plan & Biomethane Industrial Partnership (May 2022)	45% of gross final consumption of energy from RES by 2030. To replace 20% of Russian gas imports by biogas, by 2030.
France	
“Energy, methanation, autonomy, nitrogen” (2013)	Deployment of a thousand additional agricultural biogas plants before 2020
Law 2015-992 of Energy Transition for a Green Growth (2015)	32% of final national energy consumption from RES by 2030
The 2016-1442 decree for the Pluriannual Energy Planification (2016)	Objectives of 137 MW in 2018, and 237-300 MW in 2023, of electricity produced by biogas plants
The 2020-456 decree (2020)	Objectives of 14 TWh in 2023, and 24-32 TWh in 2028 of total biogas production
Law 2021-1104 “Energy and Resilience” (2021)	Valorization of at least 70% of wastes, especially through biogas production
Germany	
EEG (2000)	Support to RES through guaranteed prices, subsidies and facilitated access to markets and grids
EEG (2004)	Support the use of energy crops for biogas production
Revision of the Federal State Building Law (2004-2008)	Favours the establishment of biogas plants
EEG (2009)	Support the use of manure for biogas production
EEG (2014)	To slow down the growth of the biogas sector
EEG (2017)	Target of a yearly expansion of the biogas sector of 150MW from 2017 to 2019 and 200MW from 2020 to 2022

EEG (2021)	Installed biogas capacity in 2030 should remain equal to 2021, to “reduce bioenergy conflicts”
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Figure 8: Main legal documents and events that have impacted the development of the biogas sector from the perspective of energy production, in the EU, in France and in Germany (source: own table).

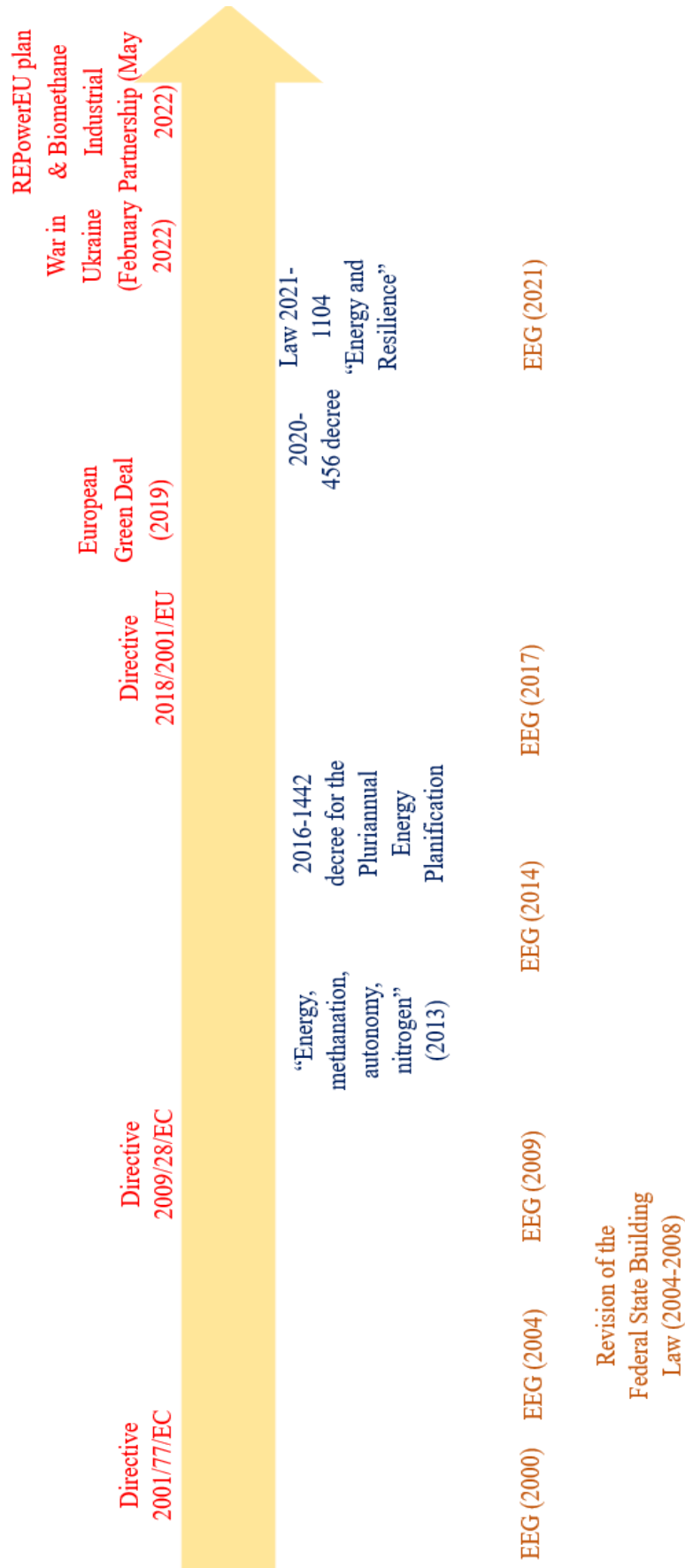


Figure 9: Timeline of the main legal documents and events that have impacted the development of the biogas sector from the perspective of energy production, in the EU, in France and in Germany (source: own graph).

Legend: in red = EU documents; in blue = French documents; in orange = German documents

2. Biogas production in European Circular Economy and Bioeconomy strategies and their applications in France and in Germany

In addition to renewable energy policies, biogas production has also been directly and indirectly promoted by EU Circular Economy and Bioeconomy policies through two main perspectives: to contribute to biowastes recovery and to close nutrient loops through the use of digestates as organic fertilizers. Before its strategic reflexions on CE, the European Commission had already issued a Green Paper in 2008 to improve the management of bio-wastes in the European Union, and had encouraged through this Green Paper the use of digestates in agriculture. A Communication from the Commission, issued in 2010, insisted again on the need to recycle and recover bio-wastes in the EU through biogas production in order to save natural resources, reduce GHG emissions and improve soils quality, and stressed that the potential for bio-wastes use was being underexploited.

The concept of Circular Economy (CE) gained a prominent place in EU sustainability policies through the “Circular Economy Action plan” first adopted in 2015 (Leipold, 2021) and biogas production became a model of CE implementation in rural and suburban areas (Pappalardo et al., 2018; Selvaggi et al., 2018). Figure 10 from the German Biogas Association (2018) is an illustration of how biogas production has been presented as a model of CE. The use of digestates as soil improvers and fertilizers, and therefore, their “return to the Earth” or “return to the soil” is a key element in closing the loop of nutrients and biomass (Inrae, 2021; Selvaggi et al., 2018). In 2017, a Communication from the European Commission on the topic of waste-to-energy clearly stated biogas production as a key element to achieve the EU material recovery and recycling targets on the condition that digestates were effectively used as fertilizers (European Commission, 2017), as described in Figure 11. In 2020, the Circular Economy Action Plan was revised as part of the European Green Deal, and CE was associated to renewable energy policies in order to contribute to the 2050 carbon-neutrality objectives and to reduce pressure on natural resources. In this perspective, biogas production clearly stands at the junction between the EU CE and RES strategies. The new Green Deal insists on the necessity to create “a well-functioning EU market for secondary raw materials” including markets for digestates and digestates-based products. This ambition resulted in the EU 2019/1009 regulation that came into force in 2022 with the aim to ease the access to the EU single market to organic fertilizers, such as digestates and digestate-based products. In addition, the current context of the war in Ukraine is also an argument to increase the use of digestates,

and organic fertilizers in general, produced within EU boundaries, because 30% of the EU chemical fertilizers are imported from Russia (EBA, 2022b).

In France, since 2012, large producers of biowastes such as food industries, gardening companies, retail and catering that produced more than 120 tons of biowastes per year, or more than 1500 litres of wasted oil per year, have been obliged to valorize their wastes through means such as biogas production. The threshold was lowered in 2016 to include all companies producing more than 10 tons of biowastes per year or more than 60 litres of wasted oil. The “anti-waste” law of 2020 lowered the threshold again to 5 tons per year in 2023 and by 2024, all bio-wastes producers will be obliged to valorize their wastes regardless of the quantity they produced, including municipalities and households, which creates interesting opportunities for biogas producers to collect and valorize this growing volume of feedstock. In addition, in 2018, the “*Feuille de route pour l'économie circulaire*” (Guidelines for a Circular Economy) stressed the importance to turn biowastes into resources and to boost circular economy in agriculture, notably through the recovery of nutrients. In 2017 and 2018 came also into force a “*Stratégie nationale pour la bioéconomie*” (National Strategy for the Bioeconomy) and a “*Stratégie Nationale de Mobilization de la Biomasse*” (National Strategy for Biomass Mobilization) that officially promoted the use of agricultural and industrial biomass, and other biowastes, to develop the biogas sector. These strategies are to be declined in the French regions through the elaboration of a “*Schéma regional biomasse*” (Regional biomass scheme) that provides, among many other things, perspectives and guidelines for the regional development of the biogas sector. These regional strategies are accompanied by the “*Plan régional de prévention et de gestion des déchets* » (Regional waste reduction and management plans) that can also promote the regional recovery of wastes through biogas production.

In Germany, the Federal Government has issued a series of National Bioeconomy and Sustainable Development strategies in the last two decades to promote the use and the recovery of biomass and secondary raw materials, and the use of wastes and by-products for renewable energy production such as biogas, in order to replace fossil fuels (BMEL, 2021; Bogner & Dahlke, 2022; Davies et al., 2016; MEAE, 2015; Richter et al., 2022). To complement these strategies, the Federal Government has progressively transformed its waste disposal and management policies into Circular Economy policies, with the enforcement of a Circular Economy Act (KrWG) in 2012, that set a recovery target of 65% of municipal solid waste in 2020, including biowastes (Nelles, 2016; Schroeder & Jeonghyun, 2019). At the regional level, the Lander are responsible to decline the KrWG in their laws and to produce “waste management plans” (Schroeder & Jeonghyun, 2019). These favourable and strong legislative

frameworks had Germany become a world leader for waste recovery and for the development of Circular Economy strategies, in the hope to fight climate change, to drastically reduce the GHG emissions from wastes management, and to save raw materials (BMUV, 2023; Nelles, 2016; Schroeder & Jeonghyun, 2019). As a result, in 2015, 6.48 million tons of biowastes were recovered through biogas and digestate production, and today the majority of biowastes is directed to the biogas sector, including household, catering and retail food waste, as well as municipal green wastes (GBA, 2022; WBA, 2019). In addition, similarly to France, the 2018 EU Waste Directive and its target to recover the totality of municipal biowastes by 2023 has created important opportunities for the German biogas sector to launch “large scale” biogas plants operating on this type of feedstock, in the coming years (WBA, 2019).

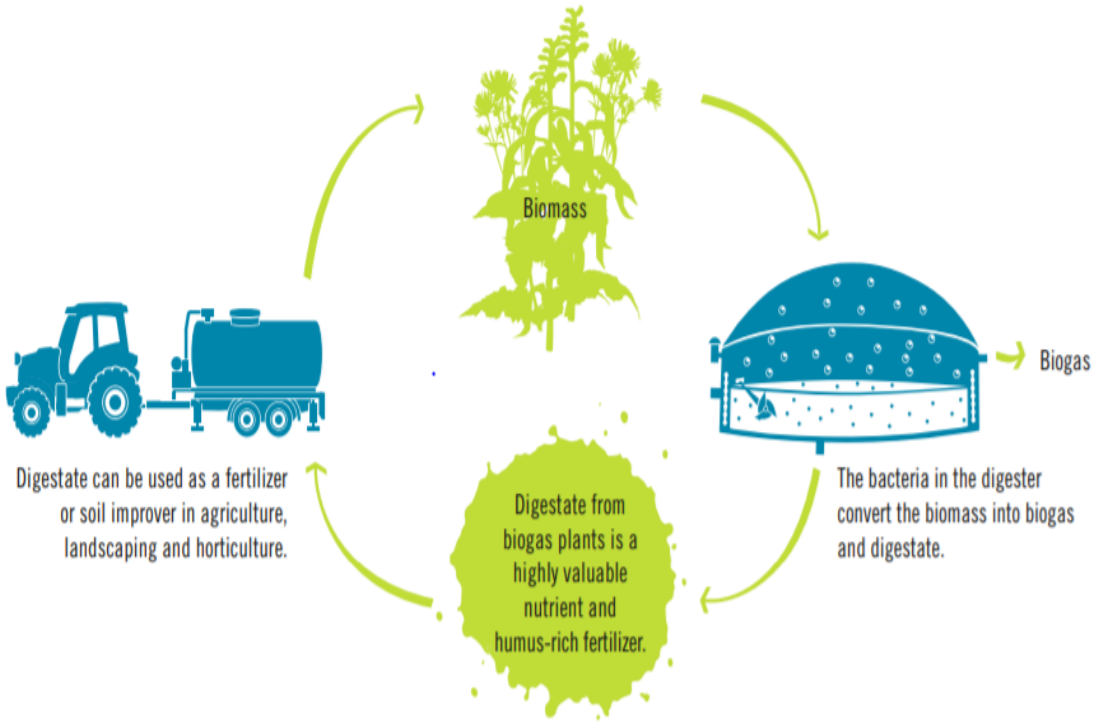


Figure 10: The representation of biogas production as a model of Circular Economy (source: GBA, 2018).

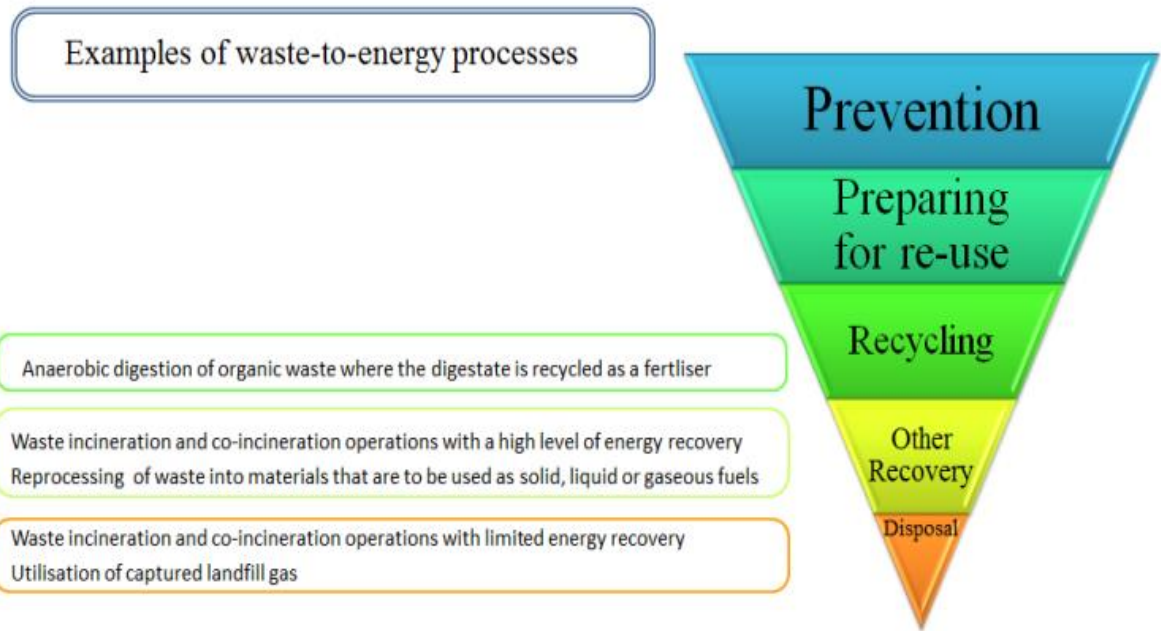


Figure 11: biogas production in the “Waste Hierarchy” (source:European Commission, 2017)

Law / Regulation / Plan / Events	Objectives
European Union	
Green Paper (2008)	To improve the management of bio-wastes in the European Union
COM(2010)235 (2010)	Promotes the recycling and recovering of bio-wastes through biogas production
Circular Economy Action plan (2015)	Biogas production becomes a model of Circular Economy
COM(2017) 34	To promote the use of digestates as fertilizers
European Green Deal (2019)	To create a well-functioning market for secondary raw materials such as digestates
Regulation 2019/1009 (2019)	To facilitate the access of digestates-based products to the EU single market
France	
Article L 541-21-1 of the Code of the Environment, Circular of 2012	Obligation to recycle biowastes for producers exceeding 120 tons/y or 1500 L/y
Article L 541-21-1 of the Code of the Environment, Circular of 2016	Obligation to recycle biowastes for producers exceeding 10 tons/y or 60 L/y
National Strategy for the Bioeconomy (2017) & National Strategy for Biomass Mobilization (2018)	To support the use of biomass for the development of the biogas sector
Guidelines for a Circular Economy (2018)	To promote the use of biowastes into resources
Law “anti-waste” (2020)	Obligation to recycle biowastes for all producers no matter the quantities, by 2014
Germany	
Sustainability Strategy (2002); National Research Strategy for the Bioeconomy 2030 (2010); Raw Materials Strategy (2010); Action Plans for the Use of Sustainable Raw Materials (2009/2010) & National Bioeconomy Strategy (2020)	Support the development of the bioeconomy, and the use of bioresources and biowastes
Circular Economy Act (KrWG) (2012)	To recover 65% of municipal solid waste by 2020, including biowastes

Figure 12: Main legal documents that have impacted the development of the biogas sector from a bioeconomy and CE perspective, in the EU, in France and in Germany (source: own table)

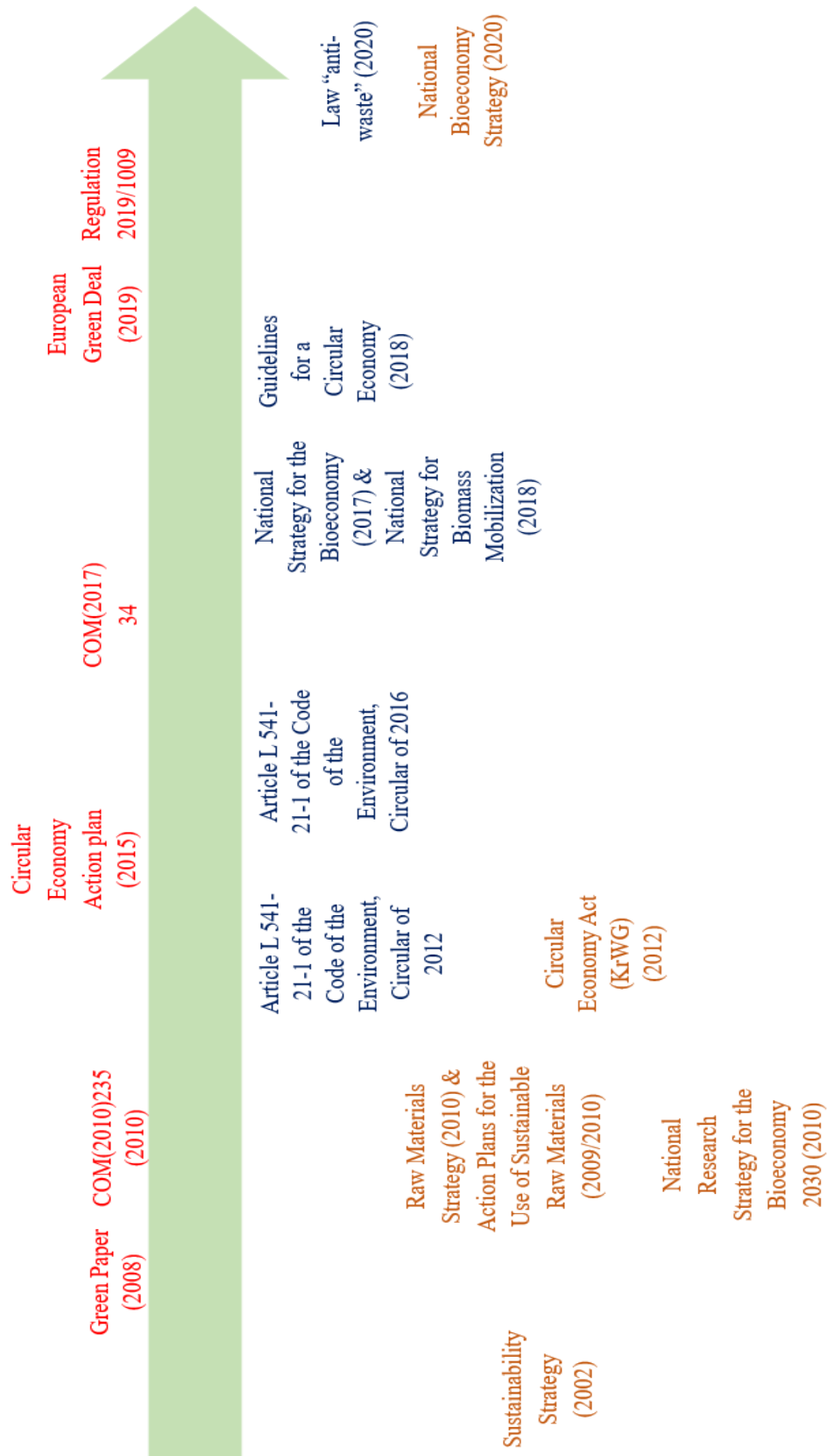


Figure 13: Timeline of the main legal documents that have impacted the development of the biogas sector from a bioeconomy and CE perspective in the EU, in France and in Germany. (Source: own graph).

Legend: in red = EU documents; in blue = French documents; in orange = German documents

3. The development of the biogas sector: evolutions and current stage

Thanks to the strong political support we described in the two previous sub-sections, the biogas sector has experienced an important growth in the EU in the last two decades. A major boom happened between 2009 and 2014 when the number of biogas plants installed nearly tripled, with more than 10 000 new biogas plants built, going from 6 227 to 16 834 installed units (EBA, 2018). A similar boom occurred for biomethane plants (biogas plants that refine biogas into biomethane) with the number of plants nearly doubling in three years, going from 187 in 2011 to 367 in 2014 (EBA, 2018). The growth continued to reach 17,783 biogas plants and 540 biomethane plants installed in 2017, for a biogas production of 65.179 GWh and a biomethane production of 19.352 GWh (EBA, 2018) (See Figures 14 and 15). In 2019, nearly 19 000 plants were installed and in 2020, there were around 20 000 plants operation across the EU, confirming the trend of continuous growth of the sector (EBA, 2020, 2021). Today, the biogas sector is said to have “created 210,000 green jobs in Europe” and to yearly save 60 Mt of GHG emissions (EBA, 2022a) and is currently “scaling-up” in the perspective of covering “up to 30-40% of the EU gas consumption by 2050” (EBA, 2022b).

Germany is by far the world leader of biogas production and has been the “driving force” of the development of the sector in Europe albeit experiencing important heterogeneity across the Lander (Brémond et al., 2021; EBA, 2018; Theuerl et al., 2019; Trombin et al., 2017; Yang et al., 2021). The country experienced a boom of biogas production from 2000 to 2012 mainly thanks to the 2004 and 2009 EEG incentives on energy crops use (Brémond et al., 2021) and from 2000 to 2017, the number of biogas plants installed rose from 850 to 9331, accompanied by an increase of maize silage cultivation of 200 000 ha in 2007 to 900 000 ha in 2018 (Yang et al., 2021). However, due to the new EEG laws from 2014, the growth of the sector slowed down and even stopped in 2018 and 2019, and the total number of plants now maintains itself around 10 000 units (Brémond et al., 2021) (see Figure 16). The other EU countries have engaged more lately in the development of their biogas sector, but some countries now hope to catch up with Germany. In France, less than 200 plants were recorded in 2013 in France (ADEME, 2016) but thanks to the favourable energy and circular economy policies, the number grew up to 900 plants in 2020 (ATEE, 2020) and reached 1 308 units on the 1st of January 2022, and more are being constructed (GRDF, 2022). This growth is expected to keep going with a forecast of 1 700 operating plants by 2023 (ADEME, 2016).

The growing number of biogas plants naturally leads to an increasing production of digestates (Dahlin et al., 2017; Monlau et al., 2015; Plana & Noche, 2016; WRAP, 2013), but

as there are still no centralized statistics on the volumes of digestates produced annually, we therefore rely on estimations from experts. The German Biogas Association (2018) estimated that nearly 130 million tons of digestates were produced yearly in the EU by the “13 000 plants”, while a report from the European Commission (2019) estimated a yearly production of 180 million tons of digestates, of which 120 million tons of digestates from agricultural feedstock and 60 million tons from other biowastes and sewage sludge (European Commission, 2019b). However, we saw in Section 1 that agricultural and non-agricultural feedstocks can be mixed to produce biogas and therefore this strict categorisation does not correspond to the diversity of digestates produced, and it therefore questions the accuracy of these numbers. Moreover, as we have nearly reached 20 000 operating biogas plants in 2022, the volume of digestates produced has logically grown above 180 million tons. A recent estimation from the European Biogas Association considered that between 222 and 258 Mt of digestates may have been produced in 2021, and estimates that by 2030, the production of digestates could double and reach between 455 and 492 Mt, and that a production of between 1.145 and 1.334 Mt of digestates could be reached by 2050 (EBA, 2022a).

Germany is by far again the largest producer of digestates, with an estimation of 85 million tons produced annually by (Damiano et al., 2015), which corresponds to the estimate given by the European Commission (2019) that “at least half” of the 180 million tons of digestates were produced in Germany, so at least 90 million tons. In France, as there are approximately 10 times fewer biogas plants than in Germany in France, we can assume that around 9 or 10 million tons of digestates are yearly produced in the country. Until recently, this increasing volume of digestates produced was not given proper consideration by the different agents of the sector, and especially by biogas producers themselves whose focus was mostly on biogas and less on digestates (Dahlin et al., 2015, 2017; Theuerl et al., 2019). Thus, this growing production, if not anticipated enough and accompanied by adequate storage and management methods, can negatively affect the development of the biogas sector, create conflicts and compromise the circularity model the sector is supposed to embody, and even become a missed economic opportunity (Dahlin et al., 2015, 2017; Logan & Visvanathan, 2019).

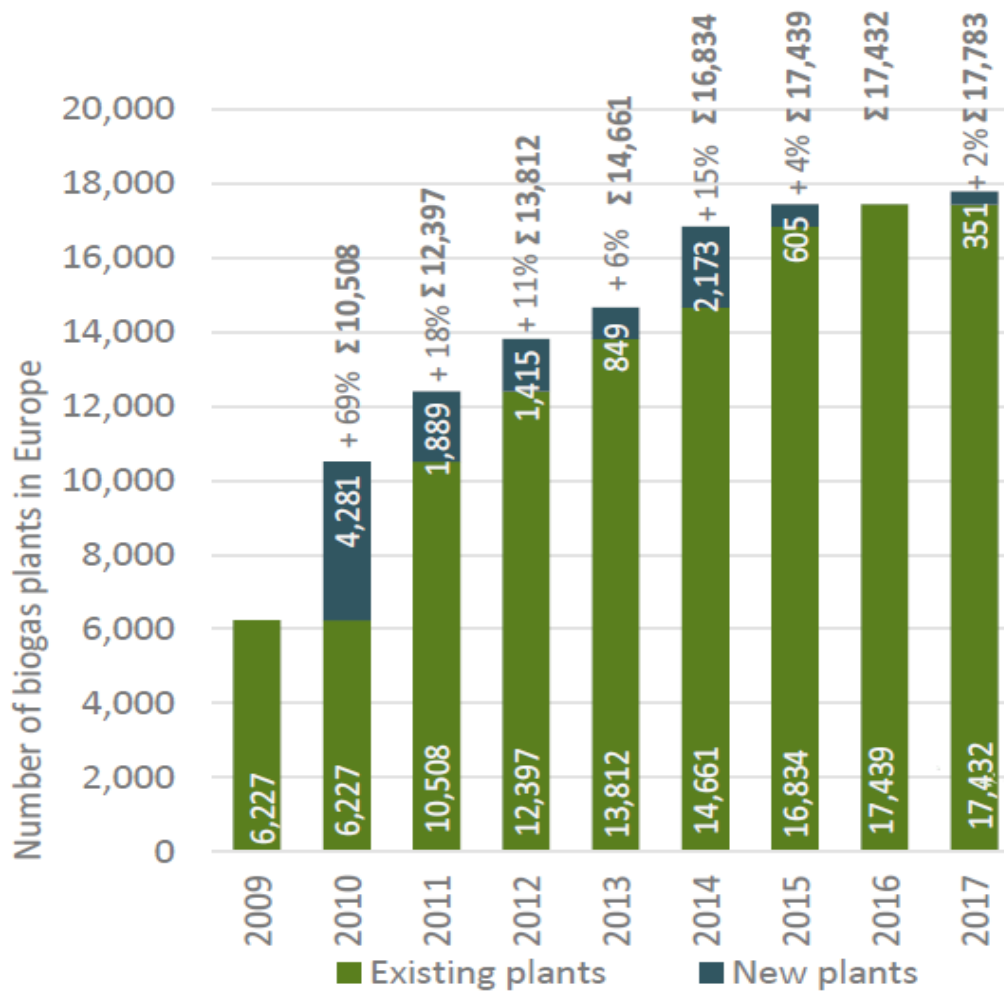


Figure 14: Evolution of the number of biogas plants in the European Union from 2009 to 2017 (source: EBA, 2018).



Figure 15: Evolution of the number of biomethane plants in the European Union from 2011 to 2017 (source: EBA, 2018).

Development of the number of biogas plants and the total installed electric capacity in megawatt [MW] in Germany (as of 10/2021)

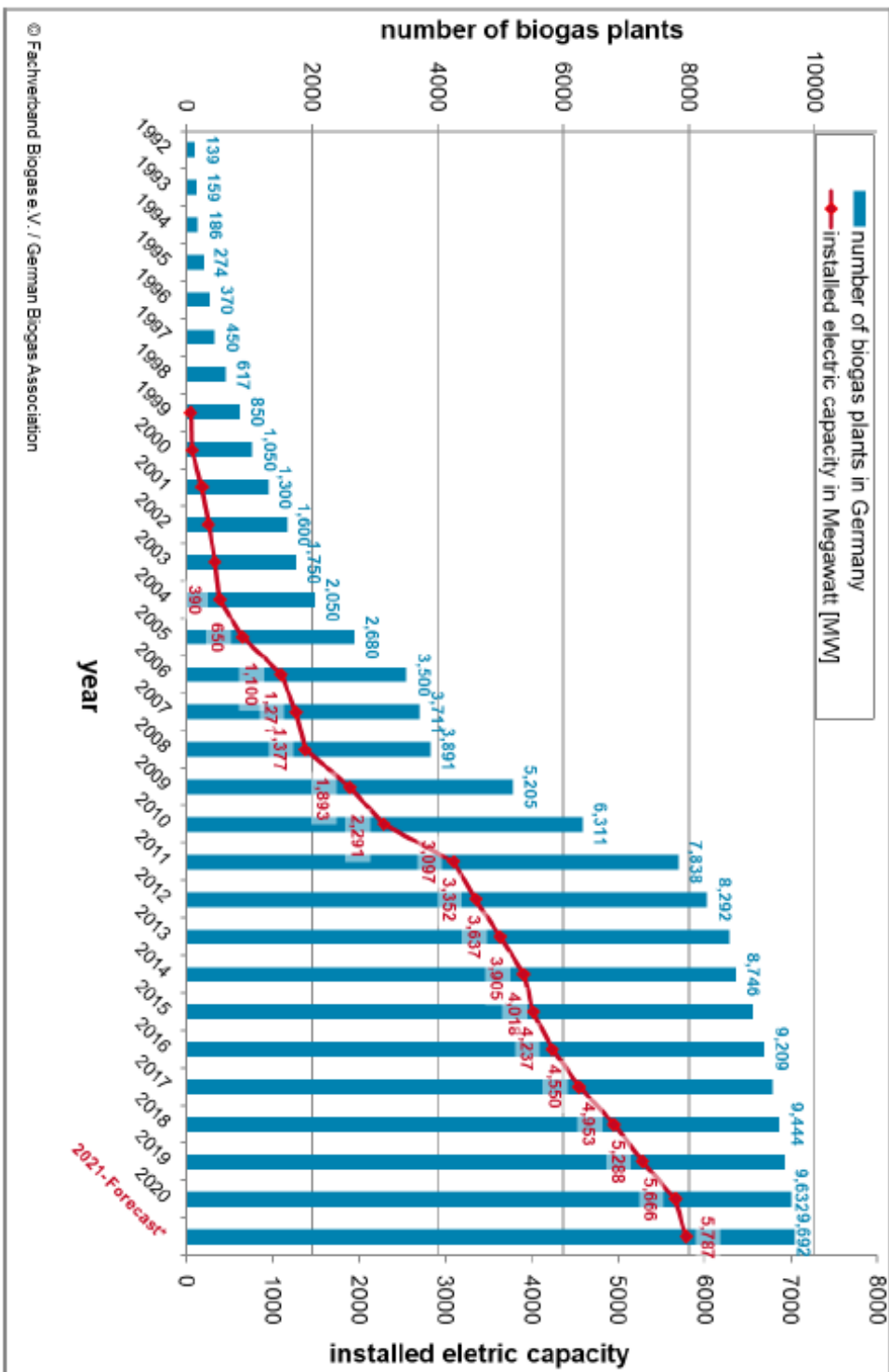


Figure 16: Evolution of the number of biogas plants in Germany (1992-2020). (Source: (GBA, 2018).

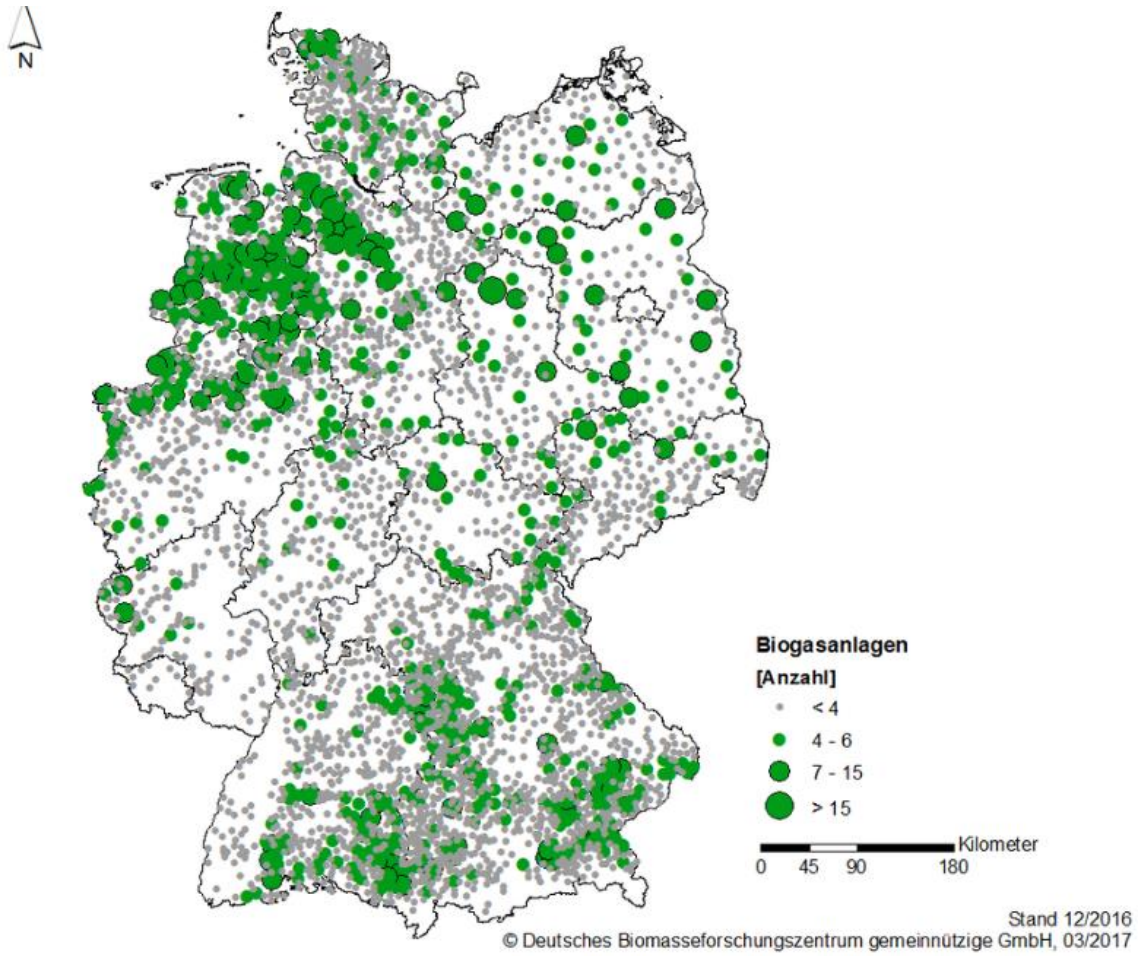


Figure 17: Distribution of biogas plants in Germany (source: Agency for Renewable Resource, 2017)

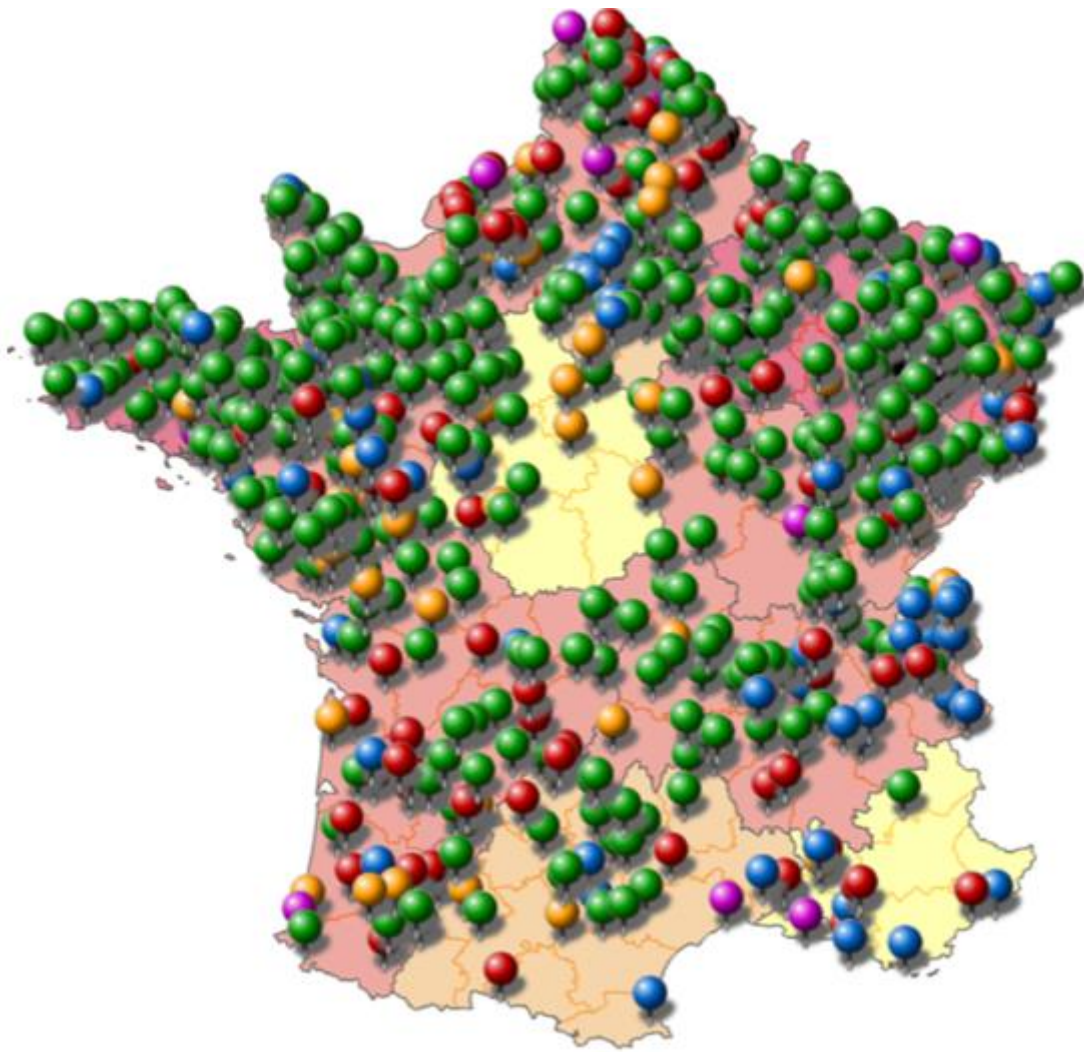


Figure 18: Distribution of biogas plants in France (Source: ATEE, s. d.)

Legend of the coloured dots: green = agricultural biogas plants, yellow = centralized biogas plants, red = industrial biogas plants, blue = biogas plants of a wastewater treatment plant, purple = municipal wastes.

ÉVOLUTION DE LA PRODUCTION D'ÉNERGIE À PARTIR DE BIOGAZ

TOTAL : 11 TWh en 2021

En TWh

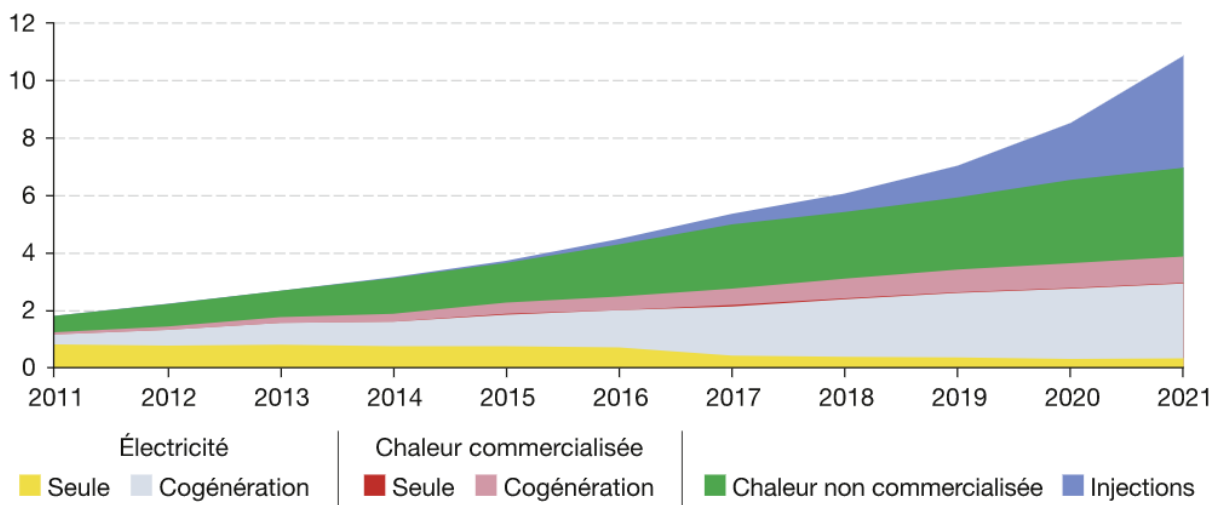


Figure 19: Evolution of the energy production from biogas plants in France (2011-2021)
Source: (MTE, 2022)

Conclusion of section 2

The deployment of the biogas sector has been desired, designed and promoted, at first at the level of the EU, and then implemented by Member States at the national level, that have set development targets. Renewable energy policies have boosted the production of biogas but with no anticipation of digestate management and of the potential negative externalities generated. In addition to RES policies, Circular Economy and Bioeconomy policies carry the political will to facilitate the use of digestates as fertilising products, for environmental and economic reasons, but also for global geostrategic reasons such as to reduce the EU dependency on fertilizers importations. The growth of the sector is also favoured by the soon-coming opportunities to collect more feedstock, especially with the new target to collect and valorize 100% of biowastes from 2024. As a consequence of these policies, the biogas sector is booming in France and has experienced a boom in Germany some years ago, although now, new German policies want to reshape the sector to address the concerns of opponents. The development of the biogas sector seems therefore adjustable to political ambitions, and politically monitored by national governments that can choose to alternatively boost or slow down its growth, in a very top-down way. Growing volumes of digestates are being produced, due to the growth of the sector, and an important growth of the production is forecast, but the management of digestates and potential negative externalities need to be better anticipated.

Section 3: Economic and legal context of the use of digestates

Introduction of Section 3

Section 3 is divided into two sub-sections. We detail, in this section, the regulatory and economic contexts into which the valorization of digestates is enshrined. In the first sub-section, we present the impacts of EU directives, and of French and German laws, on the legal status of digestates, and how this legal status opens or closes market opportunities for digestates. In the second sub-section, we present the various economic and market opportunities offered to the valorization of digestates.

1. Regulatory context for the valorization of digestates

The possibility for digestates producers to engage into different valorization options not only depends on the costs and availability of post-treatment technologies, and on market opportunities, but it also depends a lot on the regulatory context that applies to digestates.

At the EU level, the previous regulation (EC) n°2003/2003 aimed at supporting and harmonizing the marketing of mineral fertilizers in the EU single market but did not address organic and waste-derived fertilizers. To ease the access of these fertilizers to the EU single market, the updated regulation (EU) 2019/1009 came into force in July 2022, with a harmonized list of health and environmental criteria and administrative procedures to market organic fertilizers. Digestates that meet these criteria can therefore be marketed on the whole single market as *products* or be used as raw material in the production process of other types of fertilizers that will be marketed themselves in the single market. In case digestates producers only wish to use their digestates on the national market, or in case the digestates do not meet the requirements of the EU regulation, national laws therefore apply.

In France, digestates are, at first, always considered as *wastes* by the law and not as products, and therefore they cannot be freely marketed and sold, excepted under certain conditions, and under the regulation (EU) 2019/1009 (PRN, 2019). As *wastes*, digestates are automatically submitted to a “spreading plan” or “land application plan” that has to be elaborated by digestates producers and approved by State services prior to their use, and digestates have to be applied on agricultural lands. The land application plan has to provide a lot of information, including a detailed description of the geographic area where digestates are supposed to be applied, with a particular focus on the agricultural, ecological, geological, hydric and climate contexts of the area, and the presence of protected natural areas and protected water resources, the estimation of the quantities of digestates that will be produced, quality analysis on agronomic properties, heavy metals contents and trace organics, soil analysis, the lists of lands and farms that will receive digestates, the storage capacities, and technical and logistics aspects of land application. In addition, for biogas plants subject to the authorisation regime, i.e., the plants we selected in our case studies, an annual report on the use of digestates, as well as complementary analysis and information on any accidents that may have occurred have to be transferred annually to State services (CPE, 2020). The objective beyond the land application plan is to keep a traceability of digestates that are spread over time, and, in case of any health or environmental problem that may occur, the responsibility lies on digestates producers because of the status of wastes that digestates have.

Legal adaptations have been adopted over the years to allow some categories of digestates to access the status of *products* and to bypass the land application plan obligation, but in this case, the responsibility of digestates use is transferred to from the producers to the end-users. Before 2017, there were two options to obtain the product status: the deliverance of a marketing authorisation or “*Autorisation de mise sur le marché*”, delivered by the Ministry of Agriculture for 10 years after a risk and efficiency assessment executed by the ANSES¹⁶, and the compliance to established norms. The obtention of the marketing authorisation requires to prove the innocuity of digestates towards health and the environment, as well as the homogeneity, the stability and the invariance of digestates, which is quite difficult as regard to the high heterogeneity we described in section 1, which is actually a characteristic of wastes (Lupton, 2011), and therefore, the procedure is always long and costly (ADEME, 2015a; Chenon et al., 2012). Concerning the compliance to established norms, composted digestates can hope to fit into the norms NF U 44-051, NF U 44-071 and NF U44-95 (organic amendment), and potentially NF U 44-551 (growing media) and NF U42-001/A12 (organic fertiliser) (ADEME, 2015b; PRN, 2019). Since 2017, a third possibility was added to give digestates the status of products and bypass the land application plan, and consists in the compliance to specifications or “*Cahier des Charges*”. In June 2017, the specification called “*DigAgri 1*” came into force to allow digestates produced by agricultural biogas plants to bypass the land application plan if they met the requirements of the specification (such as agronomic values, heavy metals contents and pathogens limits) (PRN, 2019). In August 2019, two new specifications called “*DigAgri 2*” and “*DigAgri 3*” were enforced to include digestates that were not part of “*DigAgri 1*”, i.e., digestates obtained from the dry production process, and those produced from biowastes and from some animal by-products, however only for agricultural biogas plants (CPE, 2020; PRN, 2019). In October 2020, new specifications cancelled and replaced the three previous ones, and above all, allowed industrial biogas plants to give their digestates a status of products and bypass the land application plan. This new regulation was much criticized by some representatives of agricultural biogas producers as a potential for increased competition between agricultural and industrial biogas plants, and abuses from industrialists (Icart, 2020).

In Germany, there is no specific regulation dedicated to the management of digestates, as they are considered as organic fertilizers in the same ways as all other organic fertilizers, and

¹⁶ French national agency for health, environment and food security.

therefore do not require the elaboration of a land application plan like in France. The management and valorization of digestates are regulated by three main types of regulations, the fertilizer regulations, the hygiene regulations and the waste regulations, and these regulations apply to digestates depending on the initial feedstock used in the production process (Trombin et al., 2017). First of all, the Fertilizing Law (Düngegesetz / DüG), the Fertilizer Ordinance (Düngemittelverordnung / DüMV) and the Fertilizing Regulation (Düngeverordnung / DüV) establish the rules for the production, marketing and use of fertilizers and soil amendments, including digestates. The Fertilizing Regulation was revised in June 2017 for a stricter protection of water resources, and to better comply with the Nitrates Directive, as many regions had noticed an increase in the “nutrient concentration in groundwater”, possibly due to “the always higher number of biogas plants” that created “concerns on digestates land applications” (Trombin et al., 2017). In addition, if the initial feedstock contains biowastes, the Biowaste Ordinance (Bioabfallverordnung / BioAbfV) applies to digestates too and set the maximum volumes of digestate that can be spread on agricultural lands, as well as nutrients and heavy metals limits. The Biowaste Ordinance also requires the separation of the liquid and solid phases of digestates in order to concentrate the impurities, such as plastics, in the solid fraction, that is then eliminated through incineration, and therefore only the liquid phase can be applied on lands (Dollhofer & Zettl, 2017; Trombin et al., 2017). A major difference between France and Germany is the existence of a voluntary quality label for digestates, called the RAL quality label, that also requires the phase separation of digestates and the elimination of the solid fraction. According to Trombin et al. (2017), this certification is often a key element to have digestates used by farmers and other end-users.

2. Management and valorization options for digestates

The use of digestates as soil amendments and fertilizers in agriculture is the most common valorization method in Europe, including in France and in Germany, in order to contribute to the replacement of expensive imported mineral fertilizers (Dahlin et al., 2017; Guilayn et al., 2020; Koszel & Lorencowicz, 2015; Logan & Visvanathan, 2019; Monlau et al., 2015; Pappalardo et al., 2018; Plana & Noche, 2016; Theuerl et al., 2019; WRAP, 2013). Dahlin et al (2015) estimated that 95% of digestates in Europe were used in agriculture, with the majority of these digestates being applied on agricultural soils in their raw form, or after a solid-liquid phase separation as this technology allows better nutrient management, cheaper

transport costs and easier storage while being a quite affordable and mature technology (see section 2) (Fruhner-Weiß, 2018; Hjort-Gregersen, 2015; Trombin et al., 2017). The management of digestates, from their production at the biogas plant to their use by farmers, often implies high transportation, storage and land application costs as well as important land occupation for the storage facilities, and issues around digestates management are often not anticipated enough (Dahlin et al., 2015; Monlau et al., 2015; Plana & Noche, 2016; WRAP, 2013). These costs can become a real financial burden for the biogas plants if not anticipated and controlled, and these managing costs sometimes exceed the price at which biogas plants managers can hope to sell digestates to farmers (Monlau et al., 2015; Plana & Noche, 2016). As a consequence, markets for digestates are very often localised close to the biogas plants, within a 15-30 km radius, to reduce transportation distances and mitigate associated costs, and new alternative management options are sought to increase the profitability of biogas plants and increase the often-low economic value¹⁷ of digestates (WRAP, 2013). The land application of digestates on agricultural soils contributes to make agriculture practices more circular by closing nutrient loops but it does not differ much from traditional waste management practices that have been implemented for centuries in agriculture (Bianchi et al., 2020).

Alternative uses for digestates have therefore been explored to address issues such as, as we said, the need to increase the profitability of biogas plants, but also to remedy to the lack of sufficient access to local agricultural lands, especially for large biogas plants, and to benefit from incentives, such as the heat bonus to dry digestates, or to comply with legal constraints, such as nitrogen land application limits in some regions (Dahlin et al., 2015, 2017; Selvaggi et al., 2021; Trombin et al., 2017). These alternatives aim at increasing the marketability of digestates and encompass a wide variety of initiatives to transform, stabilize and process digestates, and to manufacture digestate-based products, thanks to the post-treatment upgrading technologies we described in section 1 (Guilayn et al., 2020; Logan & Visvanathan, 2019). Agriculture remains the major target for these digestate-based products, mainly in the form of refined fertilizing products such as ammonium sulphate and ammonium nitrate (GBA, 2018; Guilayn et al., 2020), but new markets, including niche markets, are being explored too, although it sometimes implies to export these digestate-based products far from the biogas plants, and therefore to lose the local dimension of the sector (Dahlin et al., 2015; 2017; Guilayn et al., 2020). The level of development of these digestate-based products is very heterogeneous and goes from the theoretical stage to effective marketing and includes the lab and the pilot

¹⁷ Low economic value is, in these articles, understood as low selling prices, although the value can be high to farmers that save a significant amount of money by reducing their purchase of expensive mineral fertilizers.

scales (Guilayn et al., 2020). Some specific agricultural markets are under scrutiny, such as winegrowing and horticulture (Dahlin et al., 2015, 2017; Fruhner-Weiß, 2018; GBA, 2018), as well as niche markets, with for instance, the production of feedstocks for mushroom and alga cultivation, and of feeds for aquaculture and vermiculture (Guilayn et al., 2020; Logan & Visvanathan, 2019; Monlau et al., 2015; Rigby & Smith, 2011; Theuerl et al., 2019). Other economic sectors could also offer opportunities for digestate-based products, among which, landscaping, public parks management, private gardening, plant nurseries and forestry, through products such as potting soils, growing media, litter, turf fertiliser, plant feed and composts. Several opportunities are also explored in various industrial sectors, such as in the textile, the building and the energy industry (Dahlin et al., 2017; Fruhner-Weiß, 2018; Guilayn et al., 2020; Logan & Visvanathan, 2019; Monlau et al., 2015; Plana & Noche, 2016; Rigby & Smith, 2011; Theuerl et al., 2019; Trombin et al., 2017). We can make a parallel between these initiatives and the “upcycling entrepreneurship” model defined by (Donner et al., 2020) as an “innovative way to convert low-value by-products into high-value materials”. Dahlin et al. (2015; 2017) attempted to collect information on the prices of digestate-based products and concluded to a high variability, with prices going from “negative to strongly positive” and not correlated to the nutrient values of the products. They also highlighted the difficulty to market digestate-based products in very competitive well-established markets such as the soil amendments market, with potential buyers being reluctant to buy an unknown product, and expressing ecological or ethical concerns about biogas production.

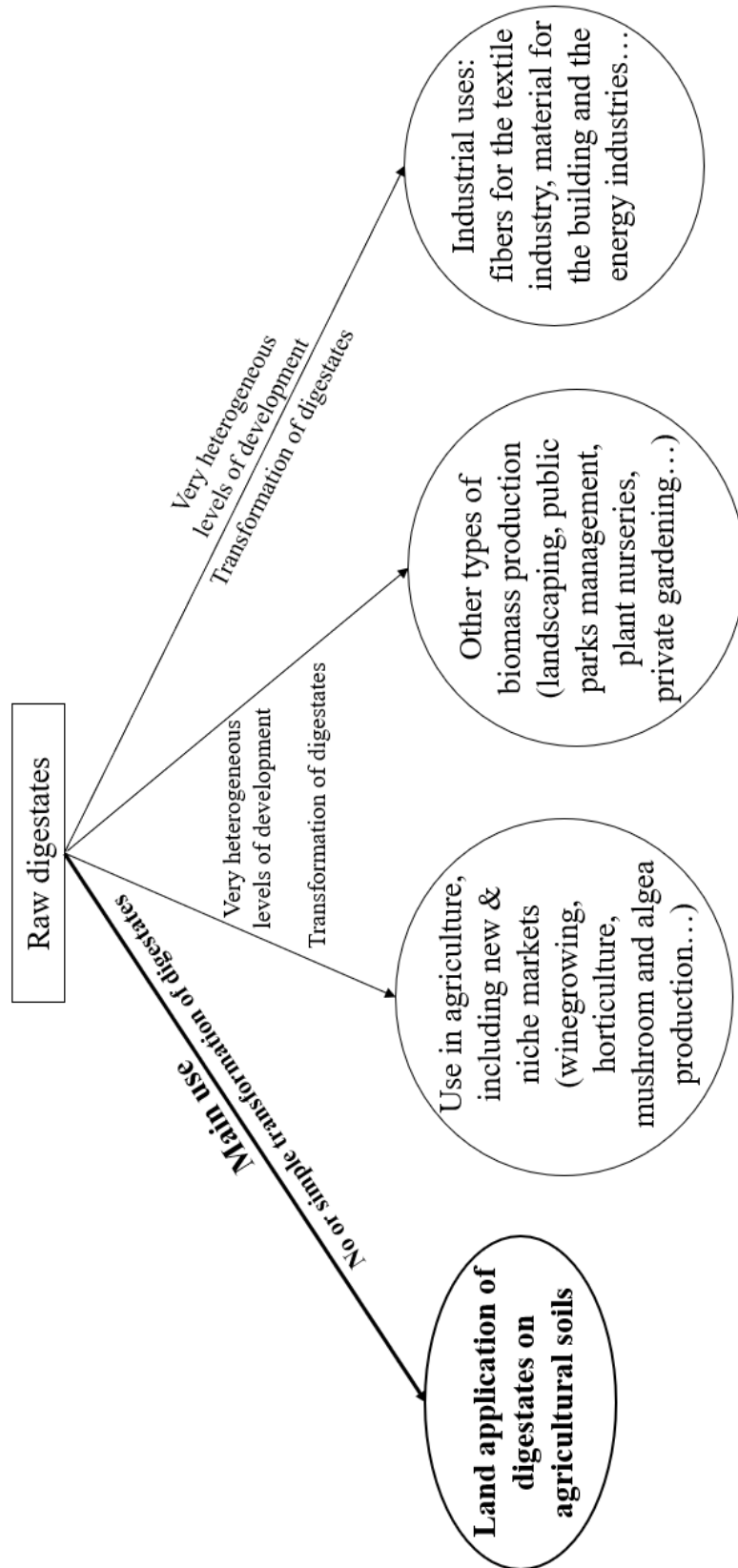


Figure 20: the different possible uses of digestates (source: own graph)

Conclusion of section 3

The use and valorization of digestates as soil amendments and fertilizers has many advantages, on one hand, such as to replace imported expensive mineral fertilizers and help farmers reducing their fertilising costs, and contribute to the implementation of Circular Economy in agriculture. But, on the other hand, the management of this by-product can be associated to important costs for the producers, such as storage and transportation costs, and become a financial burden. Therefore, digestates are mainly used locally, around biogas plants, on their territory of production, and alternative options to their widespread land application are being considered. However, a key point for their valorization is the legal statuses of wastes or products they are given, that go with different administrative and legal constraints. This status is not yet harmonised across Europe, although the regulation (EU) 2019/1009 that came into force in 2022 is an attempt to partially harmonise this status. Within Member States, the legislation on digestate management and status is often complex, and is quickly changing, especially in France, with new specifications issued every two years. Digestates, that technically are by-products, can therefore legally be either wastes or products. The sector is therefore dynamic, and evolving, and many different paths can be taken for the future valorization of digestates.

Conclusion of Chapter 1

We have described, in this chapter, the context of the development of the biogas sector, and particularly, of the use of digestate, which is the main focus of our research. The development of the biogas sector has been strongly promoted by EU and national policies, in a top-down perspective. The sector has been brought to the forefront as a model of Circular Economy by these top-down policies, and the use of digestates is a key element in this CE narrative. However, the sector is very heterogeneous and encompasses many different technical, administrative and economic realities across territories. This heterogeneity is particularly expressed in the diversity of digestates, of post-treatment technologies, of valorization options, and on their legal status, as they can be alternatively considered as wastes or products, depending on complex and quickly-evolving legislations, which maintain the ambiguity on the nature of digestates. Therefore, we are dealing with an emerging, dynamic and complex sector, whose many aspects and perspectives need to be explored by scientific research. Many ongoing

research projects address agronomic and technical aspects of biogas production and of the use of digestates. However, we will see in the next chapter that many questions still need to be explored by social sciences. These unanswered questions drive the interest and usefulness of our research.

Chapter 2: Research problem

Introduction

The aim of this chapter is to present the research questions that have emerged from the recent dynamic and complex development of the biogas sector we presented in the previous chapter, and above all, of the management and use of digestates. We first present recent scientific questioning on Circular Economy, as we explained in the previous chapter how the biogas sector and the use of digestates have been brought to the forefront as a model of CE. We explain the postulate, expressed by the recent literature on the biogas sector, that this questioning on CE can feed back into the topic of biogas and digestates production. Then, we move on to the description of more specific questions and issues that directly affect the biogas sector and the use of digestates, and how conflicts emerge from these controversies. We present the knowledge gap on the topic, and we stress out the scarcity of the literature in social sciences devoted to these issues. We introduce the recent scientific research stream on the territorial governance of the sector, and we show how this research stream has initiated a reflexion on the issues aforementioned. We then present the questions that remain, to date, unanswered. This brings us to the formulation of the research questions we aim at answering, and our research objectives, that we situate in our epistemological framework.

1. The need to consider the spatial and territorial dimensions of biogas production

We showed in Chapter 1 that the support for the development of biogas production and for the use of digestates comes from national, supra-national and regional top-down political strategies, but with the aim to valorize the local resources of rural and suburban territories. To valorize local resources while complying with global environmental concerns, theoretical approaches have been promoted, such as Industrial Ecology (IE). The primary aim of IE is to improve the management of energy and material flows to reduce the environmental impacts of economic activity. IE relies on a systemic approach and tries to analyse economic activity through the lens of the complex functioning of natural ecosystems (Brullot et al., 2018). It is usually considered that IE approaches rely on technological innovations, as well as environmental, organizational and institutional innovations, and therefore energy and material

flows must be analysed through a social and economic perspective to complement their quantitative assessment (Brullot et al., 2018). Therefore, the success of EI projects depends on the harmonious mobilization of these different innovations and thus on the cooperation of various agents aiming at the same goal (Dermine-Brullot & Torre, 2020). The question of the relevant spatial perimeter to analyse and implement IE approaches has been asked, and it seems that there is neither a unique nor an ideal perimeter. The adequate spatial scale often depends on the project, on the local context, on the availability of the necessary skills required for the project, and the possibility to spark enough interactions between agents (Brullot et al., 2018). Therefore, the spatial scale considered can be very diverse, such as an industrial district, a region or a *territory*.

The focus of projects analysis and implementation on the *territorial* scale gave birth to Territorial and Industrial Ecology (TIE) and Territorial Ecology (TE), albeit the scale of the territory can vary (Brullot et al., 2018; Dermine-Brullot & Torre, 2020). TIE and TE approaches consist in closing energy and material loops through sharing and collectively managing resources within a territory (Carrière, 2018; Dermine-Brullot & Torre, 2020). While IE focuses on the collective construction of solutions to manage material and energy flows within a territory, TIE and TE analyse the construction of the whole territory itself and the influence of its inhabitants on productive activities (Bourdin & Maillefert, 2020; Brullot et al., 2018). TIE and TE aim at analysing both the material and immaterial flows within a territory, and the interactions between agents, with an emphasis put on the diversity of agents that can be concerned by these flows. The focus is put on both a qualitative assessment of the relationships between agents, and a quantitative assessment of these flows, as well as on their governance at the territorial scale, and the need for collective action (Brullot et al., 2018; Bourdin & Maillefert, 2020).

Circular Economy is sometimes described as a complement to TIE and TE approaches, or conversely, as a global approach including TIE and TE (Brullot et al., 2018; Dermine-Brullot & Torre, 2020). As we demonstrated in Chapter 1, biogas production is promoted as an “important component of circular economy strategies” (Niang et al., 2022) by European and national policies. As TIE and TE, Circular Economy aims at closing the material and energy loops to save resources, and can encompass a variety of actions that can be deployed at different spatial scales by many different agents (Carrière, 2018; Niang et al., 2020). Indeed, the question of the relevant spatial perimeter to develop CE is raised and it seems again that there is neither an ideal nor a unique adequate perimeter (Carrière, 2018; Gallaud & Laperche, 2020; Niang et al., 2020). However, there seems to be a consensus in the French literature that CE must operate

at the *territorial* level to be fully successful, and must be part of a global *territorial project* based on the inner specificities of the territories, and on the cooperation and networking of its agents, although the identification of the boundaries of a territory is itself complex, as we saw in the previous section (Carrière, 2018; Gallaud & Laperche, 2020; Niang et al., 2020). Carrière (2018) questioned the role and the spatial adequacy of administrative and political territories, such as municipalities and regions, in the deployment of CE strategies, and claimed that regions in France, or Lander in Germany, due to their political competences, might be the best scales to impulse CE strategies.

However, while CE is becoming more and more popular, it has been accused of being partly transformed into a “buzzword” (Vivien et al., 2019) that can potentially turn into nothing more than “greenwashing” (Domingo, 2021). To date, there is still no scientific and political consensus on the definition of Circular Economy, that, according to the French Agency for the Ecological Transition, encompasses a wide variety of notions such as eco-conception, sustainable supply chains, sustainable consumption and recycling, and is considered alternatively as a tool to achieve sustainable development or a consequence of its implementation (Geissdoerfer et al., 2017; Millar et al., 2019). As a result, according to (Korhonen et al., 2018), CE remains “a collection of vague and separate ideas from several fields and semi scientific concepts”.

CE, however, is not a new concept, and circularity thinking roots back to at least the Industrial Revolution of the 19th century, when economists and engineers such as Babbage, Playfair and Marx developed their thoughts on the industrial valorization of wastes (Lupton, 2011). In addition to this thinking on industrial wastes, the recycling and valorization of wastes in agriculture, and therefore, the implementation of circular practices in agriculture, date back to even thousands of years (Bianchi et al., 2020; Lupton, 2017). The modern conceptualisation of CE comes from (Kenneth Boulding, 1966) and its essay entitled “The Economics of the Coming Spaceship Earth”, in which he urged the readers to consider the Earth as a close system whose material stocks are finite and should not be depleted at all. Therefore, the economic systems should function like ecological systems, by reusing outputs (wastes) as inputs (resources), and should use renewable energies only. Biogas production therefore fits into this model by using wastes (outputs) to produce RE and then returns its own outputs (digestates) as inputs to other economic activities (to agriculture that will produce food and biomaterials, or to the other sectors described in Chapter 1) that will themselves create outputs to supply biogas production again.

But, while at first CE was associated to concepts such as degrowth and the “steady-state

economy” from authors like (Daly, 1974) and (Georgescu-Roegen, 1979), the renewed interest in the concept, particularly from the political and business spheres, which began in 2012 and 2013, saw a shift towards an opposite approach linking CE to green and sustainable growth and to decoupling economic growth from the consumption of natural resources (Leipold, 2021; Vivien et al., 2019). As a consequence, different visions of CE now co-exist, with on one hand a vision considering CE as a new paradigm, a way of looking at the world and of stepping out of conventional production practices, and a more technical and business-oriented vision supported by political and economic institutions (Arnsperger & Bourg, 2016). For example, the definitions of CE provided by the French Agency for the Ecological Transition, the French Ministry for the Ecological Transition and from Eurostat, focus on lengthening the life cycle of goods, services and resources, on reducing the consumption of resources and the production of wastes, and on mitigating environmental damages and increasing the well-being of people, and consider CE as a tool in the hands of businesses and local public powers. However, Arnsperger & Bourg (2016), and Dermine-Brullot & Torre (2020), claim that these visions remain too much centred on the management of material flows, and give no space to the *spatial* and *territorial* dimensions of CE. Additionally, some authors argue that the scientific literature itself is too much focused on the technical and business dimensions of CE, and on “closing the loops” of material flows, with an insufficient reflexion on the *role of space* in CE implementation (Brullot et al., 2018; Niang et al., 2021). In the same way, the EU directives on CE have also been criticised for being focused on economic efficiency with no attention paid to *the territorial dimensions* of CE projects (Niang et al., 2021).

This lack of *systemic* and *holistic* approaches for CE implementation has been said, by some authors, to prevent the identification of potential negative impacts of CE, such as negative environmental externalities or conflicts around CE facilities (such as recycling facilities), that occur at the local level, when CE projects fail to meet the needs of local communities and ignore their specificities (Arnsperger & Bourg, 2016; Niang et al., 2020). Recent contributions on CE have therefore insisted on the importance of the *local anchoring* and *embeddedness* of CE projects, in order to create projects “that are truly virtuous from an environmental point of view” (Niang et al., 2020; Bourdin et al., 2021; Veyssi re et al., 2021; Niang et al., 2022). As a result, the recent, but scarce, social sciences literature on biogas production, following this perspective on CE, postulates the need for the *territorialisation* of the biogas sector, and the importance that should be granted to *territorial governance* to avoid failures of biogas projects (Bourdin, 2020; Bourdin & Nadou, 2020).

As a matter of fact, we will see in the next section that there are many controversies and

many fears about the potential negative externalities of the sector, and their impacts on local territories.

2. The controversies about the biogas sector

The development of the biogas sector is affected by rising social, environmental and health concerns about the potential negative externalities that can affect local populations and ecosystems (Koszel & Lorencowicz, 2015; Monlau et al., 2015; Schumacher & Schultmann, 2017; Zemo et al., 2019; Chodkowska-Miszczuk et al., 2019; Theuerl et al., 2019; Bourdin et Nadou, 2020). These concerns are reported by various groups of agents, such as researchers and scientists, as evidenced by the growing body of scientific literature and research projects dedicated to the assessment of the multiple impacts of digestates, but these concerns also emerge within the local communities among which the biogas sector is supposed to be deployed, as local agents are not always convinced of its sustainability (Dornburg et al., 2010), in contrast to the EU and national top-down policies that present the sector as a key answer to the current climate and energy crisis.

In this regard, one of the first concerns reported about the sector is doubts on its real greenhouse gases (GHG) emissions balance. A report from the French Ministry for the Ecological Transition (2021) indeed claimed that gas leakages were one the most recorded accidents of biogas plants, while the sector is supposed to contribute to the EU climate neutrality. The GHG balance of biogas production depends on many parameters, such as the types of feedstock used, land use change, agricultural practices and management practices of digestates, and the heterogeneity of biogas plants we described earlier fuels the controversies on the real GHG balance of the whole sector (Dornburg et al., 2010; Guilayn et al., 2020). More specifically, for digestates, gas emissions occur mainly during storage and land application, and during transport. The main gases released are CH₄ (methane) of course, but also nitrous oxide (N₂O) which is a very powerful GHG and ammonia (NH₃), that is not a GHG but is a very toxic gas, harmful both for human health and for ecosystems, as it contributes to water acidification, alga proliferation and eutrophication, and is a source of atmospheric aerosol particles (Trombin et al., 2017; Theuerl et al., 2019). However, research tends to prove that nitrous oxide emissions are lower with digestates than with feedstocks (Nkoa, 2014).

To reduce gaseous emissions, storage should be covered, transport distance should be reduced and the best land application practices, with the most appropriate equipment, should

be enforced; otherwise, in addition to gas emissions, nutrient leakages can also occur (Nkoa, 2014; Trombin et al., 2017; Theuerl et al., 2019). These leaching and leakages of digestates and nutrients fuel important concerns about surface and groundwater pollution and eutrophication, and the use of digestates as an organic fertiliser is already limited by the EU Nitrates Directive of 1991 in certain regions where there is an excess of nitrogen (Dornburg et al., 2010; Plana & Noche, 2016). In addition to concerns on nitrogen pollution, the phosphorus content of digestates can also impact the quality of surface water, and is also a source of controversies (Plana & Noche, 2016; Trombin et al., 2017). In Germany, for example, there have been concerns about the role that digestates use has on the eutrophication of the Baltic Sea, whose water-basin extends to the North of the German territory (Trombin et al., 2017). Numerous biogas plants are located in the North of Germany because of the important concentration of animal husbandry and therefore the important availability of manure as feedstock. Although digestates are suspected to contribute to nutrients excess in water, it remains however difficult to determine which share of the pollution is due to the land application of digestates or to other agricultural activities. Digestates often contribute to the surplus of nutrients in regions where the high volumes of manure are already largely responsible of the situation. As a result, it is the whole regional agricultural system that is criticized, and digestates are only a part of it (Trombin et al., 2017).

In addition to this difficulty to precisely assess the responsibility of digestates in environmental problems at the regional scales, the literature points out the difficulty to reach a scientific consensus on the environmental impacts of the various stages of bioenergy production due to many “conflicting results”, and especially on topics such as impacts on biodiversity (Dornburg et al., 2010). This absence of consensus is particularly true for what concerns the qualities and real impacts of digestates, and it fuels suspicions and controversies (Theuerl et al., 2019). In a similar way, Trombin et al. (2017) conclude, in their study on the risks and threats caused by biogas production and digestates use, that the biogas sector is “neither good nor bad” concerning, for instance, nutrient issues, but that the sector reflects the controversies affecting the global agricultural system on which it is embedded.

However, specific issues with digestates should not be eluded. For instance, as Trombin et al (2017) explain, “Germany has a long record of more or less serious accidents” due to the important development of the sector, and, for instance, specific regulations have been implemented to limit the leakages of digestates in case of accident. In France, the report from the French Ministry for the Ecological Transition (2021) explains that 77% of the accidents caused by the biogas sector are due to the leakage of dangerous matter in the environment, such

as digestates (MTE, 2021). Excess of nutrients can also be due to a nutrient imbalance between the regions where the feedstocks are produced, and the regions where digestates are applied, if their perimeter differs. This seems specifically the case for energy crop cultivation, that can be transported on longer distances than digestates (Trombin et al., 2017).

These fears for water resources are completed by larger concerns about the contents of heavy metals, trace organics and organic pollutants, phytotoxic elements, antibiotics, pathogens, such as Enterobacteriaceae, Salmonella, Escherichia coli, Listeria and Campylobacteria, weed seeds, non-biodegradable elements such as plastic, and the high salinity of digestates (Dabert et al., 2013; Guilayn et al., 2020; Nkoa, 2014; Plana & Noche, 2016; Rigby & Smith, 2011; Theuerl et al., 2019). Numerous scientific studies express concerns about the effects on soils, water and biodiversity that a long-term accumulation of these elements in the environment could have (Guilayn et al., 2020; Nkoa, 2014). However, research tends to prove that the presence of the unwanted biological elements is reduced in digestates, compared to the initial feedstocks, thanks to the anaerobic digestion process, and that heavy metals are made less chemically accessible, although it depends, again, on the types of digestates considered, and, to the contrary, some studies have highlighted a persistence or an increase of the concentration of these unwanted compounds (Guilayn et al., 2020; Theuerl et al., 2019).

From a more social perspective, local concerns and complaints about the management and the use of digestates management mainly target the stench rising from fields or from the production and storage facilities, the noise and the increased traffic and road congestion due to daily or seasonal operations, and the negative impacts of these facilities on landscapes, all of these aspects affecting the quality of life of local communities, and other economic activities such as tourism (Bourdin & Nadou, 2020; Chodkowska-Miszczuk et al., 2019; Giuliano et al., 2018; Soland et al., 2013). The concerns and complaints about the negative externalities of the valorization of digestates are partly corroborated by the report of the French Ministry for the Ecological Transition (2021), which details the consequences of the (proportionally) increasing number of accidents, such as, more or less severe human injuries, damages on wildlife, cattle and infrastructures, stench, air, water and soil pollution, water and gas shutdowns for local population, local population lockdowns, traffic disruption and economic losses for the biogas producers. The report also points out the causes of these accidents, which are mainly infrastructural and equipment failures and inadequacy, and human and social failures, such as the lack of skills and knowledge, inadequate management practices, inadequate risk management, and inadequate and insufficient controls.

Finally, the cultivation of energy crops, mostly maize, for biogas production is also a major concern, with fear on land-use change, landscape transformation, competition with food production that often results in market disturbances and rising food prices, and depletion of water resources (Dornburg et al., 2010; Yang et al., 2021). The oppositions to massive energy crop cultivation in Germany led to the suppression of the energy crop cultivation bonus for the biogas sector in 2014, and the recent will to stop the growth of the sector, as we detailed in Chapter 1. Concerning the depletion of water resources, Dornburg et al (2010) insisted on the heterogeneity of water availability across regions and especially across water-basins, and therefore recommended that bioenergy production models be differentiated and adapted to local contexts.

We saw that there are many controversies and fears around the biogas sector, and especially many controversies focused on the management and the use of digestates, and the related negative externalities. We will see in the next section that local oppositions to biogas projects and to the use of digestates emerge from these fears.

3. The local oppositions to the biogas sector

We saw in the previous sections that, at first, some researchers claim that not enough attention is being paid to the territorial dimensions of circular economy projects, and that, additionally, many social, environmental and health controversies affect the biogas sector and the use of digestates.

These controversies and concerns about biogas and digestates are associated, in the scientific literature, with “heated debates” amongst local communities (Dornburg et al., 2010), as well as “low social acceptance”, “resistance”, “disputes” and many “local oppositions” to biogas production (Bourdin, 2020b; Depoudent et al., 2020; Giuliano et al., 2018; Niang et al., 2021, 2022). In a study, conducted, precisely, in France and in Germany, Schumacher et al. (2019) revealed a significant “rejection”, “resistance” and “opposition” to biogas plants, this “substantial public opposition” being caused by “environmental concerns”. Bourdin et al. (2020) claim that, in France, oppositions to biogas plants are “frequent”, and these “social oppositions” are source of “conflicts”, and affect the “success” of biogas projects. They also emphasize the anticipatory nature of these local conflicts, i.e., many conflicts emerge before the construction of the biogas plants. Because of these local conflicts, (Bourdin, Colas, et al.,

2019) claim that “industrial projects” are struggling to get off the ground.

Biogas projects are therefore not automatically welcome biogas projects (Bourdin, Colas, et al., 2020), although they are strongly promoted by public policies. These local oppositions represent a serious threat to the development of the sector and is one of the current major challenge that the sector faces (Bourdin, Colas, et al., 2020; Giuliano et al., 2018; Niang et al., 2021, 2022). Local conflicts have many harmful consequences on biogas plants, such as delays or even cancellations of plants construction, and disturbances or even interruptions of operations (Bourdin, 2020; Bourdin et al., 2020; Niang et al., 2022). It has been estimated that up to 30% of biogas projects fail to start their operations because of these local conflicts (Bourdin & Nadou, 2020; Chodkowska-Miszczuk et al., 2019) is a serious threat to the sector’s development objectives.

Bourdin (2020) argues that the choice of the localisation of the biogas plants is often the primary source of conflicts, as the neighbors fear to suffer from the potential negative externalities we described in the previous section. In addition, it is often considered that biogas plants impact more rural than urban landscapes, increasing the potential for conflicts in these areas (Bourdin, 2020). Dornburg et al., (2010) claim that debates and conflicts on the appropriateness of using local biomass resources for bioenergy production, instead of food production, are often widespread too among local communities, and generates opposition to bioenergy projects. Furthermore, (Bourdin, Nadou, et al., 2019) considered two main reasons for the emergence of conflicts: poorly designed projects, or the local existence of a minority of strong opponents, despite a relevant design of the project. According to Bourdin & Nadou (2020), these issues are often rooted in problems of local coordination and territorial governance, and on a lack of trust towards the project leaders (Bourdin, 2020). Soland et al. (2013) found out about the importance of information flows and exchanges between local agents in the “local acceptance” or the “opposition” to biogas plants.

Also, in their study, Chodkowska-Miszczuk et al., (2019) concluded that the problems and the “inconvenience” caused by the management of digestates was one of the most important issues of biogas plants. However, they did not dive deeper into this issue and did not try to understand the local coordination around it. Their results were confirmed by a study carried out by the French Agency for the Ecological Transition and the French Agricultural Chambers, that concluded to increasing disputes around the management and the use of digestates (Depoucent et al., 2020). This conclusion led the authors to claim that social issues on digestates need to be better understood, and the perception local agents have of these issues should be studied (Depoucent et al., 2020). The authors also argue that biogas plants can awake and aggravate

pre-existing territorial tensions and conflicts. As a consequence, Bourdin et al., (2020) call for the need to reconcile the interests of global public policies (ecological and energy transition) and local interests (the fears of the negative externalities of the biogas sector). But according to Schumacher et al., (2019), local conflicts are “not an inevitable fact” and their emergence and prevalence “depend on the context”.

Although the recent scientific literature has identified the existence of conflicts around the management and the use of digestates, and has linked them to issues of local coordination, we will see in the next section that research on the topic remains very scarce.

4. The scientific literature remains scarce

4.1. A sparse social sciences literature on digestates

For now, and to our knowledge, the literature exploring the issues around the management and the use of digestates remains very scarce. As Bourdin (2020) claims, the literature that focuses on wind power is rich, but the empirical social sciences literature on biogas plants remains very sparse. Concerning digestates, the literature has focused on marketing issues and the identification of market opportunities. Rigby & Smith (2011), WRAP (2012), Dahlin et al. (2015; 2017) and Guilayn et al. (2020) have explored market opportunities for digestates and digestate-based products, while WRAP (2013) have examined and compared supply and distribution models. Pappalardo et al. (2018) and (Selvaggi et al., 2018, 2021) have tried to estimate the willingness to pay (WTP) for digestates of farmers, and the effects that information offer about the qualities of digestates can have on the WTP. Giuliano et al. (2018) tried to assess how a new technological tool dedicated to increase the transparency of the monitoring and of the quality control of the process of production of biogas and digestates could increase local social acceptability, with therefore some elements of reflexion on the coordination of local agents and the exchanges of information. Soland et al., (2013) tried to find out the determinants of local acceptance and opposition of biogas plants in Switzerland through a survey on more than 500 local inhabitants, and Schumacher et al. (2019) tested the “public acceptance” of biogas plants in the Upper Rhine Region (including the French and the German parts of the region) through online surveys on thousands of local residents, but they did not mention digestates. Chodkowska-Miszczuk et al., (2019) tested the spatial embeddedness of biogas plants in Central Europe through surveys and interviews with experts, and mentioned the role of digestates in the emergence of local tensions. Depoudent et al. (2020) conducted a

study from the French agricultural chambers and the French Agency for the Ecological Transition, with the aim to understand the success and failures of territorial biogas plants in the West of France, through the analysis of the regional press, semi-structured interviews, document analysis, and expert interviews. They tried to understand conflicts to anticipate their emergence, and, as we explained previously, they concluded with the need to further explore the rising conflicts around the use of digestates.

Some researchers recently investigated conflicts and coordination issues around biogas plants, but without addressing the specific question of digestates. Bourdin, Colas, et al., (2019); Bourdin, Nadou, et al., (2019), and Bourdin & Nadou (2020), through the collection of quantitative data and semi-structured interviews, tried to understand the reasons why biogas projects fail or succeed.

They analysed the coordination of local agents and the territorial governance through the use of the proximity theory. However, in these articles, digestates are just mentioned as a potential source of negative externalities that can impact the emergence of local oppositions, without further results. (Bourdin, 2020b) complemented the aforementioned studies by the analysis of the regional press in the West of France, with the aim of understanding why local agents oppose biogas plants. But again, the specific issues related to the management and the use of digestates were not further explored. In addition, these studies particularly focus on ex-ante oppositions and conflicts which can prevent the construction of a biogas plant, and on ex-ante territorial governance mechanisms, which mean, before the production and the use of digestates, and the potential related conflicts that could emerge.

In the continuation of these research, Niang et al. (2021; 2022) conducted semi-structured interviews in the frame of a single-case study of a biogas plant in the West of France. They tried to understand the role of some specific local agents to prevent the emergence of local oppositions and conflicts against the biogas project. They use again the proximity theory to analyse territorial governance, and to understand the role of proximity in the emergence of local conflicts. They highlighted the role of unwanted geographical proximity in the emergence of local oppositions against the biogas plant, mainly because local residents were “concerned about the risk of explosions, as well as environmental damage, possible noise or odor pollution, and pollution linked to the increase in traffic”. We saw in the previous section that these concerns partly relate to digestates, but these studies did not investigate more this topic. Interestingly, Niang et al. (2021; 2022) adopted a dynamic approach of territorial governance mechanisms, by analysing the life of the biogas plant during ten years, the evolution of the territorial governance, and how territorial governance helped anticipating conflicts.

However, there is still an important knowledge gap on the specific topic of digestates, on the local coordination of agents around the management and the use of digestates, and on the understanding of the conflicts that can emerge. The points of interests raised by our sponsors, i.e., the French Environmental Agency and Avril group, as well as Chodkowska-Miszczuk et al. (2019) and Depoudent et al. (2020), remain unexplored by scientific research. In addition, we will see in the next sub-section that the topic of the local coordination of agents around biogas plants remains globally too little explored.

4.2. The territorial governance of biogas plants remains little explored

We have explained in the previous section that recent research on the local oppositions to biogas plants, from (Bourdin, Colas, et al., 2019, Bourdin, Nadou, et al., 2019), Bourdin (2020), Bourdin & Nadou (2020) and Niang et al. (2021; 2022), took the perspective of the proximity theory to analyse the impacts of territorial governance in the anticipation and emergence of local conflicts. According to Niang et al. (2021), the literature on the territorial governance of biogas plants is for now “emerging”, and only little attention has been paid to territorial governance mechanisms at work for biogas projects. Projects of biogas plants often involve plenty of different stakeholders, with their own modes of operation, which can make local coordination difficult and affect the success of projects (Bourdin et al., 2020; Niang et al., 2022; Torre, 2014). However, only “few works” have addressed these issues of local coordination around biogas plants, although they derive from similar questions raised by the social sciences literature on the bioeconomy and circular economy, about “the capacity of actors to coordinate and implement effective territorial governance” around CE projects (Niang et al., 2022).

Leloup et al. (2005) defined territorial governance as a way to explore the notion of governance adapted to territorial dynamics. They follow the idea that territorial governance goes against the traditional top-down approaches of local economic development, and involves the increasing participation of many different agents, to local coordination mechanisms, and to local decision-making processes, despite their potentially diverging interests. They argue that this diversity is even more necessary in our modern world, where no single agent can pretend to have all the necessary skills, knowledge and resources to manage local issues alone. From an economic perspective, territorial governance is therefore defined as the process of coordination of local agents in the aim of organising local economic activity, with the

underlying assumption that the territorial scale is the best scale to coordinate collective actions (Leloup et al., 2005). According to Leloup et al. (2005), the specific contexts of each territory influence the local territorial governance, and the local non-economic institutions can facilitate coordination. They argue that local public powers often hold the most important role in local coordination processes, but many interactions and interdependencies between public and private agents are also at work, as well as there can be much interlinking between different spatial levels of governance. Territorial governance is often associated to the creation of new mechanisms and structures to help local agents with concertation, negotiation, and decision-making processes, in order to evolve collectively towards common territorial goals (Leloup et al., 2005). However, (Torre, 2011) argues that the mechanisms of territorial governance are not yet stabilized, and their usefulness needs to be better understood.

As a result of the literature review we carried out and presented in this chapter, we will explicit and sum up, in the next section, the research questions that have emerged, and that will be addressed by our research investigations.

5. Our research questions

We showed, in the previous sections, the existence of many controversies around the development of the biogas sector, and especially on the management and the use of digestates. Due to these controversies, biogas projects are not automatically welcomed by local communities, and local oppositions, rejections, tensions and conflicts emerge. These conflicts sometimes lead to the failures of projects, or to delays in projects, or to the interruption of the operations of biogas plants. The recent literature has claimed the importance to understand how territorial governance can influence the emergence and the solving of these conflicts. In addition, some authors have argued that the territorial dimensions of biogas projects should be more studied. However, despite these claims, and despite the rising issues around the management and use of digestates, the literature on the topic remains very scarce, and our research sponsors, that are major actors of the development of the biogas sector, as well as some authors, have acknowledged the existence of this important knowledge gap. To date, and as far as we know, there has been no research on the role of territorial governance mechanisms in the management and the use of digestates, and their impacts on the emergence and solving of related conflicts.

We therefore aim, through our research, at contributing to bridge this knowledge gap.

We aim at **gaining empirical experience on the topic through the exploration of different case studies, across different territories**. Through our theoretical and empirical investigations, we aim at answering the main research question of this manuscript, which is: **How can territorial governance mechanisms impact the emergence and the solving of local conflicts around the management and the use of digestates?**

This main research question is composed of several different dimensions that we can explicit in the following sub-questions:

-What is the nature of these conflicts and what are the dimensions of territories they affect? Can we identify conflicts that are specific to certain territorial contexts, and conflicts that are consistently observed between different territorial contexts?

-How do local agents coordinate around the management and the use of digestates, and how does this local coordination impact the emergence and the solving of conflicts?

-How do the issues around the availability and the uncertainty on the information and knowledge about the properties and impacts of digestates, notably reflected by the controversies we exposed previously in this chapter, impact the local coordination of agents?

Thanks to the answers to these questions, we aim at formulating recommendations of governance that may help stakeholders of the biogas sector to anticipate and solve the conflicts related to the management and to the use of digestates. However, our research relies on a relativist epistemological postulate, as we consider that governance is a socially constructed object that does not exist *a priori*, but is the result of the interactions between agents. Our research on territorial governance are therefore based on a constructivist paradigm, and we do not search for the absolute truth. Consequently, we acknowledge that our recommendations of governance may have to be adapted depending on different contexts. However, we postulate a part of realism in our topic. Biogas plants, and digestates, do have impacts on their environment, whether positive or negative. We postulate the existence of a natural and physical reality of these impacts, that is not socially constructed. But the truth about some impacts has not been reached yet, hence the controversies, and the truth may not be reachable in some cases, at least currently, due to the limitations in technological and scientific advance. In this sense, we follow (Kant, 1781), in the idea that we may not be able to know the essence of reality but this reality exists independently from the perception or the capacity that agents have to apprehend it. We

postulate that this unreached, and maybe unreachable reality can lead to conflicts, each agent having its own subjective perception of reality. To answer these conflicts, agents have to interact, either to find ways and means to reach the truth collectively, or to achieve a social consensus on unreachable truths. At the level of territories, it is through the form of territorial governance that agents may be able to reach the truth or a consensus about it, hence our interest about it.

Conclusion of Chapter 2

In this second chapter, we presented the research questions and the research objectives that will drive our theoretical and empirical investigations on the local coordination of agents around the management and use of digestates. We presented some claims made by the social sciences literature about a lack of territorialisation and a lack of consideration for the territorial dimensions of CE, and therefore, for the territorial dimensions of biogas production and digestates use. We will therefore take the perspective of investigating the territorial dimensions of our research topic. We aim, through our investigations, at bridging the knowledge gap on our topic, and at contributing to enrich the scarce social sciences literature devoted to the subject. Additionally, we aim at providing tools for the stakeholders of the biogas sector, through the means of recommendations of territorial governance. Therefore, in the next chapter, i.e., chapter 3, we present our analytical framework, which is composed of theoretical propositions that help us to start answering our research questions, as well as of research assumptions that will be tested during our field investigations.

Chapter 3: Analytical framework

Introduction

The aim of this chapter is to present the analytical framework that will allow us to start answering our research questions, and to formulate assumptions that we will test in our field investigations. In the first section, in order to be able to understand the nature and the territorial dimensions of potential conflicts related to the management and the use of digestates, we take the perspective of territorial economics to understand the concept of territory, its definition and its characteristics. It leads us to explore the concept of territorialisation that we evoked in the previous chapter, and that is mobilized by the recent literature on biogas production. The concepts of territories and of territorialisation help us understanding how economic activity can affect and be affected by the different dimensions of a territory. It then brings us to the exploration of the concept of territorial capital. We present its definitions and components. The use of this concept in our field investigations will allow us to characterise the nature of the conflicts related to the management and the use of digestates, to identify the territorial dimensions affected by these conflicts, and how these dimensions can be mobilized to anticipate and solve the conflicts. In the second section, we explore how local agents interact around the mobilization of this territorial capital. Following recent research on the biogas sector, we mobilize the concepts of proximities to understand local interactions. We then move on to the definition of territorial governance, and of conflicts, and we explore how territorial governance, through the mobilizing of proximities, can help anticipating and solving local conflicts. In the third section, we suggest that the nature of digestates can lead to different situations of information acquisition and transfer. We assume that these different situations may impact the emergence and the nature of local conflicts, and that territorial governance, through the activation of proximities, may have to adapt to these different situations, in order to anticipate and solve conflicts. The chapter ends with a conclusion.

Section 1: The mobilization of the territorial capital

Introduction of Section 1

Section 1 is divided into four sub-sections. In the first sub-section, we present the concept of “territory” in economics, its definitions and characteristics from the perspective of territorial economics. We also detail the links between territories and local economic agents, and the role of territories in the development of local productive activities. In the second sub-section, we move on to the concept of “territorialisation”, whose definitions allow us to formulate assumptions on how economic activity can be adapted to its territorial context. In the third and fourth sub-sections, we expose and detail the concept of territorial capitals, and especially, how this concept has been mobilized by the social sciences literature on the biogas sector. We explain how this concept can help us answering some of our assumptions on the territorial anchorage and territorialisation of the sector. We end this section with a conclusion and a transition to the next section.

1. The territory as a social construct

The notion of “space”, and of “territory”, in economics, was initially far from being considered in its whole complexity and depth (Torre, 2002). The initial focus of neoclassical economics analysis was on firms and not on territories, and space was just “a point” where a firm was localised (Zimmermann, 2008). In this perspective, space only mattered to find the best localisation for a firm. The interest for the localisation of the firms progressively evolved to be considered as a productive factor among others. From the 1920’s and Marshall’s work on districts emerged a real interest for the impacts that relations between firms and agents located in the same place had on the economic development of their territories. The importance of information and knowledge exchanges, and of cooperation between firms and agents belonging to the same territory was being acknowledged, with the idea that these relations differentiated territories and impacted in different ways the development of local economic activity (Pecqueur, 1987; Torre, 2002; Zimmermann, 2008). As a consequence, territories could not be considered as passive “receptacles” of economic activities anymore, but they emerged in economic thinking as “sets of many different agents” pursuing both individual and collective aims, and playing an active role in the strategies of local businesses (Brulot et al., 2018; Leloup et al., 2005; Pecqueur, 1987; Pecqueur & Zimmermann, 2004; Zimmermann, 2008). Territories became an “explicative variable” of economic development and even a “territorial variable” that could go against top-down political development policies if antagonistic to local resources and interactions (Pecqueur, 1987). This led to the emergence of the field of territorial economy,

or economics of territories, that focuses on the local and endogenous economic dynamics based on the specific resources (both material and immaterial) of territories (Leloup, 2010).

From the perspective of territorial economy, territories are defined as “organized” places, “built”, “collective” and complex “social constructs” where agents experience life in a specific way (Chevalier & Pola, 2014; Dermine-Brulot & Torre, 2020; Dubresson & Jaglin, s. d.; Leloup et al., 2005; Zimmermann, 2008). Territories become themselves “collective agents” of economic development (Leloup, 2010), produced by and producers of specific resources, expressing historical, social and cultural roots that create a specific identity, and a specific context for economic development that cannot be transposed to other territories (Chevalier & Pola, 2014; Leloup et al., 2005; Pecqueur, 1987). It results in a diversity of territories where same policies and same resources are applied and valorized differently and in which agents are more or less used to network, work together and exchange information (Brulot et al., 2018; Leloup, 2010). As a consequence, each trajectory of territorial development appears unique, and to understand these trajectories, Leloup (2010) proposed a systemic approach called the “system-territory” in which territories are considered as complex dynamic systems.

The “system-territory” is a “combination of a place, of agents, and activities” governed by the three principles of system analysis: 1) the totality principle: the whole system-territory is different than the sum of its constituents; and therefore requires a holistic analysis of its functioning 2) the interaction principle: there is a necessity to understand the relations and interactions between the different agents of the system; 3) the organization principle: the system-territory acquires a form of specific structuration and organization, a specific governance. Adopting a dynamic systemic approach allows us to understand the evolutions of the systems and the evolutions that occur within the systems through a time perspective (Leloup et al., 2005). Based on the three principles of system analysis, Leloup (2010) listed four components of territorial development that evolve over time: the coordination of agents, the implementation of projects through the mobilization of local resources, the structuration of space and the definition of territorial boundaries, and the creation of a regulation that is specific to the territories. In addition, these “system-territories” must be seen as open systems, open towards other territories and towards natural systems (Brulot et al., 2018). Within these open systems, humans interact in many ways, through “social relations, economic cooperation, conflicts, strategic interactions, exchange of goods and services, and exchange of information” (Bourdeau-Lepage & Huriot, 2009), and these exchanges and flows of people, information, goods, and services also happen between territories, through “networks” that “interconnect,

cross and merge” (Terrier, 1989). These networks of people and infrastructures allow connections between territories even when there is “no spatial continuum” (Terrier, 1989). The connection between these “system-territories” implies that the impacts of biogas production and digestates use in a territory can affect other territories in many aspects, such as environmental aspects, as well as social and political aspects.

However, systems, although open, have boundaries, and the identification of the relevant boundaries to analyse and deploy economic development strategies, such as Circular Economy strategies, has been a major question of research in the past decades (Carrière, 2018; Terrier, 1989). Terrier (1989) claimed that there could not be a unique answer to the question, as the relevant perimeter to be considered would depend on the economic activity, but should at least include the whole area in which this activity takes place. This perimeter often expands beyond the political and administrative boundaries that square the national territory and its real boundaries are socially constructed and constantly reshaped by the crossing of networks and the interaction of agents that mobilize resources to build shared perspectives and projects (Leloup et al., 2005; Niang et al., 2020). As a result, this socially constructed space is often ruled by different administrative authorities and represents in itself a new territory (Leloup et al., 2005). Niang et al. (2020) proposed the notion of “activation territory” that corresponds to a constructed territory that crosses different administrative territories and within which local agents cooperate to activate local resources and face common challenges. In light of this complex and moving definition, the question of the spatial perimeter that should be considered by policymakers and project developers when developing a biogas plant unit, and by researchers when analysing projects, must be asked.

As a consequence, we assume, in our field investigations, that the management and the use of digestates, and the potential related conflicts, impact, and maybe reshape, the boundaries of territories. Hence, due to the complexity and the variety of territorial specificities, and the dynamic nature of “system-territories” and of their boundaries, we assume that the deployment of the biogas sector cannot be done homogeneously across the different territories. Therefore, to better consider these territorial specificities, we will dive deeper, in the following section, into the notion of “territorialisation” that we mentioned in the previous chapter, and in the claims made by the scientific literature to investigate more the territorial dimensions of biogas production.

2. The concept of territorialisation

As we explained in the two previous chapters, the support for the development of biogas production and the use of digestates come from national, supra-national and regional top-down political strategies, but with the aim to valorize the local resources of rural and suburban territories, and to be part of a territorial project based on the cooperation of local agents. To solve this paradox, the recent literature has insisted on the need for the *territorialisation* of the biogas sector and the importance that should be granted to *territorial governance* to avoid the failure of biogas projects (Bourdin, 2020; Bourdin & Nadou, 2020) (see Chapter 2). Moreover, as highlighted by Torre & Zuindeau (2009), environmental issues very often hold a territorial component and therefore, the answers to these issues, such as CE answers, need to be territorialized too (Niang et al., 2020). Territorialisation is “often synonymous with a spatial shift from the national to the local” level (Dubresson & Jaglin, 2005) but different understandings of the concept coexist.

The English-speaking scientific literature understands the concept as the way to manage and control local resources and local agents in a “bounded and controlled space”, through territorial projects whose success implies “establishing new laws, regulations, and authorities” and coercive actions (Bassett & Gautier, 2014). This approach connects with the four components of territorial development of “system-territories” stated by Leloup (2010), i.e. the development of a territorial project that structures space and generates regulation. However, this focus on control and management seems to maintain a top-down development approach with the spatial shift from the global to the territorial level being the only change.

The French-speaking literature on territorialisation focuses more on the links that exist and that can be created in a territory, between its agents and a project. Ginelli et al., (2020) define territorialisation as “the processes that strengthen the links between a project and all the components of a territory” and a way to adapt the development of an economic sector to the specific needs of a territory and its agents (Fleuret, 2015). The components of the territory that must be involved in the territorialisation of a project are numerous and diverse, and can include for instance the material, the cultural and the organizational dimensions of a territory. To link the project to all these different dimensions requires the “mobilization and creation of numerous resources” in the territory, such as “economic, social, political, cultural, environmental, landscape...” resources (Ginelli et al., 2020). Previous research on biogas projects has also highlighted that multiple territorial dimensions, such as social, cultural, institutional and political dimensions, must be mobilized and interlinked to achieve the territorialisation and the

territorial embeddedness of biogas plants, that cannot be reached if the management of nutrients and biomass physical flows are the only dimensions considered (Bourdin & Nadou, 2020; Chodkowska-Miszczuk et al., 2019). Chodkowska-Miszczuk et al., (2019) call the result of this combination of dimensions “site-specificity”, that makes it very difficult to transpose a project of biogas production and digestates management to another territory, another “site” (Niang et al., 2021). As a result, to be successful, biogas project leaders must include their project in a global territorial project that is of interest for the whole dimensions of the territory (Bourdin, 2020a; Bourdin, Colas, et al., 2019; Bourdin, Nadou, et al., 2019). Otherwise, it is estimated that 20 to 30% of biogas projects fail to start their operations because of a lack of local embeddedness and territorialisation (Bourdin & Nadou, 2020; Chodkowska-Miszczuk et al., 2019) which is a serious threat to the sector’s development objectives.

(Bourdin, Colas, et al., 2019) suggested that a lack of sufficient territorialisation and embeddedness threatened the “place identity” and the “place attachment” felt by local agents for their territory, and they would therefore set up “place-protective actions” to express their opposition to the projects. (Bourdin, Colas, et al., 2019) define “place attachment” as the “emotional and symbolic bond that unites individuals with their neighborhood”; “place attachment” goes beyond the NIMBY (Not In My Backyard) concept, as local agents would refuse the project not only due to individual disadvantages the project might bring to them personally, but because they refuse to allow their territory as a whole to be affected by the project.

Based on the two different approaches of territorialisation, we assume the necessity of both to organise the management and the use of digestates, in a way that anticipates and solves local conflicts. We assume the existence of a coercive and regulatory dimension, and the need for the mobilization of multiple territorial dimensions, such as social, cultural, political and institutional dimensions, to organise the use of digestates. In our field investigations, we will therefore look for the role, the influence and the decisions of one or several local authorities, and the creation of new rules, to validate or reject the assumption of the coercive and regulatory dimension. Concerning the mobilization of territorial dimensions, we are going to look, in the next section, into the concept of territorial capitals, that we will mobilize later for our field investigations.

3. The territorial capital

We exposed, in the previous sections, the claims made by the scientific literature about the needs for territorial projects, and therefore biogas plants, to mobilize and connect the different dimensions, components and resources of their territory, in order to be successful. These resources are often identified as “capitals” in the literature, and more specifically “territorial capital(s)” or “rural capital(s)¹⁸” when applied to the territorial scale. The origins of the notion of territorial and rural capital vary depending on the authors.

According to Chevalier & Pola (2014), the notion of territorial capital allows to understand and analyse the social and economic context in which economic activities emerge, in line with the increasing interest given to the role of territories and space in economic development, as we explained in the previous sections. From a policy perspective, Chevalier & Pola (2014) argue that this notion also derives from the shift that occurred in the conception of territorial development, which is, a shift from a top-down approach based on centralized powers designing economic development strategies, towards an approach that grounds territorial development in the valorization of the specific inner resources of local territories, i.e. in the specific *capitals* of the territories.

Brulot et al. (2018), on their side, root the concept of territorial capital in the notion of social embeddedness detailed by (Boons & Howard-Grenville, 2009), which also derives from this primary idea that any activity in a territory is somehow influenced and related to its socio-economic context, and is therefore *embedded* in its territory (Boschma, 2005). Social embeddedness has been divided into five sub-categories upon which Gobert & Brulot (2018) aimed at building a territorial capitals framework, these categories being: cognitive and cultural embeddedness, structural embeddedness (that relates to the structure of relations and interactions on a territory), political embeddedness (that relates to the institutional context, understood both as the norms and values that shape relations and as the role and involvement of public powers), spatial embeddedness (that would correspond to the notion of spatial proximity we describe later in Section 2), and temporal embeddedness (agents sharing the same time perspectives). Based on these categories, Gobert & Brulot (2018) proposed to divide the territorial capital into six components (Figure 21): 1) the natural capital, that includes landscapes, ecosystems and natural resources and that can be considered by agents as a true component of their territory’s identity. The natural capital can be transformed and valorized to

¹⁸ The singular and plural forms are used alternatively in the literature. The singular form implicitly corresponds to the sum of all capitals.

develop a territorial project. 2) The organizational capital, that corresponds to the formal and informal relationships that have emerged between local agents through past and present interactions (previous projects, previous conflicts...). The organizational capital of the territory is formed upon the individual social capitals of its agents. 3) The cultural capital, that is based on both the history and past experiences of the territory and its agents, and on how agents forecast the future of their territory. 4) The institutional capital, that corresponds to the political resources of the territories and the implication of public powers in local projects, as well as their capacity to lead economic development in a certain direction through strategies and orientations; 5) the infrastructural capital; 6) and the cognitive and technical capital.

From another but similar perspective, Gkartzios et al. (2022) consider that the concept of territorial capitals derives from those of rural capitals conceived by Bourdieu, and aimed at developing a global framework of territorial capitals of rural territories. These rural capitals are divided into economic, social and cultural capitals, and they are based on goods, such as land and natural resources, as well as on skills and behaviours, and they are mobilized by agents and groups of agents to achieve their objectives. The economic capital is defined as the possession of material resources such as land and financial resources; the social capital represents “the capacities that derive from social exchange, between individuals or members of a social group, although cultural capital “primarily circulates within family groups”. Based on this approach, Gkartzios et al., (2022) aimed at developing a global framework of territorial capitals of rural territories, and described rural territories as “composites of built, economic, land-based and socio-cultural capitals”. These four capitals are themselves divided into sub-capitals that sometimes merge and overlap due to their dynamic nature, and consider that their list of sub-capitals is “nor exhaustive neither present in every territory”. The “built capital” echoes the infrastructural capital of Gobert & Brulot (2018) as it is composed of economic infrastructures, i.e., all infrastructures facilitating economic activity (workspaces, housing, transportation...), environmental and nature-based infrastructures, i.e., all infrastructures linked to the exploitation and preservation of natural resources, and socio-cultural infrastructures, i.e., all “forms of social spaces” (schools, outdoor public places...). The “economic capital” is composed of financial resources and material resources “with exchange value” such as “land and property”, and it therefore overlap with the built capital. The financial dimension of economic capital is an interesting complement to the framework of Gobert & Brulot (2018) as financial resources are quite always a necessity to develop any project, and their abundance or scarcity are respectively an advantage or an obstacle to the project development. In addition, the economic capital is also composed of soft assets such as the economic culture of the territory, the business environment

and the business networks, that would well complement the cultural, cognitive and technical capital of Gobert & Brullot (2018). The “land-based capital” corresponds both to the natural capital as it includes landscape, ecosystems and natural resources, and to some aspects of the cultural and organizational capitals as it is sometimes a community-managed asset that contributes to create social links and is part of the community’s identity, in line with Gobert & Brullot (2018). Finally, the socio-cultural capital corresponds to both the organizational and cultural capitals of Gobert & Brullot’s framework. From a territorial perspective, these capitals would be mobilized by agents to achieve objectives of territorial development (Brullot et al., 2018).

It was initially considered that these rural capitals existed quite homogeneously within territories and not as specific and varying assets of these territories. The introduction of the term “territorial” instead of “rural” capitals therefore means that these rural capitals are not homogeneously distributed across rural territories, but on the contrary, each rural territory holds a specific combination of these capitals, creating a specific political and socio-economic context, a “site-specificity”, that creates a specific path to economic development and influence the success and failure of development projects (Brullot et al., 2018; Gkartzios et al., 2022; Gobert & Brullot, 2018), and in our case, the success or failure of biogas projects. Gkartzios et al. (2022) call this connexion between capitals the “spatial energy” of a territory that enables local communities to achieve development goals that have been designed based on the specific resources available on the territory. However, Chevalier & Pola (2014) claimed that these capitals, these resources, can be of a dual nature and become either advantages or obstacles to the development of a project.

In addition, the literature often endorses a dynamic definition of territorial capitals, that can reinforce each other and be transformed into new capitals or support the creation of new capitals. Territorial capitals are the “material and immaterial” resources that already exist within a territory, and that are possessed and mobilized by agents, added to the new resources that are created over time by collective dynamics, they therefore both pre-existing to any actions, but they also emerge when agents mobilize them (Brullot et al., 2018; Chevalier & Pola, 2014; Gkartzios et al., 2022; Gobert & Brullot, 2018). Chevalier & Pola (2014) insist on this dynamic and temporal dimension by placing the territorial capital at the intersection between two axes, a temporal axis that corresponds to the history of the territory and the future project that may be developed, and a spatial axis that represents the internal and external interactions between local agents and with other territories or extraterritorial agents (figure 22).

Based on these two axes, we can assume that, for a same project, there might exist

interactions around territorial capitals at different spatial levels, and also between the different spatial levels, as well as a timeline of continued and/or discontinued interactions. Indeed, the spatial perimeter within which these capitals are mobilized not always corresponds to administrative and political territories but instead, the ways these capitals are mobilized define moving and multiple territorial boundaries that evolve over time (Chevalier & Pola, 2014).

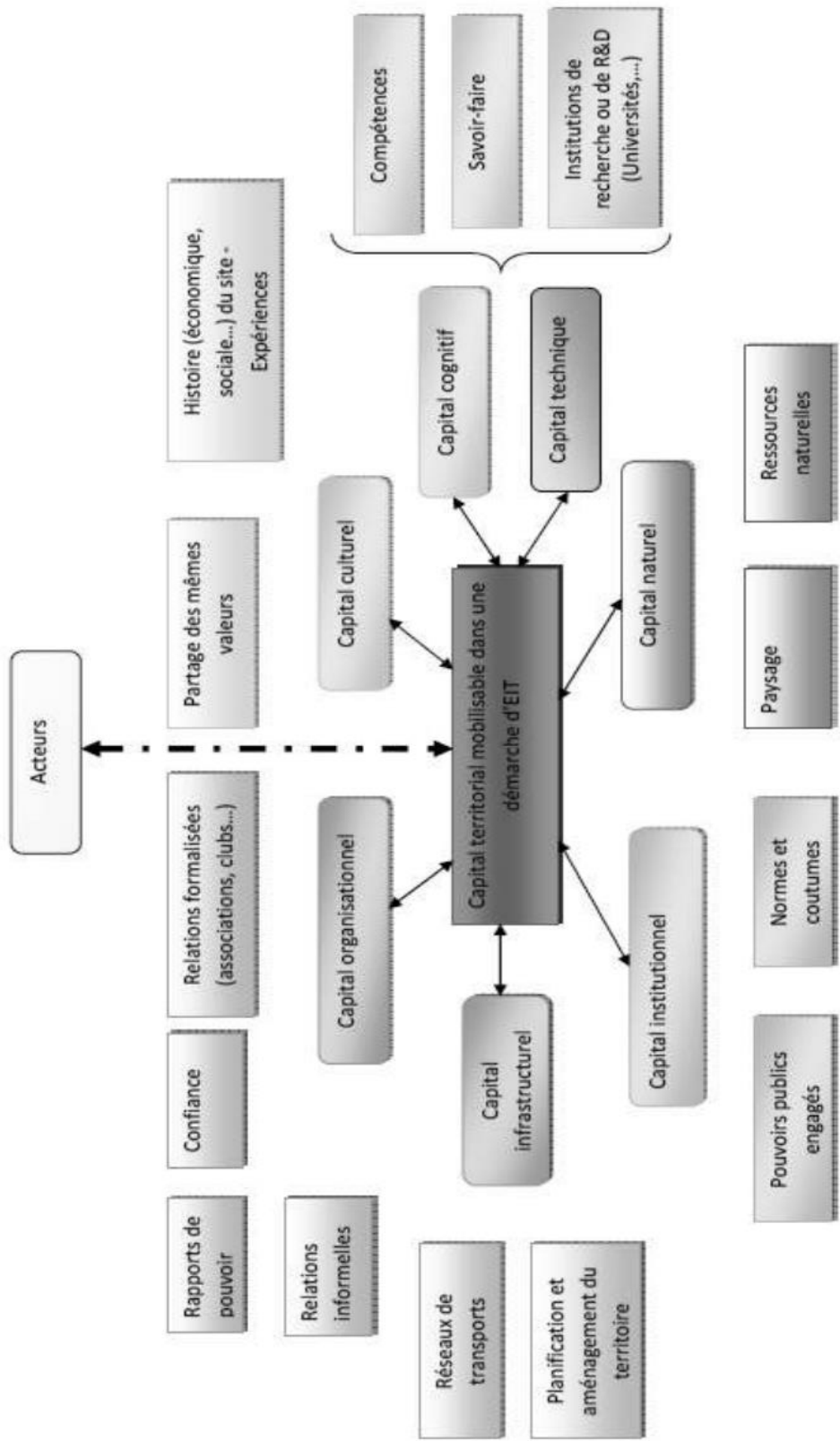


Figure 21: the different dimensions of the territorial capital defined by Gobert & Brulot (2018). (Source: Gobert & Brulot, 2018).

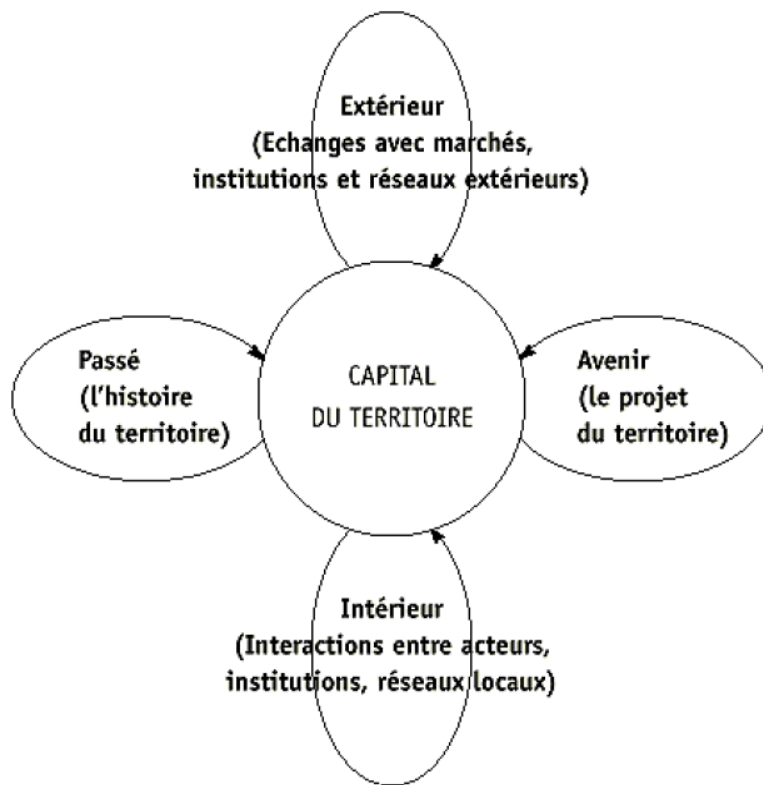


Figure 22: the time and spatial dimensions of the territorial capital (Source: Chevalier & Pola, 2014)

4. The components of the territorial capital mobilized by biogas production and digestates management.

The notion of capitals, and especially territorial capitals, is not always explicit in the socio-economic literature on biogas and digestates, that by the way, remains scarce, but it can be traced in the description of resources used and digestates management activities.

The necessary use of “resources”, both “material” and “immaterial” resources, or “tangible” and “intangible” resource (Bourdin & Nadou, 2020), or even “territorial resources” (Depoucent et al., 2020) is always emphasized for the successful operation of biogas plants and digestate valorization, although digestates are rarely the focus of the literature. Of course, as biogas production is based on the transformation of biological resources, the natural capital plays an important role in biogas plants operations. The mobilization of the natural capital therefore lies in the valorization of “local biomass resources” through “input mobilization” and material and energy flows and exchanges between different groups of agents (Chodkowska-Miszczuk et al., 2019; Niang et al., 2021; Niang et al., 2022). But the natural capital can also be involved in local protests against the operations of biogas plants when these operations are seen as potentially harmful towards the environment, especially concerning the impacts of digestates land application, and when the plants’ facilities are considered as unaesthetic and damaging for the landscape (Chodkowska-Miszczuk et al., 2019; Bourdin et al., 2020b). These aesthetic considerations can also be linked to the cultural capital of the territories, as part of the cultural representation agents have of their landscapes, as part of the *place-identity*. This is an illustration of the *dual nature* of territorial capitals described by Chevalier & Pola (2014), as the natural and cultural capitals can be either mobilized and valorized to support the production and use of biogas and digestates, but they can be also be source of oppositions towards biogas plants if local agents see biogas plants as a threat and aim at protecting these capitals from this threat.

In addition, the mobilization but also the protection of the natural capital, as well as the management of digestates, require the mobilization of other forms of capital. The valorization of digestates requires multiple actions such as processing, sorting, upgrading, storage, transportation and land application, that are made possible only if the adequate infrastructures and equipment are available in the territory (Chodkowska-Miszczuk et al., 2019; Niang et al., 2021, 2022; WRAP, 2013). In addition to this infrastructural and equipment capital, the operation of the plants and the handling of digestates can require specific technical and

cognitive skills and knowledge (WRAP, 2013), as well as sufficient financial resources (Bourdin, 2020). Niang et al (2021) also highlighted the necessity to consider “risk management”, that directly implies the protection of the natural capital through the mobilization of the equipment and infrastructural capital on one hand, and on the cooperation of various public and private agents of the territory on the other hand.

These cooperation and coordination of local agents are made possible by the nature of social relations and interactions on the territory, and relies on the exchange of knowledge and information, and on collective learning (Niang et al., 2020, 2021, 2022; Soland et al., 2013). The positive and fruitful interactions between agents depend on the “relational and social capital” of project leaders and on the various parties involved in the biogas plants’ operations, and especially those of farmers (Chodkowska-Miszczuk et al., 2019; Depoudent et al., 2020; Soland et al., 2013). Indeed, farmers often belong to different social groups and therefore “mobilize various social resources” through working activities, political mandates or local relations” to help the project emerge and be successful (Depoudent et al., 2020). Trust from local agents towards the parties involved in the biogas plants’ operations is a crucial dimension of the social and relational capital mobilized, that can also be enhanced by some specific actions such as hiring local people, that will therefore be loyal to the project (Bourdin, Colas, et al., 2019; Chodkowska-Miszczuk et al., 2019; Depoudent et al., 2020; Niang et al., 2022; Soland et al., 2013). The mobilization of the relational and social capitals of each party involved activates the organizational capital of the territory which is needed to achieve concrete goals that will satisfied the largest number of local agents, such as finding the right places to build the biogas plants. In addition, the relations that farmers and projects leaders have with local politicians is considered as a key factor to enhance the embeddedness and the success of the project, as local politicians often benefit from a high social and relational capital and have a central place in the organizational capital of their territory (Bourdin, Colas, et al., 2019; Depoudent et al., 2020). The mobilization of this institutional capital can enhance and complement insufficient organizational capital, for instance in the cases where the project leaders are farmers, and are often less used than industrialists or public authorities to implement coordination and concertation over their territory, or insufficient cognitive and technical capital, when project leaders, such as farmers again, have difficulties to manage administrative tasks (Bourdin, 2020).

In our research, we aim to identify the dimensions of the territorial capital mobilized by the management and the use of digestates in our case studies, and to identify the dimensions that are impacted by the conflicts, or/and that are sources of conflicts. Based on the scientific literature we presented above, we assume the necessary mobilization of the following

dimensions of territorial capital (see Figure 23): the natural capital, the infrastructural and equipment capital, the financial capital, the cultural capital, the technical and cognitive capital, the institutional capital and the organizational capital. We also assume the dual nature of these capitals, i.e., the possibility for these capitals to be mobilized in order to facilitate the management and the use of digestates, or to oppose the use of digestates. To understand how these capitals can be activated and mobilized, including in a dual manner, we will dive, in the next Section, into the concept of proximities, that has been used by the literature on biogas production to explain how local agents coordinate to mobilize territorial resources, for the success of projects, or to oppose them.

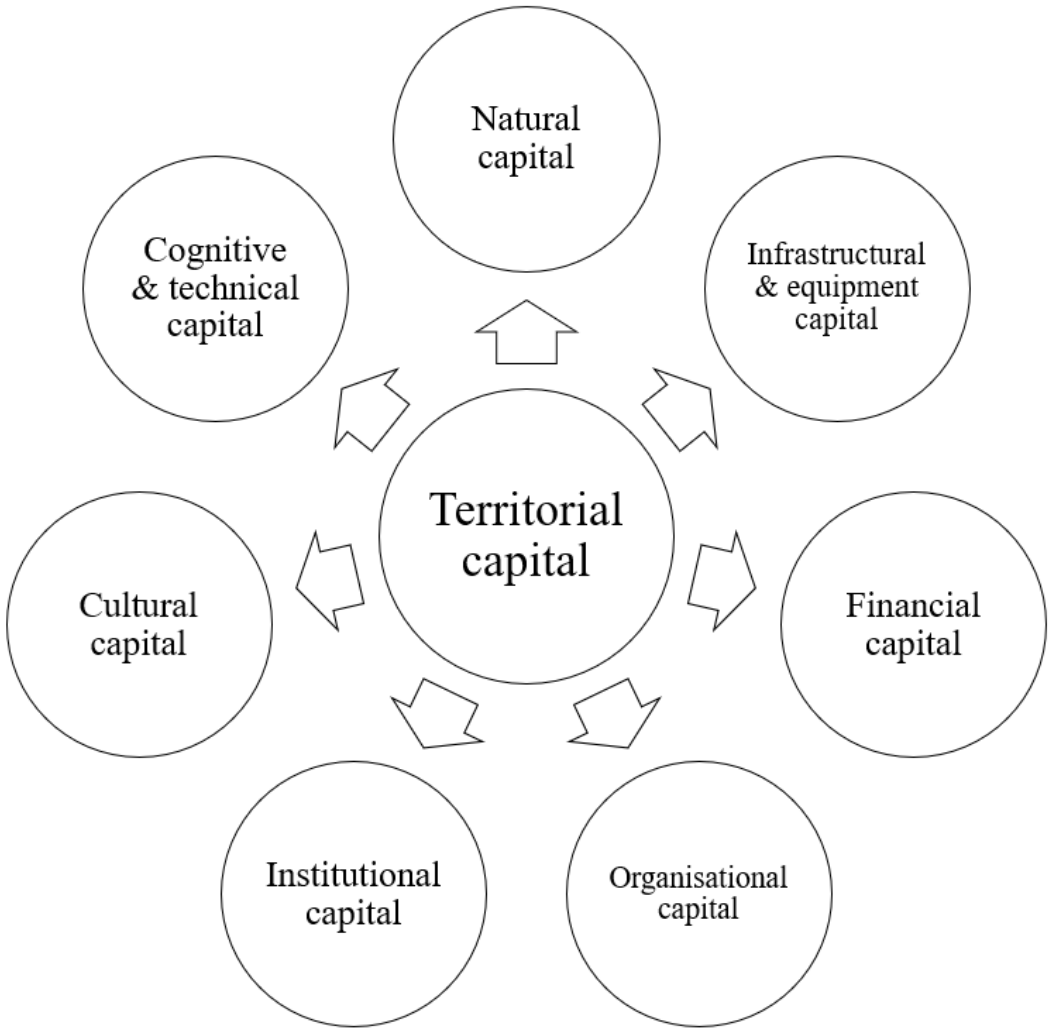


Figure 23: the components of the territorial capital associated to the biogas sector in the scientific literature. (Source: own graph).

Conclusion of Section 1

We presented, in this first Section, the emergence of a “territorial variable” that shapes the local development of economic activity. This “territorial variable” is the result of the combination of specific territorial resources, of local agents and of the relations between these agents. These combinations lead to a diversity of territories, that are defined as dynamic complex open systems with moving boundaries. These open “system-territories” are composed of many internal connections and interactions, and they are also connected to other territories. We assume that the development of the biogas sector, and the use of digestates, might be specific to the various territorial contexts that the “territorial variable” incarnates. Circular Economy should embody this idea of “territorial variable” by supporting the emergence of local projects rooted and adapted to their specific territorial contexts. However, the socio-economic literature argues that the biogas sector still needs to be better embedded in the various territorial contexts where it aims to be deployed, and that for now, many projects fail due to a lack of territorialisation. We assume, based on the two approaches of territorialisation we described in this section, the need for both a coercive and regulatory dimension to organise the management and the use of digestates, and the need for the adequate activation and mobilization of multiple material and immaterial territorial resources, called territorial capitals, through the interactions between various groups of local agents. We assume that the activation and mobilization of these capitals defines and reshapes territorial boundaries, in a dynamic perspective, as we postulate territories as “social and built constructs”. We therefore aim to identify, in our research, the territorial capitals mobilized and activated for and by the management and the use of digestates, and by the potential related conflicts. We also aim at understanding how it reshapes the boundaries of the territories where biogas plants are located. To understand how these capitals are activated and mobilized, we are going to explore, in the next section, the concepts of proximities and territorial governance, that offer a descriptive and prescriptive analytical framework to the coordination of local agents around economic activity.

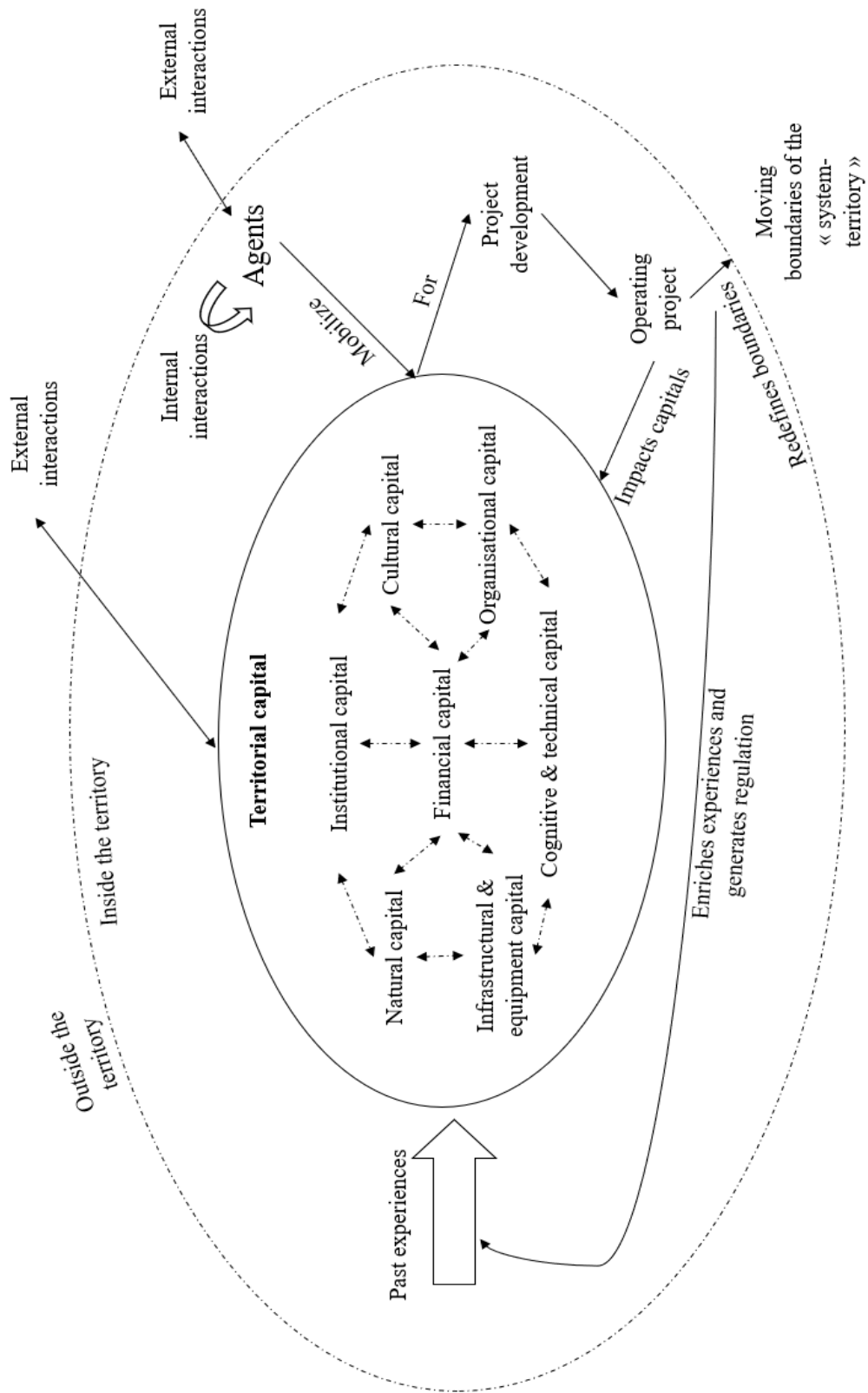


Figure 24: synthesis of Section 1. (Source: own graph).

Section 2: Proximities and territorial governance

Introduction of Section 2

Section 2 is divided into three sub-sections. In the first sub-section, we present the concept of proximities and its different theoretical variations. We explain how the framework of proximities can allow us to understand the determinants and the modes of coordination of local agents aiming at organising economic activity in their territories. However, in the second sub-section, we explore how local interactions, through the activation of proximities, can lead to tensions and conflicts. We define tensions and conflicts according to the social sciences literature on the conflicts in rural and suburban areas. We expose the claim, made by some authors, of the need to anticipate and solve these conflicts through means of territorial governance. In sub-section 3, we move on to the exploration of how territorial governance, through the adequate activation of proximities, can in return help anticipating and solving conflicts. We detail general considerations about territorial governance and the role of proximities, and we then expose the recent literature that has addressed the issues of territorial governance and proximities attached to biogas plants. It allows us to highlight and identify assumptions and theoretical propositions found in the literature, that we will test in our field investigations.

1. Proximities and the coordination of local agents

1.1. Definition and origins of proximity

As Bourdeau-Lepage & Huriot (2009) explain, there are obstacles to the positive interactions needed between agents to develop spatially embedded projects, or *territorialised* projects, such as physical distance, diversity of beliefs and diverging perspectives on the future of their territory. To overcome these obstacles and to facilitate their coordination, economic agents need to create or activate *proximities* (Boschma, 2005; Bourdeau-Lepage & Huriot, 2009; Gallaud, 2018; Pecqueur & Zimmermann, 2004; Zimmermann, 2008). The activation of these proximities aims at reducing uncertainty as well as enhancing coordination, collective

learning and innovation (Boschma, 2005). The interest of the concept of proximities in economic analysis lies in the introduction of “a spatial dimension in the coordination of stakeholders” (Bourdin & Nadou, 2020) that allows to fully integrate the spatial variable, or “territorial variable”, in the analysis (Torre, 2002), and therefore to better understand the process of coordination of agents at the local level (Zimmermann, 2008). The concept of proximities comes from an interactionist approach of coordination, where agents are considered heterogeneous, with complex and singular behaviours, which differs from the classical coordination approach that assumes the existence of rational agents and perfect information (Zimmermann, 2008).

According to Torre (2002), and to the French school of proximities, the notion of proximity is rooted on “the economic and geographic distance” that exists between individual and collective agents, who all “own different resources”, or different *capitals*, and the notion embodies the relationships, and the formal and informal interactions that agents experiment and activate to “solve economic problems”. Therefore, the unit of analysis of the proximity approach goes beyond the study of the sole behaviour of agents, and considers the relations *between agents* (Zimmermann, 2008). The existence, or the creation, of proximity between two elements or two agents implies a certain degree of similarity between at least one constituent of these elements, that must “share” a common dimension (Le Boulch, 2001). This similarity, this shared parameter, can be found for many different dimensions such as cultural, social, psychological and spatial aspects. The concept of proximity therefore relies both on the *similarity* between agents, and on the *distance* that separates or brings agents together, and this distance can be either expressed in a geographical space, or in an “abstract space”, such as cultural space, social space and economic space, although both types of “spaces” can be interconnected (Bourdeau-Lepage & Huriot, 2009).

However, proximity corresponds to a “qualitative assessment” of distance, i.e., a perception of distance by agents, whereas the distance itself is the quantitative variable. Proximity is therefore a subjective notion, and what is identified as close by an agent often seems more important to him / her than what is considered as remote or distant (Le Boulch, 2001). Based on this concept of qualitative assessment of distances, proximities are often divided into two, three or even five groups in the literature, the two main groups frequently encountered being the spatial or geographical proximity, and the organized proximity, especially in the French-speaking literature (Torre, 2014; Torre & Zuindeau, 2009). Boschma (2005) has deliberately departed from the classic conception of two or three groups, with the

aim to clarify and specify each proximity, and has considered five dimensions of proximity: geographical, institutional, social, organizational and cognitive proximities (Figure 25).

1.2. Geographical proximity

Geographical proximity is, at first, commonly defined quantitatively as the “physical distance” (Torre, 2002; Torre, 2014) or “spatial distance” between agents (Boschma, 2005; Gallaud, 2018), or more precisely, as the “*opposite* of the geographic distance quantified in terms of route length” (Bourdeau-Lepage & Huriot, 2009). However, the proximity literature usually insists on the sometimes-relative nature of geographical proximity, due to the diversity of means of transportation that can connect spaces more or less easily, and the subjective psychological evaluation of the physical distance by agents (Boschma, 2005; Torre & Rallet, 2005; Torre, 2014).

The early literature on proximities insisted a lot on the “many advantages” of geographical proximity (Boschma, 2005), that was quite always seen as a positive influence on local coordination, bringing local agents together and therefore facilitating “direct interactions” and “face-to-face relations” (Zimmermann, 2008), which allow information and knowledge exchanges (Boschma, 2005). It was therefore considered that the shortest distances between agents were preferable to transfer this knowledge and information, and that the longer the distances, the more difficult it was to transfer information (Boschma, 2005). However, the development of modern communication technologies has increased the relative nature of geographical proximity (Torre, 2002; Torre, 2014), as it allows for the existence of a “virtual geographical proximity” that can supplement or even replace the traditional “physical geographical proximity”, by allowing the exchanges of information and knowledge without the need to physically bring agents together (Bourdeau-Lepage & Huriot, 2009). However, virtual geographical proximity still relies on the will of agents to come together and exchange information. Another distinction has been made, in the literature, between permanent and temporary geographical proximity, the latter allowing agents to occasionally meet and to “organise moments of contacts” (Gallaud, 2018; Torre, 2014) in order to satisfy punctual needs of face-to-face interactions (Bourdeau-Lepage & Huriot, 2009; Bourdin & Nadou, 2020; Torre, 2014).

It was then acknowledged that geographical proximity could have a more complex

influence on relations between agents, and that negative impacts should also be accounted for (Boschma 2005; Gallaud, 2018). As an example, Bourdin & Nadou (2020) highlighted the difference between “chosen” geographical proximity, when, for instance, firms choose to locate their economic activities close to each other in a cluster, in order to cooperate and benefit from each other, and “imposed” or “unwanted” geographical proximity, when spatially closed agents have no intention to positively interact, and can be disturbed and unsatisfied with this proximity, leading to the emergence of conflicts (Torre, 2011, 2014).

In our field investigations, we therefore assume that geographical proximity, in its positive form, can support local coordination and help activating and mobilizing territorial capitals. But, also, in its negative form, we assume it can lead to tensions and conflicts, when, for instance, local agents, and especially neighbors, oppose the use of digestates. We will also be looking for the use of temporary proximity to solve local conflicts.

However, geographical proximity, in its different variations, is not a sufficient condition, and sometimes not even a necessary condition, for the cooperation and coordination of local agents, and it needs to be associated with other forms of proximities, that also provide “alternative solutions to the problem of coordination” (Boschma, 2005; Bourdin & Nadou, 2020; Torre, 2014; Zimmermann, 2008). The importance of geographical proximity on coordination must therefore not be assessed alone, although geographical proximity, when present, usually strengthens the other dimensions of proximity (Boschma, 2005).

1.3. Organized proximities

The notion of organized or organizational proximity has therefore been introduced as a way to allow and facilitate the interactions between agents that do or *do not* experience geographical proximity (Bourdeau-Lepage & Huriot, 2009; Torre, 2014). Gallaud (2018) gives a broad definition of organized proximity as “all the ways agents have to be close except spatially”, and more specifically, organized proximity would correspond to the closeness or distance in terms of organising economic activity (Boschma, 2005; Torre, 2002), and the increased potential for interactions offered by an organization to its members, the definition of organization remaining broad (company, social network, community...) (Torre & Filippi, 2005).

According to Torre (2011), organized proximity allows at least six types of interactions,

which are: 1) communication, i.e. the transmission of a message to get support and/or approval, 2) information, i.e. the transmission of data, 3) consultation, i.e., the collection of opinions, 4) dialogue, i.e. to bring interested and involved agents together, 5) concertation, i.e., the collective construction of projects, and 6) negotiation, defined as reaching a decision approved by all the involved agents. Organized proximity relies on two pillars: a sense that agents have of belonging to the same networks, same relations frames, and same organizations, and a sense of similarity, provided by a shared adhesion to a project, shared values or shared “norms of coordination” (Bourdin & Nadou, 2020; Gallaud, 2018; Torre, 2002, 2014; Torre & Filippi, 2005). In our field investigation, we will check the existence of these six types of interactions between the local agents involved in the management and use of digestates.

Boschma (2005) chose to specify three other categories of proximities, i.e., the institutional, the cognitive and the social proximities, that are often all included in the organized proximity category. Boschma (2005) roots institutional proximity in the existence of an “institutional context” that impacts, supports or refrains interactions between agents and regulates their relations, that would correspond to the institutional capital of a territory. This institutional context is made of formal institutions, i.e., the rules and laws, often coming from the State-level, and of informal institutions, such as habits, common practices and customs, closer from the local scale. However, Boschma (2005) considers that institutional proximity only refers to “the institutional framework at the macro-level”, although the norms and values that influence the relations of agents at the scale of the “micro-level” exchanges are embodied in the social and organizational proximities we describe next. Institutional proximity therefore corresponds to the sharing of both formal rules and laws, and informal habits and values between economic agents. Institutional proximity provides “stable conditions” for interaction, and therefore for information and knowledge exchange, but Boschma argues that too much institutional proximity can refrain the birth of new practices and of innovations, and therefore the acquisition of new knowledge, while too little institutional proximity leads to a “lack of social cohesion and common values” and thus weakens the potential for interactions. Therefore, “effective institutional structure” implies a mix between “institutional stability”, in order to reduce uncertainty and opportunism, and “openness” for newcomers, and “flexibility”, to let agents experiment “with new institutions”.

However, new experimentations, and the acquisition and transfer of new knowledge require that individual and collective agents share the “same knowledge base” in order to “learn from each other”, or, in other words, that they share some common dimensions of the local cognitive and technical capitals. But, on a territory, knowledge is often “dispersed among

different organizations”, and there is a need to bring the different agents together to share these multiple and complementary pieces of knowledge and information, or these cognitive and technical resources, and a need to develop their capacity to “exploit the new knowledge”, and therefore to increase local cognitive and technical capitals (Boschma, 2005). There is, therefore, the need of cognitive proximity, i.e., a certain degree of closeness of the cognitive bases of the different agents, in order to facilitate communication and collective learning. However, too much cognitive proximity may also prevent agents from acquiring new knowledge, and a certain degree of cognitive distance, with some agents owning different pieces of knowledge, or different cognitive and technical resources, must be maintained. An effective acquisition and exchange of new knowledge therefore relies on the adequate combination between “maintaining some cognitive distance” and “securing” a certain degree of cognitive proximity, or a “shared knowledge base” (Boschma, 2005). For instance, agents belonging to the same organization and experiencing a high cognitive proximity can exchange knowledge with each other, as well as they can interact with agents that do not belong to the same organization, and with whom they experience more cognitive distance, and therefore cognitive and organized proximities can complement each other (Boschma, 2005).

Finally, Boschma (2005) roots social proximity in the literature on social embeddedness, which we mentioned in Section 1 concerning the embeddedness of biogas plants. Boschma makes a parallel between organized proximity, that would correspond to the level of organizations, and social proximity, that corresponds to the interactions, learning processes, and exchanges of information at the level of individual agents. Social proximity heavily relies on trust and on positive relations such as “friendship, kinship, experiences”, and therefore, on the mobilization of the social and cultural capitals on local agents. Social proximity encourages communication but Boschma considers that too much social proximity, and therefore too much loyalty and commitment between agents can prevent them from acquiring new knowledge and from innovating.

We choose to mobilize the framework provided by Boschma (2005), in addition to the French School of proximities, as we assume it can help us to capture more details on the types of interactions at work in our case studies. For instance, the use of the concept of institutional capital can help us to reach a more detailed understanding of the role of institutions in our case studies, and to deeper understand their coercive and regulatory role. The cognitive proximity can help us to better understand the mobilization of the cognitive and technical capitals, for which we assume, if we refer to our epistemological framework, an important role to reach the “truth” or a consensus about it, about the impacts of digestates on their environment. Finally,

the social proximity can allow us to consider different levels of coordination, including a micro-level composed of direct interactions, that we assume included in higher levels (territorial, regional...).

1.4. Combining proximities

These five categories of proximities are “strongly interconnected”, and particularly the institutional, social and organized proximities, as the two latter are embedded in the institutional context (Boschma, 2005). Geographical proximity can also strengthen other proximities to a significant extent, by facilitating informal relations and trust building for example. Also, it is often the combination of all the proximities, called “territorial proximity” by Bourdin & Nadou (2020), that provides solution to local problems of coordination (Boschma, 2005; Torre, 2002) and allows a territory to “emerge” (Zimmermann, 2008). According to Carrière (2018), this combination of proximities can, of course, happens within already-existing and bounded administrative and institutional perimeters, but their emergence can also redefine the perimeter of territories. Therefore, territories are both generated by proximities, and generators of proximities, in the same way as they are both created by and creators of resources or capitals, that are mobilized by agents through the existing proximities, or through the creation of proximities, for various means, such as the valorization of these capitals through economic activities, through the development of territorial projects, or to protect these capitals. However, proximities remain “potentials” that can be activated or not by agents over time, in different intensity and frequency, and therefore, a dynamic approach to study the activation of proximities within territories is necessary (Boschma, 2005; Gallaud, 2018; Torre, 2014).

According to (Bourdin, Colas, et al., 2019), a successful territorial project emerges when agents have activated and combined all proximities adequately, which allows for an adequate mobilization of territorial capitals, and projects’ failures are often due to weak organized proximity, if we understand organized proximity as including social, institutional and cognitive proximities too. Furthermore, the combination of imposed geographical proximity and weak organized proximity can create conflict or “voice confrontation”, and Bourdin & Nadou (2020) claim that “territorial proximity” is especially analysed when these conflicts emerge (Boudin et Nadou, 2020). These imposed and weak proximities create an “imposed territory”, and usually agents sought to reduce their imposed territory, whereas chosen or positive proximities, wilfully

activated by agents, create chosen territories that agents sought to increase (Gallaud, 2018; Le Boulch, 2001). Therefore, we assume, in our field investigations, the necessity of an adequate combination of proximities to anticipate or solve the emergence of conflicts. Our aim, in our case studies, is hence to understand the local combinations of proximities, and their influence in the anticipation and solving of conflicts. In the next sub-section, we are going to explore the definitions and characteristics of conflicts, that we will need to identify the potential conflicts in our case studies.

	Key dimension	Too little proximity	Too much proximity	Possible solutions
1. Cognitive	Knowledge gap	Misunderstanding	Lack of sources of novelty	Common knowledge base with diverse but complementary capabilities
2. Organizational	Control	Opportunism	Bureaucracy	Loosely coupled system
3. Social	Trust (based on social relations)	Opportunism	No economic rationale	Mixture of embedded and market relations
4. Institutional	Trust (based on common institutions)	Opportunism	Lock-in and inertia	Institutional checks and balances
5. Geographical	Distance	No spatial externalities	Lack of geographical openness	Mix of local 'buzz' and extra-local linkages

Figure 25: the five proximities defined by Boschma (2005). (Source: Boschma, 2005)

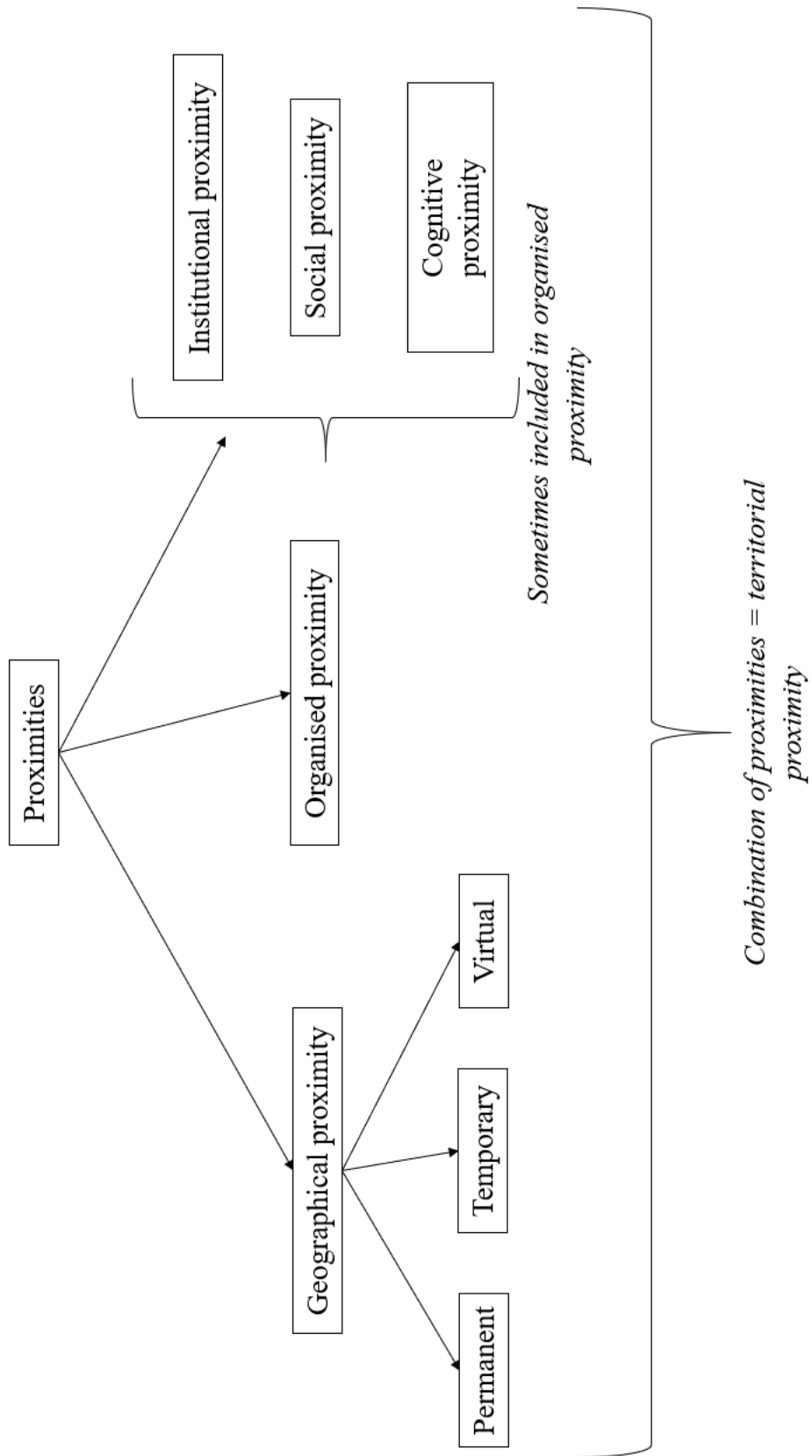


Figure 26: the different types of proximities. (Source: own graph).

2. Tensions and conflicts in rural and suburban territories

As we explained in the previous sub-section, the activation of proximities can have positive outcomes on local coordination, but can also create tense situations. Indeed, the will to decrease their “unwanted” or “imposed” territories can lead local agents to engage into conflicts with each other. According to Gallaud (2018), that reuses the definition of Wall & Callister (2000), conflicts emerge when, on a territory, at least two agents have diverging aims that impact the resources or the goals of the other agent. Indeed, in rural and suburban territories, many different activities and many different agents coexist, and these agents often share diverging or even antagonistic visions of their territory and its development. Torre (2011) adds that in rural and suburban territories, local agents are increasingly heterogeneous and complex, and local communities want to be more and more involved in the design of territorial projects. The interactions between local agents to organise the development of their territory or the emergence of a new project can therefore lead to positive outcomes such as sharing, cooperation, trust and synergies, but also to disagreements that possibly generate conflicts and crisis, and lead to the cancellation of projects, or to their modification (Bourdin & Nadou, 2020; Torre et al., 2006, 2016). However, in many cases, these disagreements just remain tensions between agents, and can last for years without leading to conflicts. Tensions finally become conflicts when at least one agent decides to officially and publicly engage into a conflict (Torre et al., 2006, 2016). In our field investigation, we aim at observing tensions and conflicts while acknowledging the differences between them. Through the analysis of proximities, we aim at understanding why tensions can become conflicts, and why they sometimes remain only tensions. We will try to identify what mechanisms of territorial governance avoid the shift between a tense and a conflictual local situation.

Torre et al. (2016) highlighted, through their research, the persistence and frequency of conflicts over the use of space in rural and suburban territories, which can take the forms of increased judiciary procedures against projects, demonstrations, appeals to the media, violence, voice confrontation, as well as the use by opponents of the increased body of norms and regulations, that slow down the development of projects. We will be using these definitions of conflicts in our investigations, to find out the forms of conflicts that emerge about the management and the use of digestates.

Torre et al (2006) argue that there is always a “conflictual dimension” in the development phases of a new project, and that rural and suburban areas territories always experience conflicts in one way or another, over time. Conflicts emerge when a part of the local

population has been left unsatisfied during the development of a project, and unsatisfied agents use conflicts to gain a place in the discussions and the development process, and to modify the decisions made without their consent. Conflicts, therefore, either target the unsatisfactory decisions made, or/and the representativeness of decision-makers (Torre, 2011, 2014), but they can also target the very existence of a project itself, or only some of its dimensions (Gallaud, 2018). We therefore assume that we will find these two dimensions of conflicts in our own investigations.

According to Torre et al. (2016), the majority of conflicts in France have an anticipatory nature, as opponents to projects aim at avoiding their concrete realisation, in order not to suffer from the potential negative externalities they fear. Conflicts are, however, very diverse, in terms of their expression, of the agents involved, of their objects, and of their territories. Three categories of conflicts have been elaborated: conflicts of superposition, i.e., where different agents want to use the same space for different or even concurrent activities, conflicts of contiguity, i.e., when different activities have conflicting spatial boundaries, and neighboring conflicts, i.e., when local agents fear the negative externalities of neighboring activities (Gallaud, 2018; Torre, 2014). Among local conflicts that occur in rural and suburban territories, energy production and waste treatment facilities seem to be very targeted, with even an increase of conflicts against the construction of such facilities (Torre, 2014; Torre et al., 2016), and biogas plants are precisely both energy production and waste management facilities. These conflicts are mainly rooted in the fear of the negative externalities of productive activities, including agricultural activities, and are mainly centred around pollutions, smell, noise and different types of risks, and it has been noticed that water resources are increasingly sources of conflicts (Torre et al., 2016).

The research conducted by Torre et al. (2016) over many years have enable them to identify categories of agents involved in these conflicts. The first category concerns neighbors and environmental associations, that aim at protecting local citizens' rights, the environment and biodiversity. These associations are very numerous and important in the French context, as they help structuring the contestations and building underlying argumentation. These associations often take part in concertation and negotiation processes, as well as in opposition actions, elaboration of shared norms, and therefore their role in the discussions on the development of territories is essential. Another category of agents is made of the State and local public powers. State bodies can either be the subject to oppositions, but they can also play the role of opponents to some projects and activities. Private companies also constitute a category, as they are often accused of being sources of pollution, and oppositions can emerge when new

facilities are installed or extended. Finally, Torre et al. (2016) identify farmers as a category often targeted by conflicts because of the negative externalities of their daily activities such as noise, smell during land application and traffic disturbances, and about some of their practices such as the use of pesticides and land application of manure, and these conflicts often lead to the loss of the positive image associated to their work. Therefore, we postulate, for our investigations, the existence of, at least, these five categories of agents involved in the potential conflicts and we will try to interview representatives from these five categories. We will test their actual role in coordination processes and in the conflicts, and especially, their role in both the implementation of regulation and coercive action, as well as in the mobilization of territorial capitals.

Conflicts are therefore an essential part of rural development, as well as local and regional governance, as they represent the local resistance to change and to innovation, the latter being understood in its multiple sense, i.e., technological, organizational, social, institutional, and economical newness (Torre, 2011; 2014; Torre et al., 2016). As a matter of fact, territorial projects bring newness that can crystallise existing oppositions. But conflicts themselves are source of innovation, such as governance innovation, in order to include new agents that were left behind by the governance processes, or to make hierarchical changes in governance structures, technical and legal innovation and changes in the project, and also sometimes, social innovation with the reorganization and the creation of new social groups (Torre, 2011; 2014; Torre et al., 2016). Conflicts are therefore both the product of territorial changes, and they also produce changes within territories (Torre, 2014). In this perspective, Torre et al., (2006) consider conflicts as an “active phase of confrontation” or a “negative phase of concertation” that is not a fatality but rather one of the stages of local dynamics, and an integral part of governance processes, and they therefore reject the binary vision of the existence of a constant territorial harmony versus a constant conflicting situation, but instead, they claim that governance processes are made of an alternance of complementary more harmonious and peaceful phases of negotiation and collaboration, and more violent phases of conflicts that, in the end, can contribute to positive local dynamics too, as they allow local agents to learn from each other, maintain communication flows and improve local connections (Bourdin & Nadou, 2020; Torre, 2011, 2014; Torre et al., 2016). Conflicts are therefore part of an evolving process, and local interactions need to be understood over time (Torre et al., 2006; Torre, 2011), in a dynamic perspective, as must be the mobilization of territorial capitals through proximities, and, as a result, the whole life of a territory, as a dynamic evolving system. But, despite their potential contribution to positive governance dynamics, the importance of handling and

monitoring conflicts in rural area, through means of territorial governance, has been acknowledged (Niang et al., 2020; Torre et al., 2006). In the next sub-section, we are going to explore how the adequate activation of proximities, in the frame of territorial governance, can contribute to the anticipation and the solving of conflicts.

3. Territorial governance

3.1. Definitions and characteristics

Conflicts, as we explained above, can be considered as an integral part of territorial governance processes, as the complementary phase of harmonious cooperation and negotiation phases (Bourdin, Colas, et al., 2019; Niang et al., 2021; Torre, 2011), and they can bring changes to territorial projects that, as a result, may better satisfy some of the local agents that felt to have been left aside, and conflicts can therefore be qualified as an “indispensable step” in governance processes (Bourdin, Colas, et al., 2019). But Bourdin et al. (2020) also ask if conflicts can be considered as “failure” in territorial governance, and in our case, conflicts that last can damage the development of the biogas sector if no satisfactory way out is found. Hence, there is the need to efficiently address these conflicts, by adequate means of territorial governance, in order to effectively bring out these positive changes, and not to only acknowledge and accept the existence of these conflicts. Indeed, Niang et al (2021) argue that territorial governance “lessen neighborhood conflicts” by allowing “the dissemination of information and knowledge” and by involving local populations into decision-making processes.

Territorial governance is defined by Niang et al (2021) as a “process of building common frameworks to coordinate territorial representations and strategies”. As we mentioned in the fourth section of Chapter 2, we understand the definition given by Niang et al. (2021) in an “economic perspective”, i.e., building these common territorial frameworks to initiate, help and support the coordination of local agents in their aim of organising economic activity in a territory (Leloup et al., 2005). It involves to create complex partnerships in the territory and to federate local agents around the project (Leloup et al., 2005) through the creation of a “framework of trust and consultation” (Bourdin, Colas, et al., 2019), that allows agents to develop shared long-term perspectives on their territories, despite their diverging opinions

(Leloup et al., 2005). Niang et al. (2021) argue that market coordination is not sufficient in the case of local Circular Economy projects, such as biogas plants projects, and there is therefore the need to reach local agreements that are based on the cooperation between local actors. Territorial governance processes therefore imply to bring together, and to create compatibilities between different types of local and extraterritorial agents (Bourdin, Colas, et al., 2019; Bourdin, Nadou, et al., 2019; Leloup et al., 2005), with “different backgrounds and different interests”, and operating at different territorial scales, such as associations, institutions, local public powers and productive agents (Niang et al., 2021). However, Leloup et al (2005) insisted on the need to go much beyond the simple consultation of these agents, and, instead, to generate enthusiasm, acceptance and involvement in the project through new governance mechanisms. (Bourdin & Maillefert, 2020) insisted precisely on the importance of governance processes, not only in the emergence, but on the continuity and sustainability of CE projects over time.

Among the different roles that agents can play in governance processes, the role of intermediation has been identified as a key element to offer a framework for cooperation, and to involve a maximum of local agents in the governance process (Bourdin & Nadou, 2020; Carrière, 2018; Niang et al., 2022). Bourdin & Nadou (2020) define intermediation as a way to create “a connection between stakeholders in order to increase their chances of jointly developing new products or services”. When this intermediation aims at achieving a project with a territorial dimension, Bourdin & Nadou (2020) name it “territorial intermediation”. Local intermediaries activate territorial proximities, and therefore, they create connections between local agents, which increase their chance of working together on territorial projects, i.e., it increases their chance to coordinate (Bourdin & Maillefert, 2020; Bourdin & Nadou, 2020). Intermediaries can even support the emergence of a “territorial culture” that will shape territorial governance mechanisms and structures, and they are key players in designing innovative governance mechanisms (Carrière, 2018).

Intermediaries can endorse three roles to initiate territorial proximity, called facilitator, neutral actor and educator by Bourdin & Nadou (2020), or facilitator, mediator (that we relate to neutral actor), and sensitizer (that we relate to educator) by Gobert & Brulot (2018). The role of facilitator is to provide help in the mobilization of resources, i.e., on the mobilization of the territorial capital in its different dimensions, although the role of educator consists in facilitating exchanges of information and knowledge, i.e., facilitating the mobilization of cognitive and technical capitals specifically. The role of neutral actor is close to the role of facilitator, as it provides resources to project leaders and it helps local agents to network, but it remains neutral towards the project itself (Bourdin & Nadou, 2020). Of course, these three roles

can overlap, and they can be endorsed at different moments of the project's life, thus the role of intermediary needs to be understood, again, in a dynamic perspective.

Although the negative impacts of unwanted proximities can lead to conflicts, the activation of territorial proximity, and particularly of the different dimensions of organized proximities, can help solving these conflicts (Gallaud, 2018; Torre, 2014). Gallaud (2018) identifies two main ways to combine proximities in order to solve conflicts: first, a “cooperative solving” way, that aims at collectively finding solutions and elaborating shared perspectives between conflicting agents, through the combination of strong organized proximity and temporary geographical proximity; secondly, a “non-cooperative solving” way that will either lead to the avoidance of the conflicts, or to the imposition of a solution by one particular agent that holds a certain power on the territory, this non-cooperative solving corresponding to a combination of low organized and geographical proximities.

However, in addition, opponents too can mobilize territorial proximities to reach their objectives, and orientate the solution of the conflicts, notably by activating their network, i.e., by activating the logic of belonging of organized proximity, and by gathering with other agents that have the same opinions on the projects, i.e., by activating the logic of similarity (Torre, 2014). Moreover, opponents are often educated people that can mobilize intellectual and social resources, i.e., they can activate cognitive and organizational capitals, as well as they can benefit and learn from past experiences (Torre et al., 2016). We assume that these past experiences can therefore enrich the different dimensions of the territorial capital, as we demonstrated in Section 1, but this time, to the benefits of opponents. As a consequence, local opponents too can coordinate, but in order to protest against the projects, which lead to concrete actions such as the creation of petitions (Bourdin, Colas, et al., 2019). Moreover, Torre et al (2016) claim that, although territorial governance and intermediation can support the involvement of third parties, through legal requirements such as public meetings and public surveys, and through making information available to all agents, and therefore help anticipating conflicts, these governance mechanisms can also become tools that can be used by opponents to protest and assert their claims.

Consequently, territorial governance, through the adequate combination of proximities and the involvement of many different local agents, can support the anticipation and solving of conflicts, especially when an agent plays the role of intermediary. In the following subsection, we will explain how these theories on territorial governance have been applied and tested by the recent literature on biogas plants.

3.2. Territorial governance of biogas plants

Niang et al. (2021; 2022) argue that biogas plants introduce changes and innovations in the coordination of local agents, over the management of material and immaterial flows involved in the plants' operations. They claim that biogas projects are often a test to existing local and regional coordination. According to (Bourdin, Colas, et al., 2019) and Bourdin & Nadou (2020), the question of the proximities is very important for biogas plants, because of their use of local resources, and the necessary interactions between local agents to manage the use of local resources. There is therefore a combination between spatial closeness, i.e. geographical proximity, and more or less formal interactions (more or less institutionalised and organized interactions), facilitated by organized proximities. The adequate activation of proximities in the frame of territorial governance is thus a key element in the success of biogas plants. Niang et al. (2022) argue that, at first, permanent geographical proximity is a basis for the development of projects and the exchanges of information, as it helps allowing direct interactions, and the mutualisation of resources, or *territorial capital*. Spatial proximity also enables the “junction” between the competencies of the various agents of the territory and thus a relevant distribution of roles. Geographical proximity is therefore beneficial for biogas plants, and contribute to their territorialisation. However, unwanted geographical proximity can also provoke local oppositions and conflicts, due to the fears of negative externalities (Bourdin, Nadou, et al., 2019; Niang et al., 2022). But, in another perspective, Niang et al. (2022) argue that the mobilization of permanent and temporary geographical proximities can support the activation of organized proximities that will be used to solve these conflicts.

Recent empirical research highlighted the importance of the involvement of various agents in the territorial governance processes to legitimize projects of biogas plant, especially local elected officials, as well as the importance of “transparency” throughout the steps of the project (Bourdin, Colas, et al., 2019; Chodkowska-Miszczuk et al., 2019; Depoudent et al., 2020; Niang et al., 2022). On the contrary, a lack of communication, especially from the owner of the biogas plant, as well as a lack of consultation, concertation and information of local agents, due to “badly” or “law” organized proximities”, can lead to local oppositions and to the failure of projects (Bourdin, Colas, et al., 2019; Bourdin, Nadou, et al., 2019; Bourdin & Nadou, 2020). Indeed, (Bourdin, Nadou, et al., 2019) argue that if local agents feel “ill-informed” or “uninvolved” in the project, they can organise themselves into local associations to oppose the project. The creation of local associations leads to emergence of a sense of belonging to the

same cause among opponents, which consequently facilitate organized proximity. Different types of organized groups can consequently exist on the territories, i.e., groups of opponents that can organise themselves against the organized proximity group that supports the biogas plant. As a result, (Bourdin, Nadou, et al., 2019) list two situations that can lead to the failure of projects: a lack of local coordination, and a local governance facing organized opposition. Hence, if organized proximity is not activated or activated too lately, tensions and conflicts emerge (Bourdin, Colas, et al., 2019; Bourdin & Nadou, 2020). But indeed, local agents need to feel the sense of belonging to the same project to engage into a fruitful coordination, and to mobilize organizational proximities (Niang et al., 2021). These results are in line with previous research from Soland et al (2013) that claimed that it was “impossible” to build biogas plants without giving local inhabitants a possibility of dialogue, i.e. to activate organized proximities and to involve different groups of agents in local governance. In our field investigations, we are going to explore the types of interactions between local agents, using the list of six categories of interactions listed by Torre (2011) we described earlier, and how it has enabled local agents to “dialogue” about the management and use of digestates.

Recent empirical research highlighted the importance of one central agent in the territorial governance process, playing the role of an intermediary, maintaining interactions and relations between all the agents involved in the project, and building trust among agents (Bourdin, Colas, et al., 2019; Bourdin, Nadou, et al., 2019; Bourdin & Nadou, 2020; Niang et al., 2021). In addition, if the local intermediary is capable of expressing the concerns of some categories of agents about the biogas plants, the risks of facing organized proximities against the biogas plant seem to be diminished (Bourdin, Colas, et al., 2019; Bourdin & Nadou, 2020). Bourdin & Nadou (2020) also argue that the role of territorial intermediary is even more important when the biogas project leaders are foreign to the territory. There seems to be an emerging consensus in the literature on the key role played by local politicians in the local acceptance of biogas plant projects. Although the involvement of local elected official often slows down the implementation of projects, it allows to federate more local agents, it helps organising meetings and it really gives a territorial dimension to the projects (Bourdin, 2020; Chodkowska-Miszczuk et al., 2019; Depoudent et al., 2020; Niang et al., 2022). Recent empirical research tends to demonstrate that, therefore, this role of intermediary is played by local elected officials, or more generally by the “local public authority”, or “local public powers”, as local elected officials often benefit from dense social networks, and can more easily educate other agents about the projects, and inspire confidence (Bourdin, Colas, et al., 2019; Bourdin & Nadou, 2020; Niang et al., 2022). (Bourdin, Nadou, et al., 2019) even insisted on

the need of a “neutral” local public authority to play this role of intermediary. In this perspective, our aim, in our field investigations, will be to explore if a local agent, or several local agents, have tried to play this role of intermediary, in the coordination process about the management and the use of digestates, and the potential influence of this or these intermediaries in the anticipation and solving of conflicts. We will also observe if this role is played by local elected officials, or local public powers. We will explore the role of local public powers in the coordination around the management and use of digestates, and the solving of conflicts, and we will pay attention to their supposedly neutrality.

More generally about Circular Economy projects, Carrière (2018) also highlights the central role of local, as well as *regional* public powers in the implementation of projects, through the mobilization and enrichment of cognitive and technical capitals, done by contributing to local data and knowledge acquisition and transfer, by creating local platforms for information sharing, by supporting research and education around the projects, and by sharing and promoting “good practices”. Therefore, we assume the potential existence of multiple levels of coordination in our case studies, and we will try to identify them.

However, (Bourdin, Nadou, et al., 2019) also highlighted the importance of the support of the Chamber of Agriculture, in France, when the project leaders are farmers, to give confidence to the other agents involved. Therefore, (Bourdin, Colas, et al., 2019), in reference to Kortsh et al (2015), insist on the need to adopt a multi-actor analysis of territorial governance processes, and not to focus on certain categories of agents only. Territorial governance processes therefore rely on the role played by key agents, as well as on the interactions between different groups of agents more or less involved in the implementation of the projects (Niang et al., 2021; 2022). Empirical research from (Bourdin, Colas, et al., 2019; Bourdin, Nadou, et al., 2019) on the territorial governance of the biogas plant “Biogaz de Gaillon” in the West of France, highlighted the importance of the communication between various and numerous groups of agents, as well as the key role of intermediary played by local elected officials, and particularly by the mayor, the help of supporting structures, and the simultaneous use of geographical and organized proximities to reach a successful local coordination. They also pointed out that, sometimes, a good and efficient consultation of third parties is enough, and no additional governance tools are needed. If geographical and organized proximities are adequately activated and combined, i.e. if territorial proximity is adequately mobilized, and if it allows local inhabitants to “feel well-informed and heard” by projects leaders and local politicians, then no conflicts should emerge (Bourdin, Nadou, et al., 2019). Indeed, the adequate use of organized proximities can initiate “fruitful exchanges” between all the local agents

involved in the biogas plant, and the potential opponents, and allow to “overcome misunderstandings and technical obstacles” (Niang et al., 2022). The mobilization of organized proximities will be favoured by the logic of belonging, with for instance, some agents involved in the management of the biogas plant and also members of the same local organization. This local organization can offer a framework for dialogue and consultation about the project. The logic of similarity will also play its role, with for instance, shared concerns and interests about environmental issues, waste management and Circular Economic, among the involved parties. In this case, the construction of the biogas plant, its management and the organizations involved in it, can strengthen the ties that already exist between some of the local agents, and strengthen the sense of belonging and similarity. However, these organizations need to be trusted by other local agents too, in order to avoid conflicts (Niang et al., 2022).

Therefore, if we refer to the three types of governance detailed by (Gilly & Perrat, 2003) which are: private governance, i.e., a private organization is the key agent in the process of coordination of local agents, public or institutional governance, i.e., one or several institutional agents are the key players in the process of coordination, and mixed governance, which is an hybridization of private and public governance, the territorial governance of biogas plants projects tends to be either a public or a mixed governance. In addition, whatever the type of governance, Gilly & Perrat (2003) insist on the role of the State in the governance process, as it is always an important discussion partner.

Niang et al (2021; 2022) highlighted some of the specific governance tools, permitted by the activation of geographical and organized proximities, and that allow local agents to successfully coordinate around a project of biogas plant, and to share good practices. They found out about the importance of networks to guarantee the durability and sustainability of projects, as well as to facilitate the circulation of flows and the mobilization of technological innovations, the sharing of knowledge, and to allow collective learning. Exchanges and interactions between local agents can occur more or less frequently, such as, “face-to-face dialogue”, “consultation” during “deliberative assemblies”, meetings “at the project leader”, “more or less formal meetings and contacts”, “telephone contact” and “regulatory meetings of the site monitoring commission”. The inclusion of local opponents in these exchanges is said to significantly reduce the emergence of conflicts (Niang et al., 2022). Niang et al. (2021; 2022) also insist, by the way, on the importance of the site monitoring commission, that “represents an essential framework for exchange and information on risk management”, and that naturally include groups of opponents. Niang et al. (2022) also argue that these different interactions strengthen organized proximities in return. Concerning our field investigation, we assume that

we are going to find the same mechanisms in our case studies.

The necessity for various agents to coordinate through these tools also relies on the fact that, although local public powers are considered as central agents in territorial governance, it has been acknowledged that State representatives and local elected officials cannot implement and manage territorial projects alone, and do not have all the necessary skills and knowledge to solve related issues (Torre, 2011). There is, for instance, an increasingly important role played by local and supra-local associations in governance processes, and, more generally, an increasing number of spatial levels of governance, going from the very local to the global level, including the regional, sub-regional and national levels, with many interactions between the levels, and many different agents involved (Torre, 2011). Local associations can for instance be involved, with State services, in the “regulatory governance of the risks” associated to biogas plants (Niang et al., 2022). However, the degree of involvement of these various agents also depends on the legitimacy they have in the eyes of other agents, that depends on different collective and individual parameters, such as the power they effectively hold on other agents, their capacity to create a consensus, their expertise and know-how, and their charisma (Gobert & Brullot, 2018). Therefore, although some organizations and institutions do have powers on their territory, such as State services, their legitimacy in governance processes is not always considered as automatic by other local agents, but it depends on the skills they really hold and on the nature of their pre-existing relationships with other agents (Gobert & Brullot, 2018).

Finally, as each biogas plant is unique and specific to its territorial context, territorial governance may vary and be adapted to each territory (Brullot et al., 2018; Chodkowska-Miszczuk et al., 2019; Niang et al., 2021). Territorial governance must therefore be analysed in a dynamic perspective, as it is composed of many different phases, that evolve over time, and that involve many different agents, at different spatial and time scales (Leloup et al., 2005; Torre, 2011). In Chapter 4, in which we detail our research materials and methods, we will explain in detail and justify this choice of the dynamic perspective we take for the analysis of territorial governance.

Conclusion of Section 2

The concept of proximity allows us to integrate the spatial, or territorial, dimension in the understanding of the coordination of agents at the local level. Proximities can be declined into up to five categories, which are: geographic, organized, institutional, social and cognitive proximity. Proximities can have both a positive influence on the coordination of local agents, particularly when they are rightfully combined, but unwanted proximities can also lead to conflicts. Conflicts are persistent and frequent in rural and suburban territories, and are therefore considered as integral parts of territorial governance processes. However, conflicts can also threaten the development of the biogas sector by leading to failures and delays in the operations of biogas plants. Therefore, territorial governance also aims at anticipating and solving these conflicts. Intermediation has been highlighted by the literature as an important role in territorial governance processes, to activate territorial proximities, with, especially, the aim of solving conflicts. This central role has also been highlighted by recent research on biogas plants, but the necessity to involve many different local agents in territorial governance processes also appears to be very important for the success of biogas plants. In our field investigations, we aim at identifying the role of the different proximities, and their combinations, first, in the mobilization of the territorial capitals related to the management and the use of digestates, and then, in the emergence or in the solving of related local conflicts. We will also aim at identifying the different groups of agents involved in territorial governance processes, and the role they play in the activation of proximities. Furthermore, as we explained in Chapter 2, there are many controversies on the nature and impacts of digestates on their environment. We therefore want to dive deeper into the role of these controversies in the activation of proximities and in territorial governance processes, which is the purpose of the following sub-section.

Section 3: Acquisition and transfer of information in situation of shared uncertainty

Introduction of Section 3

Section 3 is divided into two sub-sections. In the first sub-section, we present how the recent research on the governance of biogas plants highlighted the importance of transparent acquisition and transfer of information about digestates between local agents, in order to ensure a smooth local coordination. However, in the second sub-section, we explain that this information is not always available to every agent, and can also be unknown to all agents more or less directly involved and impacted by the management and the use of digestates. We then formulate hypothesis on the impacts these different levels of information availability can have on the emergence of potential conflicts, and on the mechanisms of coordination.

1. The importance of information transfer for biogas plants projects

The possession and transfer of information on biogas plants, and on digestates in particular, are often at the heart of the controversies that emerge within territories (Bourdin, Colas, et al., 2019; Bourdin & Nadou, 2020). The lack, or the insufficiency, of information, communication and consultation between local agents, and especially with the initiators of a project, can favour local oppositions to the construction and the operation of biogas plants and therefore, prevent local coordination (Bourdin, Colas, et al., 2019; Bourdin, al., 2020; Bourdin, Nadou, et al., 2019). (Bourdin, Colas, et al., 2019) argue that local agents interpret information based on their cognitive skills, and therefore, the flows of information in a territory also rely on its cognitive capital. Hence, the process of sharing and explaining reliable and trustworthy information, proofs and data, appears to be very important, and intermediaries are assumed to play a significant role in this matter (Bourdin, Colas, et al., 2019). There is, also, the need of efficient information transfer soon enough before the construction of the biogas plants, and during their lifetime, to gain the support of local agents (Bourdin et al., 2020). However, most of the local inhabitants consider that communication comes too lately, and this delay often fuels tensions or even conflicts (Bourdin, Colas, et al., 2019; Bourdin, al., 2020; Bourdin, Nadou, et al., 2019). The lack of communication and dialogue is often addressed after the emergence of conflicts, often in the form of crisis communication, and it can break the connections between

local agents, if trust is broken (Bourdin et al., 2020; Bourdin, Nadou, et al., 2019).

These information exchanges should involve many different agents within the territory of the biogas plants, as there must be an efficient communication between the agents directly involved in the project, i.e., directly involved in the construction and the operation of the biogas plant, but also towards third parties, such as local inhabitants, that are not directly involved in the management of the plants, but that can fear negative externalities (Bourdin, Nadou, et al., 2019; Chodkowska-Miszczuk et al., 2019). There is specifically the need for the efficient dissemination of information and knowledge, from the owners and managers of the biogas plants towards local inhabitants, on biogas and digestates production in general, and on the specific characteristics of the local biogas plant, and its digestates (Chodkowska-Miszczuk et al., 2019). Otherwise, (Bourdin, Colas, et al., 2019) argue that the circulation of information about the risks and potential problems, that occurred in other territories, can affect the local acceptance of biogas plants, and boost oppositions, although the knowledge on these issues can be more or less mastered by opponents. In these cases, temporary geographical proximity is often activated, through visits of biogas plants, and neutral experts are invited to certify the information on potential risks (Bourdin, Colas, et al., 2019). In addition, new technological tools and innovations can allow for the shared acquisition of data and knowledge, and therefore, increase transparency and trust among local agents. This makes them feel more secure towards the plants' operations and the associated risks, and guidance tools such as guides of good practices, if followed by plants managers, can also increase the confidence of local agents (Bourdin, Nadou, et al., 2019; Giuliano et al., 2018).

Transparency from biogas plants managers is considered as a key element to avoid tensions and conflicts, and especially "education" and "clearer information and instruction" about digestates qualities and use, to "ensure the smooth and beneficial coexistence" of biogas plants and local communities ((Bourdin, Nadou, et al., 2019; Bourdin & Nadou, 2020; Chodkowska-Miszczuk et al., 2019). Transparency is said to increase trust towards managers of biogas plants, which is considered as crucial, especially when local agents know little about anaerobic digestion, which is often the case. When local agents are already used to work together, and to work with the projects' leaders, trust is already rooted in local relationships (Bourdin, Colas, et al., 2019; Bourdin, Nadou, et al., 2019; Soland et al., 2013). In this case, Soland et al. (2013) argue that local agents are more likely to accept potential negative externalities from the plants' operations, and to be more appreciative of positive externalities. However, recent research highlighted a global lack of knowledge about the qualities of digestates, whether among farmers or other potential users, and the literature often recommends

that digestates producers, or other agents, provide more information to potential users, in order to increase their trust and their will to use them and to pay for them (Dahlin et al., 2015; 2017; Pappalardo et al., 2018; Selvaggi et al., 2018; 2021). But, we argue that, considering the benefits but also the potential negative externalities related to the management and the use of digestates, the type of information provided, the identity of the informer, its bias and its goals must be carefully considered.

(Bourdin, Nadou, et al., 2019) identify four levels of information exchanges and involvement of local agents: first, a simple transfer of information from biogas plants managers / owners to third parties, second, the consultation of third parties to collect their opinions, third, the cooperation between plants managers and third parties, and fourth, a certain degree of control of the biogas plants by third parties. They consider that the more local citizens are involved in the projects, the less rejections and oppositions to the biogas plants. Bourdin & Nadou (2020) mobilize here again the role of intermediaries, especially local public authorities, to facilitate the transfer of information and the involvement of local agents, and to introduce and provide knowledge and resources from outside of the territories.

However, in all the research we presented above, information is considered as already existing and possessed by some agents, that have to share it with other agents. The emphasize is therefore put on the importance and the modes of sharing relevant information. But we saw in Chapter 2 that there are many topics for which the information and knowledge about digestates is controversial, or unknown, and that cannot be known, at least for now, with current technological and scientific advance. The economic literature on wastes, through the mobilization of theories from the field of Economics of Quality, has highlighted the existence of different categories of economic objects, depending on the availability of information about their characteristics. In the next sub-section, we will explore these categories and how they can influence the coordination of local agents.

2. Shared quality uncertainty on digestates

We exposed in the previous sub-section the claims made by the literature about the need to transfer and acquire information and knowledge on the qualities of digestates. But we also explained in Chapter 2 that the existence, the accessibility and the consensus around this information is not always evident. The field of Economics of Quality defines four types of

goods based on the availability of information on these goods, and on the ways to acquire the unavailable information. These four types are: search goods, experience goods, credence goods and indeterminate goods (Lupton, 2005). The three first types of goods, namely search, experience and credence goods, all relate to the problem of asymmetric information, that corresponds to a situation where “buyers lack information on the quality of the product (good or service), whereas sellers have full information” (Lupton, 2005). We argue that when recommendations are made on the need to transfer information and knowledge on digestates, it is implicitly assumed a situation of asymmetric information, where some local agents do possess information, while other do not. We now move on to the description of these three first categories.

Search goods, as defined by (Nelson, 1970), correspond to goods for which information on the qualities can be acquire through prior inspection and research, before their acquisition and use (Lupton, 2002, 2005)As we explained in Chapter 1, a certain amount of knowledge on the qualities and impacts of digestates has already been produced by numerous agents such as researchers and public authorities. Therefore, general information on digestates is quite easily available for farmers or other users that would like to acquire and use digestates, or to any other local agent that would be more or less directly impacted by the use of digestates, such as local inhabitants and local associations for environmental protection.

Experience goods correspond to goods for which the users acquire information about their qualities and impacts after purchasing them, by using them and observing their effects (Lupton, 2005; Nelson, 1970). We can assume that digestates have some “experience” characteristics, as farmers, or other users and local agents, can directly observe the impacts of the use of digestates on soils, on natural resources and on the local quality of life. However, as we explained in Chapter 1, digestates are very heterogeneous goods whose qualities can vary depending on many parameters, and certain characteristics cannot be directly observed through use, or through prior investigation, such as the content of pathogens or heavy metals. Information on these characteristics is acquired by the producers of digestates through various costly biochemical analysis (see Chapter 1). Therefore, farmers, other users and any local agent interested in knowing this information would have to rely on the information provided by producers. In case they would not trust producers, and would like to acquire this information by themselves, they would have to carry out the same costly analysis, which might be too costly for some agents.

In face of such situation, Dahlin et al (2017) argue that digestates have some “credence” characteristics, that justify the need to provide clear and transparent information to potential

users. Digestates would therefore, in this case, correspond to credence goods, that are defined as goods for which users can “encounter problems in evaluating the quality of these goods, as quality can neither be evaluated in normal use nor known before purchase”, and which evaluation would require “additional costly information” (Darby & Karni, 1973; Lupton, 2005). Concerning experience and credence goods, Lupton (2005) adds that their real quality can be in fact lower than expected by users, which can create disappointment and can lead users to turn away from these goods.

Then, there exist situations when there is an uncertainty about the qualities of a good, and this uncertainty is shared by all agents that are directly or indirectly concerned by the use of this good. This uncertainty is also considered as “non-neutral” (Lupton, 2005). This situation corresponds to “indeterminate goods”, when “no one can grasp the whole truth about the goods” and “the product is ‘incomplete’, and requires further scientific knowledge in order to be assessed better” (Lupton, 2005). The qualities and impacts of these indeterminate goods cannot be known through research (search goods), or by using them (experience goods), or thanks to additional costly information (credence goods), because information is just not available and not possessed by any agents, at a certain point in time, due to the actual state of knowledge (Lupton, 2001). Lupton (2005) argues that the main issue related to shared uncertainty is about the safety of indeterminate goods, and therefore, the uncertain future impacts of these goods. Lupton (2002, 2005) gives the example of the scientific controversies about the environmental and health impacts of the land application of sewage sludge, for which there was no scientific consensus, and therefore “contrary judgements” coexisted. This situation led some agents to support the use of sewage sludge, while other agents, such as some food industries and retailers, opted to ban it. Pappalardo et al (2018) argue that digestates experience a situation of “uncertainty”, and we precisely showed, in Chapter 2, that there is still no firm consensus on some of the health and environmental impacts associated to the use of digestates, especially on the long-run. We therefore argue that digestates have some characteristics of “indeterminate goods”.

As a result, we assume that digestates, depending on the situations and on the qualities considered, can have some experience, search, credence and indeterminate characteristics (Figure 27). We therefore assume that situations of asymmetric information and of shared uncertainty can exist, and also co-exist, locally. In our field investigations, our aim will be to try to identify these two types of situations, and to what dimensions of the territorial capitals they are related. We will also try to identify what groups of agents are involved in these situations, and how they interact to share existing knowledge, and to produce and acquire the

missing knowledge. We assume that these two different situations can produce different types of tensions and conflicts, that can be anticipated and solved by different combinations of proximities. We assume different territorial governance processes for these two situations. We will therefore try to identify and compare the mobilization of proximities in these two situations, and the outcomes of territorial governance processes in the acquisition and sharing of new knowledge.

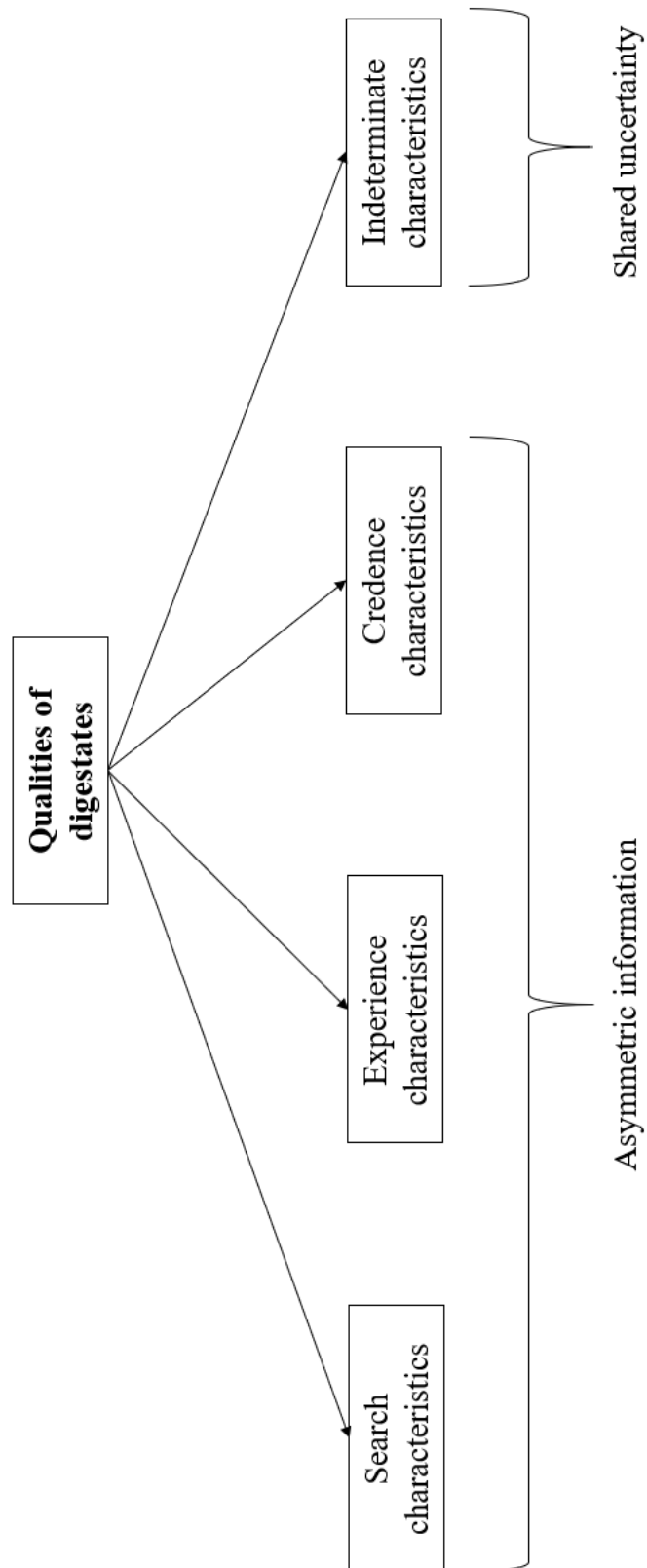


Figure 27: the different situations of information transfer and acquisition based on the qualities of digestates. (Source: own graph).

Conclusion of Section 3

We highlighted the importance of transparent acquisition and transfer of information about the operations of biogas plants, and especially about the management and the use of digestates. This transparency is supposed to build trust between local agents, and particularly towards the producers of digestates. This mutual trust is therefore said to facilitate the smooth coordination of local agents. The acquisition and transfer of information is facilitated by different means, such as innovative technological tools or use of guides of “good practices”, and again, by the intercession of territorial intermediaries. However, by referring to theories from the field of Economics of Quality, and used by some economists to study wastes, we showed that digestates can fall into four different categories depending on the availability of information about their qualities and impacts. Digestates can have search, experience, credence and indeterminate characteristics, and be therefore involved in situations of asymmetric information and shared uncertainty. We formulated assumptions on the impacts of these different situations on the emergence of conflicts, and on the activation and mobilization of proximities, and we are going to explore these situations in our case studies.

Conclusion of Chapter 3

In this chapter, we defined territories as built and social constructs, composed of multiple dimensions. Territories are open systems, within which local agents interact to develop economic activity, as well as they interact with other territories. We highlighted the diversity of territories and of their inner material and immaterial resources. We explained that economic activity shapes and redefines territorial boundaries, and we therefore assumed that the same applies for the management and the use of digestates. Also, through the different understandings of the concept of territorialisation, we assumed that the development of a local economic activity free of conflicts requires an adequate mobilization, by local agents, of the various territorial resources, as well as the implementation of coercive and regulatory action. We will therefore try to observe these two dimensions in our field investigations. We then identified, in the literature, seven types of territorial resources, also called territorial or rural capitals, that can be, or are, mobilized by the biogas sector: the natural capital, the infrastructural and equipment capital, the financial capital, the cultural capital, the technical and cognitive capital, the institutional capital and the organizational capital. We assume the necessity of an adequate

mobilization of these capitals to ensure a conflict-free management and use of digestates. In our field investigations, we aim at identifying, when there are conflicts, to which capitals they are related. Also, based on the literature that postulates the evolving mobilization of capitals through time and space, we assume, in our case studies, different time and space levels of activation of territorial capitals. The activation, the mobilization and the creation of these territorial resources require a certain degree of interaction between local agents. These interactions can be facilitated by the activation of proximities. The adequate combination of proximities, called territorial proximity, can help local agents to mobilization the territorial capitals in a way that avoid the emergence of conflicts. We therefore assume the necessity of the adequate activation of territorial proximity to ensure a non-conflictual management and use of digestates. We presented five types of proximities, based on the literature: the geographical proximity, the organized proximity, the social proximity, the institutional proximity, and the cognitive proximity. However, proximities can also generate tensions and conflicts when they are unwanted and imposed. The literature distinguishes between tensions and conflicts, and we assume the existence of both tensions and conflicts in our case studies. We will try to understand, in terms of proximities and interactions, the mechanisms that sometimes lead to conflicts instead of remaining at the stage of tensions. Although conflicts are considered as integral part of human interactions, and therefore of local governance, the literature on biogas plants insists on the necessity to anticipate and solve these conflicts through means of territorial governance. Territorial governance is said to be facilitated by the activation of territorial proximity. In our field investigations, we will try to identify the role of the different combinations of proximities, in the mobilization of the territorial resources related to the management and the use of digestates, and then, in the emergence or in the solving of related local conflicts. We will also aim at identifying the different groups of agents involved in territorial governance processes, and the different role they can play in the activation of proximities, such as the role of intermediary. However, based on theoretical inputs from the field of Economics of Quality, we also suggested that the nature of digestates can lead to different situations of information transfer and exchange, i.e., on situations of asymmetric information and shared uncertainty. We therefore assume the existence of both situations, in our case studies, and we assume the emergence of different types of conflicts, that we aim at identifying and characterising, and of different combinations of proximities to solve them. In the following chapter, we will therefore expose the materials and methods we use to investigate our case studies, in the perspective of answering our research questions and testing our assumptions.

Chapter 4: Materials and method

Introduction

The aim of this chapter is to provide the reader with an understanding of the research method we applied in our field investigations. This chapter is divided into three sections. In the first section, we justify and detail the choice of the qualitative case study method to answer our research questions and test our hypothesis. In the second section, we provide a description of our case studies, and we explain how and why we selected these cases. In the third section, we present the data sources we mobilized, and the method we used to collect and analyse the data. We end the chapter with a general conclusion.

Section 1: the qualitative case study method

Introduction of section 1

In this first section, we justify the choice of our research method for our field investigations. We first explain why we chose to follow a qualitative approach and how this method is well-suited to answer our research questions, and then we explain why, within the qualitative method, we carried out holistic multiple-case studies, in an iterative fashion.

1. The choice of the qualitative methodology

We selected the qualitative methodology for our research, as a logical extension of our interpretivist and constructivist positioning that we mentioned in the general introduction of this manuscript, and its underlying relativist assumptions about reality. We then belong to heterodox economics (Livian, 2018). Following this approach, we consider that reality is socially constructed, and the understanding of the complex imbrications between situations and agents requires an interpretivist approach, as it is too complex to be done only by “random sampling” or “calculation” (Baškarada, 2014; Njie & Asimiran, 2014).

Qualitative research allows researchers to dig into complex phenomena about which very little is known (Njie & Asimiran, 2014). As we explained in the previous chapters, there is an important gap in the scientific literature, which otherwise remains very scarce, about the

understanding of coordination mechanisms around the use of digestates, and the identification of related conflicts. In addition, we explained, in the previous chapters, that coordination mechanisms around territorial projects, as they often involve many types of agents and of interactions, are complex phenomena. Our research topic therefore focuses on a complex phenomenon about which little is yet known, which fits well in the qualitative approach. Livian (2018) too claims that the aims of qualitative research are to better understand a phenomenon, but also to provide new knowledge to help field agents deal with the phenomenon. This is precisely what we aim at through our empirical research, as we explained it in the previous chapters, i.e., first, to contribute to filling the knowledge gap on our topic, and also to provide recommendations to the agents involved in the biogas sector, in order to help them with local problems of coordination around the use of digestates.

The use of the qualitative method for our research enables us to develop a “holistic treatment” of our topic (Njie & Asimiran, 2014), which is in line with the necessary holistic understanding of territorial dynamics that we highlighted in the previous chapters. Our aim is to identify and understand the “nature” and the “underlying qualities” of potential conflicts, as well as of interactions and coordination mechanisms and structures, but “as understood and interpreted by people” (Njie & Asimiran, 2014). We are therefore not looking for the “quantities” or “frequencies” of observations (Baškarada, 2014). Moreover, adopting the qualitative method allows us to understand the complex and evolving aims, intentions and logics of the agents involved in the coordination processes and in the conflicts (Livian, 2018).

Stake (2010) lists the various “contexts” in which human actions is embedded, and that can be explored through qualitative research, i.e. “temporal and spatial, historical, political, economic, cultural, social, personal” (Njie & Asimiran, 2014), which directly echoes the framework of territorial capitals we presented in the previous chapters, and therefore suits well our purpose to explore these capitals. Similarly, (Mason, 2002) claims that the qualitative method allows the researcher to capture “the understandings, experiences and imaginings of [its] research participants, the ways that social processes, institutions, discourses or relationships work and the significance of the meanings that they generate”. This also echoes our quest to identify and analyse the territorial capitals and the different types of proximities and interactions that operate in the situations we aim to investigate, and how they generate meanings in the experiences of local agents.

Thus, the holistic approach of qualitative research allows researchers to understand human and social facts as intricated in their contexts, and to situate the data and information collected in these contexts (Livian, 2018; Njie & Asimiran, 2014). The qualitative method will

therefore enable us to collect information from various sources in our research fields, and to explore how the contexts influenced these sources. This will help us to understand human interactions and conflicts around the use of digestates, through the prism of the specific territorial contexts in which they emerge. As a consequence, our research does not aim at providing results that can be generalised to every context. But, at least, we aim at identifying the existence of repeating patterns in the mechanisms of governance and in the emergence of conflicts, that can enrich theory and serve as a basis for reflexion for the agents that will develop new biogas plants and use digestates. However, we may also identify elements that can only relate to specific contexts.

(Peshkin, 1993) listed four objectives that can be reached by qualitative research. The first one is description, i.e., “to reveal the nature of a situation, setting or process” (Njie & Asimiran, 2014). The second one is interpretation, i.e., to gain new insights in a situation. The third one is verification, described as testing some assumptions. And the fourth one is evaluation, understood as testing the effectiveness of practices and processes. Through our qualitative research, we aim at describing the situations around the use of digestates, the interactions of agents, and to describe conflicts if they exist. We try to interpret how the conflicts have emerged, how they have been solved. We also aim at testing the hypothesis we described in our previous chapters, such as the role of intermediary. Finally, we can make our own assumptions, based on our observations, on the effectiveness of local coordination mechanisms.

However, as Njie & Asimiran (2014) claim, “qualitative research is generic and needs a direction”, and one possible direction is the case study method, which allows researchers to dive “deep into a specific unit, person, program or institution for a greater understanding which would not have been possible through other means”, and “to study complex phenomena within their contexts” (Baxter & Jack, 2008). We explain in the next sub-section our choice to follow a case study approach.

2. The choice of the multiple-case study method

2.1. Objectives of the holistic multiple-case study

The case study method, described as “perfectly fine in economics” by Teiu & Juravle (2011), is supposed to “facilitate describing, understanding and explaining a research problem

or situation”, and allows the researcher to carry out an “intensive analysis of an individual unit —e.g. a person, a community or an organization” (Baškarada, 2014). Case studies are used as an “empirical investigation” that aims at clarifying “decision or a set of decisions” (Teiu & Juravle, 2011) while considering the “contextual conditions” in which these decisions occur (Baxter & Jack, 2008). More precisely, Yin (2003) argues that the case study method fits well research purposes for which “the barrier between the context and the case are porous” and when the “investigator has little or no control” on the event he/she wants to study. We precisely aim at analysing the roles and impacts of the specific contexts of our case studies, described in terms of territorial dimensions. We want to analyse present events (the conflicts and the coordination mechanisms) in a real-life context, and to understand the past evolutions of these events, and the consequences of this past on the present situations (see Figure 24). Also, we have no control over the events studied. Thus, our research objectives fit well in the case study approach.

In addition, Yin also claims that the case study method is suited for research that aims at answering “how and why questions”, although it is also possible to answer “what questions” through *exploratory* or even *descriptive* cases. “How and why questions” are rather answered through *explanatory* cases.

How main research question is precisely a “how question”: *How can territorial governance mechanisms impact the emergence and the solving of local conflicts around the management and the use of digestates?* The case study method is therefore well-suited to answer our research question. In addition, we explained, in Chapter 2, that our main research question can be divided into sub-questions, some being again, on one side, “how questions”: *How do local agents coordinate around the management and the use of digestates, and how does this local coordination impact the emergence and the solving of conflicts? How do the issues around the availability and the uncertainty on the information and knowledge about the properties and impacts of digestates, notably reflected by the controversies we exposed previously in this chapter, impact the local coordination of agents?*

On the other side, we also have “what questions”, that correspond to the exploratory and descriptive part of our research work: *What is the nature of these conflicts and what are the dimensions of territories they affect? Can we identify conflicts that are specific to certain territorial contexts, and conflicts that are consistently observed between different territorial contexts?*

Therefore, we have, in our research, a part devoted to exploration and description, that corresponds to the exploration of a topic for which research remains very sparse, and a part devoted to explanation, that will allow us to build explanations about the phenomena we

explore, and in the end, to formulate recommendations based on these observations and these explanations.

Also, exploratory and descriptive cases are used for theory *building*, whereas explanatory cases are used for theory *testing* (Yin, 2003). Consequently, as we have both exploratory and descriptive, and explanatory dimensions in our investigations, the case study method allows us to build new theoretical propositions about the mechanisms of coordination around the use of digestates, and the nature of potential conflicts, and to test the hypothesis we presented in Chapter 3.

However, the results obtained through the investigation of case studies are “generalizable to theoretical propositions and not to populations or universes”, and are therefore used “to expand and generalise theories and not to enumerate frequencies” (Yin, 2003). We therefore acknowledge the limited generalisation of our results, and the recommendations of governance we aim at formulating must not be considered as absolute truths, but as tools that help stakeholders to organise the management and the use of digestates, and that must be adapted to the contexts and the situations that stakeholders face.

Figure 28 from Baškarada (2014) sums up some of the stages followed during case study research. The planning stage corresponds to the identification of the research questions and of the theoretical propositions we detailed in the previous chapters. Research funding partners can be associated to this phase, if they come with specific research questions (Baškarada, 2014). As we explained previously in the general introduction of this manuscript, our partners had themselves identified some research needs (knowledge gap on digestates), and we will show in the next sections that we integrated some of their observations in our research cases (such as the regions and the type of biogas plant). The design stage corresponds to the definition of the type of cases investigated. We follow the categories created by Yin (2003) and presented in figure 29. We chose to follow the holistic multiple-case design (see the black circle we made on Yin’s figure), also called “collective case studies” by Stake (1995) in Baxter & Jack (2008). The multiple-case design allows us to examine “several cases to understand the similarities and differences between the cases”, as well as to “to analyze within each setting and across settings” (Baxter & Jack, 2008). The other stages of our investigation are detailed in the following sections. We therefore carried out a holistic multiple-case study research based on qualitative evidence. We explain in the next section that this method is fitted for a hybrid or iterative approach.

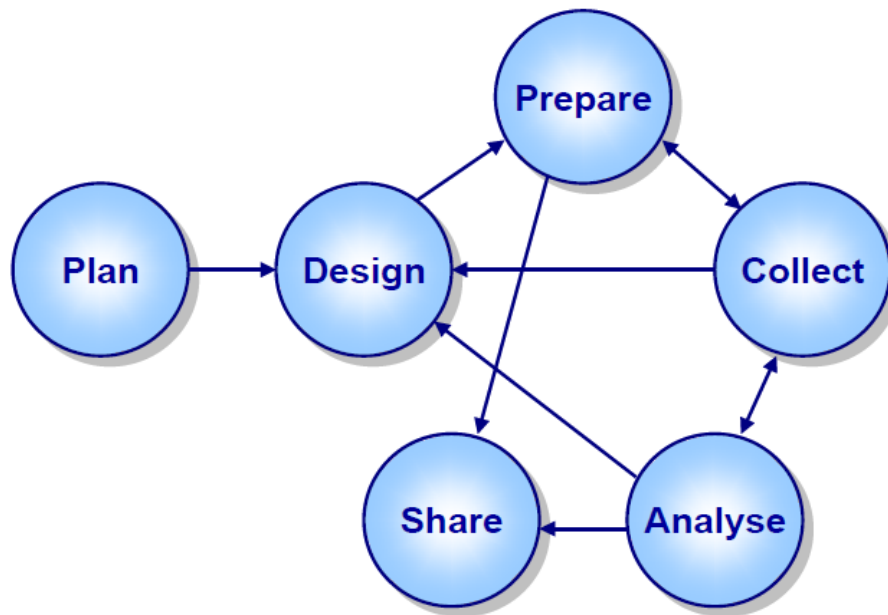


Figure 28: “The Case Study Process”. Source: (Baškarada, 2014)

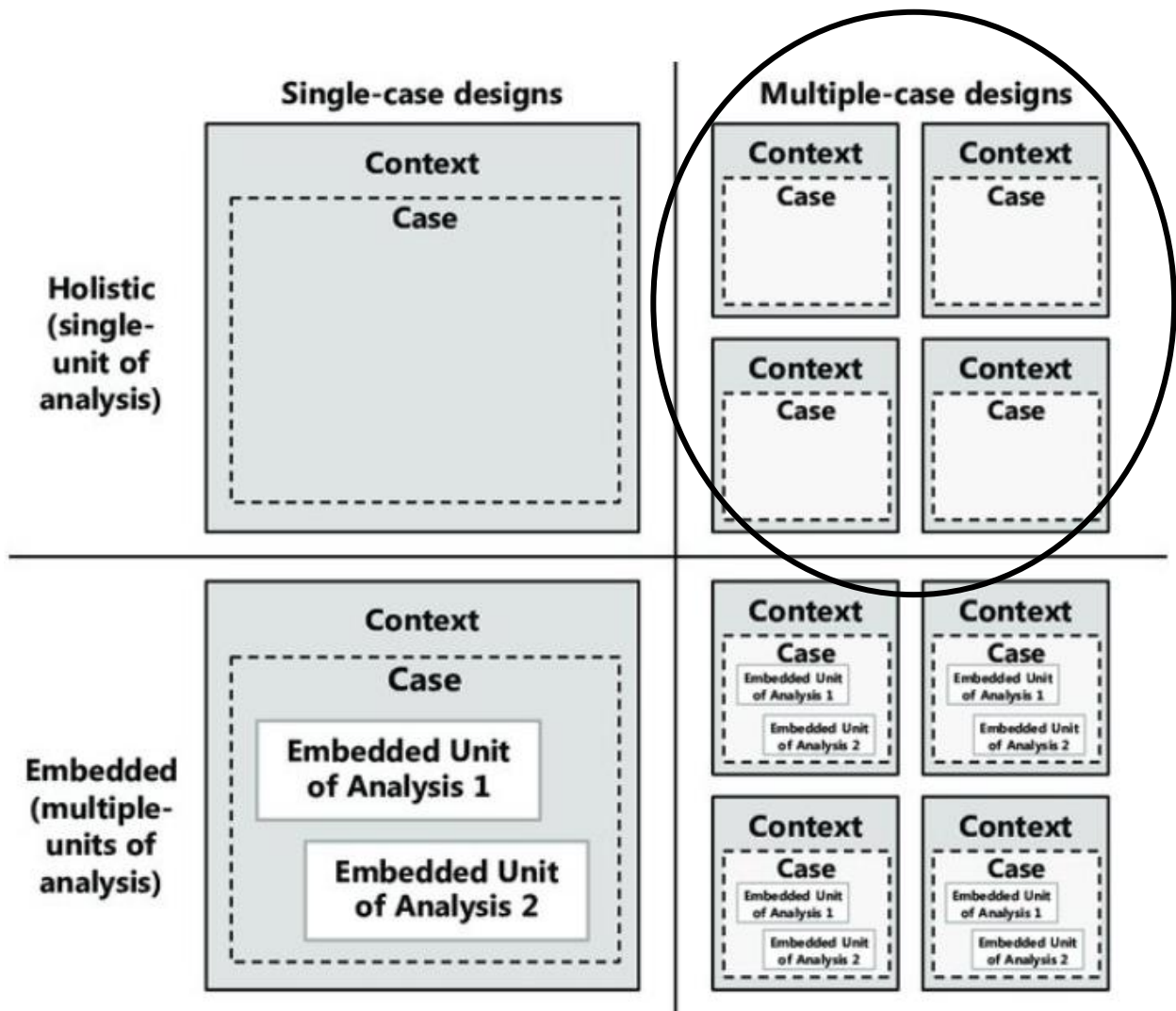


Figure 29: “Basic Types of Designs for Case Studies. SOURCE: COSMOS Corporation” (source: Yin, 2003).

2.2. The iterative approach

According to Livian (2018), qualitative research fits well the inductive approach, as it allows the researcher to collect important amount of information, and to “observe” and “describe” new phenomena by giving a primary importance to the data collected on the fields. However, by constantly going back and forth from the data to theory, qualitative research becomes iterative or hybrid, or mixed, i.e., not purely inductive but not purely hypothetical-deductive as well, which would not fit in the constructivist paradigm. Indeed, the case study research is associated with “flexibility and adaptation”, and its design can be constantly adapted depending on the information progressively collected and analysed (Baškarada, 2014; R. Yin, 2003). The theory too, is constantly enriched with the new materials collected (Baškarada, 2014). Hence, “case studies allow for confirmatory (deductive) as well as explanatory (inductive) findings” (Baškarada, 2014). This approach is in line with the Wallace wheel of science (Wallace, 1971), which combines the deductive and the inductive approaches. In figure 30, we adapt the wheel of science to present our iterative approach.

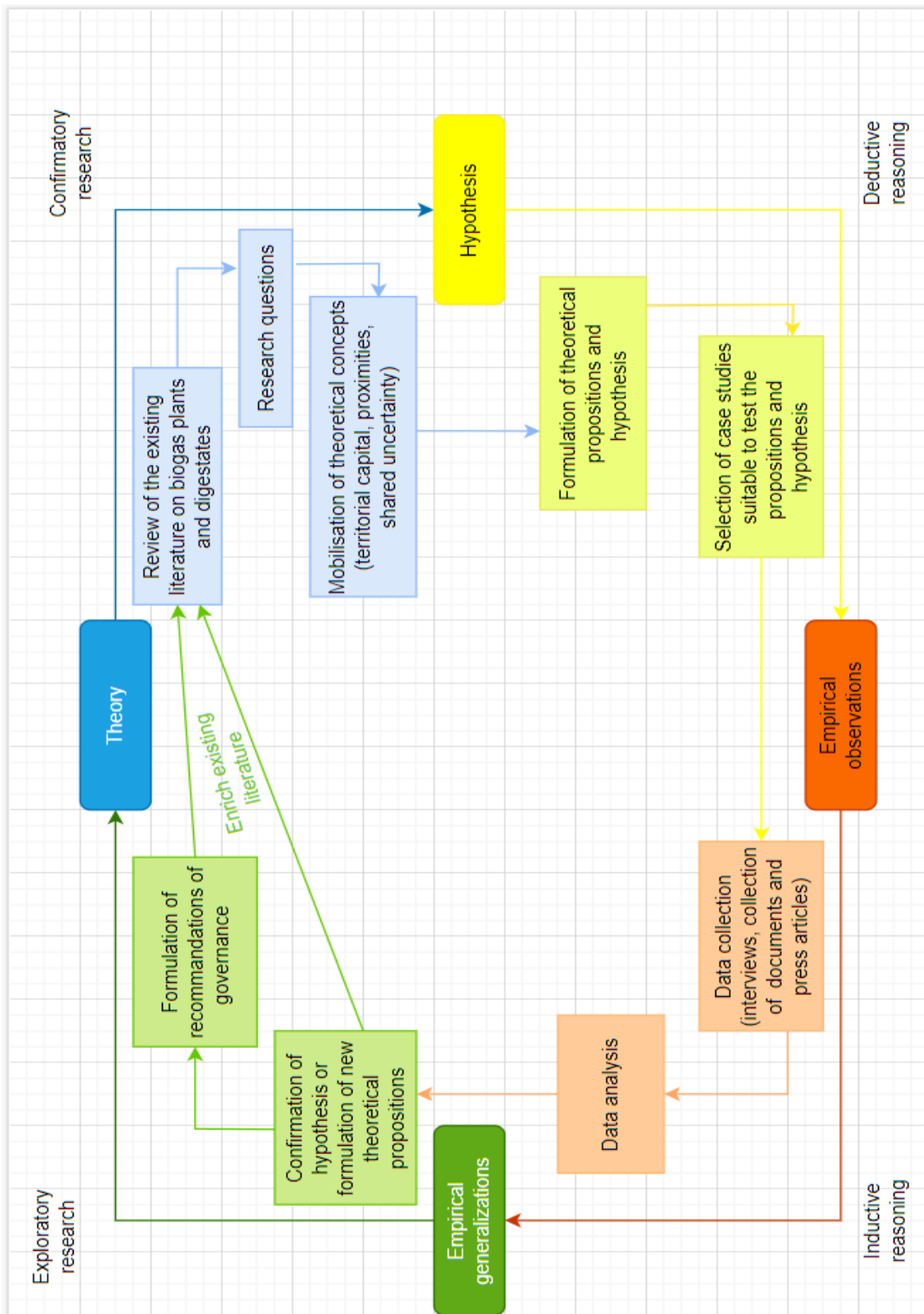


Figure 30: the wheel of science adapted to our research (source: own graph, adapted from Wallace, 1971)

Conclusion of Section 1

In this section, we presented the choice of the qualitative method, as an extension of our interpretivist and constructivist epistemological positioning. The use of the qualitative method allows us to develop a holistic understanding of our topic, to capture its complexity, and to analyse the phenomena we observe in their contexts. To give a “direction” to the qualitative method, we chose to carry out holistic multiple-case studies. Our case studies have both an exploratory and descriptive aspect, that allows us to formulate new theoretical propositions build new theories on unexplored dimensions of our topic, and an explanatory aspect, through which we test the theories and assumptions we exposed in Chapter 3. We explored our case studies in an iterative fashion, which is, mostly inductive, to give the priority to field discoveries, but also through constantly going back and forth to theory. In the next section, we focus on our case studies to explain how we selected them and what are their main characteristics.

Section 2: selection and description of the cases investigated

Introduction of section 2

In this second section, we first expose why and how we selected our case studies. We then present the boundaries of our cases. We finally propose a synthetic description of each of our cases.

1. Selection of the cases

The selection of our cases is the result of preliminary interviews with experts of the sector about interesting cases to investigate complemented by the investigation of the grey literature and of the press (Figure 31), and also by discussions with our funding partners to take into account their particular interests and needs, that mainly concerned the types of biogas plants and the regions where they were located. The results of these discussions and these primary investigations led us to select cases that were either “notorious” for the existence of conflicts around the management and use of digestates, to be compared to “model” cases that were not known for conflicts, and that even appeared to be “models” of “good governance”

according to experts and to the grey literature. In addition, we showed in the previous chapters the importance of the local contexts in shaping economic activity and local coordination. We therefore aimed at investigating biogas plants located in different contexts, to explore how these different contexts, the different *territorial dimensions*, influenced the emergence of conflicts and how local governance culture influenced the conflicts. We therefore chose to compare similar types of biogas plants but located in different contexts.

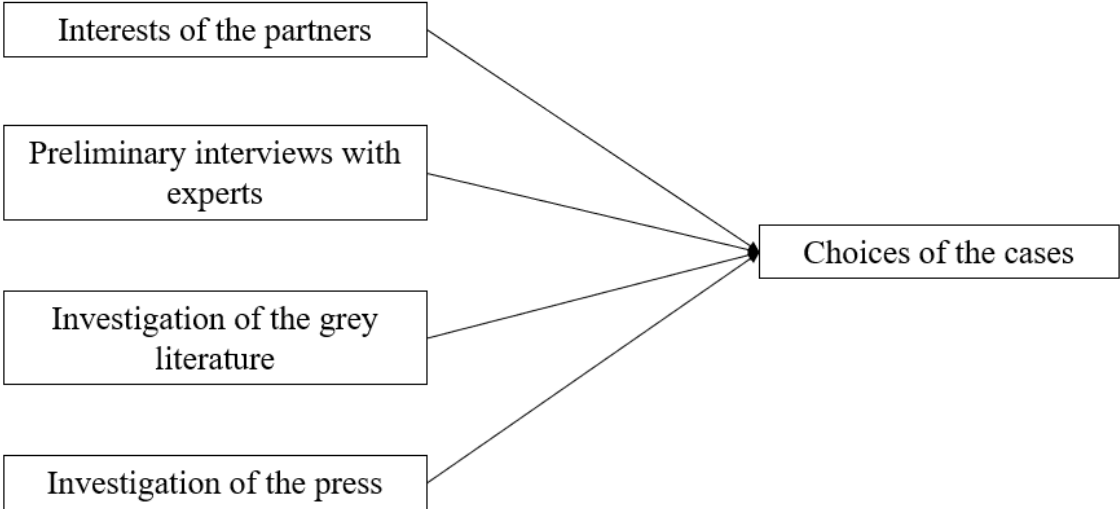


Figure 31: sources used to select our case studies (source: own graph)

Marshall et al. (2013) argue that there is no consensus in the literature concerning the number of cases to investigate, citing Creswell (2007) that recommended to investigate “no more than 4 or 5 cases”, while (Yin, 2009) suggested to choose between six to ten cases. We chose to investigate five case studies, following the recommendations made to us by senior researchers to not select too many cases, because of the time constraints of the PhD funding. We also assumed that these five cases would already allow us to explore a variety of contexts. We selected four biogas plants in four different regions of France, and one biogas plant in Germany, that we investigated after the French cases, in order to observe if similarities could be found with the four cases in France, or if different results emerged. The choice to explore only one case in Germany was made because we primarily wanted to focus on France, and to complement our findings for France by the investigation of the German case. In this sense, this single German case could be assimilated to the *critical single case*, defined by Yin (2003) as a case that is used to confirm or to challenge previous observations and findings. We selected this case study after investigating the French cases, and therefore we carefully selected the German

case among many possible cases, in order to be able to confirm or challenge, through this case, our findings of the French cases. Yin (2003) also warned that the limit of the critical single case is that the case could turn out not to be adequate to confirm or challenge previous findings, therefore we very carefully selected our German case.

Başkarada (2014) presented two tables with “non-mutually-exclusive taxonomy for the selection of cases”. In table 1, our cases would correspond to “best cases” and “worst cases”, and in table 2, our cases could correspond to “critical cases”.

Table 1: Instance Selection in Case Studies [19, p. 25]

Selection Basis	When to use and what questions it can answer
Convenience	Case selected because it was expedient for data collection purposes.
Bracketing*	What is happening at extremes? What explains such differences?
Best Cases*	What accounts for an effective program?
Worst Cases*	Why isn't the program working?
Cluster*	How do different types of programs compare with each other?
Representative*	Instances chosen to represent important variations.
Typical*	Instance chosen to represent a typical case.
Special Interest*	Instances chosen based on an unusual/special attribute.
Probability	What is happening in the program as a whole, and why?

* Purpose

Table 2: Strategies for the Selection of Cases [17]

Extreme/deviant case	Extreme or unusual case.
Maximum variation cases	Cases which are very different on one dimension.
Critical case	A case with strategic importance to the general problem.
Paradigmatic case	A prototypical case.

Figure 32: types of cases. (Source of the two tables: Başkarada 2014)

We finally selected five biogas plants that have an industrial dimension, i.e., that can fall under the categories called “industrial” in the different owner and feedstock-centred typologies we presented in Chapter 1, or that can either be called “centralized” and “territorial” in some typologies. We excluded on-farm and agricultural biogas plants from the scope of our study, following the interests of our partners for industrial biogas plants, and also following some claims made by the literature that industrial biogas plants face more difficulties and

oppositions ((Bourdin, Colas, et al., 2019), which make them interesting cases for the investigation of conflicts. Therefore, our cases are all owned by industrialists and / or public powers, and their feedstocks are composed of a variety of organic matter and wastes, such as industrial and municipal wastes, green wastes, agricultural residues and sewage sludge. All our French cases also fall under the authorisation legal regime, except for the German case, because this environmental regulation does not exist in Germany, as we explained in Chapter 1. It was therefore impossible to compare biogas plants in France and in Germany based on these legal typologies, as they differ a lot. Consequently, we focused on the owner and feedstock-centered typology in order to find a comparable German case. We chose the following cases (Figure 33):

1. The industrial biogas plant of Châteaulin, located in the Brittany region, in the west of France. The Brittany region is an important agricultural region of France, with especially a lot of intensive animal breeding. The Avril group is also significantly present in the region. This biogas plant is a notorious case, mainly because of an environmental accident that occurred with digestates in August 2020. The accident was widely publicised in the following months and years. The case is therefore interesting to understand why the accident happened, how and why conflicts emerged after this accident, and how they were or why they were not solved.

2. The biogas plant “BioQuercy” of Gramat, located in the Occitanie region, in the south of France. The biogas plant and the land application of digestates are located in the territory of the “*Parc Naturel Régional des Causses du Quercy*” (PNRCQ) (Natural Regional Park of the Causses of Quercy). Traditional extensive sheep breeding has been the most important kind of agricultural activities for a long time. This biogas plant is also a notorious case, and experienced lots of controversies, in recent years, that even echoed in the national press, and mainly because of the potential negative externalities of the land application of digestates (Le Monde, 2019). The case is interesting to explore how and why these controversies emerged, what types of conflicts resulted from the situation, and how the local territorial governance tried to deal with these conflicts.

3. The biogas plant “Bionerval” of Passel, located in the Hauts-de-France region, in the north of France. Agriculture is important in the region and is oriented towards the production of cereals and industrial crops from large farms. There is a long history of regional coordination around the use of organic fertilizers and especially sewage sludge. The biogas plant is one of the most ancient ones of the region, and the Avril group is used to interact and work with the successive owners. No conflict was known to us *a priori*. This case is interesting to understand

how territorial governance has permitted the biogas plant to operate, manage and valorize digestates for more than a decade without local conflicts *a priori*.

4. The biogas plant “Terragr’eau” of Vinzier, located in the Auvergne-Rhône-Alpes region, in the East of France. The biogas plant and the application of digestates are located on the impluvium of the famous Evian water. Traditional extensive cow breeding and cheese making under signs of quality are the main local agricultural activities. This case is considered by some of the experts we interviewed as a model of “good governance”, and of protection of natural resources, and particularly the precious local water resources. This case is therefore interesting to understand what “good governance” means in terms of management and use of digestates, and how local agents managed to promote the use of digestates as a way of protecting local natural resources despite the many environmental controversies we described in the previous chapters.

5. The biogas plant of Zittau, named “Biomethan Zittau”, located in the Land of Saxony, in the East of Germany. It is a transborder biogas plant, located in Germany but the feedstocks come from the voivodship of Lower-Silesia, in Poland, and the digestates are used in Lower-Silesia too. Conflicts emerged in Poland, but not in Germany, around the management and the use of the digestates. This case was selected later, and investigated after the French cases, following the iterative approach we described in the previous section, and the critical single case study described by Yin (2003). As we explained before, the aims were to explore if similar conflicts and territorial governance mechanism had emerged, which would confirm our findings for the French cases, or to observe different patterns that would challenge our observations, and raise an interest to carry out further research on other German cases. Also, we observed, for the French cases, some issues with the management of digestates related to regional borders. The aim with our German-Polish case was to test this “border” issue and to emphasize it through the transnational border parameter. Finally, we also observed, when selecting the biogas plant, that conflicts were reported in the press for the year 2013, and no other conflicts were reported later. We therefore assumed that the conflicts had been solved and that the biogas plants could have continued its activities for years after them, making this case interesting to understand the mechanisms behind the solving of conflicts.

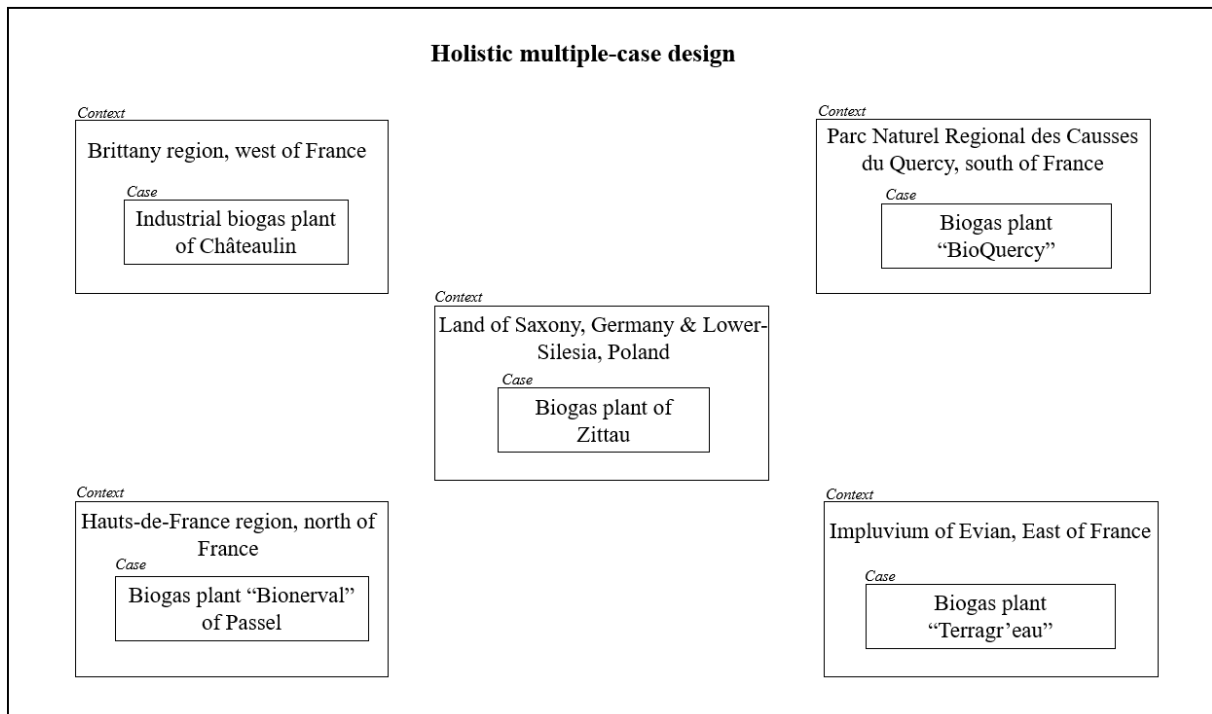


Figure 33: The holistic multiple-case design adapted to our cases. (Source: own graph).

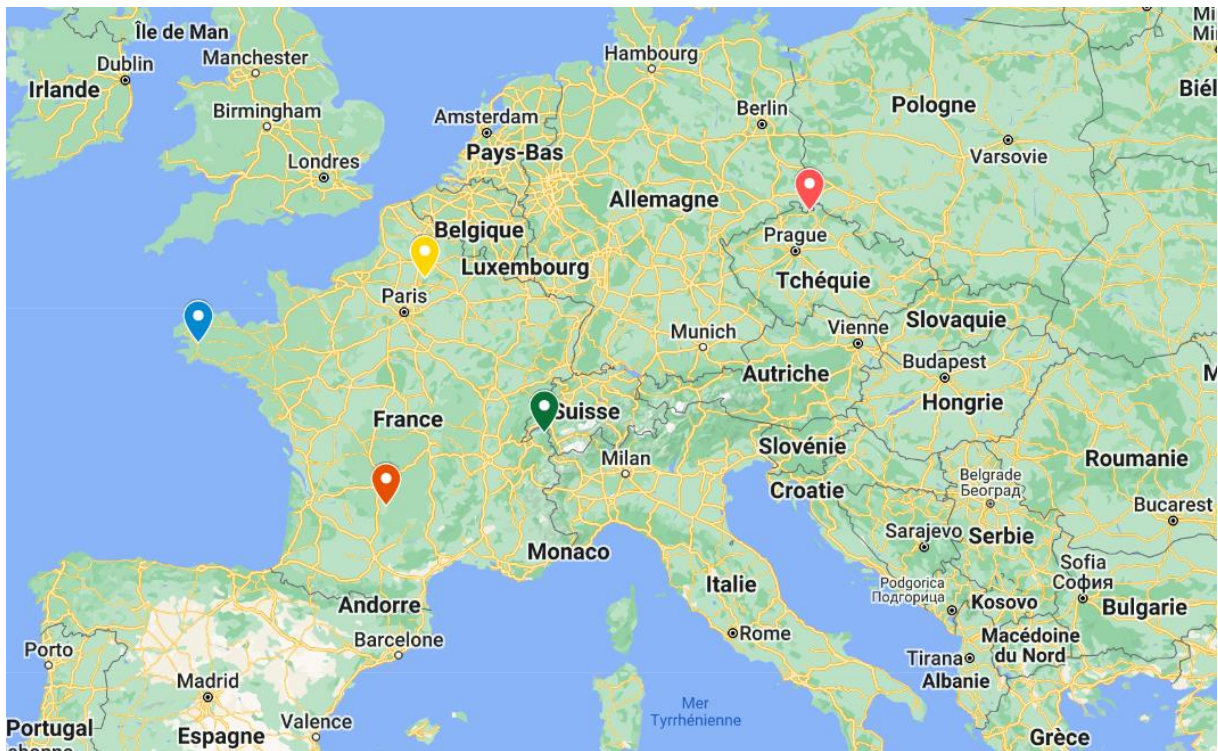


Figure 34: The location of our case studies. (Source: own graph. Made on google maps).

Legend: blue mark = industrial biogas plant of Châteaulin, red mark = biogas plant "BioQuercy", yellow mark = biogas plant "Bionerval", green mark = biogas plant "Terragr'eau", pink mark = Biomethan Zittau

2. Activity, spatial and time delimitation of our cases

After we selected our case studies, it has been necessary to “bind” our cases, i.e., to define their boundaries (Baškarada, 2014; Baxter & Jack, 2008). Baxter & Jack (2008) argue that a case can be bound “(a) by time and place (Creswell, 2003)” and “(b) time and activity (Stake)”. First of all, our cases are bound by activity, as we study the coordination and the conflicts over one specific activity, which is the management and the use of the digestates produced by the biogas plants we selected. All other local activities that are not related to these digestates are therefore excluded from our research, which mean, for instance, that we do not study the conflicts and the coordination mechanisms around the management of the feedstocks used in these biogas plants. We therefore do not study all the material flows (energy flows, flows of feedstocks) around the biogas plants, as (Bourdin, Colas, et al., 2019) and Niang et al (2021) did. Secondly, our cases are spatially bound by the places and areas in which the activity of management and use of digestates occur. We assumed, in Chapter 3, that these places and areas create or shape the boundaries of a *territory*, these boundaries spatially bind our investigations. Finally, we adopt a dynamic approach to study the interactions and conflicts over the management and use of digestates, i.e., we aim at studying them over time, following the perspective adopted by previous research. (Bourdin, Colas, et al., 2019; Bourdin, Nadou, et al., 2019), Bourdin & Nadou (2020), as well as Niang et al (2021; 2022) studied the evolutions of different projects of biogas plants over the years, either from the beginning of the projects, or from the beginning of the operations of the plants. The aim of this dynamic approach is to observe the evolutions of local interactions to understand their outcomes, how they lead to successes or failures over time, and how local coordination evolves depending on the emergence of obstacles and challenges, or of new opportunities and perspectives offered to the biogas plant. We therefore decided to start our investigation with the beginning of the operations of the biogas plants, as it corresponds to the beginning of the activities of management and use of digestates. We aim at observing the tensions and conflicts, the interactions and mechanisms of coordination from the beginning of the operations of the plants, to the year 2022, which is the year we put an end to our field investigations.

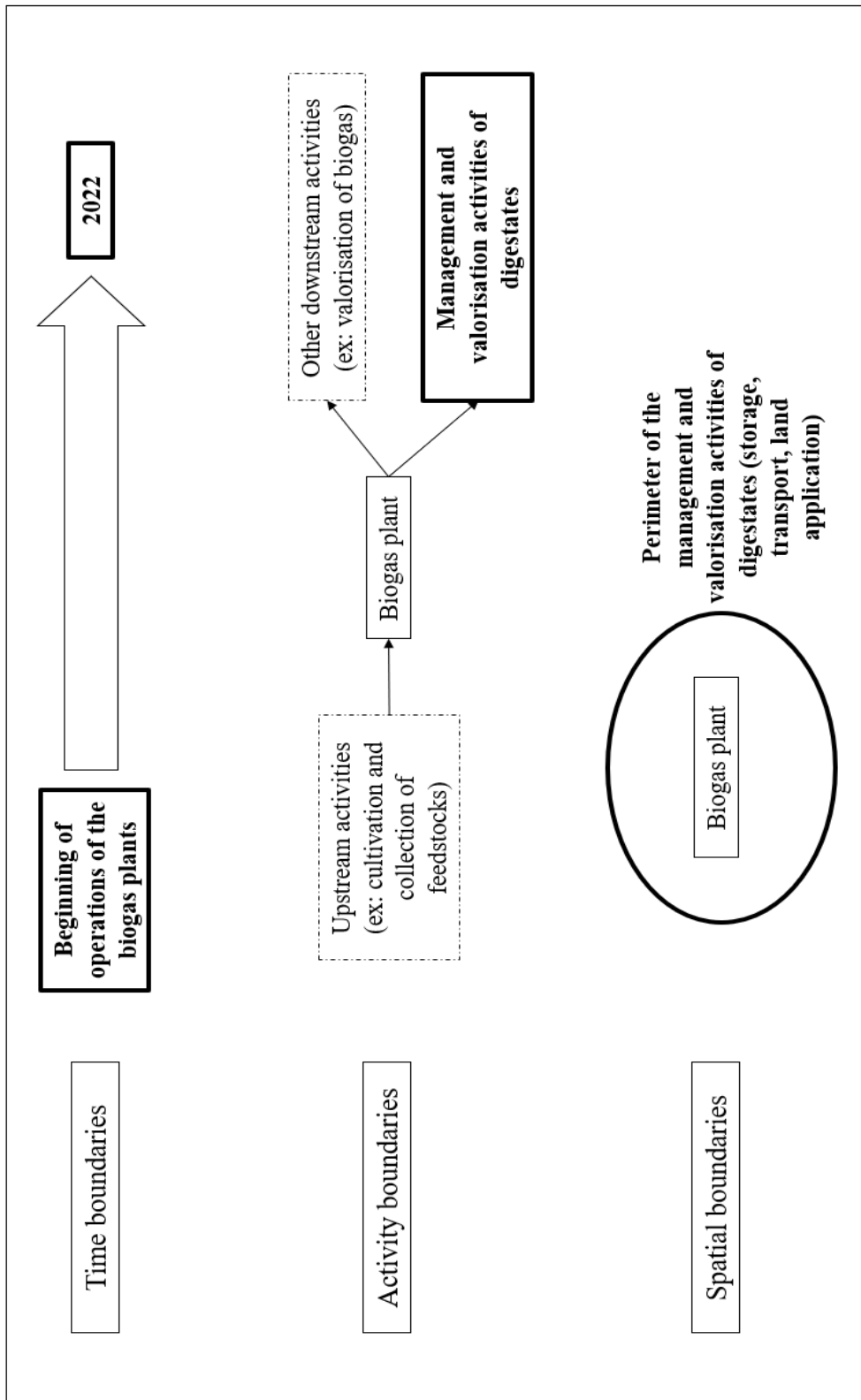
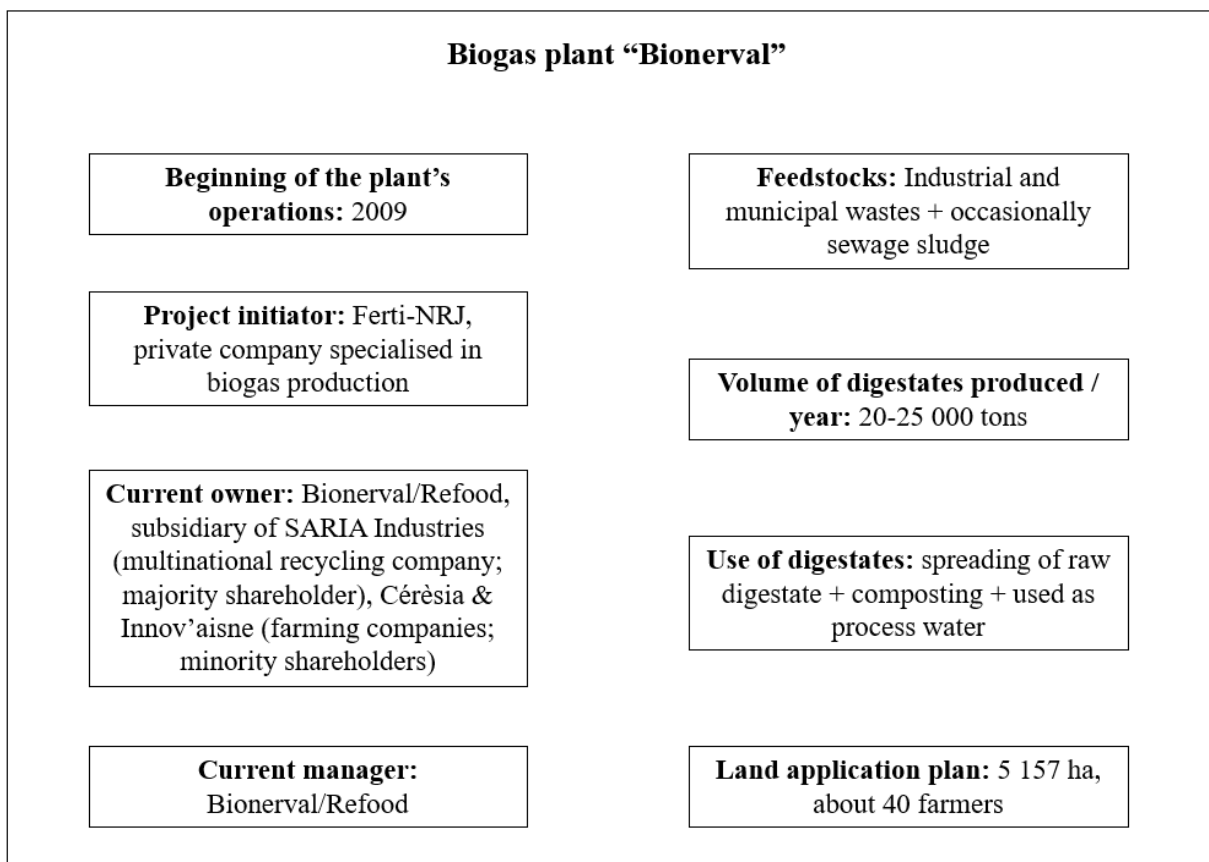


Figure 35: the boundaries of our case studies. (Source: own graph)

Legend: **Text in bold** = boundaries of the cases

3. Description of the cases

The five following boxes present the main characteristics of the biogas plants we studied. We display the year when the plants started their operations, the initiators of the project, the current managers and the current owner of the plants, the types of feedstocks used, the volumes of digestates produced annually, their modes of valorization, and the number of farmers that receive digestates.



Biogas plant “BioQuercy”

Beginning of the plant’s operations: 2016

Project initiator: Fonroche Biogaz, private company of the energy sector

Current owner: Fonroche Biogaz (majority shareholder), now subsidiary of TotalEnergies, and La Capelle (farming cooperative; minority shareholder)

Current manager: Fonroche Biogaz (TotalEnergies)

Feedstocks: 52% of industrial wastes + 48% of agricultural wastes (mainly poultry manure)

Volume of digestates produced / year: 45 000 m³

Use of digestates: land application

Land application plan: 4 625 ha, about 70 farmers

Biogas plant “Terragr’eau”

Beginning of the plant’s operations: 2016

Project initiator: Société des Eaux d’Evian (Evian Water Company), subsidiary of Danone (multinational food company)

Current owner: Communauté de Communes Pays d’Evian Vallée d’Abondance (local community of towns)

Current manager: Serfim Group (construction, recycling, depollution industries; plant management) + SICA Terragr’eau (farmers company; digestates management)

Feedstocks: Agricultural residues (90%) + industrial and green wastes (10%)

Volume of digestates produced / year: 27 000 tons of liquid digestates + 6000 tons of solid digestates

Use of digestates: land application of liquid digestates + composting of solid digestates

Land application plan: 1 379 ha, about 40 farmers

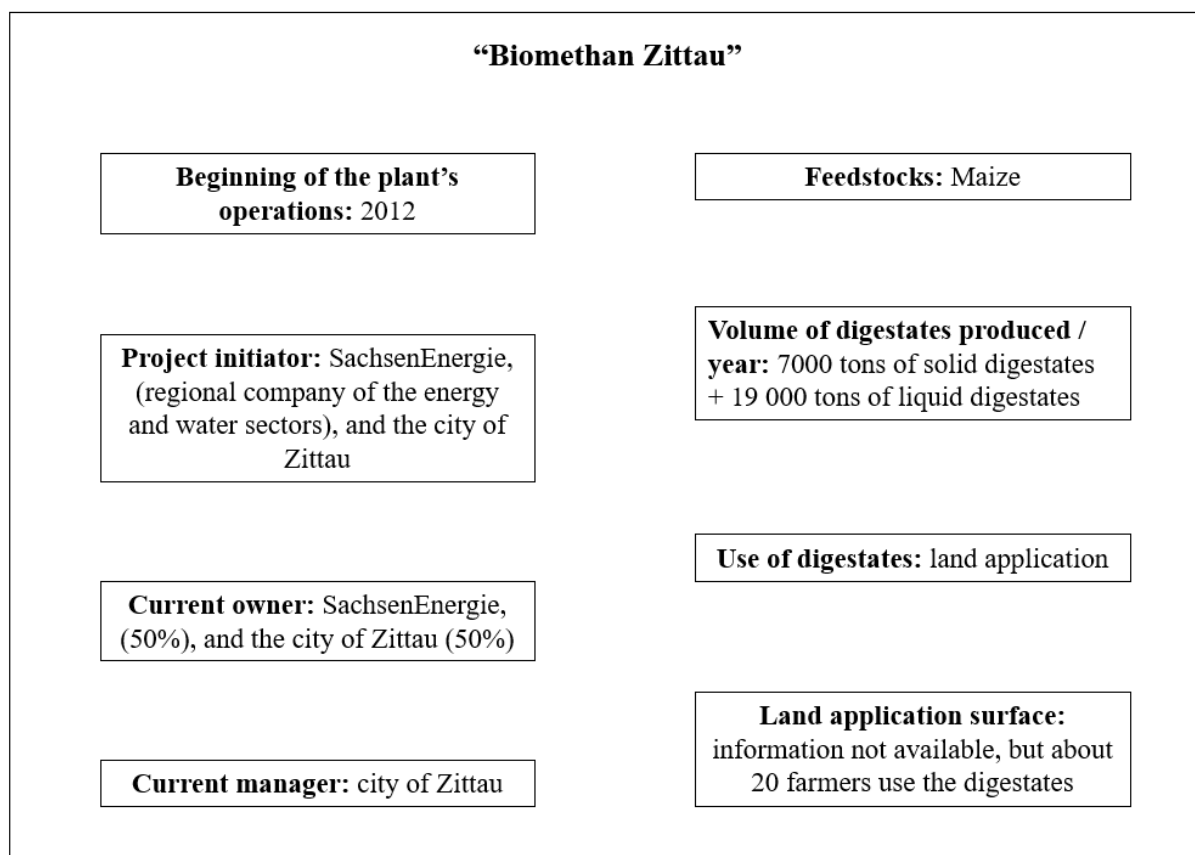
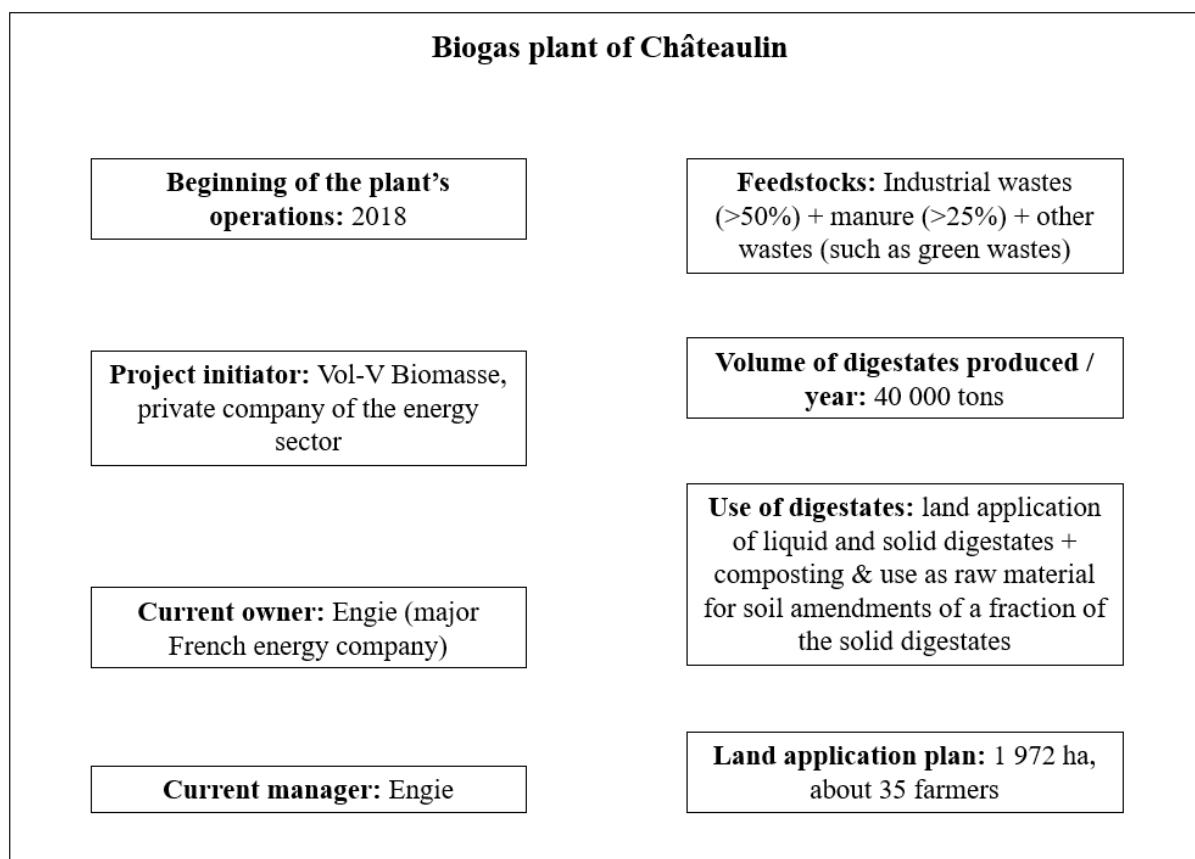


Figure 36: main characteristics of our case studies. (Source: own graphs)

Conclusion of section 2

In this section, we explained that we selected five case studies, four in France and one in Germany. These cases were chosen through preliminary talks with experts, discussions with our research partners, and a skim reading of the press. We selected cases for which no conflicts had been reported, to our knowledge, and cases for which conflicts had been reported, for comparison purposes. We bound our cases by activities, i.e., we focus on the activities of management and valorization of digestates, by time, i.e., from the beginning of the aforementioned activities to 2022, and by place, i.e., we considered the spatial perimeter into which these activities take place. In the next section, we present how we collected data from these case studies, and how we analysed them.

Section 3: the collection and analysis of data

Introduction of section 3

In this section, we present how we collected our data. We detail our data sources, and we present the interview guides we used, as one of the methods we mobilized to collect data. We then explain how we analysed the data.

1. The collection of data

1.1. The sources of data

The scientific literature on qualitative and case study research insists on the necessity to collect data and evidence from various and multiple sources (Baškarada, 2014; Baxter & Jack, 2008; Teiu & Juravle, 2011). The diversity of sources is supposed to enhance the credibility, the accuracy and the reliability of the findings, and should reduce bias (Baškarada, 2014; Baxter & Jack, 2008; Teiu & Juravle, 2011). Also, as we have chosen the qualitative case study method to be able to study complex phenomena and to gather plenty of information about them, the variety of sources are said to help researchers to capture the many different facets of complex phenomena, and to understand them holistically (Baxter & Jack, 2008). Finally, the diversity of data sources allows for the triangulation of data (Teiu & Juravle, 2011; Yin, 2009)

Previous research on biogas plants using the qualitative case study method mainly collected data from semi-structured interviews, complemented by review of the regional press, analysis of meetings between stakeholders, analysis of documents from various groups of agents involved in the life of the biogas plants, and informal talks with local agents (Bourdin, Colas, et al., 2019; Bourdin, Nadou, et al., 2019; Bourdin & Nadou, 2020; Depoucent et al., 2020; Niang et al., 2021, 2022). We followed the same approach and collected data from three main sources: **semi-structured interviews**, **review of the press** (mainly regional, but also national and specialized), and **analysis of documents related to the management and valorization of digestates**. When necessary, we sometimes complemented the information with more informal **mail exchanges** with some agents.

Concerning **the press review** as a source of data, Bourdin & Nadou (2020) argue that regional press is a “particularly interesting observation tool” as it is the “main medium for local news”, although other types of press (national, specialized) can also be rich in useful data for the researchers. Also, the analysis of the regional press has already been used to study conflicts linked to the energy transition (Bourdin & Nadou, 2020; Bourdin et al., 2020). For our investigations, we collected **60** articles that mentioned our case studies, mainly from the regional press, but also from the national and the specialized press, when our case studies were mentioned in these media. We mostly collected these articles through research by key-words in search engines.

Our interest in reviewing these articles is that they describe, even partially, the activities of management and valorization of digestates of our case studies, and they present the agents involved in these activities. When they report a related conflict, they provide a description of the territorial dimensions, or territorial capital, affected by the conflicts, as well as the agents involved. They also sometimes allow us to catch a glimpse of the types of interactions and the modes of coordination between the agents involved, and the proximities involved, especially the unwanted geographical proximity.

Concerning the **document analysis**, we collected documents from very different sources, with the aim to gather as much information as possible on the management and valorization of the digestates of our case studies, and on related conflicts. We collected these documents through research by key-words in search engines, and through exchanges with our interviewees (for instance, interviewees from State services sometimes transferred us internal reports about our case studies). We also reviewed websites of companies, consular bodies, associations and public powers, when they displayed information about our cases, and we collected videos and posts on social media when they were any. In total, we collected and

reviewed 77 documents and websites, all sources and types included. We can sum up the types and sources of documents as follows:

- Official documents released by State services (such as, permit for land application of digestates),
- Internal reports from State services,
- Official documents released by other types of agents (such as local water management authorities),
- Communications / presentations / statements / informative documents from various groups of agents (such as local associations, consular bodies and local public powers),
- Posts on social media from various groups of agents,
- Web-pages of various groups of agents,
- Videos (mainly from YouTube, and mainly released by companies managing the biogas plants),

Again, these documents provide a description of the activities of management and valorization of digestates of our case studies, and the role, as well as the objectives, of the different groups of agents. When they report a conflict, they allow us to identify the territorial dimensions affected, and the role of the different agents in the emergence and/or escalation and/or solving of these conflicts. They also allow us to identify which groups of agents possess information, and what information they possess, and therefore we can identify situations of asymmetric information and of shared uncertainties. The documents can also reflect the activation of proximities, for instance, organizational proximity, as they display exchanges of information between organizations and within them (for instance, when reports are exchanged between groups of agents in order to implement adequate modes of digestates management). Finally, the documents produced mainly by State services allow us to observe the implementation of new regulations and norms on the territory, and to identify control and coercive actions, and their effect on the management of digestates.

The press articles, documents and websites reviewed are presented in the annexes n°1 and n°2.

In the methodological framework of **semi-structured interviews**, the interviewees are considered as owning precious knowledge on the topic of research. This method allows not

only to confirm theory, but also to produce new theoretical propositions (Pin, 2023), which is very much in line with our epistemological framework. This method implies the preparation of interview guides, that contain questions and themes to be evoked during the interviews. The themes and questions are elaborated based on the theoretical framework, with the aim to test the research assumptions. We present the guides in the next sub-section and in appendix. The themes and the questions are used to orientate the interview, but in a flexible fashion, to let the interviewee express as many spontaneous information and details as possible (Pin, 2023). Similarly, Baškarada (2014) argues that semi-structured interviews are a very relevant research tool as its flexibility allows researchers “to better understand the perspective of the interviewees”. In addition, during semi-structured interviews, researchers can “refocus the questions” and “prompt for more information” if new interesting elements are brought by the interviewees. We therefore conducted semi-structured interviews to follow the method used by previous research on the topic, and to serve our purposes, i.e., to explore specific themes with our interviewees while giving them the possibility to add any relevant additional information (exploratory research) and to be free to express their point of view. However, concerning the number of interviews needed to cover a topic in qualitative research, the methodological literature does not provide a consensual answer (Marshall et al., 2013). Usually, authors recommend to carry out at least 10 to 30 interviews in order to reach theoretical saturation, and to not hesitate to go up to 50 interviews, to be sure to capture other themes and categories that would not have been mentioned in the 10 to 30 first interviews (Marshall et al., 2013). However, the literature warns researchers about the risks of not being able to spend enough time and resources on the analysis if too many interviews and too many data are collected (Marshall et al., 2013). Also, the methodological literature recommends to consider the number of interviews performed by previous research. (Bourdin, Colas, et al., 2019; Bourdin, Nadou, et al., 2019) and Bourdin & Nadou (2020) used 49 interviews in total across their case studies, while Niang et al (2021; 2022) carried out 27 interviews on one case study. Depoucent et al (2020), on their side, carried out 38 interviews across nine case studies, and 36 interviews of experts to address more general issues, i.e. 74 interviews in total. Chodkowska-Miszczuk et al. (2019) carried out only 19 semi-structured interviews, across two case studies, but their aim was to complement the quantitative survey they had done previously. They interviewed owners and managers of biogas plants, as well as local inhabitants, local companies, “local authorities” and “local leaders”, and local NGOs.

Following the recommendations of the methodological literature, and the method used by previous research, we interviewed 50 local agents across our five case studies, plus 19

experts to discuss more generally the challenges and conflicts around the use of digestates. Thus, in total, we carried out 69 interviews. Due to the Covid pandemic, and to logistic constraints and/or the preferences of some interviewees, some of the interviews were conducted face-to-face, other through video-conference, and other through phone call. Also, in five cases, interviewees did not want to be interviewed but they accepted to answer written questions. We therefore sent them our interview guide, and we collected their written answers. Concerning the oral interviews, the shortest one lasted 30 minutes, and the longest one 135 minutes, and the average duration is of 64 minutes. Also, the interest of semi-structured interviews lies in the possibility to collect the perspectives of different agents and groups of agents involved in our case studies. Depoudent et al. (2020) interviewed “projects leaders, local inhabitants, experts supporting the projects, associations” and “local elected officials”, and they explain that the groups of agents interviewed varied across cases to adapt to the characteristics of the biogas plants. (Bourdin, Colas, et al., 2019; Bourdin, Nadou, et al., 2019) and Bourdin & Nadou (2020) interviewed “territorial entities”, local inhabitants, farmers, local elected officials, associations and local companies. Niang et al (2021; 2022) interviewed local inhabitants, projects leaders, local authorities, government agencies and State services, local companies and farmers. We therefore aimed at interviewed the same diversity of local agents in our investigations. We identified the agents we needed to interview through a first scan of the press articles and of the documents we collected, and then we added some agents when their involvement popped up in some interviews. In annex n° 3 we present a summary of these interviews, and in annex n°4 we present an anonymised list of experts.

In the following sub-section, we will detail the interview guides we used, and how the topics covered helped us collect useful information to test our hypothesis and answer our research questions.

1.2.The semi-structured interview guides

The interview guides synthetize the topics we discussed with the different categories of respondents. These guides are available in annex n°5, and we present in annex n°6 the record of one interview.

We present here the main topics we discussed during the interviews. First of all, at the beginning of all the interviews, we asked the interviewees to present themselves, their activities

and their organizations. With this first question, we collected the detailed description of the groups of agents and of the organizations involved in the management and the use of digestates, and in related conflicts.

We then moved on to the first theme discussed, which is, the organization of the activities of management and valorization of the digestates. Through this first theme, we could identify:

- the different steps of the activities of management and valorization of the digestates,
- the groups of agents involved and their role in the different activities (transportation, storage, land application, quality control, environmental control, support...),
- the resources used, i.e., the territorial capital mobilized for the different activities,
- the activation of proximities to organise these activities, and the types of interactions.

We then discussed a second theme, which is, the existence of obstacles, challenges and conflicts around the management and the use of digestates. Through this second theme, we could identify:

- the dimensions of the territorial capital involved in the tensions and conflicts around the management and valorization activities of digestates,
- the role of proximities, and especially unwanted proximities, in the emergence of tensions and conflicts,
- if a shared lack of information or a situation of asymmetric information was mentioned in the emergence of conflicts,
- the agents involved in the emergence and / or in the solving of the tensions and the conflicts, and their role (role of intermediary for instance),
- the solutions implemented to solve the conflicts, including, the interactions required to implement these solutions.

We finally discussed a third theme, which is the production and transfer of information about the properties and impacts of digestates, more oriented into the exploration of situations of asymmetric information and shared uncertainty. Through this theme, we could identify:

- the agents involved in the production and transfer of information, and their role,
- the agents receiving the information,

-the territorial capital mobilized to produce and transfer this information,

-the proximities mobilized to produce and transfer this information, and the types of interactions,

Finally, we asked to all the respondents, at the end of the interviews, if they wanted to add anything they thought relevant for the topic, and that had not been brought up during the interview. This was often the occasion for the interviewees to emphasize a particular aspect of the topic that they thought was really important.

2. The analysis of the data

The recent research on the topic, that followed a case study approach and conducted semi-structured interviews, mainly analyses the data collected through a monographic approach, and cross-cutting thematic analysis. Depoudent et al. (2020) used a monographic approach to trace back and describe the projects from the beginning to the date of the interviews, and observe the emergence of different events and the evolutions of relations between the stakeholders. This monographic approach allows us to trace back and describe the establishment of the activities of management and use of digestates on the territories investigated, and the emergence of tensions and conflicts. We can observe the different events that occurred, since the beginning of the valorization of the digestates, to the date we conducted the interviews. Then, Depoudent et al. (2020), as well as (Bourdin, Colas, et al., 2019; Bourdin, Nadou, et al., 2019) and Bourdin & Nadou (2020), carried out a cross-cutting thematic analysis, to compare their case studies based on specific themes. We also carried out a cross-cutting thematic analysis to compare our case studies based on the themes we discussed in our interview guides, related to our analytical framework. To help us with this task, we used the Nvivo® software in which we uploaded our data. Nvivo® is designed to provide support in the management and the analysis of qualitative data. With Nvivo®, we noted and “coded”, in our data, and for each case:

- 1) A first theme related to the organization of the valorization of digestates, in relation with the first theme of our interview guides.

- 2) A second theme related to the emergence of conflicts, in relation with the second theme of our interview guides.
- 3) A third theme related to the resolution of conflicts, in relation with the second and the third themes of our interview guides.
- 4) A fourth theme on coercive and regulatory actions, mainly in relation with the second theme of our interview guides.

The following table details our coding:

Themes	Codes
First theme: organization of the valorization of digestates	References to the dimensions of the territorial capital
	Notions of time and space
	Agents involved
	References to proximities
Second theme: the emergence of conflicts	References to the dimensions of the territorial capital
	References to the dimensions of the territorial capital
	Agents involved
	References to proximities
	References to situations of asymmetric information
	References to situations of shared uncertainty
Third theme: the resolution of conflicts	References to the dimensions of the territorial capital
	References to the dimensions of the territorial capital
	Agents involved
	References to proximities
Fourth theme: the regulatory and coercive actions	Regulatory, coercive and control actions
	Agents involved

Figure 37: the codes used to analyze our data on Nvivo®. (Source: own table).

Then, thanks to the “Nodes” functionality of Nvivo®, that groups the results of the coding by themes¹⁹, for all the cases, we could compare the results across our cases, i.e., which cases presented similar results and which didn’t, and, based on that comparison, we could build up the analyses we present in chapters 5 and 6.

Conclusion of section 3

In this section, we explained that we used multiple sources of data to collect information, which are: semi-structured interviews, press review, document analysis or review of the grey literature, and mail exchanges. We conducted 69 interviews, among which, 50 interviews with local agents, and 19 interviews with experts. In total, we interviewed eight categories of agents, and we presented, in this section, the corresponding interview guides and the themes we discussed during the interviews. Our analysis of our data lies partly on a monographic approach, to describe the event that occurred in the life of our cases, and on a cross-cutting analysis with the support of the Nvivo® software.

Conclusion of Chapter 4

In this chapter, we presented the method we followed to conduct our field investigations. First of all, the use of the qualitative method allowed us to dig into an unexplored topic, and to collect rich and numerous details, information and observations. Within the qualitative method, we conducted holistic multiple-case studies, to compare between five cases, four in France and one in Germany, all located in different regions, and therefore, in different contexts. This method therefore allows us to observe and analyse events in their context, and to capture the influence of these contexts over them. During our investigations, we followed an iterative approach, to be able to collect and reveal unpredicted new information, as in the inductive approach, but through a continuous enrichment of the theory. We selected our cases, through preliminary interviews with experts, skim reading of the press and discussions with funding partners, to find cases that would be suitable to answer our research questions. To collect data

¹⁹ As an example, Nvivo® groups all the “verbatim”, or references, about the dimensions of the territorial capital linked to the emergence of conflicts, across the cases.

in our cases, we used multiple sources of evidence: semi-structured interviews, review of the grey literature, press review, and mail exchanges. With so, we could develop a monographic view of the events that occurred during the lifetime of our different cases, and we analysed our data through a cross-cutting analysis using the Nvivo® software. In the next two chapters, we present our analysis of the data collected through the method we just described, and we discuss them.

Chapter 5: Organization and conflicts over the valorization of digestates

Introduction

In the three first chapters, we presented our theoretical investigation of our topic, our research aims and our assumptions. In chapter 4, we presented the material and methods of the field investigations we conducted to test and validate our assumptions. In this present chapter, as well as in the next one, we present the results of our field investigations, and we discuss them in the light of our previous theoretical investigations. Section 1, 2 and 3 are dedicated to the presentation of our results, and Section 4 is the discussion of these results. The results are presented through main themes, the sub-sections and paragraphs, within which our case studies are compared. We display, throughout these main themes, and in the text, the verbatims that we collected to illustrate our demonstration. This chapter is dedicated to the presentation of our results concerning the activities of valorization of digestates, and the description of the related conflicts. In Section 1, we present the various and heterogeneous contexts into which our case studies are embedded (natural, cultural, agricultural...). In Section 2, we show how these contexts provide opportunities for the valorization of digestates, but they can also be fertile grounds for conflicts. We describe the main issues and conflicts that our case studies experienced. In Section 3, we add to the conflicts aforementioned, the fears and tensions generated by the situations of asymmetric information and shared uncertainty on the impacts of digestates. Finally, in Section 4, we discuss these results and check the validity of our assumptions. We then conclude the chapter.

Section 1: The valorization of digestates is embedded in ambivalent territorial contexts

Introduction of Section 1

One expert we interviewed said: *“The context is very important to understand the attitude towards digestates and their recovery potential (expert 2).* Our investigations revealed a lot of detailed information about these contexts in which our case studies are embedded. We first present the natural and agricultural contexts in which the management and the valorization of digestates take place, then we expose the economic and institutional contexts, and finally, we detail the cultural and cognitive contexts.

1. The natural and agricultural contexts

To start with section 1, we first present our results related to the natural and agricultural contexts into which our case studies are embedded. Firstly, we show the importance of the protection of water resources, as part of the natural capital, and then we explain how local agricultural activities impact the protection of these water resources.

1.1. Vulnerable water resources that must be protected

The results of our case studies, and the interviews with experts, reveal heterogeneous local natural contexts in the territories where the biogas plants are located, but with similar challenges that emerge.

In the region where the Bionerval biogas plant is located and spread its digestates, i.e., mainly the Oise, but also the Aisne and Somme departments, water protection appears to be the major concern. The prefectural decree of 2015 allowing the land application of digestates, and the Opinion from the Environmental Authority of 2018 (concerning the third land application plan), highlight that the three departments, and the municipalities concerned by the land application of digestates are “*nitrate vulnerable zones*”, and that the land application plan extends on “*3 groundwaters, one is more or less vulnerable depending on the sector (different soils), one is vulnerable, and one is very vulnerable to nitrate pollution*”. This situation led the Environmental Authority to highlight “*important points to monitor: water quality, and trace metals & trace organics in soils*” regarding the land application of digestates of Bionerval. In addition, “*the geology of the Oise is very heterogeneous, which is a particularity of the Oise. One parcel can be on two different soils*” (DDT²⁰ 60). This situation leads to “*tensions on water resources in the Oise*” with “*almost 50% of the municipalities*” where “*nitrate limits are exceeded*” and “*lots of lands saturated in nitrates*”, according to the main grouping of environmental associations of the department (ROSO²¹). In addition to this quality issue, there are also issues of quantity of water available, leading to conflict of use between market gardening and energy crops. Therefore, concerning water resources, “*the Picardy plateau is a tension zone*”, according to the ROSO, but, on the other side, the founder of the biogas plant claims that, in the region, “*sedimentary soils filter matter well*”, which is thus positive for the protection of underground water submitted to land applications. From these first results, a

²⁰ DDT = Department Direction of Territories (State service)

²¹ ROSO = Federation of the organizations for the safeguard of the Oise

diverging opinion seems to emerge between environmental associations, and the biogas plant, on the topic of water protection.

Water protection also appears as a major concern in the region of the BioQuercy biogas plant, although it takes a different form. According to a Letter from the Lot Department Committee of Speleology and the Midi-Pyrénées regional committee of Speleology to the Prefect of the Lot (2017), "*protecting the karst and water resources is a priority issue for the PNRCQ²² in its charter*" especially because of the "*purity of groundwater and scarcity of surface water*", as highlighted by a report of inspectors from the Ministry for the Ecological Transition (2019) on the biogas plant. The SDAGE²³ Adour-Garonne also identified the local karst as a "*zone to be protected for the future*" because of the "*strategic water reserve, to be protected from any deterioration*", but also because of an important geological, ecological and prehistorical heritage composed of many decorated caves and unique ecosystems that attract thousands of tourists. Additionally, as explained in the letter, the local regional karstic system is "*an already vulnerable area*" defined by its heterogeneous and complex environment which is difficult to understand and to produce knowledge about, resulting in a "*shared ignorance about it*", which is confirmed by the local press, that highlights the "*lack of knowledge of the karst system and soils*" (ActuLot, September 2017). We observe for this case the first hint of a situation of shared uncertainty, where no agent or group of agents of the territory seems to have a complete knowledge on the local situation.

Local agents we interviewed for the biogas plant of Kastellin, in Brittany, also highlighted the importance of water protection for their region. State services insisted on the "*issues for the protection of surface water*", with "*little vulnerability of groundwater, but high vulnerability of surface water*" (DREAL²⁴ 29). The issue with surface water has been confirmed by the EPAGA²⁵: "*yes, surface water issue, not groundwater, most of the biggest water intakes are on surface water, the issue is on surface water*", and by the local press: "*two thirds of Brittany's drinking water comes from surface water*" (France 3 regions, 2020). In addition, the DDTM²⁶ (29) insisted on the long-term character of the issue of "*water quality*" that "*is old and prevalent in Brittany*", which has shaped the local institutional environment: "*for 40 years in*

²² PNRCQ = Natural regional park of the Causses du Quercy

²³ SDAGE = master plan for water development and management

²⁴ DREAL = Regional direction for the environment, land planning, and housing (State service)

²⁵ EPAGA = Public agency for the development and the management of the Aulne river watershed

²⁶ DDTM = Department direction for territories and the sea

Brittany, there has been a problem with nitrates, with European litigation. Many human resources, credits and other resources have been allocated to this issue". And as confirmed by an expert: *"Before Kastellin, the fears about the pollution of water were already there"* (expert 10). This issue notably led to the notorious issue of green alga, as confirmed by the EPAGA: *"there are existing fears about green alga"*.

Consistently with the previous cases, the importance of water protection in the region of the Terragr'eu biogas plant was highlighted by several agents and documents, but mostly for surface water, and not groundwater, similarly to Kastellin. According to the APIEME²⁷, Terragr'eu is located on the *"impluvium"* of Evian, which is *"an area dating back 45,000 to 20,000 years ago, created by the alternating movements of the Rhône glacier"*. The impluvium is composed of *"layers of moraine, which is a rock that naturally protects the Evian aquifer from major risks of pollution"*. The sub-soil is also composed of layers of glacial sands that allow for the *"filtration and the purification of water"*. Therefore, *"Evian water is protected from pollution under the impluvium thanks to the geology of the impluvium, but surface water can be contaminated"* (APIEME), and in addition, as mentioned by the Environmental Authority in 2015, the impluvium was not classified as a nitrates vulnerable zone since then. However, local ecological situation can evolve, and according to the DDPP²⁸, concerning water protection, *"we felt less concerned because until last year there were no nitrates vulnerable zones in the region and we felt protected, but now we have some zones that are classified as vulnerable"*. In addition, the Environmental Authority mentions that on the impluvium, there is an *"outcrop of groundwater and very permeable soils"*. Also, the CCPEVA²⁹ mentioned a *"geological context very different from that of the Lot"*, i.e., from that of BioQuercy and its karstic subsoil, and the Chamber of Agriculture declared *"if we had been in a karstic zone, we might not have carried out this project"*, confirming the importance of the geological context in the local choices made about biogas production.

However, concerning the German case of Zittau, and maybe because of the lack of information we could collect on the natural context through interviews and documents, we did not observe a similar trend concerning water protection. However, according to the German Biogas Association, *"water protection is a big point"* for the biogas sector and for the land application of digestates in Germany, and *"the water side, the associations of the water*

²⁷ APIEME = Association for the protection of the impluvium of the Evian water

²⁸ DDPP = Department Direction for the protection of populations (State service)

²⁹ CCPEVA = Community of municipalities of the Pays d'Evian Vallée d'Abondance

production, don't want nitrates in the water". Also, the current managers of the biogas plant specified that the plant was not located in "any protected area".

To conclude with this part, for our four French cases, the vulnerability of water resources, as part of the natural capital, and the necessity to protect them, play an important role in the local contexts into which the biogas plants and the land application of digestates are embedded. Some specificities remain: for the cases of Bionerval and BioQuercy, both surface and groundwater are threatened by pollution, whereas for the cases of Kastellin and Terragr'eau, due to different geological and hydrographic systems, only surface water is threatened. In addition, Kastellin water resources seem to have been threatened for a long-time in the region of Kastellin, whereas the threats seem to be more recent for the region of Terragr'eau. In Germany, there are also concerns about water pollution in regions where digestates are applied, which confirms what we explained in Chapter 2, but we found no specific information for our case study of Zittau.

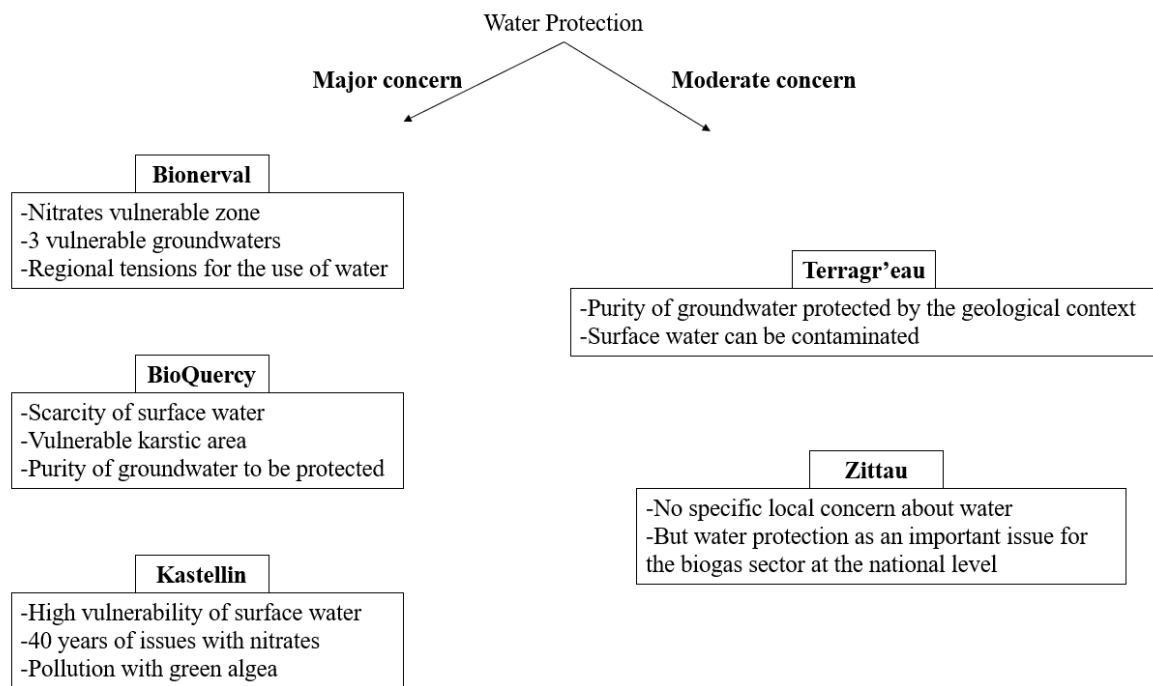


Figure 38: the concerns about water protection (source: own graph).

1.2. Agricultural activities impact the vulnerable natural capital

Our interviewees and the analysis of documents also portrayed, in addition to the local fragile natural capital that must be protected, different agricultural contexts that pre-existed to the land application of digestates, and that already impacted the fragile environment.

According to the DDT (60), the issues of nitrates in the water resources of the territory of the Bionerval biogas plant “*stems from farmers' practices*” and from the “*poor management of fertilizers*”, the “*over-fertilization of agricultural lands*” and from “*poor manure plans*”. In addition, the specialization of local farmers, in the Picardy region, “*in large-scale crops and cereals*” cultivation and the “*loss of livestock farming*” has led to “*a sharp drop in the amount of organic carbon in the soil*” and a major use of mineral fertilizers (managers). To compensate this situation, farmers “*returned to the spreading of wastes*” (managers) which led to many different land applications in the region such as: “*paper mill sludge, sugar mill scum, compost, sewage sludge, catchment sludge*” (DDT 60), that can also contribute to the local surplus of nitrates.

Our other case studies present very different agricultural contexts. In the region of BioQuercy, “*the land is very heterogeneous, in terms of biotope and types of farming*” (farmer), and is composed of declining “*sheep farming*” and “*pastoral areas*” (PNRCQ), “*with semi-industrial duck production replacing extensive sheep farming*” (Inspectors report, 2019) as well as “*a lot of vineyards and arboriculture in the region, and few field crops*” (MESE³⁰ Occitanie). Farmers interviewed confirmed this change in agricultural activities, declaring that they “*earn nothing with sheep, whereas off-farming allows you to have more income*”, and that biogas production is indeed part of this global evolution of agriculture in the region. This change in the local agriculture has been raising concerns for years, according to a local environmental association: “*30 years ago, hydrogeologists were concerned about the consequences of the evolution of agriculture in the area with regard to caves*”, and that “*thirty years ago, people were already saying to stop spreading organic matter. But there was no response from the authorities*”. These fears are also spread among farmers, with the local section of the Confédération Paysanne³¹ union claiming “*we are already faced with intensive, polluting agriculture*” (La Dépêche, March 2018), which tend to be confirmed by the Inspectors from the

³⁰ MESE = Mission of expertise and monitoring of land applications

³¹ One of the French union of farmers

Ministry for the Ecological Transition that reported the pollution of soils, subsoil, and caves by the land application of livestock effluents.

We also observed issues with livestock effluents in the region of Kastellin (Brittany), although the agricultural system is again very different from the previous cases. The regional agricultural system is there characterized by “*large farms*”, “*problematic pig farms*” associated to “*pollution and risks to humans*”, and especially the notorious green algae issue we already mentioned, that created “*public spaces polluted because of farmers*” leading to “*farmers left with a not very high sympathy capital*” (expert 10). The Chamber of agriculture confirmed this “*long history of animal waste management*” and the “*major problems with livestock effluents*” that led to “*a reduction in the number of farms and livestock, strong regulations, with strong spreading constraints, and treatments on the units*”. Local environmental associations insist on the impact of this agricultural model: “*this is intensive and industrial agriculture which has bludgeoned the soil. There is hardly any water table and the water is mainly surface water, so when the soil is bludgeoned, the water goes into the river and we have green algae*”. This situation led local authorities to implement specific rules, such as “*avoid spreading in green algae basins as much as possible*” (DREAL 29). However, according to the Mayor of Châteaulin, town where the biogas plant is located, “*the presence of livestock in Finistère, which is a characteristic of the region, allows the maintenance of meadows and a certain polyculture. Areas with only cereal production also pose environmental problems.*” She expresses a more nuanced vision of the agricultural context, and we can observe, through this, first traces of diverging opinions between the different groups of agents.

In the region of Terragr’eau, agricultural activities have an ambivalent status and impacts. According to the SICA Terragr’eau, the territory is a “*rural area, dynamic agriculture*”, with “*many farmers in the area*”. In addition, farmers play an important role as “*grasslands represent 60% of the infiltration surfaces and it is therefore the farmers who protect the water resource*”, this is why “*supporting farmers to maintain grassland is a key element for Evian*” (APIEME). However, the Chamber of agriculture highlights a “*decline in surface area but livestock numbers are maintained*” with a “*tendency towards intensification*”. In addition, the territory is submitted to a “*very strong urban pressure*” due to the presence of the Swiss border and the attractiveness of Geneva, inducing “*strong fears about the maintenance of meadows and agricultural activities*” because “*property developers are looking at the plateau*” (APIEME). Moreover, the SICA mentioned a problem of very fragmented agricultural lands that “*poses difficulties for land applications*”. And last but not least, the

APIEME pointed the structural problem of the territory composed of “*mainly small and family farms with limited effluent storage capacity during the winter period*”, leading to the “*storage of effluent on frozen ground*” inducing “*nitrate leaching problems, odor problems, neighbor conflicts, impact on tourism*” and the “*impluvium covered with manure piles*”, and a loss of organic fertilizer compensated by the use of mineral fertilizers.

Again, for our German case study of Zittau, we could not find enough information on the local agricultural activities and their impacts on the natural capital, but the interviews with experts revealed a global “*problem with surplus of manure*” (expert 11) inducing “*massive nitrates problems in the aquifers*” (expert 15), which looks similar to the issues found for the regions of Kastellin and BioQuercy.

To conclude with this part, we saw that for Bionerval, AD emerges in a territory where agricultural activities and practices can threaten the natural capital, but can also provide opportunities for the land application of many local by-products from various economic activities, thus playing a role in local circular economy and in the mobilization of the local economic capital. For BioQuercy, the local changes in agricultural activities and practices are seen as a threat for the local natural capital, and biogas production emerges in a local context that is already tense. For Kastellin, biogas production emerges in a long history of damages of the natural capital by the regional agricultural system and practices. For Terragr’eau, AD emerges in a territory where agricultural activities and practices can either be considered as a protection of the natural capital, but the issues with the infrastructural & equipment capital linked to traditional agricultural activities threaten both the natural and the economic capitals. Finally, in the German territory, some farming practices are also seen as a threat to the natural capital, and AD is embedded in this tense context, confirming the situation we described in chapter 2.

Agricultural context

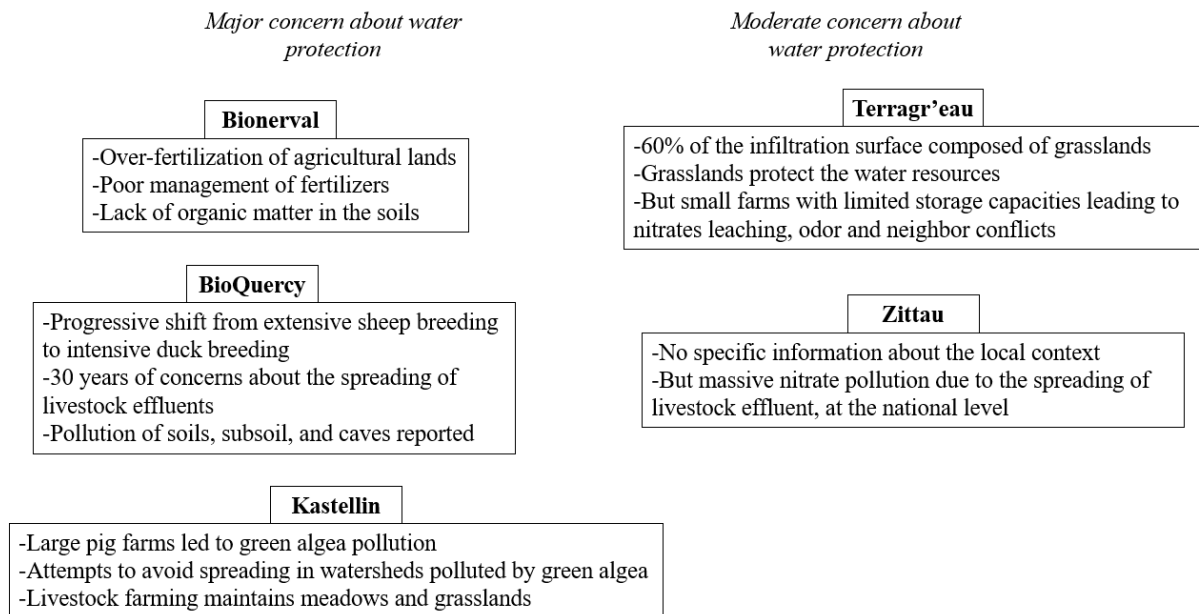


Figure 39: the agricultural contexts linked to the concerns about water protection (source: own graph).

2. The economic and institutional contexts

We now move on to the presentation of our results about the economic and institutional contexts. We first show that the economic contexts can be either favorable or less favorable to the valorization of digestates. Then, we show that these economic contexts are embedded in institutional contexts that reveal heterogeneous levels of coordination across the territories.

2.1. An economic context that is both challenging and favorable to biogas plants

2.1.1. The importance of agro-industrial activities in the territories of Bionerval and Kastellin

Interviews and documents report a regional context with many land application plans and a potential competition between them, although not necessarily, for both Bionerval and Kastellin. The public inquiry of 2019 (Bionerval) reported a “*region with many industries and many land applications*” and the Chamber of Agriculture claimed that “*when we set up a land application plan, there are often farmers on several land application plans*”. This situation leads to digestates being “*in strong competition with other waste products, such as poultry droppings*” (managers), although some other interviewees nuance this remark:

“But there is no real competition between the organic fertilizers, for instance, poultry droppings are much more expensive than digestates, and are used differently and have different effects” (vice-CTO),

“digestates compete with WWTP³² sludge, but not with paper mill sludge because it is the equivalent of lime, and so it is complementary with digestates” (DDT 60),

“the possible competition between the land applications is an issue that must be monitored. You have to be vigilant” (SATEGE³³).

The ICPE request of May 2018 for Kastellin also mentions that *“the region has a long experience of land application of organic matter”* with a *“lot of organic matter in the region”*, leading to a potential but not obvious competition between organic fertilizers:

“it can be competition at any level, between digestates and pig manure, for example. But this is hardly noticeable because there is room for everyone, because of the dynamics of decrease in livestock farming and the number of farms, and there is much less tension over land application than in the 2000s, but it depends on the places.” (Chamber of Agriculture).

However, the management of these land application plans is not always well-mastered:

“there are many farmers who are on land application plans when they have never received any land application”, “sometimes, farmers do not remember that there was another land application plan on their parcels. This is because of the problem of updating the land application plans” (Chamber of Agriculture, Bionerval);

“the management of organic fertilizers in Brittany is very poor, hence the import of synthetic fertilizers” (EPAGA, Kastellin).

But both the international and regional economic contexts also provide opportunities for digestates:

“With the fourfold increase in the price of mineral fertilizers, there is a growing interest in digestates for the next spring” (vice-CTO, Bionerval),

“economically it is profitable, especially with the price of organic fertilizers” (ETA³⁴, Bionerval).

³² Waste Water Treatment Plant

³³ SATEGE = Service for the technical support of land applications

³⁴ ETA = Agricultural works company

This interest for digestates is confirmed for Kastellin:

"especially in the context of the war in Ukraine with ammonitrate at 1300 euros per ton" (DDTM 29),

"practices are changing because it's affecting the wallet at the moment, so farmers are changing their practices" (EPAGA),

"paradoxically, Brittany imports mineral fertilizers, so digestates can replace mineral fertilizers" (AILE³⁵).

In addition, as *"Brittany is well equipped with ETAs and CUMAs³⁶, because they are used to dealing with livestock effluents"*, these CUMAs and ETAs *"can play an important role in the organization of the biogas plant project"* (AILE).

2.1.2. The very specific context of Evian water production (Terragr'eau)

The territory of Terragr'eau is impacted in the same way as Bionerval and Kastellin by the international economic context: *"With the prices of mineral nitrogen, the members don't want to buy mineral nitrogen anymore"* (Farmer), *"since the price of nitrogen has doubled, we try to produce more"* (managers), creating opportunities for organic fertilizers and digestates in particular.

However, at the local scale, the territory experiments a very specific economic context. Documents on the biogas plant sum up the economic situation:

*"The Pays d'Evian is characterized by the need to reconcile strong agricultural activity, in particular through the production of PDO³⁷ cheese, the need to preserve the quality of water infiltrating from the plateau and strong tourist activity"*³⁸,

*"protecting the wetlands of the Pays de Gavot helps to preserve the aquifer exploited by SA des Eaux Minérales d'Évian, which taps the springs at the foot of the northern slopes of the plateau"*³⁹.

³⁵ AILE = Local initiatives association for the energy and the environment

³⁶ CUMA = Cooperative for the use of agricultural equipment

³⁷ PDO = Protected denomination of origin (official sign of quality)

³⁸ Document « Installation : Terragr'eau : SUIVI TECHNIQUE, ECONOMIQUE, ET SOCIAL D'INSTALLATIONS DE METHANISATION (February 2019)

³⁹ Document « INSTALLATION DE MÉTHANISATION Sur le territoire des communes de FÉTERNES et VINZIER par la SAS TERRAGR'EAU » (2018)

Cheese-making is a long-standing activity on the territory, with many “*cheese factories*” (Environmental Authority, 2015), and farmers that “*have been able to structure themselves into PDO quality chains with interesting value-added*” (Chamber of Agriculture). The major importance of water production adds up to cheese-making and tourism: the Plateau de Gavot, where the digestates are applied, is a “*territory of economic interest for Evian and for the municipalities on the lake*⁴⁰” because of the presence of 35 water catchments (EVIAN / APIEME; documents). There is therefore “*the willingness to preserve Evian water and to preserve the tap water*” (CCPEVA).

Evian sums up the importance of the local water resources to them in these words:

"Evian water is our business. If the water is polluted, we close up shop. We invest a lot in the preservation of the environment and in the relations with local actors, because when relations deteriorate, it can be very damaging";

"This is our first quality approach. It is our economic and social mission, to strengthen political and local links."

2.1.3. The quest for economic dynamism in the territory of BioQuercy

Agricultural activities are shifting from extensive sheep breeding to intensive duck breeding because “*farmers want to transform their business to encourage young people to take over their farms*” (Report Inspectors, 2019), which led to the existence of La Quercynoise, a subsidiary of La CAPEL gathering 200 duck breeders⁴¹. However, duck breeding also has its challenges, with the bird flu that affected local farms in 2016, and obliged farmers “*to bury the manure, but it was difficult to bury it on very stony meadows*” (Farmer), opening the path to transform this manure into digestates and benefit from the induced hygienisation.

But financial and economic issues on the territory, not just among sheep breeders but also with the PNRCQ: “*It's an agricultural area it's important to have an agricultural officer, and it's a pity there's only one. But it's a question of resources*” (PNRCQ), “*the park is looking for money for everything*” (mayor); and with other economic sectors: “*in the Causses, we are lost, we no longer have a petrol station, we have to travel 20km to fill up, there is a station that has to be done for 20 years*” (farmer). To this difficult economic situation adds up the challenge to preserve tourism: “*the park is a safeguard, and tourism. The park's interest is to have as*

⁴⁰ Lake of Geneva

⁴¹ <https://www.bioquercy.fr/>

many people as possible come" (mayor), "there is a wildlife park in Gramat so we agreed not to spray during school holidays" (managers). Finally, the "difficult context of the war in Ukraine" (farmer) also affects this territory.

2.1.4. The difficulty to contract with farmers in Zittau

In Germany too, we observed that the local economic context was more or less favorable to the development of the biogas plant of Zittau. From the favorable side, there was, in 2009, the creation of a unit specialized in the development of biogas projects at the regional energy company: *"In 2009, a new department was created at Sachsen energy to develop biogas and other renewable energies" (managers), and although "food industry is not located here in the region", "there is a lot of agriculture".* However, the managers found it *"difficult to have contracts with the farmers"*, and this issue is repeated with other biogas plants: *"we have it in Germany with another plant for instance, it is impossible to have enough maize contracts"*. Due to the location of the plant, close to the Czech and the Polish borders, the managers tried to contract with Czech farmers located at *"maximum 30 km"* from the plant, but in vain, and were obliged to *"to make contracts with lands at 50km"*, in Poland: *"Only on the Polish side there was still free land" (managers).* Finally, concerning the war in Ukraine, the managers say: *"the prospects are good. The war in Ukraine has affected fertilizers' prices"*, which is confirmed by UBA⁴²: *"there is a current increase in the interest for digestates because of the war in Ukraine and the rise in prices of chemical fertilizers"*.

To conclude with this part, we observed that each territory is affected by the international economic and political context of the war in Ukraine, which represents an opportunity for digestates to replace costly mineral fertilizers, which was also confirmed during the interview with the German Federal Environmental Agency. Additionally, we had similar observations for the territories of Bionerval and Kastellin: the local economic and organizational capitals can be both favorable and unfavorable to the land application of digestates, because this land application fits into a global activity of land applications of organic by-products, but the potential competition between the organic fertilizers can become an obstacle to the valorization of digestates. In a similar way, the economic context in the region of Zittau had both a positive and a negative impact on the project, supporting its launch but making it difficult to contracts with local farmers. Concerning Terragr'eu, the economic

⁴² UBA = German Federal Environmental Agency

context (water and tourism) is strongly dependent on the natural capital, hence the necessity to preserve the latter. In addition, a formalized organizational proximity already exists between farmers thanks to the multiple DPO, and therefore we can assume the existence of an organizational capital whose mobilization can be an asset for the valorization of digestates. The territory of BioQuercy is submitted a difficult financial and economic context, and biogas production and digestates valorization can be seen as one of the solutions to solve the economic challenges.

Case	Favorable points	Unfavorable points
Bionerval	Territorial experience with land applications of organic fertilizers	Potential competition with other organic fertilizers
Kastellin	Territorial experience with land applications of organic fertilizers	Potential competition with other organic fertilizers
	Territory well-equipped in ETAs and CUMAs	Remaining issues of poor management of organic fertilizers
Terragr'eau	Strong will to preserve the grasslands / wetlands of the Evian's impluvium	Urban pressure on agricultural lands
	Organizational experience of farmers through local DPO cheese production chains	
BioQuercy	Agricultural shift towards intensive duck breeding. Need to sanitize duck manure. Risks of bird flu.	Lack of human and financial capital on the territory to support the agricultural sector
Biomethan Zittau	Development of a local branch of the regional energy company to develop biogas	Difficulty to have contracts with farmers in Germany

For all cases	Important rise in the prices of mineral fertilizers due to the war in Ukraine	
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Figure 40: economic and agricultural advantages and drawbacks to the valorization of digestates. (Source: own table).

2.2. Heterogeneous institutional contexts that reveal different degrees of coordination

2.2.1. A long history of coordination incarnated by original institutions (Bionerval and Terragr'eau)

In the regions of Bionerval and Terragr'eau, we observed that coordination over agricultural activities, and for the protection of natural resources, has been formalized and institutionalized through the creation of original governance structures, long before the launch of the biogas plants we are interested in, creating a very specific institutional context.

In the 1980s and the 1990s, the Artois-Picardy Water Agency “*had already set up a pre-SATEGE structure to monitor sludge spreading, in collaboration with the chambers of agriculture, with the aim of centralizing data on the spreading of WWTP sludge*” (Water Agency). The aim was to support the land application of WWTP sludge “*especially in the context of industrial crops in the Hauts-de-France*” (Water Agency). But the, the region was impacted by a “*crisis of confidence in the 1990’s about the land application of sewage sludges*”, “*economic players and industries such as Bonduelle started to draw up specifications against WWTP sludge. There were doubts about the entire waste recycling industry*” (Water Agency). There were therefore, “*discussions in 1996 at the scale of the watershed*” (Water Agency), “*During the crisis of confidence, the Agency brought all stakeholders to the table*” (Water Agency);

“*Even before the national level asked the right questions, the stakeholders of the Artois-Picardy basin were already around the table*” (Water Agency).

As a consequence, before the issue of the land application of digestates came to the surface, “*at the scale of the Artois-Picardie watershed, the Water Agency was already used to work with the Chambers of Agriculture on the issues related to sewage sludges and industrial effluents, to elaborate guidelines about their valorization, for instance*” (Water Agency). We see here that organizational proximity was already activated between the main stakeholders of the

Artois-Picardy watershed, to manage the land application of organic fertilizers, long before the beginning of the valorization of digestates. This organizational proximity was mobilized to produce information and tools for the sector, thus, to enrich the local cognitive & technical capital. Thanks to these discussions, the stakeholders also wrote a Chart for land applications: *“the principle of equity in the chart is to ensure that the rules are applied equally in all departments and for all effluents”* (Water Agency), i.e., to fix homogeneous rules within some territorial boundaries, which bring us back to the definition of territorialisation in the English-speaking literature: the way to manage and control local resources and local agents in a “bounded and controlled space” (Chapter 3).

In 1998, there were new texts produced at the national level that *“the watershed prefects could set up external bodies to support them in their decisions”*, which was therefore a national support to the activation of the regional organizational capital. This led, in the Artois-Picardy watershed, to the creation of the *“Conférence Permanente des Epanrages”* (Permanent Conference for Land Applications) (CPE), which is *“a more political body”*, whose purpose is to *“bring together a lot of people”* in order *“to validate the technical documents, such as the guidelines”* (Water Agency). To complement the work of the (CPE), the SATEGE and MUAD were created in the Nord, Pas-de-Calais, Somme and Aisne departments (the departments of the Artois-Picardie Watershed), financed by the Water Agency and the Chambers of Agriculture, to produce *“guidelines”* to help the stakeholders understand the laws and regulations, and propose *“good practices that go beyond regulation, they are recommendations”*, as well as to *“help State services deal with land application plans”*, especially as regard to the *“coherence”*, the *“sizing”* and the *“overlapping”* of these plans (Water Agency).

These political and technical bodies created the SYCLOE tool, a software that allows to centralize and record all land application plans on the watershed, in order *“to check and avoid over-fertilization and check the flows of trace metals and other pollutants”*. *“The implementation of SYCLOE was one of the strong conditions to continue [the land applications]: a transparent traceability tool, common to all actors, to monitor land application at the parcel”* (Water Agency). However, there is no equivalent to the SATEGE or the MUAD in the Oise department, because this department belongs to the territory of the Seine-Normandie watershed, *“and for financial reasons mainly, the Seine-Normandie Water Agency does not wish to fund a SATEGE in Oise”* (Chamber of Agriculture). To remind the reader, the land application plan of the Bionerval biogas plant extends of the Aisne, Somme and Oise department, and therefore on two different watersheds. One part of the plan is embedded in the

institutional context with described above, while another part is not submitted to this territorial organization.

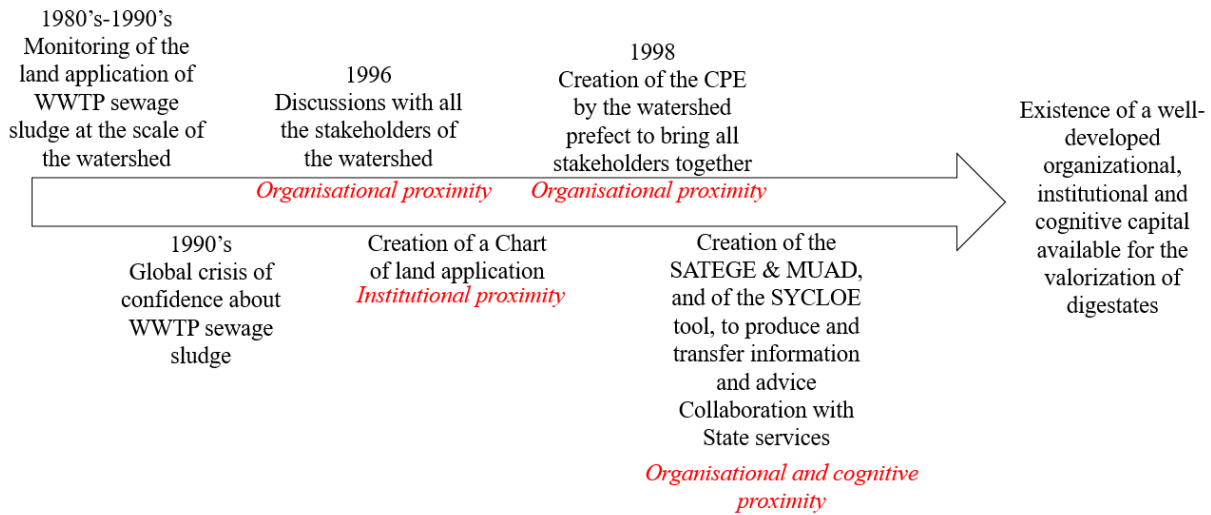


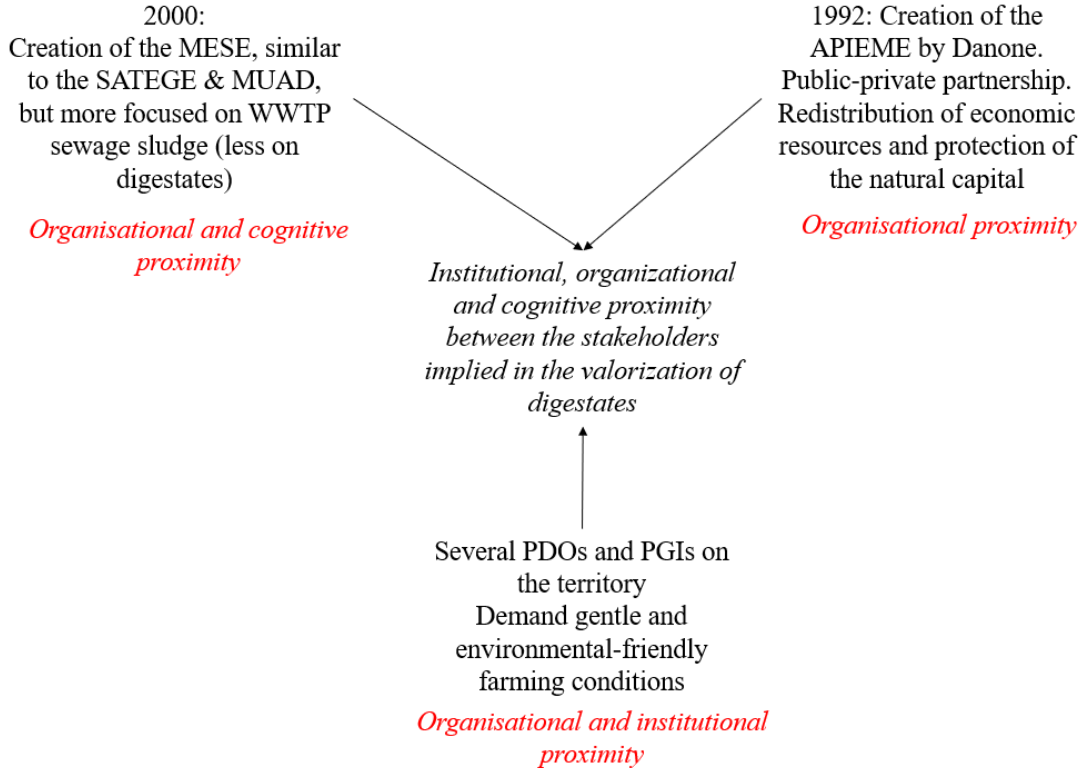
Figure 41: the development of the institutional context of land applications, in the region of Bionerval (source: own graph)

In the region of Bionerval, the formalization and the strengthening of the coordination between stakeholders were initiated by public powers and led to the creation of public structures (CPE, SATEGE, MUAD). In the region of Terragr’eau, it is at the instigation of a private actor, Danone, through its subsidiary Evian, that local coordination was formalized. There was, in 2000, the creation of a MESE (Expertise and Monitoring Mission on Land applications) in the department of Haute-Savoie, where Terragr’eau is located, with some quite similar missions to those of the SATEGE and the MUAD, but without the political aspect of the CPE. Also, the missions of the MESE are still centered on the land application of WWTP sludge, and much less on digestates, and the link with digestates mainly consists in “*check[ing] the overlap between wastewater treatment plant sludge and digestate [land application plans] before validation by prefectoral decree*” (MESE 74).

Earlier than the MESE, in 1992, was created the APIEME, an association composed of the Evian water company and the municipalities where Evian water springs emerge (APIEME). The objectives behind the creation of this structure were to: “*create a system of governance to redistribute economic resources and to preserve mineral and drinking water resources*”, to “*protect the resource for the next 200 years*” (APIEME). The redistribution of economic

resources targeted the municipalities without springs, “so that the money generated by the sale of water would go to the municipalities that incur costs to protect water without receiving royalties because they do not have emerging sources, compared to the municipalities with emerging sources that receive royalties” (farmer). Thirteen municipalities were thus involved in this “public-private partnership aiming at reconciling the preservation of water resources and local development in the impluvium, particularly farming”, including municipalities with springs and without springs but located on the impluvium (L’Usine Nouvelle, November 2017).

In addition to the creation of this structure of governance targeting the preservation of the environment and agricultural development, the territory is also home for several PDOs and PGIs⁴³ that “already demand gentle and environmentally friendly farming conditions; they bring in practices that are consistent with Evian’s stakes in protecting water resources” (SICA). Therefore, “the APIEME does not seek to add operating constraints because there are already constraints in the specifications of the PDOs and PGIs” (APIEME). We therefore observe the existence of an institutional context that supports the converging of interests of local agents, which results in an institutional proximity between the different agents consequently submitted to the same norms and the same values.



⁴³ PGI = Protected geographical indication (official sign of quality)

Figure 42: the institutional context of land applications in the region of Terragr'eau (source: own graph)

2.2.2. An institutional context impregnated by the presence of the PNRCQ (BioQuercy)

There is also the presence of MESEs in the Rhône-Mediterranean-Corse (RMC) watershed, where BioQuercy is located, in a similar fashion of the Terragr'eau case study. The work of the MESEs is centered on the issues related to the valorization of WWTP sewage sludge and not on digestates. According to the regional network of MESEs Occitanie, there are fewer human resources in the MESEs than in the SATEGE. Despite the will of the regional MESEs, since 2015, to monitor the valorization of all organic fertilizers, including digestates, and to work with SYCLOE, in 2022 the situation had not evolved due to financial constraints (MESE Occitanie). Moreover, in the department of the Lot, although part of the RMC watershed, there is even no MESE: *“The chamber tries to play the role of MESE, although there is no MESE in the department”* (Chamber of agriculture). We observe a very different institutional context that in the Artois-Picardie watershed.

The institutional landscape is more dominated by the presence of the PNRCQ, whose mission is *“primarily environmental, but also economic, including economic development, and promotion of the territory”* (PNRCQ). The PNRCQ sees its mission as *“a complement to what is being done in the area. We can bring ecological knowledge to agricultural organizations”*. In addition to this collaboration with the other organizations of the territory, the PNRCQ also organizes an institutional context on the territory, and activate institutional proximities between the municipalities that belong to the park: *“In practice, we don't bother because we have no power over private individuals, but we set rules for the municipalities that have voluntarily signed the charter. So, there are consequences but there are rarely regulatory. It is rarely a constraint, it is rather about concertation”*. However, although *“the PNR is not a constraint, but there is a constraining discourse, and the PNR is clothed with the image of preserving the environment, so without knowing it, people have perceptions of what the PNR is a priori”*.

2.2.3. A more traditional institutional context (Kastellin)

Our research did not reveal the presence and the role of a specific governance structure in the territory of the land application plan of Kastellin. Based on our observations, the issues related to the valorization of digestates are managed in a classical way by local state services.

The missions are shared between the DREAL and the DDTM. The DREAL is more focused on controlling biogas plants themselves, although the DDTM controls the agricultural parcels where digestates are applied (DREAL 29): “The DDTM controls farmers under the PAR 6 bis and the nitrates directive, particularly in the green algae catchment area. Some of them are land lenders to Kastellin. We control documents and practices and we see if the fertilization balance is respected” (DDTM 29).

The institutional regional context is also shaped by the presence of the AILE (Local Initiatives Association for the Energy and the Environment) founded by the ADEME and the CUMAs of the Brittany region to support the development of renewable energies, and especially biogas production, in rural areas. The role of the AILE is to be a “*resource center*”: “*Project leaders come when they have concerns, when they don't have answers to their questions*”; “*We solve problems, we put the right people in touch with each other, we redirect poorly designed projects*” (AILE). We will expose further the importance of the AILE in the activation and the mobilization of the regional cognitive capital.

Finally, the land application plan of Kastellin extends on the Aulne river watershed, which is managed by the SMA (Mixed Union for the river Aulne) and the EPAGA (Public Agency for the Development and the Management of the Aulne watershed). However, the EPAGA has “*no role with the designers of land application plans, no opinion to be formulated, no solicitation. We have no right to look at this. We don't even have all the land application plans*” (EPAGA). We observe here that some institutional players of the territory are not mobilized in the management and valorization of digestates, despite the important environmental challenges on local water resources.

2.2.4. The weight of local associations

Our research also revealed the importance of local environmental and citizens associations in the local institutional landscapes.

In the Oise department, where Bionerval is located, local environmental associations have federated, since 1976, in the ROSO (Grouping of Safeguard Organizations of the Oise), and the ROSO is now composed of approximately 75 associations (ROSO). The ROSO claims its importance in the territory, due to its expertise, and hard work:

“It's a quasi-professional structure, with skills that allow us to fight a 10-year battle. And as it is a federation of associations, it gives us weight and resilience. We know our subjects very well, we work on them. We really prepare the files”;

“We try to work hard on the subjects, to argue, and we study the decisions for hours”;

“Citizens mobilize around projects they don't agree with. But for me, what interests me as president of the ROSO is to leave a lasting legacy. Any new prefect is surprised because the ROSO is really a special structure, with real expertise born of learning and experience”;

“It's the ROSO that is getting things done. We are pursuing many territorial authorities on environmental issues in particular”.

The institutional landscapes of the regions of Kastellin and BioQuercy are also influenced by many environmental and citizens associations but without a global organization that would federate them. The regional and local press cites multiple times several associations involved in the issues with Kastellin, such as Eaux & Rivières de Bretagne (Waters and Rivers of Brittany), Bretagne Vivante (Living Brittany), Les Faucheurs volontaires du Finistère (The Voluntary reapers of the Finistère) (France 3 Bretagne, 20, 21, 26 & 30 August 2020; Ouest-France, March 2023). According to Bretagne Vivante, these associations “*are closer to the Confédération Paysanne*”, which is one of the French unions of farmers. We observed the same situation in the territory of BioQuercy, with several associations cited multiple times by the national and the local press, and the Report of MTE Inspectors (2019): the GADEL (Association for the Defense of the Environment in the Lot), the Speleology Committee of the Lot department, the “Collectif citoyen lotois” (Lot’s citizen collective), as well as national associations: France Nature Environnement and the CSNM (National Scientific Council on Biogas production), and again, the Confédération Paysanne union (Touleco green, 2017; La Dépêche, 2018; ActuLot, April & November 2019, 2022; France Bleu Occitanie, 2019; Médiapart, 2019; La Dépêche du Midi, 2019, January & November 2021, 2023).

The very interesting difference with Terragr’eau is that we did not find any reference to local environmental or citizens associations that could have been more or less involved with digestates and biogas production. This case clearly stands out from the other cases on this topic.

Concerning Zittau, we could not find any references to associations that pre-existed to the biogas plant and to the valorization of digestates, and that intervene in the issues around digestates, as for Terragr’eau, but we acknowledge that it could be because of a lack of data we could collect.

2.2.5. A nationwide pattern of coordination and organization favorable to Biomethane Zittau

For the Zittau biogas plant, the managers first evoked the national institutional context that was favorable to the development of biogas production when their project was launched:

“From 2000, with the EEG law, there was lots of support for biogas plants in Germany, although there were some conflicts around renewable energies at first. But from 2008-2009, companies started to invest massively in renewable energies and biogas”.

Then, they mentioned the partnership concluded between Sachsen Energie and the city of Zittau, at the origin of the project:

“It is usual in Germany to do such partnerships and to have a lot of energy companies and water companies. It’s typical for Germany, to have this shareholder connection, it’s typical to operate together. The large company such as Sachsen Energie has more experience and strategic thinking and so they help the small cities in strategic thinking”.

The existence of a repeated pattern of organization between energy companies and public authorities, which turns out to be a fruitful ability to activate organizational proximity, combined to a favorable national institutional context seem to have been an asset for the development of biogas plants such as Biomethane Zittau.

To conclude with this part, we observed that the valorization of digestates fits in different pre-existing regional and local institutional contexts that reflect different degrees in the organization and the formalization of coordination between stakeholders. In the region of Bionerval, we observed more than 30 years of institutionalized coordination on the management of land applications of organic matter, combined to a capacity of local environmental associations to federate and to make an impact in the institutional landscape. In a similar albeit different way, we observed, in the region of Terragr’eu, around 30 years of institutionalized coordination on agricultural topics through a private-public partnership. In the territories of Kastellin and BioQuercy, we observed the presence of many environmental and citizens associations but without specific coordination between them. However, in the territory of BioQuercy, we observed that the PNRCQ tries to organize coordination, especially on agricultural and economic topics and it creates institutional proximity between the actors of the territory; around Kastellin, our research did not reveal any specific pre-existing mechanisms of coordination, and we observed that there might have been a lack of activation of organizational

proximity on the topic of land applications. In an opposite fashion, Biomethane Zittau seems to have benefitted from a national habit to activate organizational proximity.

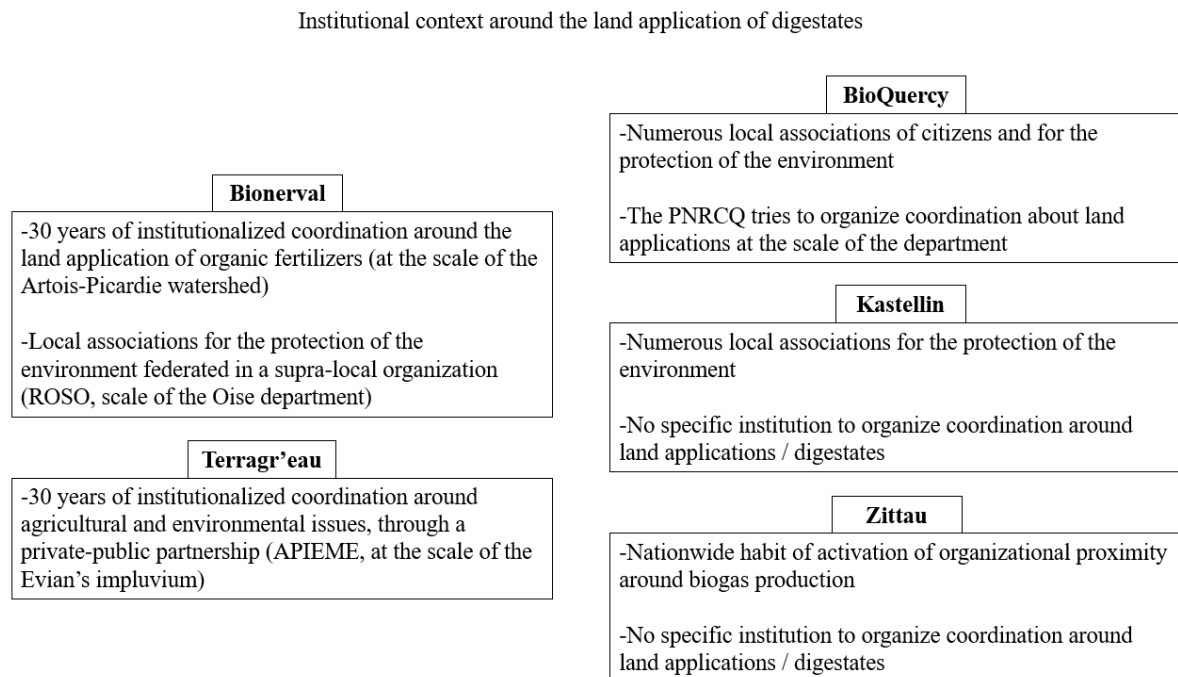


Figure 43: the local and regional institutional contexts around the land application of digestates. (Source: own graph).

3. The cultural and cognitive contexts

3.1. Cultural divergencies about agricultural development

Our investigation revealed the existence of diverging opinions and tensions on the local models of agricultural development, and questioning about which model biogas production seem to support. We observed these tensions and questioning in the territories of Bionerval, Kastellin and BioQuercy, but not for Terragr'eau and Zittau.

In the territory of Kastellin, local actors acknowledge the existence of long-term and large-scale conflicts about agricultural development: “we have experienced 30 years of conflict over the vision of agriculture with associations such as Rivière de Bretagne” (AILE). Local associations usually criticize the industrial model: “We have a lot of truck farmers”; “Agriculture should be changed. And we continue to produce sh*t” (Bretagne Vivante). These conflicts impact the opinions local agents have on biogas production and significantly held a political dimension:

“Some of the arguments put forward against anaerobic digestion are political. Attacking anaerobic digestion is tantamount to attacking the fundamental issue, which is the dominant agricultural model rejected by opponents” (AILE);

“The real issue is which agricultural model biogas production is based on. If agriculture wants to move towards agro-ecology, is anaerobic digestion a hindrance or not?” (AILE).

This question is answered by Eaux et Rivières de Bretagne by *“biogas production speeds up the industrialization of the countryside and diverts food crops for energy purposes”* (Ouest-France, August 2020). In addition, local associations criticize the reasons why biogas production is developed: *“They make biogas plants because their intrinsic production is not profitable”*; and they question the interest of using digestates: *“If they were more extensive, they would recover pig and cow manure, it's gold”*. *“They just have to change their farming system. It is up to them to change, to switch systems. There has been a chronic loss of fertility in France for several years. And it's not thanks to digestates that the soil will be fed”*. However, other local agents have a more nuanced vision of the topic, although they acknowledge certain fears about the natural capital, and problematic functioning:

“The only fears were the drifts and seeing agricultural land diverted. I am sensitive to these arguments of the ecologist groups in the regional council” (Mayor).

“The issue of digestates is seen as an opportunity that is totally compatible with agroecology, but the actual management is not always the case: large farms have fertilization models that are not always optimal, but this is not solely the fault of digestates” (Chamber of agriculture).

We observed a similar cultural and political pattern in the territory of BioQuercy around agricultural development: *“Two visions and two trajectories of agriculture clash: new farmers who set up with capital and a small farm that survives, and established farmers who struggle to survive” (Farmer)*. This political “clash” leads to questioning about which agricultural model biogas production supports: *“It is a certain type of agriculture that is supported in the Lot, an intensive and productivist agriculture. Biogas production makes it possible to create off-ground farming and to have more liquid manure” (Collective)*. However, as for Kastellin, other agents express a more nuanced vision of the issue:

“Since there has been biogas production in the region, I'm not sure that any new farms have been created. Agriculture has tended to decline in the region” (Chamber of agriculture),

“the PNR is opposed to certain agricultural development practices in abundance because of the objectives of sustainable development and preservation of the environment” (PNRCQ).

In the territory of Bionerval, opponents to the biogas plant express their rejection of current farming practices and of *“productivist agriculture”* that impacts the natural capital: *“There is no soil preservation, there is erosion, they go like crazy with impossible gear”. “The machines that smash everything so heavy they are, so big they are”. “I am very angry against how the system works. We overfinance agriculture, we overfinance biogas production. Times have changed, agriculture as we know doesn't have to last forever. We need to rethink our agriculture”* (Mayor). We observe in these sentences the desire of some local agents to move to a different agricultural system, however the tensions and questioning do not seem to have reached the depth we have observed for Kastellin and BioQuercy.

Interviews with experts have confirmed these observations:

“there is a division between those who are for tradition and those who are for transition” (expert 10);

“There are very different views on agricultural development, the agricultural model, the circular economy, the ecological transition. Some people are opposed to biogas plants because they do not have the same vision of the agricultural world. It depends a lot on the territories” (expert 10).

There is therefore the necessity to *“consider the history of the project leader and how he is rooted in the territory, and the history of the territory itself: are there previous biogas plants, previous conflicts, networks?”* (expert 10). Experts also confirmed the questioning on what system biogas plants support, rather agroecological systems, or intensive livestock farming?

However, we observed a rather homogeneous cultural context in the territory of Terragr’eau: *“The farmers are all pro-FNSEA so they have more or less the same basic ideas”* (SICA); *“We are an agricultural territory, we work with the agricultural world”* (CCPEVA); and a nuanced vision of agricultural development: *“We are not in industrial agriculture and yet we have big tractors. The two are not incompatible”* (CCPEVA).

Our investigation did not allow us to collect information about the cultural context of Biomethan Zittau.

3.2. Different levels of technical support

We observed cognitive contexts⁴⁴ shaped by different levels of technical support provided to the biogas sector and to the land application of digestates.

For Bionerval and BioQuercy, we observed the activation of the cognitive & technical capital by public institutions and associations. In the territory of Bionerval, the strong institutional context around the land application of organic matter, composed of the SATEGE, the MUAD and the CPE, as well as of the Chamber of agriculture of the Oise, is mobilized to provide technical support to the sector and to enrich the local cognitive & technical capital:

“We advise, we push the sector upwards. We must not lose this technical advisory role” (Water Agency);

“We hold yearly meetings with the producers of effluents to sensitize them about land application” (Water Agency);

“The Chamber of Agriculture is involved from providing information to farmers to providing technical support. We have two major axes: training and advising, and giving our opinion on land application plan, mainly on the pedological part” (Chamber of agriculture).

In addition, the ROSO also contributes to the cognitive & technical capital on the side of consultation topics: *“The ROSO has developed a consultation guide, and the ROSO has received awards and distinctions for its work on consultation”* (ROSO).

There are therefore different groups of agents on the territory that contribute to the activation and the enrichment of the cognitive & technical capital.

In the territory of BioQuercy, the Chamber of agriculture of the Lot argues that *“we have the possibility of supporting waste producers. We support at several levels: drawing up the spreading plan, annual monitoring of the spreading of digestate, soil analyses, sampling”*, as well as *“we accompany and lead the group having a biogas plant project, we organize events with selected speakers to explain biogas production”*. The MESE Occitanie, at the regional level, also contributes to enrich the technical & cognitive capital through *“the production of documents such as technical guides and how to draw up a land application plan”*. The specificity of this territory, with its karstic subsoils and the presence of many caves, leads also

⁴⁴ By cognitive context, we mean to investigate the stage of the cognitive & technical capital, and the cognitive proximities.

to the existence of a specific technical & cognitive capital held by specialized associations that aim at supporting the other local agents: *“The caving committees wish to share their expertise on the subject of karst with the institutions”* (Letter of the Lot department and the Midi-Pyrénées region speleology committees to the Lot prefecture).

For Kastellin and Zittau, the technical support remains in the hand of public agents. In the territory of Kastellin, the AILE plays, in some ways, a similar role to the institutions of the territory of Bionerval, as a *“resource center”*: *“project leaders come when they have concerns, when they don't have answers to their questions”*. Concerning digestates specifically, *“AILE is called upon to provide training to biogas plants or other players in the sector”* (AILE). In Zittau, a partnership was created in 2003 between the University of Görlitz/Zittau and the municipality of Zittau to improve and help with the energy transition and energy efficiency, especially on biogas production, thus providing knowledge and skills to local players.

Finally, for Terragr’eau, both consular bodies and private agents support local agents and enrich the local technical & cognitive capital. There is, on one side, the support provided by the Chamber of Agriculture: *“we provide technical support because farmers have questions about the uses of digestate and we carry out agro-environmental studies to protect the environment”*. In addition, Danone, as a private actor, also plays *“an important role”*:

“They have been present in the area for a long time and have been working on environmental issues for a long time” (managers);

“Danone had been looking for some time to implement actions to preserve water and the environment. As early as 2007, there was a lot of thinking going on” (Chamber of Agriculture).

Moreover, the consular body, i.e., the Chamber of Agriculture, and the private agent, Danone, have been working together *“for more than 20 years”*, with for instance: *“For some time now, Danone has launched its own regenerative agriculture programme. The chamber plays the role of technical advisor”* (Chamber of Agriculture).

3.3. Issues with skills and resources

Our investigation with experts, and for the cases of Bionerval, BioQuercy and Kastellin, revealed issues with skills and resources that are more or less available to the agents in the sector. However, interviews conducted for Terragr’eau and Zittau did not reveal similar issues.

The first topic highlighted concerned the culture of risk management that seems to be

more developed for industrial biogas plants than for agricultural biogas plants, which is therefore a cognitive advantage for our case studies:

“Industrial biogas plants consider that they are better equipped, better trained and more competent than agricultural biogas plants to manage risks and accidents” (Managers – Bionerval);

“the technical and financial capacities are much more readily available in industry, with a risk culture” (DREAL 29 - Kastellin);

“I would say that there are even more risks with agricultural biogas production, because it is a very advanced technology with multiple sources of breakdowns and accidents” (EPAGA - Kastellin);

“Engineers are more used too industrial equipment than farmers, and there may be better risk management for industrial plants” (Expert 15).

The second topic highlighted concerns the general lack of attractiveness and skills within the sector, for many groups of agents, State services, operators and managers of biogas plants, municipalities, and consultancies:

“There is a lack of skills in design offices. Reflections that do not go all the way. In terms of public policy, they see no further than the regulatory framework for the biogas plant” (DDT 60 – Bionerval);

“There is a problem of competence of State Services” (mayor – Bionerval);

“There is a problem of attractiveness of the sector. A lack of qualified personnel. Salaries are not attractive enough. There are recruitment difficulties. And a lack of skills and training” (managers – Bionerval).

“With this system, we elected officials are at hue and dia. You can't be focused on everything. In a small town, we do not have an army of technicians. It's good to involve elected officials, but we are quickly overtaken by events” (mayor – Bionerval).

“There is a lack of competence of the operators of industrial biogas plants” (DREAL 29 - Kastellin).

There are also internal problems of *“skills on the part of agents in terms of industrial processes in particular. ICPE inspection missions have been opened up to people who have no training*

in industrial issues. We need to restore skills in staff through in-house training of agents. We are dealing with process complexities that need to be updated and questioned” (DREAL 29 - Kastellin). This lack of skills and knowledge also impacted Germany but the sector managed to increase its skills: “This was really a problem. So, there was a lot of trainings, visits, a lot of exchanges, lots of biogas experts with round tables twice a year at DBFZ⁴⁵. In a way we have the state of the art now. Now we have well-established systems, and experience” (expert 11).

The other issue we observed was an issue of lack of staff in state services and local institutions to support and accompany the development of the sector, at least in the territories of Bionerval and mainly of BioQuercy:

“There is a lack of staff on State services” (ROSO – Bionerval);

“As there are few staff in the park, the PNR has not set itself a target in the biogas sector” (PNRCQ – BioQuercy);

“The Chamber of Agriculture does not have a specific advisor to accompany the installation of biogas plants” (Chamber of Agriculture – BioQuercy).

Finally, we observed a issue with equipment, logistics and training availability, mainly for BioQuercy, and an issue with training for Kastellin: *“Training, it’s an issue” (AILE - Kastellin); “There is no logistical system for mass spreading of digestates in the area” (MESE Occitanie – BioQuercy); about the land application in the local karstic system: “For the moment, we have not yet developed a guide for the Lot because there is no funding” (Chamber of Agriculture – BioQuercy); “We have tried to set up a training course for farmers who take digestate, to do some agronomy, explain the equipment, the dosage... but for the moment not yet” (Chamber of Agriculture – BioQuercy).*

To conclude with this part, we observed a cultural and political clash between different visions of agricultural development in the territories of Bionerval, Kastellin and BioQuercy, which we did not observe for Terragr’eau and Zittau. This situation creates a fertile ground for local conflicts about the biogas plants and the use of digestates, which are sometimes accused of supporting intensive and polluting farming systems. To this cultural context adds heterogeneous cognitive and technical contexts. We observe different modes and levels of technical accompaniment that depend on the institutional contexts we described earlier in this Section. There also seems to be a global tendency towards a lack of human, financial and

⁴⁵ German Biomass Research Centre

equipment resources in the biogas sector, and a lack of skills and knowledge from many different groups of agents: State services, consultancies, managers of plants... However, it also seems that industrial biogas plants, which are the focus of our research, have more financial and technical resources than agricultural biogas plants, and are therefore better equipped to deal with risk management.

Cases	Cultural divergencies about agricultural development	Different levels of technical support	Issues with skills and resources
Bionerval	Some local oppositions to “productivist agriculture”	Several regional and sub-regional organisms & associations provide technical support (SATEGE, MUAD, ROSO)	Global tendency towards a lack of human, financial and equipment resources in the biogas sector, and a lack of skills and knowledge from many different groups of agents: State services, consultancies, managers of plants...
BioQuercy	Clash between two visions of agricultural and territorial development	The main supports come from the Chamber of agriculture of the Lot	
Kastellin	Existence of long-term and large-scale conflicts about agricultural development	Support provided by the AILE and by the chambers of agriculture	
Terragr’eau	Homogeneous opinion about agriculture in the territory	Support provided both (and in partnership) by the chamber of agriculture and by Danone	
Zittau	<i>No observations</i>	Partnership between the municipality and the University of Görlitz/Zittau	

Figure 44: synthesis of the cultural and cognitive contexts. (Source: own table)

Conclusion of Section 1:

We demonstrated in this section, through the analysis of our data, that our case studies are embedded in heterogeneous local and regional contexts, with some similarity between certain contexts, and differences. These similarities and differences create unique territorial

combinations. Therefore, it validates the methodological assumptions we made in chapter 4, about the diversity of contexts that our case studies would allow us to investigate.

One constant for our French cases is the vulnerability of water resources and the induced fears for the protection of this component of the natural capital. Also, agricultural activities are often seen as threats to the protection of water resources, mainly in the territories of BioQuercy, Kastellin and Bionerval, and also in Germany, but as an opportunity to protect the resources in the territory of Terragr'eau, if an improvement of the infrastructural & equipment capital is made. As a result, biogas production and the land application of digestates is often seen as potential additional threats, or as new opportunities to protect the natural capital, depending on the territorial contexts.

In addition, the economic and organizational contexts appeared to be more or less favorable or unfavorable to the valorization of digestates, and a more or less developed organizational proximity pre-exist between local agents, depending on the economic history of the territories. Institutional contexts also differ and embody different degrees in the organization and the formalization of coordination between local agents, and we observed different degrees of institutional proximity constructed over past decades. Time therefore appears as an important parameter in the construction and the shaping of the different resources and proximities that pre-exist to the valorization of digestates.

But obviously, the spatial scale too appeared to be a differentiating element between our different cases, with alternatively the scales of the watershed, of the department, of the region, of the Natural Regional Park, and of the municipality being the receptacle and the “activation territory” (Niang et al. 2020) of the different resources.

The cultural contexts too are source of duality, as pre-existing cultural clashes can be fertile ground for new conflicts, whereas shared cultural values support the coordination of local agents towards a common goal. In addition, shared cognitive & technical resources, sometimes enriched by specific agents, can support this coordination, whereas we assume that missing common resources can reinforce existing tensions. The duality of these contexts, both favorable and unfavorable to the valorization of digestates, create unique territorial combinations that lead to both opportunities and conflicts around the valorization of digestates, as we will explain in Section 2.

Section 2: From these ambivalent contexts emerge opportunities and conflicts

Introduction of Section 2

In this section, we present, at first, how the different contexts detailed in Section 1 create opportunities for the valorization of digestates. In a second part, we show how these ambivalent contexts also generate fertile grounds for tensions and conflicts around the valorization of digestates. After the conclusion of the section, we display timelines of the main events of our case studies.

1. Opportunities and organization of the valorization of digestates

1.1. The mobilization of the agro-industrial context for both the sources of feedstocks and the valorization of digestates (Bionerval, Kastellin, BioQuercy and Zittau)

For the biogas plants of Bionerval, Kastellin, BioQuercy and Zittau, we observed drivers for the launch of the projects and for the uses of digestates rooted in the mobilization of the local agro-industrial contexts we presented in section 1.

Concerning the location of Bionerval, in the Community of municipalities of the Pays Noyonnais, which includes the city of Passel where Bionerval is precisely located, this place was “*interesting because at the barycenter of the targeted agro-industrial waste deposit*” (managers). We observe here the mobilization of the economic capital we described in section 1. Once the location of the biogas plant had been decided, “*Cérèsia and Innov'aisne were invited to join the capital because they were composed of farmers owning lands available for the valorization of digestates*” (managers). We observe here an attempt to set up organizational proximity between the biogas plant and local agricultural companies to mobilize land resources.

However, at first, the biogas plant composted the totality of its digestates because no land application plan had been accepted by State services. Then, to set up the first land application plan accepted by State services: “*The biogas plant needed a land application plan, and a land application plan for the sugar factory already existed. Eric Delacour explored the area covered by this land application plan and contacted the farmers in the plan*” (Farmer). Again, the existing economic and agricultural contexts served as a basis for the valorization of digestates. As a result of this investigation, “*a dynamic group of farmers located 20 km from the site, with many hectares of land, showed great interest, largely because they were already*

compost customers and the digestate was very cheap. The confidence and the knowledge of the biogas plant had already been built up. The crux of the matter was the low price and the knowledge and trust in the biogas plant” (managers). We observe here the importance of good experience and trust, and therefore, of some social proximity, in the will of farmers to accept the digestates.

Later, in 2015, the biogas plant was purchased by SARIA, an industrial company that owns several biogas plants and manage, in total, 30 000 ha of land application plans. The experience and knowledge, i.e., the cognitive & technical resources of SARIA were used as an argument in the expansion of the land application plan: *“I used our past experiences with the land application plans of the other biogas plants we own, and I highlighted this experience in the discussions with the DREAL”* (vice-CTO). Here, we see that the experience gained by SARIA in other territories was used to enrich the cognitive & technical resources of the territory.

However, the current land application plan (3rd version) extends on different territories that are considered heterogeneous by the local agents (three departments and different agricultural areas): *“We have the joy (ironically) to deal with different visions and different organisms. Each territory has its own perspectives; each territory has its own sensitivity”* (Vice-CTO). Local agents consider that *“the land application plan is divided in two regions: there are land applications departing from the biogas plant and land applications departing from the storage of Barleux⁴⁶”*. The heterogeneity of the economic and agricultural contexts within the land application plan is described by agents as follows:

“The agricultural landscape of Passel is particular: the economic aspect is much less important than in other areas. The farming population lives well and does not see the economic interest of digestate compared to the disadvantages. On the Barleux side, the crops are different, so the clientele is much more demanding, and the degree of demand on the soil is not the same either” (vice-CTO);

“In Passel, there is still a lot of livestock farming, so the guys are not looking for a by-product when they already have their effluent” (SARL Cadet).

As a result, the land application plan extends on three different administrative territories (three departments) and on two different territories (Barleux and Passel) that are defined and bounded by their economic and agricultural contexts.

⁴⁶ Barleux is a small city in the Somme department at around 40km of Passel

The land applications are carried out by a local company called SARL Benoît Cadet. The same fees are charged to all farmers in the region of Passel (3€/m³). In the region of Barleux, the biogas plant contributes to the transportation costs to fill the storage (around 7 to 10€/tone) and the fees applied to farmers vary between 2 to 4€/m³ depending on the distance to the storage. There are also “*several remote storages*” (managers) in addition to the storage of Barleux: “*We built secured and covered storages*” (Vice-CTO); “*I accommodate a storage pocket for digestates because I am far from Passel*” (Farmer). Here we observe the necessity to mobilize the infrastructural capital to manage such a vast land application plan. To support the setting up of this quite vast land application plan, the SATEGE and the MUAD, i.e., the public institutions we described in Section 1, “*contributed a lot. There are field people, who have relationships with farmers and with industries. They have requirements, and it went very well*” (managers).

For BioQuercy, we observed the mobilization of the local agro-industrial activities around duck breeding for both collecting feedstocks and finding valorization options for the digestates. According to the managers of the plant, speaking for Fonroche, the first principal shareholder of the plant, “*the project was born out of a partnership with CAPEL for its duck manure, which smells when you spread it, but also because of bird flu*”. The objectives for the private-private partnership between CAPEL and Fonroche, were to “*sanitize duck manure, to recover slaughterhouse waste and energy for the company's activities, to have an alternative to chemical fertilizers, and to participate in the energy transition of the region*” (managers). The project really aimed at mobilizing the agricultural and economic resources of the region. A testimony from a farmer confirms the spirit of the project and highlights the potential for improved agricultural practices:

“I made the decision to join BioQuercy to sanitize the duck manure. I am very happy with the digestate: it smells 10 times less than duck manure, it doesn't burn the plant, there are no more feathers in the hay, it's more concentrated, so we use less per hectare, so we save diesel”.

The hope to induce change in agricultural practices through the use of digestates is confirmed by the grey literature:

“Spreading digestate should replace the use of liquid manure and chemical fertilizers, saving 1,030 tons of synthetic fertilizers” (BioQuercy's website);

“It frees up time for farmers” (Chamber of Agriculture).

In addition, the biogas plant is supposed to help maintaining agro-industrial activities in the region and to “*reduce financial burden for farmers thanks to digestate*” (ActuLot, November 2018). According to managers, there was “*no problem at the beginning of the project*” and the land application plan was set up “*with a consultancy*”, and with the technical support and the “*expert advice*” of the Chamber of agriculture. Two types of exchanges are available to farmers, either an exchange manure-digestates, or the purchase of digestates and the land application by a specialized company (Report Inspectors, 2019). In addition, as for Bionerval, there are remote storages available at farmers to store digestates (mobilization of the infrastructural capital).

Again, for Kastellin, as for Bionerval and BioQuercy, the choice of its location directly depended on the desire to mobilize the local economic, infrastructural and agricultural resources we described in section 1. The location was chosen: “*because of its proximity to the gas pipeline*” and “*the site is in the heart of an area with a lot of livestock, so they could work with local farmers*” (mayor). In addition, the location is in an “*industrial zone far from housing*” but “*close to main roads*” (mayor). From the perspectives of farmers, one motivation for participating in the project was to find a “*solution for treating liquid manure because otherwise I would have had to invest in a liquid manure treatment station, as being above 12,000 units of nitrogen*” (Farmer), which directly relates to the regional issues of water pollution by nitrates from agricultural activities (Section 1).

However, the regional cultural tensions about agricultural development (Section 1) also impacted the design of the project: “*I was suspicious at the beginning. I insisted on the fact that the biogas project had to be based on liquid manure and agri-food and green waste, so that it would be relevant for the territory, but I did not want dedicated crops. I wanted it to make sense for local agriculture*” (mayor). Thanks to the guarantee, the mayor agreed to the project, i.e., the institutional capital was activated: “*I saw it as a fairly virtuous system*” (mayor). The activation of the institutional capital was very strong for Kastellin, as “*the project was supported by the Region*” (mayor) and the biogas plant was launched in the presence of many high ranked State representatives: members of the Senates, members of the Ministry for the Ecological Transition, Prefects..., as the showcase of a top-down sector whose development has been much supported and promoted at the national level.

Concerning the functioning of the land application plan, we observed same schemes as for Bionerval and BioQuercy. Either the digestates are spread by a specialized company, or “*it's the farmers who do the spreading and they are paid for this task by the biogas plant. We do some of the spreading, which is close to our house, and the far-off land is done by the ETA. We*

are paid about 80€ per hour” (Farmer). Here again, the necessity to mobilize the infrastructural capital is raised: “we have to bring the slurry every 15 days to the biogas plant because of the low storage capacity of raw slurry on the biogas plant’s site”; “There are several remote storages of digestates. It suits us because the plant is closed at weekends, whereas we are allowed to spread on Saturdays” (Farmer).

We observed, for our German case study, similar attempts to benefit from the local agricultural context to find both resources for the biogas plant and lands for the application of digestates. Biomethan Zittau was designed “to furnish the city of Zittau” (managers). “We established a company, 50% for Sachsen Energie and 50% for the City. The project was a joint project developed together”. The project was therefore a public-private partnership, and the establishment of the company created organizational proximity between the two partners. However, there are not the same institutions in Germany such as the Chambers of agriculture in France, therefore, other types of support were sought: “A freelance agricultural expert was involved to accompany the farmers in using the digestates and growing the crops. The agricultural expert had to find the farmers. His job was to collect 1000 hectares, so 15 farmers” (managers). The aim of the project was to benefit from the local economic and agricultural context, but this context appeared to bring its shares of challenges: a lot of farmers were already working with other biogas plants, “we had some problems that some lands were too far for the operations, at 50km, and we opted for a 30 km area. But it was difficult to find all the contracts so we had to make contracts with lands at 50km” (managers). This situation is confirmed by the local Polish press (Zinfo, February 2014): “Due to long-term contracts signed by German farmers with other biogas plants in Germany, it was forced to seek supplies from the Polish side. In total, 27 contracts were signed with Polish farmers, and 900 hectares of agricultural land were allocated to the cultivation of maize in the border communes”. To manage this vast area, the managers called on “an intermediate company” that “takes liquid digestates from the plant and put in the pools (storage) and then bring back some maize”; “We organized these storages next to the fields since the beginning because too expensive otherwise”. Therefore, to overcome the local challenges and benefit from the agricultural resources, there was the necessity to mobilize the organizational capital and the infrastructural capital. In terms of contract, the managers said: “Digestates were part of the contracts since the beginning. We buy maize and the farmers they pay for the digestates”.

1.2. A solution to protect the water resources through improved agricultural practices (Terragr'eau)

The four precedent situations we described can be basically summed up as attempts to mobilize the agro-industrial resources to find feedstocks to produce biogas, and to find lands to apply the digestates. For Terragr'eau, we observed very different objectives: the main aim was to protect the water resources, in its different forms, drinking water, and snow for the tourism, to maintain the local economic and agricultural activities.

Through the setting up of the particular institutional context we described in Section 1, with the APIEME, *“a first action was launched in 1992 with farmers and INRA to identify and limit the risks and to support farmers in rational fertilization”* (APIEME), long before the project of the biogas plant. Then, there were *“field composting trials”* and a *“long history of trials to protect the water resources”* (APIEME). Long before the biogas plant, organizational proximity had been activated to protect the water resources and the territory had gained experience on this topic.

This history of cooperation went through different steps, with, since 2004, *“the collective management of effluents, with composting in the field but only for manure, and it did not treat slurry. It was not satisfactory for APIEME and the farmers. So, little by little, the biogas plant project was considered”* (farmer). In parallel, an organization of farmers, called the SICA Pays de Gavot had been created, since 1993, to support the collective thinking about the management of local manure, and it *“was the place where this reflection was born”* (about the biogas plant) (farmer). There was therefore the sense of similarity between local agents, i.e., the sense to follow a shared aim, and a sense of belonging, as they already belonged to formalized groups of thoughts.

Consequently, the idea of the biogas plant emerged as the result of years of collective thinking and attempts to coordinate around the protection of water:

“At the outset, Danone noted that there was a lot of spreading in winter because farmers did not have enough storage capacity for livestock effluents, which meant that they were spread on frozen ground or on snow. In order to avoid this spreading and the risk of water contamination, a project was launched to set up composting, but this did not work. Danone promoted biogas production to increase storage capacity, with 6 months of storage. So, no need for farmers to invest in storage” (farmer).

We see here the major role of Danone in promoting collective action. There were also additional objectives: *“to manage farmers' fertilization and to have a serious, recorded, traced spreading plan. And to have all analyses recorded, ETM, CTO, salmonella, agro values...”* (farmer). We observe here both the will to improve the infrastructural capital, and also to improve agricultural practices.

The land application plan is managed as follows: spreading takes place at between 380 and 1200m height (Réussir Lait, January 2021), and *“prices are fixed for 5 or 10 years”* for the digestates (APIEME). The land application is charged 2€/m³, the actual cost being of 9 or 10€, covered by the APIEME and by Danone. There is a storage capacity of digestates of 6 months at the biogas plant and three remote storages of 500 m³ each (Réussir Lait, January 2021). In terms of organization, the biogas plant, through the creation of the company *“SAS Terragr’eau”*, used to collect the effluents from the farmers free of charge: *“We collect the wastes, we transform it, we compost the digestates and we return the compost and the digestate to the community for free and we produce gas to finance the system”* (managers). We observe the fundamental difference with the other case studies: the production of biogas supports the management of effluents and the valorization of digestates, and not the opposite. In addition, a SICA Terragr’eau *“was created with Danone and the CCPEVA on the board of directors”* to manage *“the return to the soil of the land applications”* (Chamber of agriculture). We see here that the existing organizational proximity between local agents allowed the creation of a new organization, the SICA, and the mobilization of the organizational capital of the territory with the aim to valorize digestates. In addition, the Chamber of agriculture *“helped in recruiting and training the technician (of the SICA)”* (Chamber of agriculture). About the SICA:

“they are the ones who do all the monitoring of spreading. It works because they [the farmers] are organized. And the collection of effluents was newly delegated to the SICA as it is easier for the SICA to handle” (managers).

There is here a clear statement about the interest of an efficient organization to manage the valorization of digestates. In addition to the SICA that monitors the land application, *“it was necessary to create a CUMA, which is the same as the SICA, but to obtain subsidies. The CUMA bought a tractor and 4 barrels”*. There are also *“two ETAs in the sector who help with the spreading. The CUMA makes its equipment available to the ETAs so that they can carry out the spreading. The ETAs just invoice the driver hours and the tractor hours”* (managers). The valorization of digestates benefits from the economic and the organizational context of the territory, and necessitated investments in the equipment capital.

Opportunities for the valorization of digestates

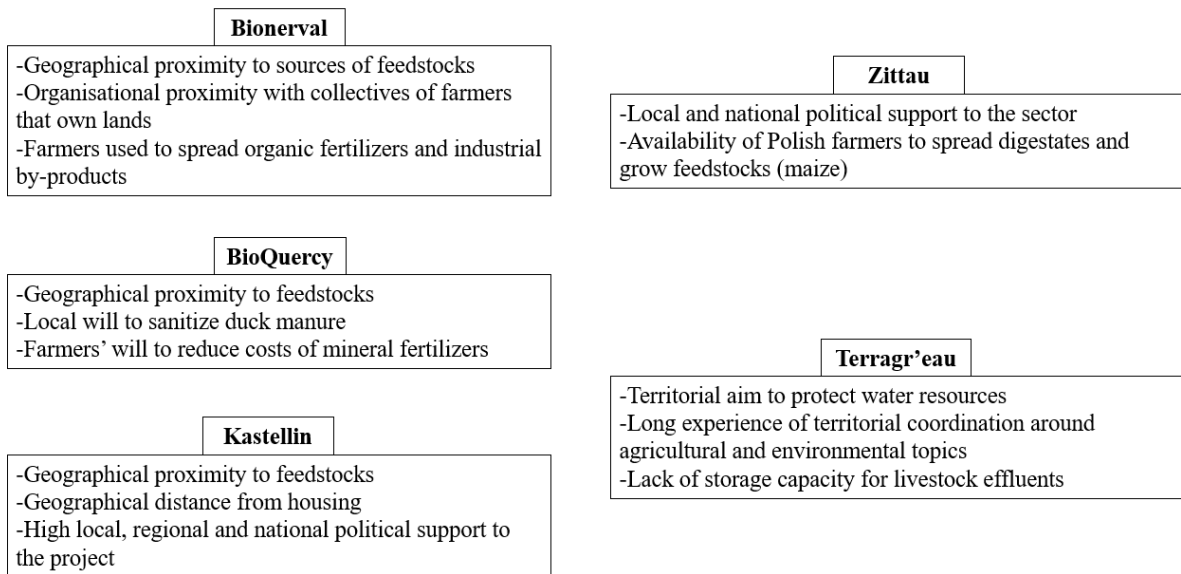


Figure 45: the opportunities for the valorization of digestates. (Source: own graph)

2. Tensions and conflicts around the valorization of digestates

We observed mainly three types of problems that led to tensions or to conflicts, and that took different forms across our case studies.

2.1. Issues with the infrastructural & equipment capital that threatens the natural capital

The first type of issues we observed for all of our French cases concerned failures of the infrastructural & equipment capital that could pose of threat to the natural capital. Some experts first evoked this specific problem, that seems to impact the whole sector: “*The adequate storage capacities of digestates is an important issue*” (expert 17); “*there is the necessity to have adequate storage capacity for the periods when digestates can't be spread*” (expert 12). We did not observe this for the German case studies.

Concerning Bionerval and BioQuercy, we observed only a few issues concerning the infrastructural & equipment capital. For Bionerval, one issue concerns the capacity to adequately mobilize the equipment capital, at the right time and at the right moment, which implies an adequate activation of the organizational capital: “*In spring, shooting windows are*

complicated. The limit is time, and the availability of equipment, which cannot be everywhere. You have to be in partnership and to be sharp" (Farmer). In addition, two incidents were mentioned that created local conflicts. One incident consisted in the land application of digestates containing a lot of plastics at a farmer, following the digestion of "*deconditioning soups*" full of plastics: "*The farmer ended up with lots of plastic scraps in his meadow. The breeder was furious, its meadow was deteriorated but Bionerval did the necessary, surely a compensation. Bionerval then installed the right filters to prevent this type of incident from happening again*" (managers). We see here that an insufficient mobilization of the equipment capital led to the pollution of the natural capital, the soil of the meadow, and polluted soils often lead to polluted waters. Another issue concerns "*several failures at the level of the biogas plant*" including the "*spillage of very black sludge in the inter-municipal ditches*" (mayor) although our interviewee could not certify that it was digestates. But this event led the mayors of Chiry-Ourscamp and Passel to fill complaints against the biogas plant and to make "*several requests for the inspection to come*" (mayor). Indeed, this spillage deteriorates the local municipal infrastructural capital, and can pollute local waters flowing in the municipal ditches.

For BioQuercy, the Inspectors' report (2019) mentions "*several leakages of digestates during the first months at farmers*" because of poorly designed remote storages. These leakages led to stopping water collection in a place called Montvalent. Due to these incidents, fears persist in the population about water protection, health and the security of infrastructures, in a territory already largely preoccupied by the protection of the water resources and the geological heritage (see Section 1). One of the groups of opponents to the biogas plant criticizes the "*increase in volumes*" of digestates "*without considering the problems of the karstic soil*", and justify their existence "*the collective was created in relation to the caves and the surrounding heritage. The caving collective says that these areas must be protected, knowing that there are already problems of closure of water treatment plants because of storms which wash out the karstic soils*" (Collective). The farmers union Confédération Paysanne also echoed these fears, citing, on their website, "*irregularities observed on the site, during land application, and on remote storages*" leading to fears about "*massive pollution due to the mass spreading of digestates*", hence the necessity to conduct "*non-violent action*" to protest.

The biogas plant of Kastellin experienced one major accident in 2020, that paved the way to years of local conflicts. The DREAL 29 confirms that there had been no conflict since the beginning of the project, in 2012, therefore we observe again here that conflicts can start multiple years after the operation of the biogas plant starts. The accident occurred during the

night between the 17 and 18th of August 2020, with a small watercourse first polluted by a massive leakage of digestates, that then reached the river Aulne, the main local river (Internal note, EPAGA, 28/08/2020). As an important water catchment was polluted because of the ammonia contained in digestates, around 180 000 inhabitants from 51 municipalities were deprived of drinking water for 5 days (France 3 Bretagne, 30 August 2020). According to the press, inhabitants “*rushed into supermarkets to buy water*” (France 3 Bretagne, 21 August 2020). To date, the exact share of responsibility between human and technical failure that caused the accident is not clarified and is still source of local debates:

“The staff had nothing to do with it, it's a design thing. In the process that was put in place, they trusted all the electronics but there was no mechanical safety behind it”; “I am not convinced that it was a human failure” (farmer);

“The problem with the accident was that there was no one at the site, and those who arrived at the site were agents without all the skills. It was a complete mess, the right decisions were not taken, nobody detected that the site was overflowing. Initially, the state services did not take the measure of the problem” (mayor);

“There are human and organizational factors behind the accident. Industrial operating practices were not mastered by the actors” (DREAL 29).

It seems that there was, at first, a technical failure in the storage of digestates, followed by several human and organizational failures, at the level of the biogas plant but also at the level of the territory (including state services), that led to the accident of this magnitude. The biogas plant had been purchased by its current owner just six months before the accident, and the DREAL considers that the purchase happened because “*the installations had reached an industrial dimension that the operators could not manage. The incident reveals that the transfer of knowledge was not up to scratch*”. In addition, the period of the year when the accident happened worsened the accident: “*When there is no more water in the sector, in central and southern Finistère, the only resource left is the Aulne. And there, we were at the end of August, in a period of low-water level already pronounced, all the communes and communities of communes were connected to the Aulne*” (EPAGA). This situation is even intensified with climate change and droughts, and during the interview in September 2022, the EPAGA said “*If at present, a similar accident that in Châteaulin happened, no one would have any water left*” (EPAGA).

This accident also echoed some fears expressed by local environmental associations and

local inhabitants in the public survey of 2018: fears of the proximity of the land application of digestates with shellfish farming, fears for some beaches in the Bay of Douarnenez already closed because of pathogens, concerns about the lack of storage capacities for digestates, and the non-compliance of remote storages at some farmers, complaints about the inadequacy of some town roads for land application machines, and degradation, dirt of roads and buildings. It echoed the fears of the EPAGA too, concerning the lack of infrastructure and equipment to protect the local water resources from any spillage: *“There are bridges upstream of water abstraction points with no devices or basins to protect the watercourses and buffer accidental spills of possible toxic substances”*.

Consequently, this accident seems to result from a combination of issues with the infrastructural & equipment capital, of a lack of cognitive & technical capital to manage industrial facilities we already highlighted in section 1, and a failure of the rightful activation of the organizational and institutional capitals.

Of course, the accident generated conflicts, in an already-fertile ground for political conflicts, as we described in section 1: *“There were demonstrations immediately after the incident on the spot in Châteaulin, by political parties who demonstrated and who denounced biogas production, and who took advantage of this to scratch the mayor who is not of the same political persuasion”* (mayor). In addition, several judiciary complaints were filled by different groups of agents: environmental associations, municipalities, the local mixed-union for water management... and the accident added fuel to the fire of existing political and cultural conflicts (see sub-section “cultural and political conflicts”).

Concerning Terragr’eau we have observed tensions about the infrastructural & equipment capital, with some fears for the protection of the natural capital, but no open conflict, and no factual damage of the natural capital. We observed two different sources of tensions: tensions about the impacts of land application operations on public infrastructures, and tensions about the on-site storage of digestates that is undersized.

Concerning the first source of tensions, interviewees argue:

“there has been contestation about the traffic of tractors and the size of tractors with 15 to 20-ton trailers by local residents and by the municipalities” (CCPEVA);

“The main problem is not the congestion of the roads but the size of the machines, because the roads are small and not well marked. Before, each farm managed its own spreading. Nowadays everything is grouped together in one place, which sometimes makes it seem like there is

congestion in one place. In the past, each farm was able to move around as it wished” (CCPEVA);

“There are some concerns about traffic, as fewer tractors are driving around, but for longer periods and always towards or from the biogas plant. Some residents on this road are unhappy with the traffic. And also because of the size of the tractors, much larger. But the size of the road remains the same and the roads are not very big, and cars are idling” (managers);

“Before, 45 spreading machines were in circulation during the same week, today there are just 5-6 but much larger. So there were complaints from mayors in the first year because of unsuitable dirt roads, and because of the size of the spreading equipment” (SICA);

“Residents' complaints are mainly about truck traffic” (APIEME).

We observe here that the operations of the biogas plant induced a change in the equipment capital, that causes nuisance to some local inhabitants due to geographical proximity, and potential damages to the public infrastructural capital.

Concerning the issue with the undersize storage:

“The under-sizing is a real major technical problem. In winter, the biogas plant is saturated, and in summer, the site is in sub-regime, so there is pressure to spread digestate in the spring” (APIEME);

“The operator is not competent, they have completely screwed up on the sizing of the site” (farmer);

“The storage problem for digestate is still not solved. There were sizing concerns for the storage at the origin of the project. No off-site storage was installed at farmers, although it was planned at the start of the project. From 2017, there were problems with full storage. Therefore, from 2018, the capacity of the biogas plant had to be reduced. From year to year it got worse. This year, the worst of the worst, there were sedimentation in the tanks, bad mixing” (SICA);

“The tensions were mainly related to storage, especially in February when the pits filled up” (managers);

“Remote storages were planned at the beginning of the project but not built. There is a problem of managing inputs before winter and problem of managing digestates after winter” (DDPP).

This situation creates “*fears about leaks and overflows due to overfilled storage facilities*” (SICA).

There were already issues with agricultural storages before the biogas plant (section 1) and the management of effluent, and the biogas plant was supposed to improve this situation. The issue on the infrastructural capital seems to repeat itself. There was also an incident with a land application carried out too close to a water catchment area, leading to a cut in the water supply of the inhabitants, but no complaint was lodged by the inhabitants, contrary to Kastellin. We will try to explain, in Chapter 6, how the local coordination of agents after the incident avoided a conflict, contrary to Kastellin.

We did not observe, for Biomethan Zittau, tensions or conflicts linked to the potential damage to the natural capital that issues with the infrastructural & equipment capital could cause. However, we acknowledge that this lack of observation could be due to a lack of collected data.

2.2. Issues caused by unpleasant smells

We observed that unpleasant smells from the different operations of valorization of the digestates caused a lot of tensions and conflicts around Bionerval, BioQuercy and Biomethan Zittau, but not for Kastellin and Terragr’eau.

One of the most important sources of tensions and conflicts for Bionerval lies in the unpleasant smell coming from the operation of the biogas plant and the valorization of its digestates. According to the managers: “*Complaints often concern odors, but on-site, and not because of land applications*”, and if they had to recreate the biogas plant, they would “*directly install closed tanks and filters*”, i.e., to better mobilize the equipment capital. The main issues with the smell “*were mainly related to the COVID period, with difficult relations with the mayor at that time*”, because of “*2,500 tons of digestate which had to be re-sanitized, with weekend work to catch up, resulting in unusual odors*” (Vice-CTO). Because of these odor issues, “*Bionerval has received at least one visit every year from the DREAL, or even more, because there have been many complaints*”; “*The many problems mainly occurred in the first 6 years, but if there are no more problems, the site will be less controlled*”, with annual controls from the beginning of the plants’ operations to 2017, nothing from 2017 and 2020, and again the issues and the controls in 2020 and 2021 (DREAL 60). These smell issues are also recorded in

documents: *“Reports of punctual unpleasant smells”* (Site monitoring commission, 2018); *“Complaints about odors from the plant”* (Le Parisien, September 2020).

We see here both the spatial and the time scale of the conflicts, with conflicts that are mainly very local and that can last for years, with periods of calm followed by renewed periods of conflicts. But unpleasant smells are not only sources of conflicts on-site, but also at some farmers. One of the farmers we interviewed related its setbacks:

“I had complaints from my nearest neighbor during the last filling of my pocket storage, because the filling schedule was delayed due to COVID. The neighbor lodged a complaint at the level of the defense of the residents. The DREAL came and they said that my pocket was within 50m of dwellings, and it is forbidden”.

He already had complaints from this neighbor during the summer land application of digestates: *“During the 2-3 days of spreading, the neighbor could no longer eat on his terrace”*, and he filled a complaint without warning the farmer.

We see here that the unpleasant smell during storage and land application generates problems of quality of life in the neighborhood, due to unwanted geographical proximity between the neighbors and the operations of valorization of digestates, and leads to neighbors taking judiciary actions against the farmers. However, these issues can be nuanced thanks again to an adequate mobilization of the equipment capital *“With the machines of Cadet, there is an automatic limitation of odor”* (Farmer), and with geographical distance, i.e., the opposite of geographical proximity: *“my storage is away from any neighbor; thus, I have no complaints or anything”* (Farmer).

Similarly to Bionerval, issues of unpleasant smell are the sources of many conflicts around BioQuercy:

“When there were problems, they were mainly olfactory problems”; *“There were unbearable smells, all the people in the surrounding villages complained”*; *“An association of local residents was set up to combat the odors”* (mayor);

“The problems for the “anti” are odor nuisance and the underground” (farmer);

“Unbearable smells day and night, a major problem for some asthmatics” (La Dépêche du Midi, February 2019).

The Inspectors report (2019) also mentions formal complaints addressed to State services because of “*nauseating odors, even causing discomfort*” with “*peaks in spring and summer, and in north-westerly winds*”, and “*odors felt up to 2 km away*”. However, here again, we observe the time dynamics of conflicts: “*The big protests have calmed down considerably*” (mayor).

The conflicts around Biomethan Zittau are mainly due to unpleasant smell coming from a remote storage of digestates in Poland, to the transport and to the land application of digestates. As for our other case studies, “*during 2 or 3 years, there were no conflicts*” (managers); we observe here again the time dimension of conflicts, that sometimes rise years only after the beginning of operations. The local press, as well as the Polish Environmental State services reported the smell issue:

“Inhabitants of Zawidów, located 20 km from Lubań, have quite unpleasant odors that come from the digestate tanks, which are stored there by the German biogas plant in Zittau. The business smells intensely, poisoning not only the town but also the surrounding villages with the stench” (Przegląd Lubański);

“There is very bad air here, you don't know what to do with it all. Run away from here or live? People get dizzy and children vomit - says one of the tenants of nearby houses” (Przegląd Lubański);

Polish state services “*reported numerous interventions from residents of Krzydlice and odor nuisances associated with use and storage of a soil improver and organic fertilizer, digestate, which is produced by the biogas plant Biomethan Zittau GmbH based in Germany*”;

“Due to the process in which the product is produced (fermentation methane), its storage and frequent transshipment, especially in the period of intensive used in the fields by farmers, it is a source of unpleasant odors for neighboring residential development”.

We observe that geographical proximity with the storage and with the activities involved in the management of digestates impacted the quality of life of local inhabitants, that complained several times to State services.

Concerning Kastellin, there was no tension or conflict due to unpleasant smell reported by our interviewees or in the documents and press articles we reviewed, probably because of

the agricultural context we described in section 1, with already a lot of land application of manure, and because of geographical distance and skillful farmers:

“There was no need to complain about the biogas plant before the accident because there has always been manure spreading and farmers empty their slurry pits and spread it on their fields, and Châteaulin is not very large, and there are no housing developments near the fields” (Mayor);

“I have never had any complaints from neighbors, neither because of the slurry nor the digestates. I apply the manure in the direction of the wind so as not to go towards the houses” (farmer).

We made similar observations for Terragr’eau. There seems to be no conflict about the smell: *“There is no frontal opposition to digestates because they are more odorless than slurry”* (APIEME);

“There are sometimes odors, but less than with other effluents” (CCPEVA);

“there has been a clear improvement in the perception of citizens, especially with regard to odors” (SICA);

“there was no concern during the public enquiry because the biogas plant is far from housing” (managers). The reasons of this quiet situation seem similar to Kastellin: a geographical distance between the operations of the biogas plant and housing, and an agricultural context with lots of land applications of manure, the land application of digestates being only an additional similar activity, or even a solution to improve the odors issues linked to manure spreading.

2.3. Cultural and political tensions

We observed political and cultural conflicts for all our case studies excepted for Terragr’eau.

The conflicts we described in the previous parts are also fueled by the cultural and political tensions we exposed in Section 1. Concerning Bionerval, the cultural rejection of modern agricultural development in the speech of some local agent also hides a more political dimension at a very local scale: *“The municipality of Chiry-Ourscamp gave an unfavorable opinion because of the proximity to homes and to the food factory that uses air as an agent for drying pasta. It is inappropriate to put smelly odors next to the qualitative food factory”*

(mayor). There is an “*extremely strong financial challenge linked to the factory's brand image*” (the factory belongs to Pastacorp-Lustucru), “*when the bosses of Carrefour come to Pastacorp, there is a bad effect with the smells*” (mayor), and the biogas plant “*brings no financial benefit for us, unlike Pastacorp, which brings wealth to Chiry-Ourscamp*”. As a result, the mayor claims that “*I would only accept the biogas plant if it caused absolutely zero nuisance*”.

We observe that this unwanted geographical proximity impacts negatively the local quality of life and the economic capital, which adds to the political and cultural tensions about agriculture and biogas production. In parallel, this cultural dimension is also evoked to explain the cultural profile of the “complainants”:

“*In general, on Refood sites, complaints come from the same people, the Complaints Experts, who are often elderly and retired*” (managers);

“*For me, elders are more understanding, as they know agriculture. Today the problem is urban expatriates in the countryside who find it difficult to understand and adapt to life in the countryside*” (farmer).

There seems to be a cognitive proximity with some elder people that “*know agriculture*”, whereas this absence of cognitive proximity with newly installed and often retired inhabitants, creates a fertile ground for conflicts.

There are important cultural and political conflicts around BioQuercy, in a territory that have already been experiencing political clashes about local agricultural development (Section 1):

“*As soon as a project is a bit big and industrial in this area, it causes a reaction. It is systematically perceived as industrial even if it is not industrial. For biogas production it's exactly that. It forces us to argue, to review the scale of the project*” (PNRCQ).

There seems to be a fundamental opposition to biogas production and to digestates: according to one interviewee, the opponents claim “*whatever you do, we are against it*” (farmer) and wish that “*there should be no digestate, there should be no biogas plant unit. At first, they didn't like the fact that it was industrial. It was a bad image of the industrial sector. But in the end, no more types of biogas plants were accepted*” (managers). These conflicts seem to be rooted in the long history of cultural and political tensions we evoked in Section 1:

“I expected these epidermal reactions, because this division in the population already existed, because it's the same people who don't vaccinate themselves, who say that we should eat raw...”
(mayor);

“Those who did this, I expected it, because they are against everything. And it's difficult to discuss with people who are against everything” (mayor).

The conflicts seem to have been particularly violent in this area, according to some agents, although, again, we observe the time dynamics of conflicts that slowly rose and finally calm down, but with the potential to rise again:

“At the beginning, the project did not seem to be shaky, so it was not considered a big deal. But it became complicated because little by little it became politically tense” (PNRCQ); *“It was a late opposition from some associations. The opposition was formed after the biogas plant got authorized”* (managers);

“The police guarded the site monitoring commission of the biogas plant, and it was filtered”
(farmer);

“The opponents at the time had put glyphosate in the digestate, so that the digestate would burn. That was about three years ago. But the protests have since died down” (farmer);

“At the moment, there is less protest, but it remains latent” (managers);

“I find that it's becoming a little more relaxed” (Chamber of agriculture).

These political conflicts lead some farmers to abandon the use of digestates:

“In all the farmers who have stopped digestate, it is more because of social pressure than agronomic pressure” (managers);

“One farmer preferred to abandon the digestate under pressure from his neighbors, even though he was part of the spreading plan. He was fed up with the reproaches of the neighbors and the village. Those who give up are those who have less character than the others. I send off those who complain” (farmer).

Concerning the profiles of the complainants, we made similar observations as for Bionerval:

“They tend to be retired people who have time. Neo-rural profile, rather urban” (managers);

“The ecologists and the retired people who come from the city”; *“They are all together, they are in a group, they get on each other's nerves. They contest everything, they have time, they*

are retired”; *“They are anti-farmer, anti-productivist*”; *“People come there to rest, to retire, they can't stand anything”* (farmer);

They are people that have *“a vision of the countryside that is not quite the same as ours”* (mayor);

“I see the main opponents as neo-rural people who do not want to be around modern farmers with their tractors” (farmer);

“These people have time, they are everywhere, it goes in all directions and that's a shame” (Chamber of agriculture).

Concerning Kastellin, the accident of August 2020 we described earlier had a wide psychological impact and revived local and regional political tensions about the biogas sector:

“The accident caused by Engie has raised fears about the biogas sector, at least locally, in the Finistère, especially as Engie is a large company with a lot of resources, so a smaller company of the agricultural type, with fewer resources to manage the damage, can potentially pollute a lot too” (EPAGA);

“Engie was a wake-up call, it was a small local earthquake, it hurt, but it also made the elected officials aware that the source can dry up, and it is vulnerable” (EPAGA);

“It clearly marked a turning point. Châteaulin demonstrated that there is no such thing as zero risk. What is complicated in Châteaulin is that there is only one source of drinking water, there is no plan B if the water is polluted, and this has a very negative impact” (AILE).

We observe that this accident has raised awareness on the weaknesses of the sector and on the vulnerability of the natural capital. In September 2020, more than 50 local and regional organisms and associations signed a *“moratorium on the development of biogas plants in Brittany and the reinforcement of the control of existing units”*, and they insisted on the logic of similarity: *“we were all affected by the industrial accident at the biogas plant in Châteaulin on August 20”*. This kind of accident has the potential to federate oppositions against the sector, and to create a rather suspicious and unfavorable cultural and political context to the development of the sector.

Concerning Biomethan Zittau, in addition to the unpleasant smell and actual fears about the preservation of the territorial capital, the conflicts in Poland seem to hold a political and cultural dimension too, due to the transnational dimension of the biogas plant:

Residents complain: *“The Germans have clean energy, and we have broken roads through trucks and the stench is unbearable”* (Wrocław TVP 3, 18 April 2013); “

“Waste from Germany ... to Polish soil. Thousands of tons of waste from biogas plants in Zittau goes to the fields in Żarska Wieś. Residents, such as Elżbieta Kwaśniewska, councillor and farmer fear that it may be harmful and are trying to stop the practice” (Radio Wrocław, April 2013 and January 2014).

In addition, the managers of the plant claimed that there was a very local social conflict on-going: *“A farmer built a digestate lagoon for us. Unfortunately, this farmer had already been in conflict with the village neighbors for years. We did not know that. When the lagoon was built, the neighbors saw an opportunity to take revenge on the farmer. We just happened to get caught in the middle with the lagoon”*. We observe here the importance of the pre-existing organizational capital, and how the state of this organizational capital influences the degree of social proximity between local agents, and how this lack of social proximity can lead to local conflicts. Finally, here again, as with the other case studies, the managers identify the complainants as *“inhabitants [that] came from big city and do not understand the smell of the countryside. They come from cities, they buy a house and want only the good aspects of the countryside”*.

We observed in Section 1 that there was no cultural clash on the territory of Terragr’eau prior to the launch of the biogas plant, and again, contrary to the other territory, we did not find any cultural or political conflict:

“There is no dispute over the biogas plant as such” (CCPEVA);

“It’s a nice project, there were tensions but no more than that, the people who are there are good and they are all for the project” (managers);

“From the moment the project was supported by Danone, the local resident suspects that it is going in the right direction” (Chamber of agriculture). We saw in Section 1 and in the first part of Section 2 that the biogas plant was the result of decades of collective thinking in the territory, and consequently it is not surprising not to observe a cultural or political rejection of the biogas plant.

Conclusion of Section 2

To conclude with this section, in the first part, we observed that the regional and local contexts we exposed in Section 1 provide opportunities for biogas production and for the valorization of digestates. For Kastellin, BioQuercy, Bionerval and Biomethan Zittau, the agro-industrial contexts provide resources for the biogas plant, as well as lands and farmers available to receive the digestates. In addition, the protection of the natural capital is often a source of motivation to use digestates. Indeed, for Terragr'eau, it is the will to protect the natural capital that creates the main opportunities for the use of digestates. For all cases, we also witnessed an aim at modifying or improving agricultural practices, and at maintaining agricultural activities through the use of digestates. We therefore propose to introduce the notion of "agronomic capital" in addition to the other components of the territorial capital we described in chapter 3. The agronomic capital would represent the agricultural practices and activities found in a territory, and that can be mobilized and transformed through territorial projects such as biogas production. Furthermore, we observed that the institutional and cognitive & technical support to the biogas plants and to its land application plan depends on the existing institutional and cognitive & technical capital we described in Section 1. The valorization of digestates also benefits from the mobilization of the organizational and economic capital, via the activation of networks of local specialized companies (ETAs, CUMAs etc...) that can help with the land application. Finally, we observed that the valorization of digestates benefits from the mobilization of existing organizational proximity between local agents, or the activation of organizational proximity through new structures of coordination, such as the SICA Terragr'eau

In the second part, we observed that the contexts we exposed in Section 1 are not just sources of opportunities for biogas production and digestates, but can also be fertile grounds for tensions and conflicts. One of the first important issue we observed concerns failures with the infrastructural & equipment capital, sometimes accompanied with failures with the organizational capital and the cognitive & technical capital, that created various incidents and accidents during the different stages of the valorization of digestates: storage, transportation and land application. These problems reactivated and sometimes amplified the fears for the protection of the natural capital described in section 1 and damaged the local quality of life. Also, these failures created, for some cases, unpleasant smell that again damaged the quality of life, except for the case studies where the right combination between geographical distance, skilful farmers and operators, and a context with already many smells from agricultural activities seemed to prevent tensions with these new smells. Finally, these material issues were

amplified by political and cultural tensions. The territories where there were already clashes on agricultural development (Section 1) often experienced rejection of the biogas plant and of its operations, from some groups of agents in the territories. Moreover, there seem to be a consensus on the “profile” of local inhabitants that are more inclined to complain against the operations of the biogas plants, which are mainly retired neo-rural people, with which a cultural gap exists compared to the agents involved in the valorization of digestates.

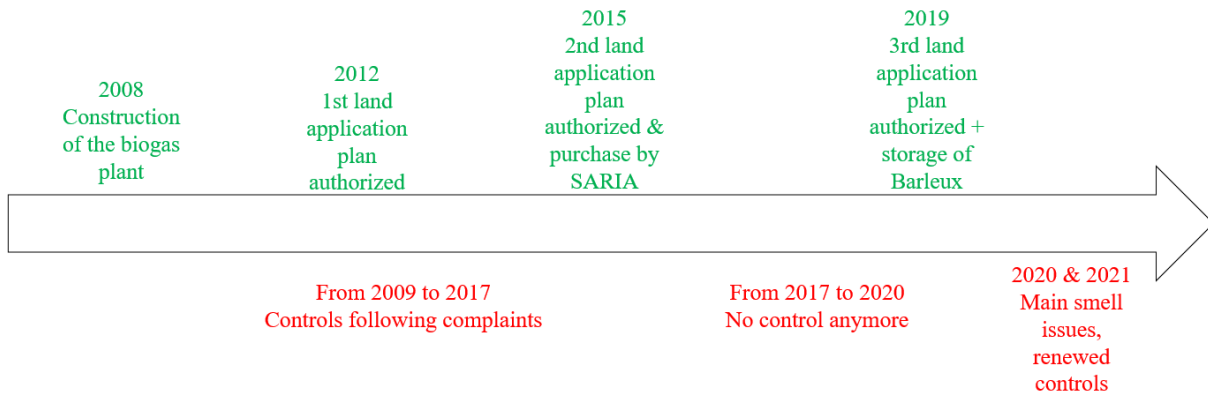
Cases	Issues with the infrastructural & equipment capital	Unpleasant smells	Cultural and political tensions
Bionerval	<ul style="list-style-type: none"> -Issues with the availability of the spreading equipment -Contamination of a meadow by plastics not removed from digestates -Spillage of black sludge in the inter-municipal ditches 	<ul style="list-style-type: none"> -Unpleasant smells at the biogas plant, at remote storages, and during land application worksites 	<ul style="list-style-type: none"> -Brand image of the Lustucru/Pastacorp neighbor factory affected
BioQuercy	<ul style="list-style-type: none"> -Several leakages of digestates because of poorly designed remote storages. Water catchment temporarily stopped. 	<ul style="list-style-type: none"> -“Unbearable” smells felt “nights and days” 	<ul style="list-style-type: none"> -Violent opposition to every project considered as “industrial”
Kastellin	<ul style="list-style-type: none"> -Major leakage of digestates in August 2020, in the Aulne river. 180 000 inhabitants deprived 	<ul style="list-style-type: none"> <i>No observations</i> 	<ul style="list-style-type: none"> -The major leakage of 2020 revived the previous regional conflicts about the development model of agriculture

	of drinking water for 5 days.		
Terragr'eau	-Contestation against the size and the traffic of the spreading equipment -Undersized storages	<i>No observations</i>	<i>No observations</i>
Zittau	<i>No observations</i>	-Unpleasant smells from a storage of digestates, in Poland	-The smell issue due to the storage revived previous neighborhood conflicts -Transnational dimension in the protests: Polish inhabitants accuse Germans to send them their wastes and the negative externalities

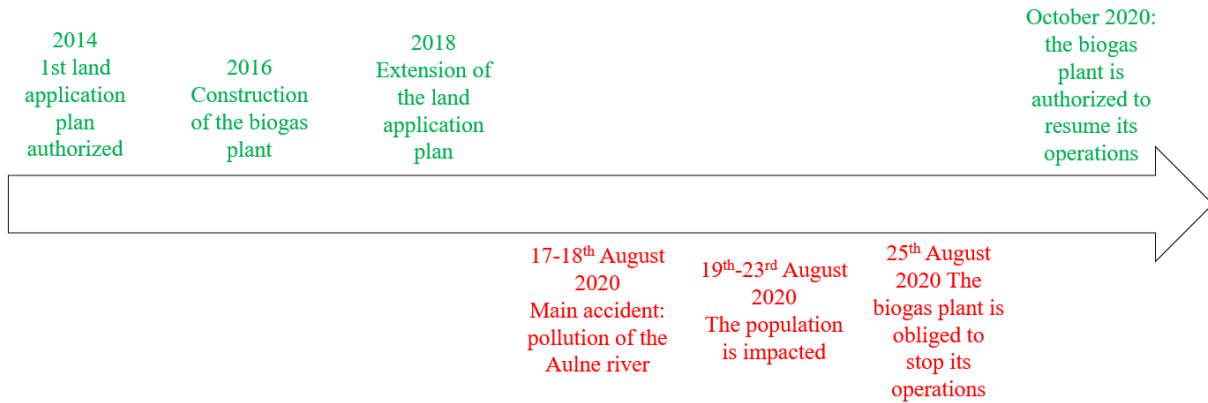
Figure 46: synthesis of the conflicts. (Source: own table)

In chapter 6, we will detail the role of the territorial coordination of agents in anticipating and solving these tensions and conflicts. But before that, in Section 3, we will present the situations of asymmetric information and shared uncertainty we observed and that have the potential to generate tensions and conflicts, in addition to the factual incidents / accidents we described in Section 2. We will also study the role of the coordination of agents in monitoring these situations, i.e. to produce and share trustworthy information about digestates, in Chapter 6.

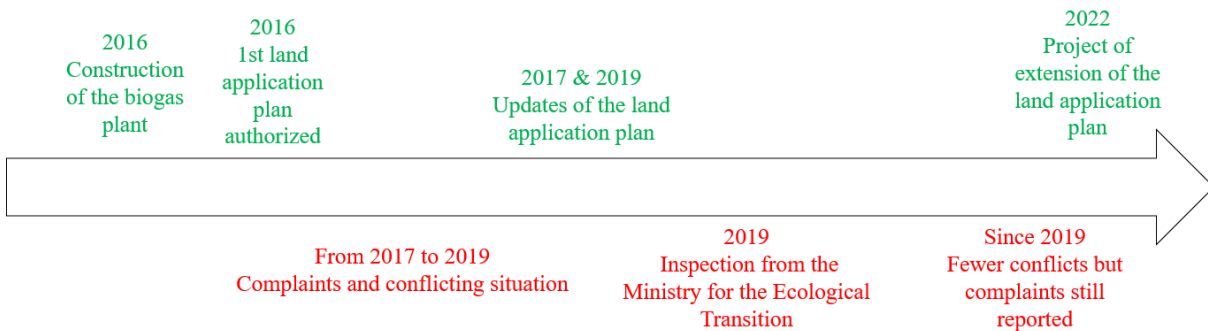
Timeline of Bionerval's main events



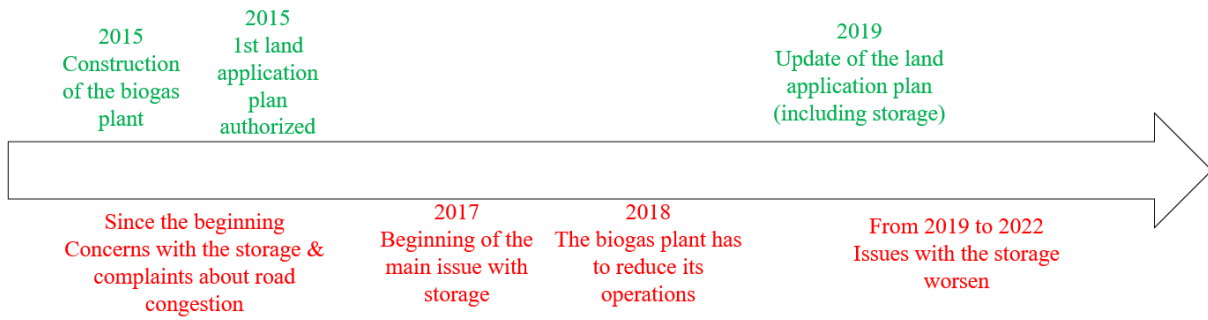
Timeline of Kastellin's main events



Timeline of BioQuercy's main events



Timeline of Terragr'eu' s main events



Timeline of Biomethan Zittau' s main events

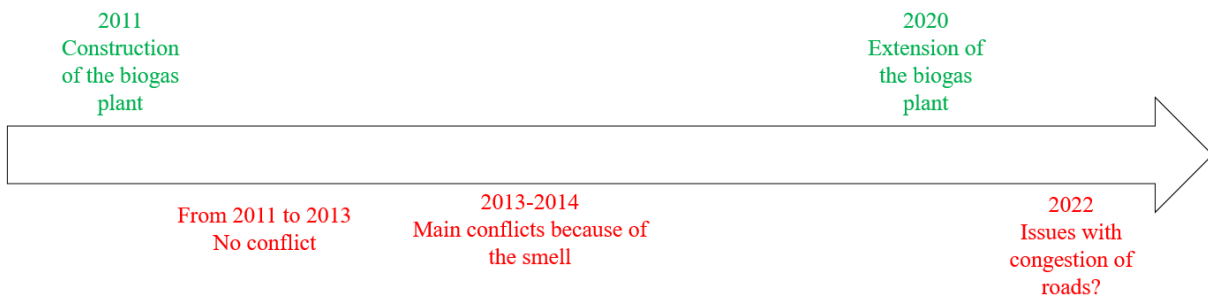


Figure 47: timelines of the main events of our case studies. (Source: own graphs)

Section 3: Fears and tensions stemming from asymmetric information and shared uncertainty

Introduction of Section 3

In the previous section, we presented our observations of tensions and conflicts that rose from actual issues and incidents with digestates that had already occurred, and whose consequences could be experienced and recognized by all the agents. In the following section, we present situations of asymmetric information and shared uncertainties on the qualities and impacts of digestates that were reported by our interviewees and that also create fears and have the potential to create, or have created, tensions and conflicts. In the first part, we present situations of asymmetric information as experienced by the direct users of digestates, i.e., the farmers. In the second part, we present situations of asymmetric information experienced by other groups of agents. In the third part, we present situations of shared uncertainty, and in the fourth and last part, we describe what we called a “fight for the truth” that results from situations of shared uncertainty.

1. Experience, search and credence characteristics of digestates through the prism of farmers

During our investigations, we observed specific concerns among farmers that we found important to present separately from the fears found globally in the territories. First of all, we observed that digestates have experience characteristics, as it is through using them and observing the results of their use that farmers come to know digestates, their impacts on the agrosystems, and how to use them properly. This experience can come from a direct use, or from observing the use by other farmers. About the direct use:

“Digestates are a new product, so it can be a problem. Those that are narrow-minded I try to get them try digestates, so that they can compare” (SARL Cadet – Bionerval);

“I have been a user of the digestates of Bionerval, since around 5 years. I don’t see impacts on soils. It is a complete fertilizer. I prefer digestates to mineral fertilizers” (SARL Cadet – Bionerval);

“If there is a problem, we will see it quickly on our land” (Farmer - BioQuercy);

“I realize that since I have been spreading it I have had no problems. My father-in-law has bees at my place and so far they have not died” (Farmer – BioQuercy);

“The first few years, it took some time to adapt, as the digestate is different from raw slurry. We learned from our mistakes” (Farmer – Kastellin);

“They realized that it was great” (managers – Terragr’eau);

“At the beginning the farmers were not sure if they could trust the biogas plant, but after some years, the farmers saw that it was interesting” (managers – Biomethan Zittau).

About observing other farmers: *“I originally applied digestates on beetroot, then also on wheat thanks to the example of CADET”* (Farmer – Bionerval);

“The farmers who are potentially reluctant to use digestates it’s because of the methanised WWTPs sludges. And those who are used to working with mineral fertilizers. But thanks to my experience, and those of others, mentalities have changed in a few years” (Farmer – Bionerval);

“There is another farmer that I work with that would like to join the land application plan to take digestate instead of his slurry, following the observation of the benefits of digestate on my farm” (Farmer – BioQuercy).

Secondly, we observed search and credence characteristics concerning the fears about the potential negative impacts of digestates on the environment, as farmers look themselves for information or choose to trust the information provided by the biogas plants:

“I insist on the quality of inputs to ensure the quality and agronomic value of digestates. Farmers like to know about the inputs” (Farmer – Bionerval);

“What is reassuring in the use of digestate is that the digestate depends on the inputs and therefore on the flora, so you can't put just anything. It's alive, it can't be toxic. The most important thing is that the biogas plant is a living thing, so that's the guarantee. The main guarantee” (Farmer – Bionerval);

“I sometimes carry out analyses of the digestate myself because I don't like the biogas plant being judge and jury” (Farmer – Bionerval);

“I had fears, I bothered [the manager] to have analyses” (Farmer – BioQuercy);

“There are specifications, I trust them. I have confidence in the digestate analyses carried out by BioQuercy” (Farmer – BioQuercy);

“I was reassured by looking at projects that don't work. I was reassured by the inputs of the biogas plant, the farming practices in the area and the very different non-karst subsoil” (Farmer – Terragr’eau);

“I have been using liquid manure for 30 years, and the flora and pH have not changed. I did an analysis and it was not far from the analysis of a manure made at home” (Farmer – Terragr’eau).

2. Asymmetric information experienced by the other groups of agents

In addition to the specific situations of asymmetric information experienced by farmers we described previously, many agents in the territories experience, or claim to experience asymmetric information on the impacts of digestates. Situations of asymmetric information, in our topic, mainly occur when the managers of biogas plants, or some public institutions, have or pretend to have information on the properties and impacts of digestates that other groups of agents do not have. The experts we interview drew a global view of the situation:

“There is communication to be done on digestates” (expert 2);

“There is a lack of knowledge about anaerobic digestion for many citizens” (expert 10);

“There is a lack of knowledge of the population on digestates that creates the controversies and the debates” (expert 14).

In our case studies, we also collected, on one side, opinions from agents that have information or knowledge and would need to better transfer it, and on the other side, opinions from other groups of agents that ask to get access to this information. From those who have information:

“People are often worried because they don't know what to expect. We try to show that we are working properly. We try to reassure people by showing what is in the digestate” (Vice-CTO – Bionerval);

“There is the need for more education on biogas plants, as many people do not know enough about it. There is an amalgam with WWTP sludge”;

“Opponents confuse the spreading of digestate with the spreading of liquid manure or plant protection products” (managers – BioQuercy);

“There is a need for education, that's for sure, by relay associations, for example” (AILE – Kastellin).

On the other side, some groups of agents ask for information but also have difficulty sometimes to trust this information: *“I wanted information on drug residues. The DGPR had not officially communicated the conclusions of the 2010-2015 national plan on drug residues. It's like that for land application, it's like that for everything. In the CSS, I always ask for a report on the monitoring piezometers to have a more complete view of what the DDT has. If the DDT does not exploit the data, the ROSO can exploit” (ROSO - Bionerval);*

“I always asks the same questions, but I never got any answer, that doesn't help” (ROSO - Bionerval);

“There is a lack of transparency of farmers with regard to environmental data” (ROSO – Bionerval);

but *“The ROSO goes a bit far in its demands, and in particular asks for things that are not publishable” (DDT 60 – Bionerval);*

“I do not trust auto-controls” (mayor - Bionerval); opponents to BioQuercy “do not trust auto-controls” (ActuLot 18 April 2019);

“There is still mistrust of BioQuercy's auto-controls and of the information transmitted. There is still a lack of information dissemination by BioQuercy. Even the fact that the analyses are carried out by certified bodies does not allay mistrust. The ability to monitor compliance with the spreading plan was called into question” (Report Inspectors 2019 - BioQuercy);

“Checking compliance with a land application plan is very complicated. We can't be behind the slurry and digestate spreaders all the time” (DDTM 29 – Kastellin).

We did not observe these situations for Terragr'eau and Biomethan Zittau. We may not have collected enough information for Zittau, but for Terragr'eau, the collective work on-going for decades may have prevented these situations to occur (see Chapter 6).

3. Shared uncertainty on the impacts of digestates

We also observed situations of shared uncertainty that echoed the fears and controversies we mentioned in Chapter 2.

Firstly, experts confirmed these uncertainties and the impossibility for now to give definitive scientific answers about the impacts of digestates:

“There is a lack of hindsight because of the lack of long-term studies. The studies will give results over 3/5 years whereas it takes less time to decry the sector” (expert 3);

“There’s not enough hindsight on the long run” (expert 16);

“Research is on-going to improve the use of digestates” (expert 17).

Experts also highlighted the role of heterogeneity in shared uncertainty, and the impacts on soils. About heterogeneity:

“There is a lot of scientific knowledge, but the impacts are very context-dependent, and very multi-factorial” (expert 2);

“It is a multi-factor issue depending on the crops cultivated, the technics used, the feedstocks used to produce the digestate...” (expert 14);

“And the impacts depend on the feedstocks used and the agricultural practices” (expert 16).

About the soils: *“There are shared uncertainties on the impacts of digestates on soils”* (expert 1);

“There is a lack of hindsight about the impacts of digestates on soils on the long run, and on soils’ biodiversity” (expert 14).

This situation of shared uncertainty is also highlighted in our case studies, but the focus of agents is more on water quality and biodiversity:

“There are fears about micropollutants and trace metals in digestates, as there is no hindsight, and many uncertainties. The DDT urges project developers to avoid spreading near catchment areas” (DDT 60 – Bionerval);

“There is no hindsight on digestates” (ROSO – Bionerval);

“There is no bibliography on certain things, we are a bit reticent with all that” (Chamber of agriculture – BioQuercy);

“We have no feedback on the impact of digestates. We are playing the sorcerer's apprentice”
(BV – Kastellin);

“We still lack hindsight on digestates today” (APIEME – Terragr’eau);

“It should be noted that during the years 2013 and 2014, residents of Krzydlice and Źarska Village feared the impact of digestates on the environment” (Polish state services).

The report of Inspectors (2019) – BioQuercy reported the lack of an appropriate biodiversity and water quality monitoring system, a lack of knowledge on the impacts of digestates on biodiversity, and a lack of knowledge and assessment measures of the death rates of bees and of the soils biodiversity.

4. The fight for the truth

We observed that the lack of information can sometimes lead to what we propose to call a “fight for information” or a “fight for the truth” between opposing groups of agents:

“There is a lack of communication and vulgarization adapted to agents that know nothing about biogas production. Oppositions pick up all these unaddressed issues” (expert 10);

“Projects leaders sometimes lack credibility because they are considered as not objective, so people go and find out for themselves on the internet and read everything and anything” (expert 10);

“There is not enough intervention of researchers, public powers, State, state agencies, in the debates. There is a lack of word of authority. The space is left free for everything and anything, and anyone. The field is open for the divisive, emotional aspect” (expert 10).

This fight for the truth sometimes comes from a bad communication from project leaders and farmers, at least for BioQuercy:

“BioQuercy did a poor job of communicating at the beginning and now we are struggling”
(Chamber of agriculture – BioQuercy);

“We are bad at communication” (farmer – BioQuercy); and this lack of communication is said to be made on purpose by some opponents: *“Few problems are reported because we don't want to weaken the sector, apparently”*; *“Every month, the collective sends a newsletter on biogas production to all the communes in the Lot, with a copy to the prefecture. And we have no*

feedback” (Collective - BioQuercy). However, on the other side, opponents are sometimes accused to use false arguments and to play on fears:

“Today, fear overcomes everything. The strategy of the people who oppose is to scare people” (managers – BioQuercy);

“The opponents sometimes have false arguments, it's not easy to work with them” (PNRCQ – BioQuercy);

“The thing about BioQuercy is that there are too many people against it, with bogus arguments, but they hurt the sector, they hurt everyone. It alienates people in the sector” (Chamber of agriculture – BioQuercy).

Finally, the question of the legitimacy of those who speak is often raised:

“Some scientists came, made specific proposals but the prefecture said they were pseudo-scientists” (Collective - BioQuercy);

“The CNVM, the CSNM, every time they have been invited to present scientific truths they refuse to come and present them. They have not made any publications, they discredit themselves as researchers but they have not made any publications” (AILE – Kastellin);

“The scientific community is very objective about the results. Science never says it's black and white, but it's mostly positive” (AILE – Kastellin);

“As long as we don't have objective criteria, we can say anything and everything” (mayor – BioQuercy).

This situation leads agents to oppose with more or less strong arguments:

“Eaux et Rivière de Bretagne for example, we are fairly well equipped to counter their arguments” (AILE – Kastellin);

“The CSNM claims to have had BioQuercy's digestates analyzed and to have found excessively high concentrations of heavy metals and siloxanes. Bioquercy retorted by showing its digestate analyses. On the subject of the beekeeper whose bees died, Bioquercy retorted by citing other beekeepers” (Médiapart, 30th January 2019).

Conclusion of Section 3

We presented in this Section the fears and questions from farmers about the contents of digestates and their impacts on their soils. To answer their questions, and to solve this lack of information from their side, we explained their need to observe the impacts of digestates, at other farmers, or directly in their fields for those that decided to give it a try. We also reported their need to search for the characteristics of digestates, by carrying out their own analyses, and the choice to believe and to trust the words and the promises of the producers of digestates in terms of quality and innocuity. Therefore, we observed the three characteristics of asymmetric information on the qualities of digestates, which are search, experience and credence characteristics, as we explained in Chapter 3. Asymmetric information on the qualities and impacts of digestates is also shared by other groups of agents that do not use directly the digestates, but that fear to be impacted by their use. We observe that a better transfer of information, and more transparency from the producers of digestates, from farmers, and from public institutions, is needed and is demanded by other groups of agents. But, on the other side, there is a lack of trust towards this information, and it can generate tensions locally between groups of agents, due to frustration not to have access to information. Also, our observations confirmed the existence of situations of shared uncertainty we assumed in Chapter 3, on the impacts and properties of digestates. These situations create reluctance and fears against the use of digestates, or against certain uses of digestates, from different groups of agents: local inhabitants, state services, chambers of agriculture. This situation leads sometimes to what we called a “fight for the truth” in the territories of BioQuercy and Kastellin, creating tensions between groups of agents that develop their own arguments in favor or against the use of digestates, and that question each other on their scientific legitimacy.

Section 4: The valorization of digestates reshapes, and is shaped by its territorial context

Introduction of Section 4

We presented our results in Section 1, 2 and 3, and we present in Section 4 a discussion of these results. We first propose to discuss the interlocking of spatial scales induced by the activities of valorization of digestates and the related conflicts, and the reshaping of territorial boundaries. Secondly, we discuss our assumptions concerning the mobilization of the different

dimensions of the territorial capital, and their dual nature. Thirdly, we discuss the role of the combination of proximities in the conflicts, and finally, we go back to our assumptions about the existence of situations of asymmetric information and shared uncertainty.

1. The definition of new territorial boundaries by the valorization of digestates and the related conflicts

The first element of discussion we propose is about the creation of new territorial boundaries through the activities of storage, transportation and land application of digestates, and the spatial location of the related conflicts. We exposed, in Section 1 of Chapter 3, the theories about the emergence of new territories through economic activities, with boundaries that do not always match administrative boundaries (Leloup et al., 2005; Niang et al., 2020), and we assumed that the valorization of digestates could create such new territories. With Bionerval, we observed that the land application extends over three administrative departments without covering them completely, which consists, already, in a new economic territory. The organization of the valorization of digestates, and the related conflicts, therefore involve agents at the department scale (department State services, ROSO...). In addition, we observed the support role of organisms structured at the scale of the Artois-Picardie watershed, which is a larger geographical scale, as well as conflicts at the very local scale, the scale of municipalities (the conflict about the Pastacorp factory). We observed therefore the interlocking of different territories of different spatial scale, bounded either by administrative, natural or economic boundaries.

We also observed this interlocking of both administrative and natural territories of different scales for Kastellin. Although the land application plan only extended on the administrative territory of the Finistère department, the 2020 accident revived conflicts at the scale of the regional territory of Brittany and impacted the natural territory of the Aulne river watershed.

The conflicts around BioQuercy's land application plan also involved three different geographical scales: the administrative territory of the Lot department, the administrative territory of the PNRCQ and the very local scale, around the biogas plant and at land applications worksite (for the bad smells).

Similarly, we observed the interlocking of three spatial scales for Terragr'eau: the administrative territory of the Haute-Savoie department, the natural territory of the Evian impluvium, and the very local scale (mainly for traffic congestion around the biogas plant).

The valorization of the digestates of Biomethane Zittau, and the related conflicts even created a new transnational territory, across Germany and Poland, and implied interactions across the border.

Consequently, a biogas plant, through its land application plan, and through the potential related conflicts, shape new territories that result from the interactions of different pre-existing territories of different geographical scales. We are here fully in line with the idea that territories are social constructs, “organized places” built and shaped by the activities of agents and the mobilization of resources (Chevalier & Pola, 2014; Dermine-Brulot & Torre, 2020; Dubresson & Jaglin, s. d.; Leloup et al., 2005; Zimmermann, 2008). Each of our case study creates its own combination of territorial boundaries, through the interactions of agents, to organize the valorization of digestates, through conflicting interactions too, and through facing local environmental challenges.

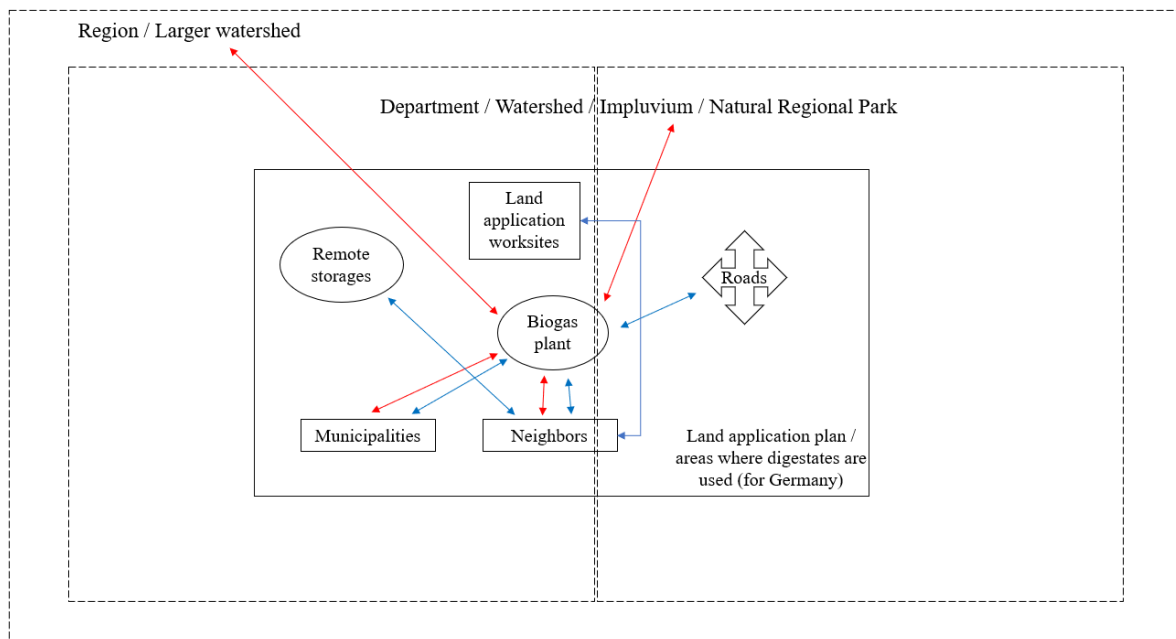


Figure 48: the different spatial scales affected by the valorization of digestates and by related conflicts. (Source: own graph)

Legend:

Dotted frames: territories crossed by the land application plan (or the area where digestates are used. The boundaries can be administrative or natural.

—→ Long-term political, cultural and social conflicts (last for many years or decades, often preceding the biogas plant)

—→ Middle-term or short-term conflicts due to actual negative externalities (last for a couple of years, months, or even days)

2. The dual nature of territorial capital

The second element of discussion we want to highlight is about the adequate mobilization of the territorial capital and its dual nature. We confirmed, through our observation, the importance of the natural capital, and especially, water resources, either as a source of conflicts against the valorization of digestates, as claimed by (Bourdin, Colas, et al., 2019; Chodkowska-Miszczuk et al., 2019) (Section 1 of Chapter 3), or as an opportunity for biogas plants to be a solution to better protect it, which has not been highlighted yet by the scientific literature. We are also in line with Torre et al. (2016) who highlighted that the protection of water was an increasing source of conflicts in rural and suburban territories (Section 2 of Chapter 3).

We also observed the importance of the economic context: the opportunities or challenges provided by the existence of other economic activities in the territories, that were not highlighted by the literature; also, the importance of the financial resources available to the biogas plant as shown by Bourdin (2020), but also to the other agents of the territory (resources for institutions to support the sector for instance); and finally, we highlighted the importance of human resources, and particularly the global lack of human resources. Based on our results, we propose to enrich the framework of the territorial capital we presented in Chapter 3, by adding the “economic, financial & human capital” that includes: the financial capital (already part of the framework), the economic capital, composed of the economic activities and companies of the territory, and the human resources available to work for the sector. Similarly, we would like to add to the framework the “agronomic capital”, that includes the agricultural practices and activities found in the territory (see Section 2). We consider that these two additional dimensions (agronomic and economic, financial & human) should be carefully assessed by project leaders to avoid issues and conflicts. We also believe that these dimensions should be assessed for all territorial projects that hold an agricultural dimension; however, we acknowledge that the agronomic dimension of the territorial capital might not be relevant for projects that have nothing to do with agriculture.

We also confirmed the importance of the mobilization of the infrastructural & equipment capital in the valorization of digestates, in line with (Chodkowska-Miszczuk et al., 2019; Niang et al., 2021, 2022; WRAP, 2012), but we went further by showing how its inadequate mobilization is a major source of tensions and conflicts, which is an important new teaching of our research. We also went further WRAP (2013) and Niang et al (2021) that mentioned the need for adequate cognitive resources, by highlighting the global lack of

necessary cognitive & technical capital for the whole sector, across the territories. We also revealed the importance of the cultural & political capital of the territories that can be a fertile ground for conflicts or a set of shared values that allow the valorization of digestates to go rather smoothly. This aspect has not been highlighted by previous research on biogas production and digestates. It is an important finding of our research. Finally, our results concerning the importance of the organizational capital confirm previous research from (Chodkowska-Miszczuk et al., 2019; Depoudent et al., 2020; Niang et al., 2020, 2021, 2022; Soland et al., 2013). The valorization of digestates directly benefits from the existing ability of agents to organize together and to cooperate, especially on other types of land application activities. In addition, the involvement of public institutions to support the sector is an asset. As a consequence, we also confirmed the duality of the different dimensions of the territorial capital, in line with Chevalier & Pola (2014). All of the dimensions, if properly mobilized, can be assets for the valorization of digestates, or, if not, can become obstacles. In addition, we confirmed our assumption of interactions around the territorial capital at different spatial scales: we highlighted these different spatial scales in the previous paragraph (Section 4 part 1); as well as the existence of a time dimension, with continued and discontinued interactions, especially regarding the conflicts, that generate more or less strong interactions that rise at some moments (during a land application period, during bad smells, because of an accident), and then diminish, and can rise again.

Consequently, we recommend a strong mobilization of the infrastructural and equipment capital to avoid issues, and conflicts. We also highlight the necessity to create a shared cultural & political capital around the question of digestates and biogas production, that can be complemented by the adequate mobilization of institutional capital to support the sector. We emphasize the importance to increase the cognitive & technical capital in the whole sector, and we encourage the design of projects that pay a careful attention to water resources, and try to show how the project can help to better protect the water resources, instead of being seen as a threat to them. Attention should also be paid to the economic capital, to avoid potential competition with other activities and to ensure the existence of necessary human resources.

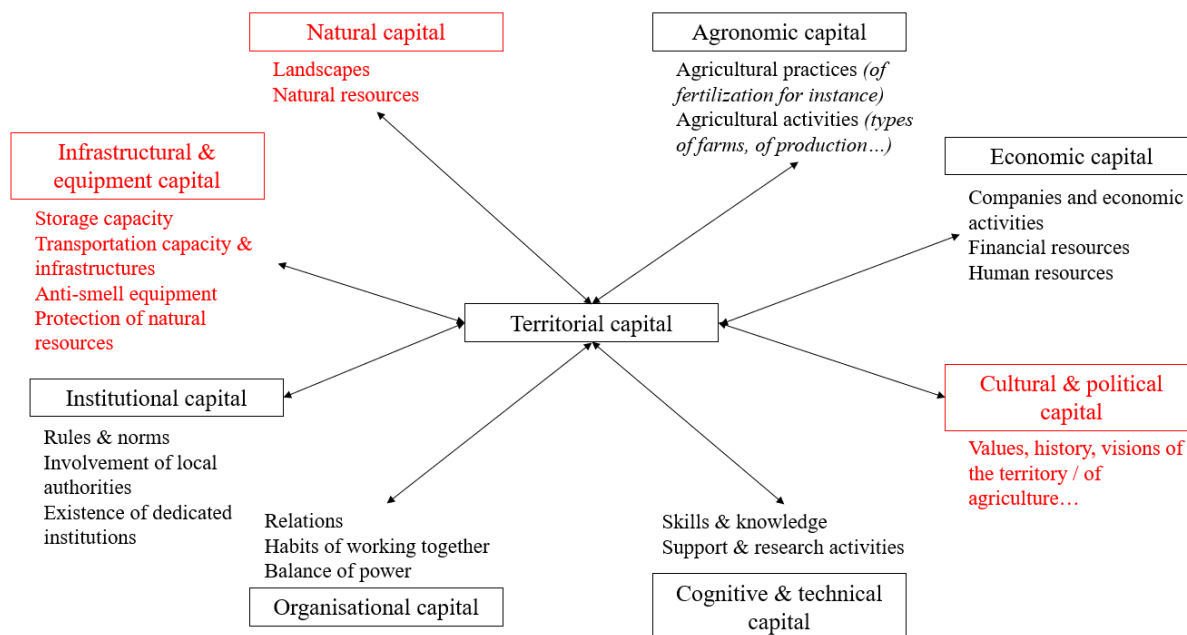


Figure 49: the different dimensions of the territorial capital that should be carefully considered when valorizing digestates. In red, the dimensions the most often affected by conflicts. (Source: own graph).

3. The adequate combination of proximities to lower the violence of conflicts

We would like to discuss now the role of proximities in the organization of the valorization of digestates and the emergence of conflicts. We clearly confirmed our assumption of the very important role of geographical proximity both as an asset for the valorization of digestates, and a source of tensions and conflicts. In line with the definition given by Bourdin & Nadou (2020), the biogas plants activated chosen geographical proximity to valorize the digestates: for instance, to be located close to farmers that have lands to spread the digestates, or to build remote storage to create proximity between the land application worksites and the storage of digestates. However, unwanted geographical proximity created tensions and conflicts with mainly local inhabitants and local elected officials, in line with (Torre, 2011, 2014). This unwanted geographical proximity can be permanent: proximity to a remote storage, or to the biogas plant, and can create long-term conflicts if no solution is provided to the related inconvenience, or it can be temporary (proximity to a land application worksite) and create temporary inconvenience. In this perspective, we have applied the framework of Torre (2014) and Gallaud (2018) on permanent and temporary geographical proximity to the understanding of the nature and characteristics of conflicts, which is, to our knowledge, an original use.

We observed different degrees of activation of these proximities prior to the valorization of digestates across our case studies. We notably observed an advanced activation of organized proximity for Bionerval and Terragr’eau, with specific institutional structures devoted to the management of digestates (APIEME, CPE), that have allowed for years these six types of interactions between local agents on this issue. An advanced activation of organized proximity creates some degree of institutional proximity, and, through the transfer of information, allows to reach a certain degree of cognitive proximity between all the agents. As we explained in Chapter 3, (Bourdin, Colas, et al., 2019) claim that the success of a territorial project relies on the adequate combination between all the proximities, and conflicts are often caused by unwanted geographical proximity combined to weak organized proximity. Moreover, (Gallaud, 2018; Le Boulch, 2001) argued that this conflicting combination leads to “imposed territory” that agents want to reduce. Our results tend to be in line with these previous studies. The most intense conflicts we observed, with demonstrations, violence, judiciary procedures engaged (BioQuercy, Kastellin and Zittau) seem to be the result of a combination of the inadequate activation of some dimensions of the territorial capital, unwanted geographical proximity and less developed organized proximities. However, in line with Torre et al. (2016), even in the cases that seem to display the best combinations of proximities and activation of the territorial capital, there are always conflicts, even at a small scale.

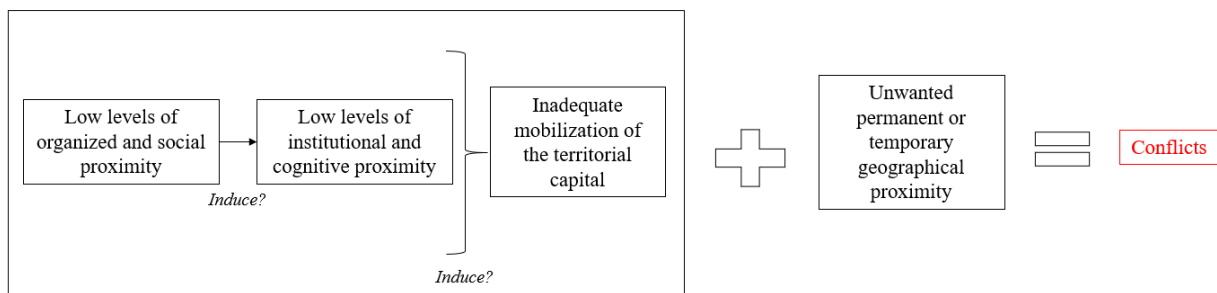


Figure 50: Proposed sequence that leads to conflicts. (Source: own graph)

4. The importance to consider situations of information asymmetry and shared uncertainty related to digestates in future research

Our field investigations confirmed our assumption of Chapter 3 about the existence of experience, search, credence and indeterminate characteristics for digestates and therefore the existence of situations of asymmetric information and shared uncertainty about the qualities and impacts of digestates. These situations impact mainly the natural, the economic and the agronomic dimensions of the territorial capital. Shared uncertainty mostly concerns the natural capital, as the impacts of digestates on the environment are mostly unknown to every group of agents across the territories, creating reluctance and fears about their use. Asymmetric information also concerns the natural capital, through the need to better transfer environmental data owned by some agents, but also the agronomic and economic capital as some agents, mainly the farmers, may not know *a priori* the impacts of digestates on their yields and on their economic profitability. Therefore, contrary to previous research on biogas plants that considered that complete information exists, the only issue being the transfer of this information (Chapter 3), we observed, on the field, situations where information does not exist at all. We assume that our original results are due to the fact that previous research only focused on the biogas plants themselves, and did not dive into the question of digestates. We therefore recommend that future research on the biogas sector, that aims at targeting issues with information, does not skip to include the specific information and knowledge issues around digestates, at the risk of missing an important part of the problem.

Conclusion of section 4

In this section, we first confirmed the assumptions we made in Section 1 of Chapter 3 about the reshaping of territorial boundaries by the activities of valorization of digestates and the related conflicts. We showed that these activities, and the related conflicts, shape new territories, and induce the interlocking of different spatial scales. We are therefore in line with the theoretical framework that consider territories as built and social constructs. We then confirmed our assumptions about the necessity of an adequate and efficient mobilization of all the components of the territorial capital to avoid conflicts, and the necessity to carefully consider the dual nature of territorial capital. We also proposed to enrich the framework of the territorial capital. Then, we moved to the discussion of our assumptions about the combination

of proximities to anticipate conflicts. Our results tend to confirm our assumptions of the need to combine an adequate mobilization of the territorial capital, the avoidance of unwanted geographical proximity, and the activation of organized proximities to avoid violent conflicts, although we confirmed that conflicts, or at least tensions, appeared to be inevitable, even in the best cases. Finally, we confirmed our assumptions of the existence of situations of asymmetric information and shared uncertainty on the impact of digestates, and their potential to generate fears, which can themselves induce tensions or conflicts.

We will now move on to the conclusion of this chapter.

Conclusion of Chapter 5

We presented, in this Chapter, the first part of our results, and a preliminary discussion of these results. We first showed, in Section 1, the variety of contexts into which our case studies are embedded; we compared these contexts and highlighted the similarities and the specificities. We emphasized the duality of these contexts, translated in terms of the duality of the different dimensions of the territorial capital. If rightfully activated, these dimensions can become opportunities for the valorization of digestates, but if not, they can become obstacles and challenges. We showed that the natural capital, the infrastructural & equipment capital, and the cultural & political capital are especially become challenges to the valorization of digestates if not adequately mobilized. We also found that the adequate mobilization of the institutional and organizational dimensions of the territorial capital seem to compensate the challenges brought by the other dimensions. We therefore validated our assumption on the necessity to adequately mobilize the territorial capital. Also, the inadequate mobilization of these dimensions generates tensions and conflicts. We observed conflicts for all the case studies, but with a more or less violent dimension, and as one expert confirmed: “there is always a background of opposition” (expert 10).

These conflicts seem to be the result of a combination of unwanted geographical proximity and a low activation of organized proximities, which is in line with previous research, but also combined to a bad activation of the territorial capital, which is a new finding. We can assume that the low level of activation of organized proximities induces the bad activation of some dimension of the territorial capital, and it leads to conflicts. We will dive deeper into the role of organized proximities in Chapter 6.

We also highlighted the existence of conflicts at different spatial scales: the very local

scale (municipalities, neighborhood), the department scale, the scales of the watershed and the impluvium, and the regional scale. We also observed different time scales for these conflicts: short-term or punctual conflicts, as well as long-term conflicts lasting for years. Also, these conflicts on digestates emerge after the beginning of the operation of the plants, although the scientific literature, as well as the support tools provided to projects leaders often focus on the conflicts that emerge before the construction of the plant. Our research highlights the importance to anticipate and solve late conflicts.

In addition to these conflicts on actual material issues and on political divergencies, we confirmed our assumptions on the existence of situations of asymmetric information and shared uncertainty on the impacts of digestates, that generate fears and reluctance, can be fertile ground for conflicts too, and generate a quest for information. These situations of shared uncertainty seem to be more developed for the case studies where the conflicts were the most violent, and where we witnessed lower level of activation of the organizational and institutional dimension of the territorial capital. Finally, although we acknowledge a potential lack of data for our German case study, we observed similar issues in France and in Germany, with repeating patterns: duality of the territorial capital, same dimensions affected by the conflicts, a quest for information...

We will now move on to Chapter 6, and to a deeper understanding of the role of proximities and territorial governance to anticipate and solve the conflicts.

Chapter 6: The anticipation and resolution of conflicts: a dynamic and multi-actor analysis of territorial governance

Introduction

In Chapter 5, we presented the territorial contexts into which the valorization of digestates is embedded, and how these contexts provide both opportunities for digestates and fertile grounds for conflicts. We described these conflicts, and the issues related to the situations of shared uncertainty and information asymmetry about the impacts of digestates on their environment. In Chapter 6, we now move on to the analysis of the mechanisms of territorial governance that are activated to organize the valorization of digestates, and we show how they allow for the anticipation of conflicts, or how they need to be reactivated, created or renewed in order to solve conflicts that could not be anticipated. Section 1 and Section 2 are dedicated to the analysis of the results. Section 3 presents a discussion of the results. In Section 1, we expose the mechanisms of coordination of agents at the local scale, both to anticipate and to solve the conflicts. In Section 2, we present the mechanisms of coordination of agents at the regional scale, again both to anticipate and to solve the conflicts. We saw, in Chapter 5, how the valorization of digestates can reshape territorial boundaries, and how complex it can be to define the local and the regional scales. In this chapter, we understand local by the scale of the interactions within the land application plan, at the level of the land application worksites, the storages, the roads, the biogas plant (see figure 48 of Chapter 5), and regional by the supra spatial levels we identified in Chapter 5, i.e., the scales of the department, watershed, region, PNRCQ, impluvium (figure 48). Finally, in Section 3, we discuss our results and we check and verify our assumptions about territorial governance.

Section 1: the coordination of agents at the local scale

Introduction of Section 1

In this first section, we start by opening a reflexion on a general lack of local coordination around the valorization of digestates. We then move on to the description of mechanisms of coordination activated prior to the emergence of conflicts, with the hope to anticipate them. Finally, we expose the mechanisms of coordination activated after the emergence of conflicts, in order to try solving them.

1. A lack of sufficient and adequate coordination to anticipate issues?

To begin with the exploration of the local coordination of agents, around the issues caused by the valorization of digestates, we propose to introduce a thought on the potential lack of consideration for digestates, at the local scale, from the beginning of the project. We assume that this insufficient consideration may induce a lack of coordination around digestates, which can influence the emergence of conflicts. Many experts emphasized this lack of consideration: “*We observe that digestates are considered too late in the project, when the project is commissioned. AILE and AAMF try to push for a better consideration of digestates*” (expert 1); “*Digestates are not the priority for new projects*” (expert 5); “*Digestates are of secondary importance in projects*” (expert 4); “*Digestates are not the priority for projects, biogas is the priority*” (expert 3). A notion of time is also introduced by two experts, inducing an evolution in the sector: “*Before 2015, digestates were clearly secondary*” (expert 9); “*For a long time, digestates were only briefly taken into account, with unpleasant surprises for project developers, such as, for instance, too many volumes to treat*” (expert 8).

This insufficient or inadequate local consideration for digestates popped up for three of our case studies in the verbatim: “*There was too much optimism in the design of the biogas plant. The quantity of digestates produced exceeded storage capacity*” (DREAL 29 – Kastellin); “*The project was presented as extraordinary, odorless, painless and economically interesting. On paper it was brilliant, on paper it was fantastic. Maybe it lacked safeguards, maybe it was rushed in the area*” (Mayor – BioQuercy); “*On paper, it was better*” (Letter from the ROSO to the Prefecture, 2014). These interviews revealed a gap between expectations and reality, and we also found this gap for Terragr’eau, with the undersized storage, and with the unexpected smells, for Biomethan Zittau. These issues were not enough anticipated, through an adequate

coordination that would have allowed the adequate mobilization of the territorial capital. Hence the need of coordination to solve these issues.

Although our previous results led us to assume that local coordination to anticipate conflicts may be insufficient, we observed several mechanisms and attempts to bring local agents together in order to avoid the emergence of conflicts. It is the subject of the following sub-section.

2. Attempts of coordination to anticipate conflicts

1. *Building trust in the vicinity of the biogas plant*

One of the first mechanisms of coordination activated by projects leaders, and farmers, is to contact the most important local agents, in order to communicate on the project and to build trust:

“To gain acceptance for the biogas plant, and then for the first digestate land application plan, I relied heavily on communication, especially with farmers” (managers – Bionerval);

“To ensure the acceptance of the land application, we communicated with local residents, and there was communication between local residents and farmers, so that everyone can discuss and understand each other's imperatives” (Vice-CTO – Bionerval);

“We invited many farmers, we produced communication materials, brochures, and we organized many meetings with the municipalities concerned by the land application plan, in the presence of the farmers accepting the digestates”; “I relied on transparency and honesty with elected officials. I invited many neighboring mayors. I tried to build trust with the elected representatives” (managers – Bionerval);

“We held an exhibition before the public enquiry: one day for farmers, one day for industrialists, one day for local elected representatives, and we even sent letters to associations” (managers – BioQuercy);

“We invite each project leader to prevent the creation of local associations by communicating well in advance. It is necessary to succeed in having a transparent dialogue beforehand and to show that the project is going in the right direction” (AILE – Kastellin).

We therefore witnessed the activation of temporary geographical proximity between projects leaders, farmers, local inhabitants and municipalities to communicate face-to-face.

We also observed, for Bionerval, the will to “show” the activities linked to the valorization of digestates: “*The spreaders don't mind showing people the land applications*” (managers -Bionerval); “*When I spread, I invite the neighbors to show and explain the product*” (Farmer – Bionerval).

In addition, to ensure the support of the main local organizations, organizational proximity was activated:

“*I also contacted the president of the ROSO from the beginning of the project to ensure the support of the association, which I obtained*” (managers – Bionerval);

“*We try to discuss with municipalities*” (Vice-CTO - Bionerval); and the will to transfer information to solve potential situations of asymmetric information:

“*We gave many details about the digestates, we provided samples, and I wanted to reassure the local inhabitants and the local elected officials in the area as much as possible and show that the nuisances associated with spreading were very limited*” (managers – Bionerval).

Interestingly, for Biomethan Zittau, there were discussions in Germany, especially with local inhabitants, to anticipate threats and tensions, “*but in Poland, no public discussion because the construction of the tank was a small project*” (managers). We saw in Chapter 5 that the conflicts emerged in Poland, because of the remote storage of digestates, and we discover here that there was no coordination with local inhabitants in Poland.

However, for Terragr’eau, we did not reveal such necessity for the project leader to build trust in the vicinity, as the project had already been designed by all the major agents of the territory, and was the outcome of years of collective work (see Chapter 5). Therefore, an additional effort is required for project leaders, to have their project accepted, if their project is not the result of a local collective work.

2. *The ambivalence of communication*

We observed, in the previous paragraph, the importance granted by projects leaders to the communication between and with the different groups of local agents, to anticipate conflicts. However, these actions of communication can also create ambivalent outcomes that are not always in favor of the digestates. Positive outcomes were mentioned, involving a successful activation of temporary geographical proximity: “*People really wanted to visit, there were a lot*

of people at the open house, it was a curiosity in the area” (managers – Terragr’eau). But more ambivalent outcomes were mentioned, mainly for Bionerval, that, we saw in Chapter 5, experienced a lot of daily tensions and conflicts at the very local level:

“We avoid public meetings but we make ourselves available to the municipal councils. We hold meetings with them, we answer all the municipal councils that ask for it”; public meetings “can be beneficial or destructive. You have to do them at the right time. There can be non-constructive people” (Vice-CTO - Bionerval);

“Nobody is disturbed by the spreading of chemical fertilizers, while we are disturbed by the spreading of digestates. What changes is that you go through public consultation for digestate, so people feel like it's different” (DREAL 60 – Bionerval);

“It’s a double-edged communication, being transparent, but too much transparency causes people to worry sometimes” (managers – Bionerval);

We also observed the difficulty, for Bionerval and BioQuercy, to activate geographical proximity:

We are not good enough on the communication about digestates. We organized an open house event 2 years ago, but few people attended because there was not enough communication about the event” (Managers - Bionerval);

“It is not the fault of BioQuercy. They organized a lot of information meetings, and there was never anyone there” (Farmer – BioQuercy);

There were even the use of communication and dialogue against the biogas plant, for Bionerval and BioQuercy:

"I asked the press to help me in my showdown with the biogas plant. The press made it possible to publicize the case of the biogas plant” (mayor – Bionerval);

“We make concessions, but you have to be wary of concessions, because the more concessions you make, the more you are asked for and that doesn't improve relations with those who contest” (managers – BioQuercy);

Consequently, communication and information are used by managers and farmers to build trust with local agents, to ensure conflict-free interactions during the different stages of the valorization of digestates. However, some reservations were expressed on the frequency and

intensity of these communication actions, as it seems that an inadequate mobilization of communication can lead to more conflicts.

3. Some elements of social proximity to facilitate and foster exchanges

We also observed some elements of social proximity that were mobilized to facilitate exchanges between local agents, to activate the organizational capital, and to consolidate trust: “*One of my sons did his internship at Bionerval, so he saw that everything was rigorous*” (farmer – Bionerval);

about the local elected officials: “*We have the advantage of knowing them and they know us. We don't hesitate to make remarks*” (ROSO – Bionerval);

“*We've known the people for 7 to 10 years. The project managers come to eat at the house or the restaurant*” (farmer – Kastellin).

This social proximity is also influenced by the economic capital of the territory, and especially by the presence of major employers that create ties between local agents:

about the company La Capel: “*I have a very good relationship with them, it is the biggest employer in the commune, so I can't systematically knock them. The meetings with them went very well. We managed to work together*” (mayor – BioQuercy);

“*I think the presence of Danone helped a lot. It's the number one employer in the area, we don't fight against Danone in the area*” (managers – Terragr’eau).

There is therefore, the need for adequate and relevant communication and information from the biogas plant, and the farmers, towards neighbors, and these communication actions can be facilitated by some degree of social proximity between the agents.

4. The coordination with farmers and between farmers

In addition to the various interactions between the different groups of agents of the territory, the coordination between farmers, and between the biogas plants and the farmers is needed to ensure a conflict-free valorization of digestates. Farmers can directly interact, if they feel it necessary:

“*We have some meetings between farmers subscribing to the land application plan*” (Farmer – Bionerval); “*between farmers, we talk but not until there is nothing that seems suspicious*” (Farmer – BioQuercy);

“We always meet together, and we have discussions with the ETAs during spreading operations, when we have questions, or to exchange advice for instance” (Farmer – Kastellin);

“The farmers too are used to network and work together on the use of digestates. They improved by learning from each other” (managers - Biomethan Zittau).

“Changes and adaptations came mainly from farmers. We exchange information on land application with each other, we talk between feedstock providers, we have meetings from time to time. Each one has his own ideas and then we share them” (farmer – Kastellin)

For Terragr’eau, there is even a formalized organization of farmers, called the SICA Terragr’eau, that was created thanks to the years of collective thinking about the biogas plant. The SICA manages the land application of digestates, and is the official voice of farmers: *“The SICA really defends the farmers, and speaks for the farmers. The SICA tries to get as much as possible from the biogas plant for the farmers”* (managers).

Therefore, farmers interact in a more or less formal way to exchange knowledge about digestates, and to mobilize the cognitive & technical capital within the farming profession, in order to ensure that the land applications run as smoothly as possible. We can assume that these interactions are facilitated by the sense of belonging to the same project, and a sense of similarity due to cognitive and maybe social proximity between the farmers that live in the same territory and have the same profession.

In addition, the biogas plants often work with a third agent, that can play the role of intermediary in the coordination with the farmers, or that can just be a support for improving land application practices. For Bionerval, a consultancy plays the role of intermediary. The consultancy: *“makes proposals for communication with farmers”* and *“communicates with the farmers about the analyses and the quality of the digestates”* (managers - Bionerval). The consultancy is therefore an intermediary for the transfer of information, in a situation of asymmetric information, where the biogas plant knows the quality of digestates and the farmers don’t. The consultancy also intervenes to maintain the sense of belonging to the same project, and therefore, to keep organizational proximity activated: *“to motivate the farmers and keep in touch with them, we hold physical meetings once or twice a year, regular telephone meetings, and an agronomic follow-up”* (consultancy - Bionerval). In addition, there is the *“implementation of a weekly monitoring of inert materials and then a daily monitoring during spreading, to guarantee the farmers a quality product”* (managers - Bionerval). These analyses go beyond the legal requirements, and are carried out to ensure that farmers are satisfied with

the quality of digestates, and to avoid potential situations of asymmetric information.

We observed a quite similar way of interacting for Biomethan Zittau, with a freelance agricultural expert playing a role in-between the intermediary and the technical support: “*Every year, we have an annual meeting with farmers to analyse the year, and to give some advice*”; “*We made a contract with a German freelance agricultural expert to help the farmers. The expert accompanies the farmers in using the digestates. He was also was involved in the discussions with the inhabitants*” (managers – Zittau).

For Kastellin and for BioQuercy, the farmers are quite autonomous in their relationships with the biogas plant. For Kastellin, the biogas plant also holds annual meetings and mobilize the chamber of agriculture “*to transform land application practices*” (farmer – Kastellin). The Chamber of Agriculture therefore does not directly act as an intermediary but as a support, to mobilize the cognitive & technical capital.

Finally, for Terragr’eau, in addition to the formalized organization of farmers, the chamber of agriculture plays a role of technical support: the chamber brings “*technical support because farmers have questions about the uses of digestates*” (managers – Terragr’eau). Danone and local farmers also play the role of intermediaries and facilitators with other farmers: to reassure farmers that could have doubt about the use of digestates and the project in it whole “*it was more the discussions with Danone and the biogas plant. There were also pro-biogas plant farmers who helped with acceptance*” (managers – Terragr’eau). There is also the mobilization of a permanent geographical proximity between the SICA and the biogas plant: “*the SICA is on site and sees how we work. The SICA offices overlook the biogas plant*” (managers – Terragr’eau). It allows the SICA and the biogas plant to “*work side by side. There are points of tension we discuss through meetings once a month, and then we discuss informally, on a daily basis*” (managers – Terragr’eau). The SICA “*does analyses from time to time*”, i.e., the SICA produces its own information to solve asymmetric information, using the search characteristics of digestates.

The originality of Terragr’eau therefore lies in the existence of a formalized organization of farmers combined with the permanent geographical proximity between this organization and the biogas plant, that facilitates the activation of social and organizational proximities. To this adds the involvement of several facilitators and supporting agents. There is consequently a strong mobilization of the organizational capital, induced by years of activation of the organizational proximities of the territory, through the APIEME notably.

In Figure 51, we sum up the different interactions we witnessed in our case studies, between farmers and with farmers.

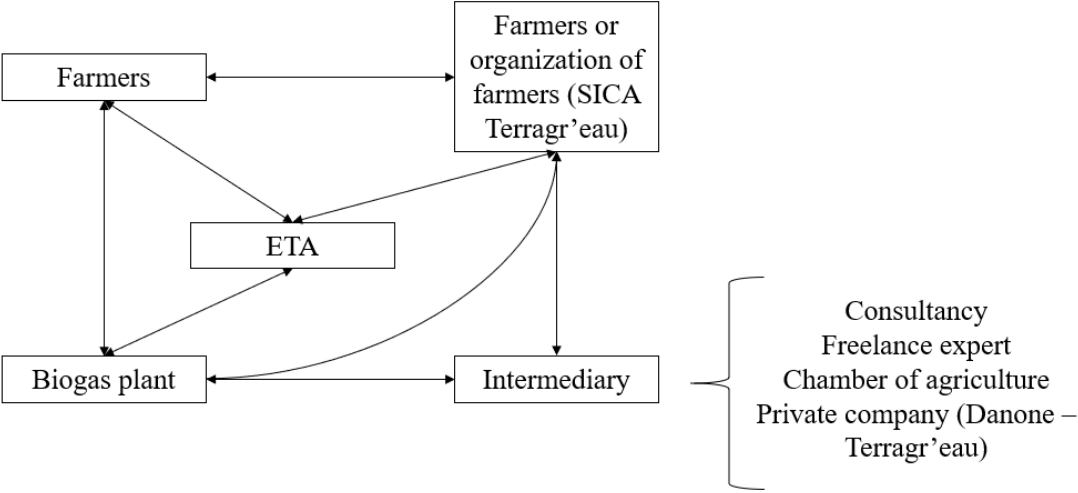


Figure 51: the coordination between farmers and with farmers. (Source: own graph)

We have presented our results about the local attempts of coordination to anticipate the emergence of conflicts, and we now move on to the local coordination mechanisms implemented to solve conflicts when they had not been avoided.

3. Attempts of coordination to solve conflicts

The first mechanism we observed is the direct interactions between the managers of the biogas plants, and the local inhabitants that complain.

1. The role of direct interactions to solve local conflicts

To allow for the direct interactions between the biogas plants and local complainants, we observed the necessity of a direct communication, on a daily basis, for the very local issues. For Bionerval, a telephone number was established to receive complaints from local residents at the biogas plant (First owner – Bionerval). This hotline works 24h/24 and is combined with a recording of complaints by the biogas plant. This hotline is mainly used to report punctual issues about the smell, which we described in Chapter 5. According to the ROSO: "Residents

who live next door are very much listened to. The telephone line really effective, really used. Residents are well listened to". In addition, local inhabitants themselves have chosen to be proactive in the communication and to establish a dialogue with the biogas plant: *"The inhabitants communicate very easily with the biogas plant and with each other. Some residents are active and pro-active. They have not delegated everything to the mayor. Individually they act for the well-being in everyday life"* (mayor – Bionerval).

The same ability for direct dialogue and communication was found for BioQuercy: *"Either people are coming to talk directly, or they make a complaint, so we contact them, we exchange, we search for compromises"* (farmer – BioQuercy). This potentiality for direct dialogue is made possible because: *"people understand, they understand well"* and that some local agents *"wish to discuss"* (farmer – BioQuercy). The biogas plant cultivated this potentiality for dialogue by activating temporary geographical proximity with the complaining neighbors: *"Regular, constructive discussions take place between the BioQuercy teams and local residents. Bioquercy has invited local residents to its site to present the improvement work and the next stages"* (ActuLot, 16-11-2018)

For Biomethan Zittau and Terragr'eau too, direct communication was implemented to solve the conflicts: *"we discussed with the inhabitants and the farmers discussed a lot with the inhabitants"* (managers – Biomethan Zittau); although we will see later that a local intermediary was necessary to really solve the conflicts. Concerning Terragr'eau, *"usually, the complainants come directly to the biogas plant to talk"* (SICA – Terragr'eau) but *"the day-to-day aspect of small tensions is managed by the SICA"* (managers – Terragr'eau).

We also observed, for Bionerval, the importance of acknowledging the issues and playing the transparency card, to build or maintain trust with local agents: *"We received many invitations from neighboring mayors. We showed them when we had problems"*;

"There were threats from neighbors to set up associations against the biogas plant, but I was able to calm things down, and I asked for time to rectify the problems. I was able to show that the company was rolling up its sleeves" (first owner – Bionerval);

This notion of time to make the necessary improvements was also mentioned by the managers of BioQuercy: *"[The opponents] want everything white at once, whereas the biogas plant tends towards white. There are always improvements to be made afterwards. We were able to improve but it took a little time"*

However, although making improvements take time, reacting quickly to issues when it is possible help avoiding conflicts. When the pollution of the water catchment by an unauthorized land application worksite occurred, the local agents around Terragr’eau reacted very quickly: *“the land application stopped, the municipalities and the State services were informed, and the water catchment stopped”* (CCPEVA); *“No complaint was lodged with the DDPP by the inhabitants. The town halls reacted but the problem was dealt with very quickly”*. And, in general, *“as soon as there is something wrong, measures are implemented”* (DDPP).

Cultivating this dialogue also took the form of organizing a “smell observatory”, to gather local inhabitants and formalize the interactions with the biogas plant (ActuLot, 16-11-2018). This observatory *“has improved things a lot”* (managers – BioQuercy). This observatory allows to report the smells and to investigate on the causes of the smells (Prefectoral complementary decree, February 2020).

We did not collect anything specific for Kastellin as the major issue of 2020 affected the whole watershed and was not dealt locally.

2. The role of local intermediaries

We have seen in the previous paragraph the role of direct interactions between the complainants and the biogas plants, and / or the farmers to solve conflicts, but sometimes, we observed that intermediaries were needed to activate proximities and facilitate interactions. This is the topic of the following paragraph.

For Bionerval, we identified two types of intermediaries that intervened to solve very local conflicts: State services, and the town councils of municipalities.

“There were quite strong neighborhood problems on the Passel site. There were complaints about noises, smells. The DREAL intervened several times to resolve the problems. We managed to find compromises” (DREAL – 60).

“For Bionerval, the town councils are intermediaries between the residents and Bionerval. Even with the toll-free numbers, residents often call the town hall. This is why it is important to talk to the town councils” (managers)

For BioQuercy too, State services are often necessary intermediaries to solve local conflicts, and town councils, when they don’t manage to play the role of intermediaries, ask themselves for the intervention of State services:

“Sometimes complaints are directly lodged to the DREAL. I had the DREAL on the phone, but they understood who they were dealing with” (farmer)

“I intervened as mayor, I reported the problems to the sub-prefecture and I phoned Fonroche. But the only coercive means was the State. The State imposed diktats and obligations” (mayor).

For Terragr’eau, the role of the municipalities as intermediaries was formalized, as a “red phone” was implemented for similar purposes of the hotline of Bionerval, but in town halls, and not at the biogas plant: *“A red phone was set up for the first land application campaign. The phone calls go to the town hall in the event of a problem and then complaints are directly sent to the SICA or the biogas plant” (managers).*

For Zittau, the local conflicts induced by the very unpleasant smells were almost entirely solved by the town hall of Sulików, that played the role of intermediary between the local complainants and the biogas plant:

“After numerous complaints from the inhabitants of Skrzydlice, the Sulików Commune decided to determine whether all the legally required procedures were followed” (Zinfo – February 2014).

“The Sulików Commune Council, wanting to take a closer look at the matter, decided to discuss the subject at the January joint meeting” (Zinfo – February 2014).

The town hall invited the representatives of the biogas plant, the Polish state services, and the representatives of the Starost⁴⁷. The town hall played the role of central actor that brought all the parties around the table of discussion, with the aim to find solutions for the local inhabitants. All the parties were invited to express themselves, and then the State services provided the results of the environmental analyses they had carried out (Zinfo – February 2014). Then, all parties had the opportunities to go visiting the biogas plant in Zittau:

“All those present had a direct opportunity to visit the site of the biogas plant. They could also check how the German side reconciles the location of the biogas plant located in the city centre with the immediate vicinity of residential buildings and trace the production process” (Zinfo – February 2014).

⁴⁷ The Starost are the Polish equivalents of the districts in Germany and the departments in France.

“During the visit of the Sulików Commune Councilors, the German side provided comprehensive answers to all questions that were asked at the meeting” (Zinfo – February 2014).

The local conflicts in Poland were therefore solved by the activation of temporary geographical proximity combined to organizational proximity, which has been called “territorial proximity” in the literature (see Chapter 3). The activation of territorial proximity, in a transnational territory, allowed for the adequate transfer of information between the different stakeholders and the resolution of asymmetric information. And the activation of territorial proximity was made possible by an intermediary, the town council of Sulików.

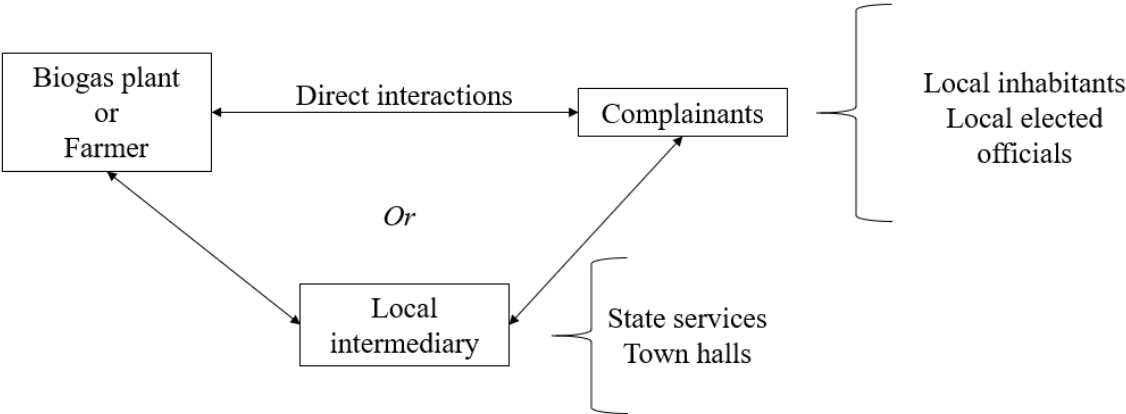


Figure 52: the resolution of local conflicts through direct interactions or through the intermediation of a local intermediary. (Source: own graph).

3. Local coordination leading to a renewed mobilization of the infrastructural & equipment capital

The communication and coordination actions we described previously were also accompanied by, or resulted in a renewed mobilization of the infrastructural & equipment capital.

In the case of Bionerval, to solve the complaints about the smell sent to the hotline, there was the “installation of a weather station to find out if the biogas plant was responsible for the odors” (First owner). This new equipment allowed to produce information in order to solve situations of shared uncertainty, where no agent knew if the digestates were the source of the unpleasant smell. In addition, after the purchase by SARIA, a combination of direct interaction and the mobilization of the infrastructural capital was implemented:

“We built secured and covered storages” (Vice-CTO)

“We try to organize preferential routes, to organize land application according to the winds, we warn municipalities when there are likely to be problems. The farmers try to warn local residents when they come” (Vice-CTO).

For BioQuercy, the managers decided to pay a particular attention to the infrastructural and natural capital: *“We had also anticipated and removed the catchments that had not been subject to a DUP⁴⁸. We're also looking at caves now. To improve.”*

For Terragr’eau too, the dialogue resulted in a transformation of the equipment capital. Due to the complaints of local mayors because of dirty roads and the size of the spreading equipment, the biogas plant decided *“to change the volume of the trucks”*; *“Little by little, smaller machines were purchased. It calmed down, the mayors and local residents got used to the size of the machines”* (farmer).

The equipment capital was also transformed for Kastellin, but not because of local conflicts and local dialogue, but because of the pressure of State services after the major accident of 2020, that is why we do not mention it in this section.

Conclusion of Section 1

In this first section, we started by questioning a potential generalized lack of coordination around the valorization of digestates, for the majority of biogas plants, because of the priority given to biogas. This issue seems to be a source of more conflicts. There is therefore the need to give more consideration to digestates when organizing interactions and collective work around the biogas plants. But, of course, we also observed mechanisms of coordination activated locally to prevent the emergence of conflicts. Firstly, we observed attempts to build trust, between the biogas plant, the farmers, and neighbors, through communication and transfer of information, and thanks to the activation of organizational proximity. However, carefulness is called upon on the adequacy of communication, as an inadequate mobilization of communication seems to lead to more conflicts. In addition, we saw that the activation of social proximity can help building this trust and facilitating communication. We also observed specific mechanisms of coordination between farmers, and between farmers and the biogas

⁴⁸ The DUP is an official document that protect a water catchment from economic activities that could pollute the water.

plants. There can be either direct interactions to anticipate potential issues, or also, the involvement of one or several intermediaries, or supporting agents, to ease interactions and solve situations of asymmetric information and shared uncertainty. We identified, as intermediaries, the Chambers of Agriculture, consultancies, free-lance experts, and local major companies (such as Danone).

When conflicts had emerged, we also observed attempts to coordinate to solve these conflicts. The implementation of direct communication between the complainants, the biogas plant and farmers, helped to find solution collectively. But again, intermediaries are sometimes needed too, to solve asymmetric information and shared uncertainty, and to find compromises and solutions between the different parties. The intermediaries we identified were town halls and State services.

Finally, as many conflicts are due to issues with the infrastructural & equipment capital (see Chapter 5), we observed that these attempts of local coordination often led to transformations of this capital.

Section 2: the coordination of agents at the regional scale

Introduction of Section 2

In this second section, we first expose the attempts of coordination to anticipate the conflicts related to the valorization of digestates. We then move on to the attempts of coordination to solve conflicts, when they were not anticipated. For both sub-sections, we present our observations about the necessity to produce knowledge, and the role of the State, and of several different other intermediaries and central agents, in the activation of coordination processes.

1. Attempts of coordination to anticipate conflicts

1. The activation of territorial proximity by regional intermediaries

One of the first mechanisms of coordination we observed, at the regional level, was the activation of the institutional and organizational proximity that already existed for the resolution

of other agriculture issues (and described in Chapter 5), but this time, applied to avoid conflicts linked to the valorization of digestates.

The case of Bionerval is a major example of how the institutional and organizational capital were mobilized thanks to the activation of the institutional and organizational proximity that had existed for decades, for other categories of land applications.

First of all, the SATEGE and MUAD, organisms we described in Chapter 5, avoid the emergence of conflicts by offering “*yearly meetings with the consultancies so that they can express their challenges and their needs*” (Water Agency), and we saw in section 1 the important role of local intermediary played by a consultancy, for Bionerval. It seems therefore important that local intermediaries can find support at the regional level. In addition to these meetings, the SATEGE and MUAD offer “*special meetings for biogas plants every two years*” (Water Agency), and “*when a new rule is to be presented at the CPE, we have meetings with the consultancies beforehand to present the project*”; “*We have gained in quality and acceptability at the basin level, thanks to a lot of pragmatism and dialogue*” (Water Agency). There is, therefore, both a top-down approach, when the institutions present the rules to the local agents, and a bottom-up approach, when local field agents are invited to express their concerns to regional agents. The combination of these two approaches allows for the dialogue and exchanges at the scale of the whole watershed.

The SATEGE and MUAD claim their role of regional intermediaries: they are “*a facilitator of exchanges between the actors of the territory*” and “*act as a link between the stakeholders*”; “*the SATEGE is normally used to reassure local stakeholders about land application*” (Water Agency).

Moreover, organizational proximities between major regional agents are maintained activated, over time, and frequently: “*There are inter-SATEGE and MUAD and DREAL meetings 4-5 times a year*”; “*State services are always present at the SATEGE steering committees. There, we talk about technical issues on the ground. We have the representation of all the people closely or remotely concerned by the land application, with the opportunity to see what is going well, what still needs to evolve...*” (Water Agency).

In addition to the mobilization of organizational and institutional proximities at the scale of the watershed, these proximities are also mobilized at the scale of the department, with a “CODERST”⁴⁹ held before the beginning of the land application operations of Bionerval: “*when*

⁴⁹ CODERST = Council for environmental, health and technological risks. To hold a CODERST is not a legal requirement but a possibility given to the stakeholders at the department scale.

there are public sensitivities, we systematically go to CODERST"; *"Going to the CODERST is not a legal obligation, but a debate on the files, with everyone giving an opinion or not. We prefer to do this so as not to be out of line, so as not to end up in court for not having mobilized the CODERST"* (DREAL 60).

Finally, to hold these meetings at the scales of the department or the watershed, either virtually or physically, there is the need to mobilize temporary virtual or physical geographical proximity. Therefore, we observed, for Bionerval, the combination of geographical proximity and organizational proximity, i.e., the activation of territorial proximity.

We did not observe such strong mechanisms for our other case studies; we assume that these mechanisms are very context-related (see the institutional and organizational contexts we described in Chapter 5, and the discussion sections). For Terragr'eau, the collective design of the biogas plant and the adequate mobilization of the territorial capital seem to have avoided the emergence of many conflicts, but the role of the governance structures such as the APIEME was mainly mentioned to solve conflicts that had already emerged, and not to anticipate conflicts during the life of the biogas plant. We will dive deeper into this in the next sub-section. To avoid the emergence of conflicts during the operations of the biogas plant, the coordination rather seems to involve the SICA, the biogas plant and the Chamber of Agriculture: *"They come regularly to the site, we discuss a lot, there's a lot of collaboration between the three of us, to reassure the farmers and show what we are doing"* (managers). There is therefore, again, the activation of geographical and organizational proximity, i.e., of territorial proximity, at the scale of the department (scale of the Chamber of agriculture).

Similarly, for BioQuercy, it is the Chamber of Agriculture that claims a role of intermediary, at the scale of the department, to activate organizational proximity and avoid the emergence of conflicts: *"The chamber's political role is that of facilitator. We try to reconcile everything. It's not always obvious"*; *"We do a lot of teaching, we do social work, it's heavy and we're not financed for that"*. We can assume that the sole role of the Chamber was not enough and could not avoid the emergence of the conflicts we described in Chapter 5.

To the contrary, we have, for Kastellin, the example of a lack of activation of organizational proximity to avoid conflicts, especially of the topic of water protection, which we saw was a major source of conflicts: the EPAGA cites many biogas plants, including Kastellin, that *"passed under the radar of the CLE⁵⁰ and this causes a lot of frustration because*

⁵⁰ CLE = Local Water Commission

no one was able to express themselves, and there is grumbling and fear". The EPAGA regrets the lack of coordination with agents of the water sector: *"we have no role, no opinion to be formulated, no solicitation. We have no right to look at this"*; *"The CLE was never consulted even when the land application plan was being extended"*; *"it's frustrating"*; *"I hope that for such a project, now, the CLE would be consulted"*.

There is, therefore, a diversity of agents that can play the role of intermediaries at the regional level, to activate territorial proximity and avoid the emergence of conflicts. Also, when territorial proximity is not activated, it creates frustration among the stakeholders and the door to conflicts remains opened.

2. The production and acquisition of information

The coordination of regional agents is also required to produce information in the situations of shared uncertainty we described in Chapter 5. To produce new knowledge can help preventing the emergence of conflicts related to fears about the unknown impacts of digestates.

Terragr'eau is an interesting example of coordination at the scale of the impluvium to produce information collectively. The organized proximity we described previously, between the main agents of the impluvium (APIEME / Danone, the Chamber of Agriculture, farmers, the biogas plant), allowed for the mobilization of the cognitive & technical capital, used to produce information.

First of all, Danone set up *"a surface water observatory in the 1990s, in parallel with the APIEME, to monitor the effectiveness of water resource protection measures"* (APIEME);

"The observatory can reassure the players. It is known by the elected representatives of the territory. When there are alerts, we share them with the elected representatives. It has made it possible to avoid the classification of a certain area as a nitrate zone, thanks to the chronological data provided to the DDPP. The observatory is at the service of farmers" (APIEME).

We see here again the central role played by Danone, in the territory, and in this case, to produce information and solve situation of shared uncertainty on the quality of water. Danone also activates the organizational proximity by providing this knowledge to the other major agents of the territory (state services, town halls, farmers).

Secondly, other research projects have been carried out to produce information: “A 3-year trial was carried out to see how the digestate reacted”; “The trial was requested by the farmers” (Chamber of agriculture) and included both agronomic experiments and “flora surveys” (SICA). These experiments helped to “build farmers’ confidence” (farmer). We see here the role of facilitator and expert played by the Chamber of agriculture, that we already mentioned in the previous sections. The trial was financed by the APIEME, and we see here the details of coordination: one agent brings the financial capital, and the other one brings the cognitive & technical capital, and these capitals are brought thanks to organizational proximity.

After the end of this trial, Danone, helped by the CDA (Centre for the Development of Agroecology) launched an ecosystem program on the impluvium, “to monitor the flora more precisely” (farmer). To help with this programme, there are “weekly telephone meetings with the Chamber of Agriculture, which is the local technical partner to support all the actions with APIEME” (APIEME). Organizational proximity is maintained activated over years between the major agents of the territory, and allows for the production of knowledge on digestates, at the scale of the impluvium, before the emergence of conflicts.

Similar experiments seem to have been implemented in Brittany, but not specifically for Kastellin. There is “agronomic tests on the use of digestates” but no environmental tests (Chamber of agriculture), and “no specific observatory on the impact of digestates on water quality. But Brittany monitors water quality a lot, and water quality tends to improve” (Chamber of agriculture). However, concerning water quality and other issues such as soil biodiversity, the Chamber of agriculture recognizes that “the duration factor must continue to be observed. This is one of the things that requires observation”. It seems that this uncomplete attempts to produce knowledge have not fully reassured the opponents we mentioned in Chapter 5, and the fears on water and soil quality remain. We will present in Section 2 how regional agents are now aiming at producing knowledge collectively, with the involvement of all stakeholders, to solve the regional conflicts around the biogas sector.

We did not observe such coordination mechanisms to produce information prior to the emergence of conflicts, in our other case studies. For BioQuercy, the agents even recognized this absence of production of information: “I don't know, I'm waiting for the study, to get objective answers”; “I'm waiting for a scientific answer because that's the only thing that will give a defensible position for everyone” (mayor);

[about land application]: *“This had not been studied, hence the interest of the observatory⁵¹. Before, we didn't ask ourselves the question of land application, whereas now it's publicly discussed. Even we, as a park, do not have all the technical knowledge about spreading. There's the need of having a neutral body that tries to capitalise on data, to reassure, or not”* (PNRCQ).

The adequate scale to produce knowledge is also questioned: *“We have put our finger on something that goes beyond us, beyond our area, beyond even the region. What do we do with agriculture? We need strong studies”* (mayor).

This question will lead us to our next sub-section, where we expose our results on the coordination of agents, at the regional scale, with the aim of answering “what do we do with agriculture?” or with biogas production, in their territories.

3. The need for regional coordination to develop a shared vision of the sector

At the regional scale, we observed the will of many agents to activate organized proximities, in order to mobilize and enrich the institutional and the cultural & political capital, to create a common vision of the biogas sector, and avoid further conflicts.

In the regions of Bionerval, BioQuercy and Kastellin, agents regret the lack of regional coordination to provide a shared vision or a shared development scheme for the biogas sector and for the land application of digestates, and they call for it:

“With the circular economy issues and all, what is the strategic vision for effluents? What means are we giving ourselves to achieve quality and traceability?” (Water Agency - Bionerval)

“What we really need is consistency. With organic effluents, we no longer know what we want” (Water Agency - Bionerval)

“I really think that there is a lack of strategic vision of anaerobic digestion in the Oise, I really think so” (Farmer - Bionerval)

“There should be a global vision of land applications and not only of digestates” (managers - BioQuercy)

⁵¹ The observatory is a project that is supposed to be set up to lower conflicts in the regions. We discuss it in Section 2.

The GADEL: *“deplores the fact that there is no departmental plan for biogas production, as there is for renewable energies, to ensure that projects are more evenly spread across the region and avoid an explosion of land applications”* (Touleco green – 31-03-2017)

“We haven't done how and where biogas production in Brittany? The associations are often rather winded against biogas production because this coherent approach has not taken place in Brittany. We need to have an integrated approach to all these issues. This is a very good question that raises the issue of the coherence of public policies. It would be up to the regional prefect to ensure consistency” (DDTM 29 – Kastellin)

But we observe also contradictory opinions on the adequate spatial scale:

“The problem is that we can't get everyone around the table on a national scale to have a vision of organic effluents and the management of organic fertilization. Hence the need for this to continue at the watershed level” (Water Agency - Bionerval)

“These issues are part of a national energy policy, not a local thing. We are obliged to have a national plan to see things clearly, and we can give our opinion locally” (mayor – BioQuercy)

[About a regional development plan]: *“It would be good to have such a scheme in Brittany for biogas production to address all these issues upstream. It remains to be seen who would be in charge: the region, the State, but with the least dogmatic approach possible”* (DDTM 29 - Kastellin)

On the contrary, this work seems to have been done, or seems to be in progress in the territory of Terragr'eau, at the scale of the CCPEVA:

“We have a territory project with a territory of excellence. The territorial project was adopted 15 days ago. The PCAET made it possible to become aware of what we were doing and where we wanted to go. We are building in the circular economy. The biogas plant can be included in the circular economy” (CCPEVA)

The embeddedness of the biogas plant in the global territorial project seems to be strong:

“It's a real territorial project, no one was left out. It's a project carried by the whole territory. It is a great territorial success to bring together so many players around a project” (managers – Terragr'eau).

For Bionerval, we observed the beginning of a coordination at the scale of the Oise department to develop a shared vision of the sector:

A department scheme for the biogas sector “*was initiated in June 2020 by the previous prefect, and co-piloted by the chamber and the DDT. The role of the chamber is to provide technical knowledge to the administration*” (Chamber of agriculture – Bionerval). We see here that organizational proximity allows for the mobilization of the technical & cognitive capital held by the chamber.

“There are working groups with the actors of the department, the chamber of agriculture, the federations. We try to give a frame to the subject. It has been in progress for 2 years. It should be signed soon. It should not replace the regulations but establish a chart, and get the parties to discuss the consultation, the technical aspects...It allowed us to discuss” (ROSO)

This scheme: *“It's good because it provides a common framework, a common way of doing things in the Oise, and it is beneficial for project developers who are sometimes at a loss”* (DDT 60).

The activation of organizational proximity allows the main stakeholders to coordinate, at the scale of the department, in order to enrich the institutional capital with new tools (a chart), that will eventually strengthen institutional proximity.

This process of coordination on the vision of the development of the biogas sector still has to be done in the territories of Kastellin and BioQuercy, and it echoes our results of Chapter 5, where we exposed the lack of shared cultural and political visions in these territories, itself source of conflicts. Further coordination should allow to establish a shared cultural & political capital, and help avoiding conflicts.

Concerning Zittau, these issues were not raised during our investigation.

We have exposed the mechanisms of coordination set up to anticipate conflicts, and now we move on to the mechanisms of coordination set up to solve conflicts.

2. Attempts of coordination to solve conflicts

1. *The inevitable intervention of the State?*

We have already observed, in the previous sections, the frequent presence of the State, whether state services or prefects, in coordination processes. We will expose, in the following paragraph, the major role played by the State in the setting up of coordination to solve regional

conflicts, and this will lead us to wonder, through this sub-section, if the intervention of the State in the organization of the sector is inevitable.

One of the first main role we observed for State bodies, is to control and correct the operations of the biogas plants when issues and conflicts have emerged. This result echoes the definition of territorialisation by the English-speaking literature, that we described in Chapter 3, i.e., control, regulation and coercive actions of an authority on a territory to monitor its economic development:

“The purpose of the site visits is to find out what is wrong, and to demand corrections. The CSS is also used for this. We are in our role as police” (DREAL 60 - Bionerval);

“In connection with the influx of complaints and requests, inspectors of the provincial Inspectorate Environmental protection in Wroclaw in 2013 conducted an investigation, to verify the use and storage of the abovementioned substance in relation to the decision of the Minister of Agriculture and Rural Development” (Polish State Services – Zittau)

About the levers for action of state services regarding the issues with the storage: *“There’s the possibility of issuing a formal notice (mise en demeure) of the biogas plant, which will be issued if it does not progress. For the time being, we have always been supportive, because it is well managed, there was a good team in charge”*. We see here the mobilization of the institutional capital to support the biogas plant in times of difficulties.

This role of controlling is often supported and encouraged by the different agents in the case studies we investigated:

“There must be very strict controls by the state” (mayor – Bionerval);

“The more control and supervision there is, the safer it will be” (AILE – Kastellin);

And some agents even criticise the lack of sufficient control:

“On paper, biogas production is attractive, but it is not sufficiently controlled” (EPAGA – Kastellin);

“I think it's not enough controlled. We need neutral people to come and control. I'm in favour of state services coming to control, but not to bother us, rather to control BioQuercy, the inputs, the quality of digestates” (Farmer – BioQuercy);

“For me, there are not enough controls, just self-control and good farming sense” (Collective – BioQuercy)

The second role we observed is the role of regional intermediary, that parallels the role of local intermediary we described in Section 1. Intermediaries are needed to anticipate conflicts, and to solve conflicts when they could not be prevented.

For Bionerval, the State played the role of intermediary to set up a site monitoring commission. The site monitoring commissions are governance tools created by the State, to solve the conflicts. They are monitored and chaired by the prefects or the sub-prefects, and gather the main groups of agents at the department scale. The site monitoring commission of Bionerval was created in 2013, and is composed of the regional administrations, local authorities, inhabitants, managers and employees, and the ROSO.

“The last two site monitoring commissions were very effective” (mayor - Bionerval);

“In the CSS it is factual, not ideological” (managers - Bionerval);

“The hotlines are generally set up after the intervention of the DREAL, after the site monitoring commission. Before, there is often a lack of communication and of dialogue. The site monitoring commission makes it possible to set up this dialogue” (DREAL 60);

“Solving problems locally is complicated. Perhaps we must find a transversal structure at the sub-prefecture level to be a judge of reason” (mayor – Bionerval);

“The elected representatives only listen to the word of the State services” (ROSO – Bionerval)

For BioQuercy, the quite violent conflicts led the State to intervene several times, to set up a site monitoring commission as for Bionerval:

“Since there have been these problems in the Lot, in order to overcome the political differences, there have been the site monitoring commission set up by the sub-prefecture” (Chamber of agriculture - BioQuercy);

About political conflicts *“It was the sub-prefect who was able to decide. But it is often according to the orientation of the sub-prefect”* (Farmer – BioQuercy)

But also, to set up “working groups” on various topics, such as the location of the spreading of digestates, and the unpleasant smells:

“The sub-prefecture has set up working groups with just about everyone, to explain where the new parcels are located, and the group makes comments on the choice of location of the parcels” (Chamber of agriculture – BioQuercy);

“There have been working groups under the pressure from the sub-prefecture, the smell has become more than reasonable” (mayor – BioQuercy);

As well as to set up a participatory observatory⁵²: *“It's the sub-prefecture that manages, who mandated the park. But they wonder if it should be done only in the Lot or at the national level. There is the need for more means, but there are not enough means at local level”* (managers – BioQuercy).

For Kastellin, the story is different. No site monitoring commission existed prior to the accident of 2020, as there was no conflict. However, the State had to intervene to manage the consequences of the accident, both in a coercive way: *“The biogas plant was closed by the administration so there was no possibility to deliver for 2 or 3 months”* (farmer – Kastellin); and in a role of central actor that activated organized and geographical proximities (i.e., territorial proximity) with the main agents of the territory, and allowed the transfer of information:

“There was a lot of information on the reasons for the accident and the actions of the State: two meetings with the elected representatives, one of which was held on the site with a presentation of the operation and the modifications put in place following the pressure from the DREAL and the prefect, then the DREAL intervened with the SDAGE of the Aulne and the mixed union. Then there were more bilateral relationships with others, in particular with the vice-president of the regional council responsible for the environment” (DREAL 29 – Kastellin).

However, the ability of the State to solve conflicts also raises the question of its responsibility in doing so, as well as in the emergence of the conflicts around a sector which development is strongly supported at the national level:

“But what bothers me is that 4-5 years before the administration gave the authorisation for this system, the administration signed the paper in the first place” (farmer – Kastellin);

⁵² We explain the setting up of this participatory observatory in the sub-section 3: “the production of information”

“The DDPP put the stamp on 6 months of storage and so everyone screwed up” (Farmer – Terragr’eau)

For Kastellin, the activation of organized proximities by the State after the 2020 accident, and the transfer of information, have been highly criticized and worsened the conflict:

“What we didn't do too well, the SMA⁵³ asked for feedback, but the State never took the time to do it, and the elected representatives are angry at the state for not doing this, and they are right. So there are fears: are they hiding things from us?” (DDTM 29 – Kastellin);

“We just have communication of the prefectural decrees, that's all. I was invited to take part in the visits, but I did not see any written conclusions from the investigation. This is how we are associated. I think it's normal that we should have the elements directly” (mayor – Kastellin);

“Following the complaint, we got no result of the investigation, the town hall was not heard, and the prosecutor just sent a letter to say ok recognition of guilt”; “I wrote to the prosecutor and there was no reply. I had asked the prosecutor to redirect the case to a public hearing but there was no response to the letter. Even as an elected official, we are nothing on cases like this, we are treated with condescension” (Mayor – Kastellin);

“Indeed, there was not enough feedback. We never got the written report, the one from Cash investigation. A meeting with the prefecture took place to acknowledge the failures but no details were provided.” (EPAGA – Kastellin)

The mobilization of the institutional capital through the legal actions undertaken by the complainants was also complicated, and created frustration and resentment against the judiciary:

“Several complaints were filed, by the SMA, town halls, all the ComCom served by SMA filed complaints. But the feedback from the court was very opaque. We asked for feedback in the CLE, they told us - yes, yes, it will be done, there's no problem. But the feedback was finally given in a very small committee and we absolutely want it to be done in the CLE” (EPAGA – Kastellin)

These situations created a feeling of distrust against State bodies:

⁵³ SMA = Mixed Union that manages the Aulne river

“The secretary general of the prefecture in Quimper, instead of denouncing the biogas plant, was attacking Veolia⁵⁴, there was a moment when I found it rather unpleasant to minimise the role of the biogas plant and ENGIE and minimise the accident” (mayor – Kastellin);

“The experience of our elected representatives is that the state services did not play fair, and that it was a bit harsh to put the blame on Veolia and not on the biogas plant” (mayor – Kastellin)

This situation of distrust, resulting from a weak activation of organizational proximity, a weak transfer of information, and a difficult mobilization of the institutional capital is a pity as State organizations originally seem to benefit from a positive aura in the mind of agents:

“When it's a state organization, when it's approved by the state, people feel more concerned. The institution provides an answer that is not perceived in the same way, it is better perceived. Why deprive ourselves of institutions that are recognised and that could respond better to the population?” (farmer – Bionerval)

“It would be a great help if the ADEME could target small mayors or even the population to communicate on biogas plants and digestates. The ADEME has a very positive aura with these small elected officials” (Managers - Bionerval)

As a consequence, we saw that the State owns control and coercive powers whose activation seems necessary in case of conflicts, and the use of these powers are supported and even requested by other agents. In addition, it is the State that chooses to allow and support the activities of the biogas plants, therefore, agents seem to consider the State responsible for solving the conflicts, at least partially. The intervention of the State in the organization of the sector appears quite inevitable.

However, the State is not the only intermediary and central actor in the resolution of conflicts. In the next paragraph, we will present the other regional agents that play a central role in the resolution of conflicts.

⁵⁴ Veolia is the company that manages public water distribution locally

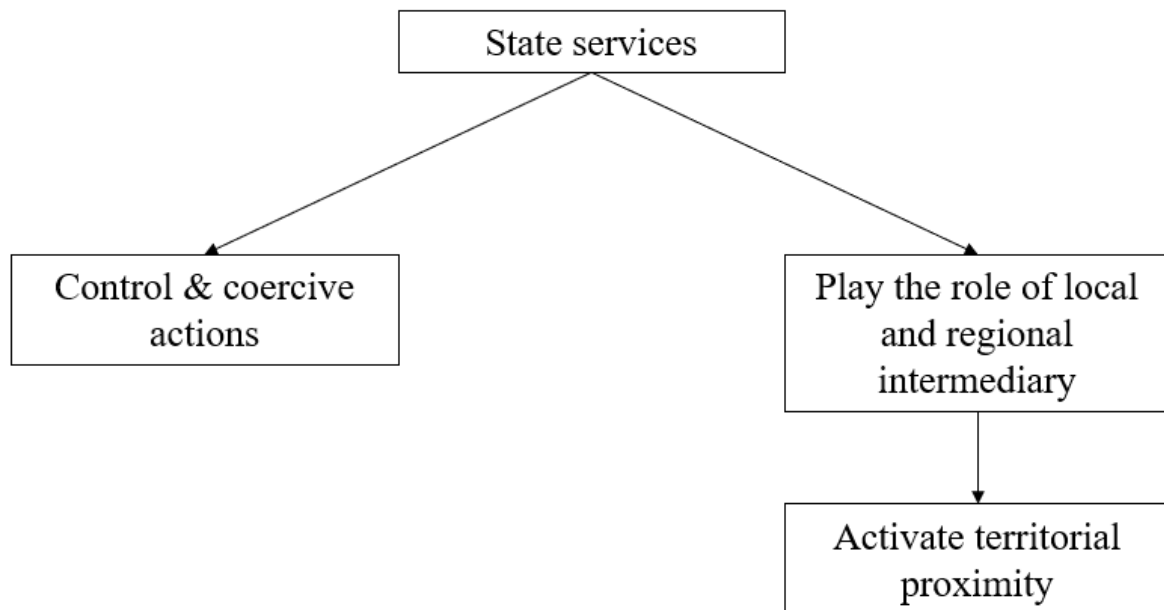


Figure 53: the different roles that State services can play to anticipate and solve conflicts. (Source: own graph)

2. The role of other⁵⁵ central regional agents

For BioQuercy, the PNRCQ, which, as we saw previously, is an important regional player in governance processes, also claims a role of intermediary between opposing groups of agents:

“We are not politicized, we can work with everyone. We are a link between different organizations that don't talk to each other” (PNRCQ – BioQuercy).

However, the credibility of the PNRCQ, and of potential other intermediaries, is questioned by the other agents:

“The PNR is like us, it doesn't know”; *“It gave a favorable opinion, but it's nice on paper. What about the reality?”* (mayor – BioQuercy);

“The Chamber of Agriculture is also going to be between the organics-I-don't-know-what and the union I-don't-know-what” (mayor – BioQuercy).

⁵⁵ Other than State services

And the perception of potential conflicts of interests by opponents also impacts negatively the credibility of intermediaries:

“The elected members of the PNR also work on the biogas plant. Some elected representatives vote for the project even though they have a direct interest in the biogas plant” (Collective – BioQuercy).

For Kastellin, the weak activation of organized proximities by the State led the mayor of Châteaulin and president of the Community of Municipalities Pleyben-Châteaulin-Porzay (CCPCP) to try activating them: *“I took the initiative of organizing a meeting with various people, including Veolia and the sub-prefecture, because not many elements had been transmitted by the State services”* (mayor – Kastellin).

“This first meeting allowed us to have information and to be involved from start to finish” (mayor – Kastellin).

“Thanks to this initiative, the elected officials of Châteaulin and the ComCom were then involved in subsequent meetings on the subject with the prefecture” (mayor – Kastellin).

The initiative of the mayor and president of the CCPCP to organize the coordination between the main regional agents seems to have been successful.

In the case of Terragr’eau, we described in the previous section, and in Chapter 5, the structure of governance at the scale of the watershed, with the existence of the APIEME, and its multiple links with the other groups of agents. This strong coordination was also mobilized to solve the conflicts linked to the under-sized storage capacities of digestates, and in this case, the State did not play any specific role in the implementation of this coordination.

“We have regular working meetings with everyone to resolve this problem” (APIEME – Terragr’eau);

“The conflict allowed for the creation of a new informal governance to work on the optimization of the site. The conflict has allowed governance and communication to be optimized” (APIEME – Terragr’eau)

“This problem made things tense at times, but it required a lot of discussion, working hand in hand to manage the problem. It led to a lot of meetings, discussions, exchanges, to see if the collective work was bearing fruit, and yes, it did bear fruit because everyone played the game” (managers – Terragr’eau)

This echoes the results from the literature we exposed in Section 2 of Chapter 3, where conflicts are sometimes considered as source of innovations and improvements in territorial governance (Torre, 2011; 2014; Torre et al., 2016).

The coordination process led to the setting up of a “*working group composed of the SICA, Evian and the ComCom to consider if the operator were to leave tomorrow*” (SICA – Terragr’eau) and to a decision to transform the infrastructural capital:

“*The CCPEVA is in the process of setting up a project to extend the storage facility*” (managers – Terragr’eau)

The resolution of the complaints about traffic jam also involved the coordination of several stakeholders, at the scale of the department this time:

“*The problem of the roads managed by the ComCom was brought to the attention of the communal and departmental authorities to study solutions. The department is willing to work with the ComCom*” (CCPEVA)

The farmers were also involved in the coordination process, and “*next time, municipalities will be included in the discussion and we are currently working with the DDPP to optimise travel by spreading and bringing back inputs*” (CCPEVA)

For Biomethan Zittau, local complainants tried to activate the regional institutional capital by appealing to regional elected officials, in order to gain institutional support and activate their coercive powers:

“*The villagers affected by the problem described above have already hired a lawyer and sent letters to the starosty⁵⁶ and voivode⁵⁷ demanding that all documents be checked and whether they were issued in accordance with the law. The matter is also dealt with by local parliamentarians, including Senator Jan Michalski*” (Lubanski.eu)

“*The inhabitants did not believe it and demanded that the district mayor cancel the permit for the reservoir and prohibit the import of digestate from Zittau to Poland*” (Chronmyklimat.pl, September 2013)

⁵⁶ The staroste is the equivalent of the head of the departments in France, and the districts in Germany.

⁵⁷ The voivode is the equivalent of the head of the regions in France, and the Lander in Germany.

However, it did not work, and as we explained in the Section 1, it is through the mediation of the local municipality of Sulików that the conflicts were solved. Therefore, the resolution of local conflicts does not necessarily need the intervention of agents at a larger spatial scale.

Consequently, we identified several potential regional intermediaries or central agents whose role can complement or substitute to the role of the State in the resolution of conflicts: elected officials at the scales of the department, the region, or Communities of Municipalities (Terragr'eau, Kastellin), the regional natural park (BioQuercy), pre-existing structures of governance such as the APIEME and its links with other stakeholders (Terragr'eau). However sometimes, regional agents could not help in solving the conflicts (Biomethan Zittau).

The resolution of conflicts often requires to acquire and produce information when conflicts are caused or worsened by shared uncertainties. We will see in the next paragraph how regional coordination can be activated to transfer, acquire and produce information.

3. Activating regional coordination to produce information

First of all, we observed, for BioQuercy, the most important attempts to coordinate at the regional scale, through the activation of organizational proximity, to produce information and try to solve situations of shared uncertainty. These several attempts seem proportional to the multiple situations of shared uncertainties on the impacts of digestates on the karstic area of the land application plan, and also proportional to the violent conflicts we described in Chapter 5. First, regional stakeholders tried to set up a scientific and participatory observatory of biogas production, chaired by the PNRCQ, and composed of 6 working groups dealing with bees, micro-fauna, percolation, agronomy, water quality and air quality (La Dépêche du Midi, 10-11-2021). However, issues with the financial capital have prevented this observatory to keep on functioning, and debates on the adequate scale to produce such information were reported:

“Technical meetings to set up the observatory did take place, and also to draw up a report, but the cost was exorbitant. Now it's the sub-prefect of Gourdon who is looking for funding.” (chamber of agriculture – BioQuercy)

“Why do all this against the Lot? We have to do it at national or regional level. So, for the past year there hasn't been much going on.” (chamber of agriculture – BioQuercy)

“It will be necessary to find recurring credits: analyses and experiments are expensive and are done over the long term.” (PNRCQ - La Dépêche du Midi, 10-11-2021)

The setting up of this observatory was announced in 2019, then there was a meeting in 2020, and another meeting in January 2021. But since then, nothing new happened (La Dépêche du Midi, 10-11-2021), which raised critics from opponents:

“This is a missed opportunity for the Occitanie Region and the department to put forward an innovative participatory approach” (Collective - BioQuercy).

In addition, another attempts of coordination to better understand the functioning of the karstic area, and the impact of the valorization of digestates on it took the form of an “intra-karst observatory”. This observatory involves many different regional agents: research centers, water agency, department and regional councils, speleology associations and is chaired by the PNRCQ. But again, the PNRCQ is currently looking for funding to maintain and develop the activity of the observatory (Inspectors Report, 2019).

Consequently, coordination at the regional level is necessary to produce information at the regional scale (here, the scale of the karstic area), but this coordination is limited by the extent of the financial capital. In addition, it appears logical that the main structure of governance at the scale of the karstic area, which is the PNRCQ, chairs and monitors these efforts. It is therefore through the mobilization of the existing institutional and organizational capital of the territory (see Chapter 5) that regional agents try to produce information.

For Kastellin, we observed the need to mobilize the technical & cognitive capital of the territory to produce information about the impact of the accident.

First of all, thanks to the EPAGA associated to Engie which owns and runs the biogas plant, and a consultancy:

“impact study on the consequences of discharging digestate into the Aulne” (EPAGA – Kastellin);

“EPAGA teams were made available and mobilized as a matter of urgency to help draw up the specifications for the study” (EPAGA – Kastellin)

However, as we mentioned in the previous sub-section, the weak transfer of information and the communication of the results let the stakeholders frustrated:

“We did not receive the results from the DREAL and ENGIE. We were a bit disappointed”
(EPAGA – Kastellin)

And the situations of shared uncertainties can also be used by some stakeholders to orientate the conclusions of new research, which in turn creates more frustration:

“Engie stated that it did not have a reference state of the fauna and the environment before the accident, so it is very hard to compare. They concluded that there was no impact. The EPAGA was frustrated because we suspect that all this will end up in the Brest harbour, and the Brest harbour is already degraded” (EPAGA – Kastellin)

We see here again that the consequences of a local spillage of digestates can potentially affect areas located more than 40 kilometres away, and therefore impact a very large hydrographic system and its ecosystems.

There has been also a recent attempt to activate organizational proximity through a *“study started by the Brittany region to assess the biogas sector in Brittany over the last ten years. Eaux et Rivière de Bretagne and the Confédération Paysanne are invited. So, the study must put everything on the table. The region is trying to reach a consensus for all the players”* (AILE – Kastellin)

This attempt goes beyond the issues of Kastellin only, but includes them, in a similar way as the participatory observatory in the Lot does not only target BioQuercy but includes it. Whereas for BioQuercy it is the PNRCQ that chairs the observatory, in Brittany it is the Region. We therefore observe again the diversity of central agents and intermediaries, across the various territories.

For Biomethan Zittau, we saw previously in sub-Section 1 that the conflicts were not solved at the regional scale, but at the local scale, thanks notably to local intermediaries. However, we observed the necessary intervention of a regional agent to produce information, the Polish state services, as representative of the State, and word of authority:

“The survey was conducted among farmers with land on which digestates were used” (Polish state services - Zittau)

“The size of the then tested physical-chemical indicators of the soil samples taken from agricultural fields on the territory of Zara village did not show violations of soil quality standards and threats to the environment” (Polish state services - Zittau)

This intervention of Polish State services echoes our questioning on the necessary intervention of the State in the organization of the biogas sector, not only in France but also abroad (in Germany and Poland).

For Terragr'eau and for Bionerval, we did not observe such mechanisms as the conflicts were not related to situations of shared uncertainty on the impacts of digestates, but on smells, storage and roads (see Chapter 5). There was therefore no need to coordinate to produce knowledge about these impacts, and, in addition, for Terragr'eau, we saw, at first, that Danone had already explored the area of the impluvium extensively, and had produced a lot of knowledge about it (see Chapter 5), and, secondly, that agents already coordinate to produce knowledge before the emergence of conflicts, which may have prevented the rise of these conflicts (see previous sub-section).

Conclusion of Section 2

In this section, we first observed that, to anticipate conflicts at the regional scale, agents mobilize the already-existing and functioning mechanisms and structures of coordination of the territory. We observed that the more mechanisms and structures of governance already working, the more they are mobilized (for Bionerval for instance). On the other side, in territories where we observed a context of weak coordination of agents (see Chapter 5), we also observed a weak coordination of agents to anticipate conflicts around digestates (Kastellin for instance). Secondly, we also observed the need to produce knowledge, at regional scale, on the impacts of digestates, to both anticipate and solve the related conflicts. But, in the territories where coordination was already strong and had allowed to produce knowledge, there were less conflicts related to the lack of knowledge, and therefore, less necessity to coordinate to solve conflicts (Terragr'eau for instance). On the contrary, where coordination was lacking beforehand, we observed a need of a lot of coordination to produce knowledge, and shared references, with the hope to solve conflicts (for BioQuercy and Kastellin for instance).

In addition, we also observed the necessity to coordinate to produce a shared vision of the sector, at the regional scale, when opinions diverge too much, i.e., when the cultural capital needs to be harmonized, through the activation of organized proximity, and even, territorial proximity. We also questioned ourselves on the inevitable role of the State, either in France, or in Poland and Germany, to facilitate these attempts of coordination, and both to solve and anticipate conflicts, because of the State's responsibility in the development of the biogas sector

and the necessary use of its coercive powers. However, we also witnessed the implication of several additional intermediaries, both to solve conflicts on actual issues, and to facilitate coordination to produce the missing knowledge that cause conflicts. Again, these intermediaries are part of the institutional and organizational capital of the territories we exposed in Chapter 5, and their action is allowed because of the specific context into which they are embedded.

We now move on to the discussion of the results.

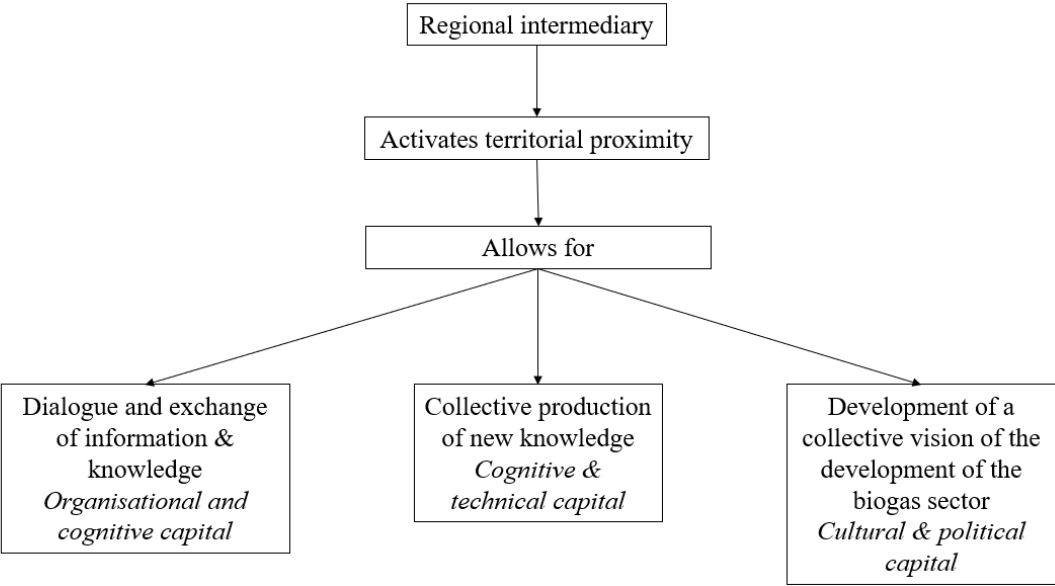


Figure 54: the roles of a regional intermediary in the anticipation and resolution of conflicts. (Source: own graph).

Section 3: the multiple characteristics and dynamics of territorial governance

Introduction of Section 3

In this Section, we present a discussion of the results we exposed in Section 1 and 2. We first start by discussing our assumptions on the necessary territorialisation of the biogas sector, to anticipate and avoid conflicts. We then move on to a discussion about the role of conflicts in territorial governance processes, and we then discuss the assumptions about the roles and identities of different intermediaries and central agents, in the anticipation and resolution of conflicts, and especially in situations of information asymmetry and shared uncertainty.

1. The territorialisation of the biogas sector: the need for both the French-speaking and the English-speaking approaches

In Chapter 2, we exposed some claims made by the literature about the need of the *territorialisation* of the biogas sector to ensure a conflict-free development of the sector. In Chapter 3, we provided the two main definitions of *territorialisation*, one from the English-speaking scientific literature, that defines it as the role of one or several local authorities that take control, coercive and regulatory actions on a territory, to monitor the development of economic activity (Bassett & Gautier, 2014), and the other one from the French-speaking literature that emphasizes the need to mobilize the resources and the local agents to adapt the development of an economic sector to the specificities of the territory (Fleuret, 2015; Ginelli et al. 2020). We assumed the need for both approaches to ensure a conflict-free development of the activities of valorization of digestates.

Firstly, we indeed observed the coercive and regulatory dimension across all our case studies, in France and in Germany / Poland. We observed, for instance, controls carried out every year by French state services until smell issues were solved (Bionerval), or controls carried out by Polish state services to verify the compliance of digestates land application with environmental standards (Biomethan Zittau). We also observed requests from State services for changes and corrections in the operations of the biogas plants, to improve the storage capacities of digestates of Terragr'eau, for instance, and the formulation of *formal notices* (BioQuercy), to ensure that corrections are made. Finally, when necessary, State services can also shut down a plant for months (Kastellin) until issues are solved and new rules of operations are established and implemented. It therefore seems that the intervention of the State, in the activities of

valorization of digestates, and through this coercive dimension, is inevitable when conflicts emerge.

Secondly, we had already demonstrated in Chapter 5 the necessity of the French-speaking approach of territorialisation, through the necessary mobilization of the different dimensions of the territorial capital, and of some dimensions in particular, to ensure as few conflicts as possible in the development of the sector. But moreover, in order to solve conflicts that could not be avoided, we observed the necessary mobilization of different dimensions of the territorial capital: the need to improve the infrastructural & equipment capital (issues with storage and road traffic for Terragr'eau), the need to mobilize the institutional and organizational capital to find collective solutions (in all of our case studies), the need to find more financial capital to produce information (BioQuercy), the need to mobilize the cognitive capital to produce information (mobilization of different cognitive resources for Terragr'eau for instance), and the need to harmonize the cultural & political capital (attempts to create a shared vision of the sector, in Kastellin or Bionerval).

Based on these results, we can therefore validate the assumptions we formulated in Chapter 3, i.e., the need for both a coercive and regulatory approach of the development of the sector, and the need to adapt the sector to the characteristics of the territorial capital available in each territory.

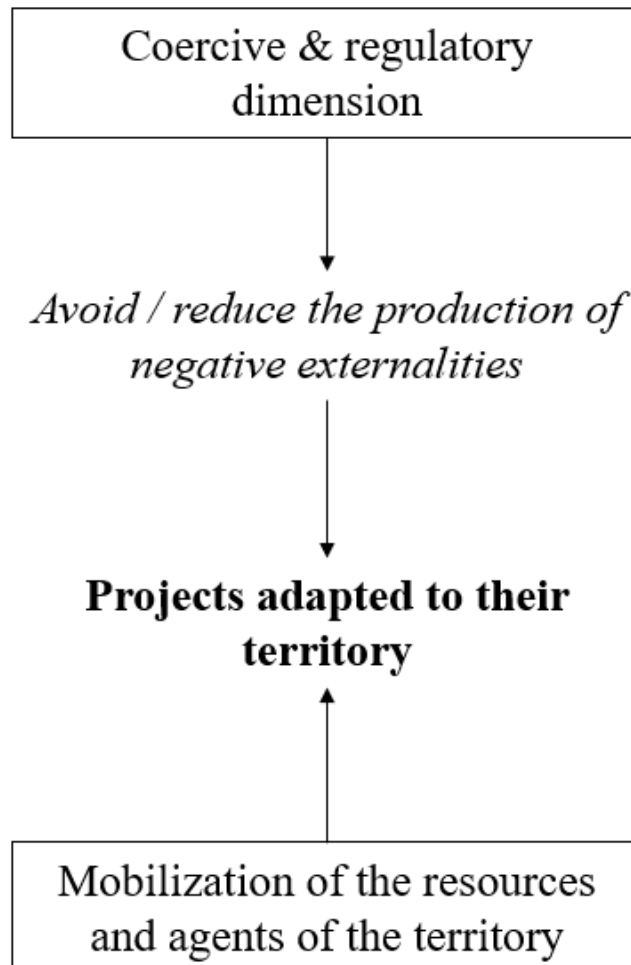


Figure 55: the combination of the two approaches of territorialisation allows for the development of projects adapted to their territory. (Source: own graph).

2. Conflicts as both failures and integral parts of governance processes

In Chapter 3, we exposed diverging opinions on the nature of territorial conflicts. According to Torre (2011; 2014) and Torre et al. (2016), conflicts are an essential part of rural development, and they necessarily come with new projects. They are not a fatality but one of the stages of local dynamics (Torre et al., 2006). These conflictual stages can even contribute to an improvement of local relationships, through a renewed communication between local agents that learn from each other (Bourdin & Nadou, 2020; Torre, 2011, 2014; Torre et al., 2016). But Bourdin et al (2020) wonder whether conflicts might not in any case be considered as failures of governance processes.

In the majority of our cases, conflicts actually did allow for new forms of communication between local or regional agents, and for new forms of coordination in order to

solve the conflicts. It was clearly stated by the agents that dealt with the storage issue for Terragr'eau:

“The conflict allowed for the creation of a new informal governance to work on the optimization of the site. The conflict has allowed governance and communication to be optimized” (APIEME – Terragr'eau)

“This problem made things tense at times, but it required a lot of discussion, working hand in hand to manage the problem. It led to a lot of meetings, discussions, exchanges, to see if the collective work was bearing fruit, and yes, it did bear fruit because everyone played the game” (managers – Terragr'eau)

For BioQuercy, the conflicts around the impacts of the land applications of digestates on the karstic environment led to set up two observatories to monitor and assess these impacts. These observatories, especially the participatory one, are supposed to bring all the local and regional agents together, including the opponents to biogas production, to work together. In addition, for BioQuercy as well as for Bionerval, site monitoring commissions were set up to solve the conflicts, and they seem to have been effective, according to what local and regional agents say. Thanks to these commissions, agents were finally brought together and capable of discussing and answering each other's questions. Furthermore, for Bionerval, direct interactions between agents that did not have contact previously were permitted thanks to the hotline. For Biomethan Zittau, thanks to the intermediation of the municipality of Sulików, all parties were finally able to seat at the same table, to talk and exchange information. Finally, for Kastellin, we witnessed, to the contrary, a weak activation of organized proximity, and a weak coordination process in the resolution of the conflicts created by the accident. And this weak coordination created even more frustration. However, to solve general conflicts about the sector in the region, we observed the setting up of a new study where all parties, including opponents, are invited. All parties will finally be able to discuss and exchange their opinion, at the scale of the whole region.

Therefore, the attempts to solve conflicts allow for new or improved communication and direct interactions between local and regional agents. But, based on our results, we also argue that these conflicts can be avoided sometimes, when communication and direct interactions are permitted and facilitated soon enough through territorial governance. For Biomethan Zittau, managers themselves recognized that there had been no interaction, no discussion and no meeting with the local agents in Poland prior to the installation of the remote storage and the beginning of land application operations. Could a more inclusive governance

process have prevented the rise of the conflict? For BioQuercy and Kastellin, the conflicts hold a significant cultural and political dimension, that was not present in the conflicts for Terragr’eau, where the inclusive and long-term governance structure of the APIEME had allowed for decades the coordination of local and regional agents around questions of territorial development.

Consequently, although conflicts seem inevitable, as it seems difficult to anticipate every cause of conflict, adequate territorial governance can prevent some conflicts to happen and ease the valorization of digestates. We will move on the discussion of these aspects of territorial governance in the next sub-section.

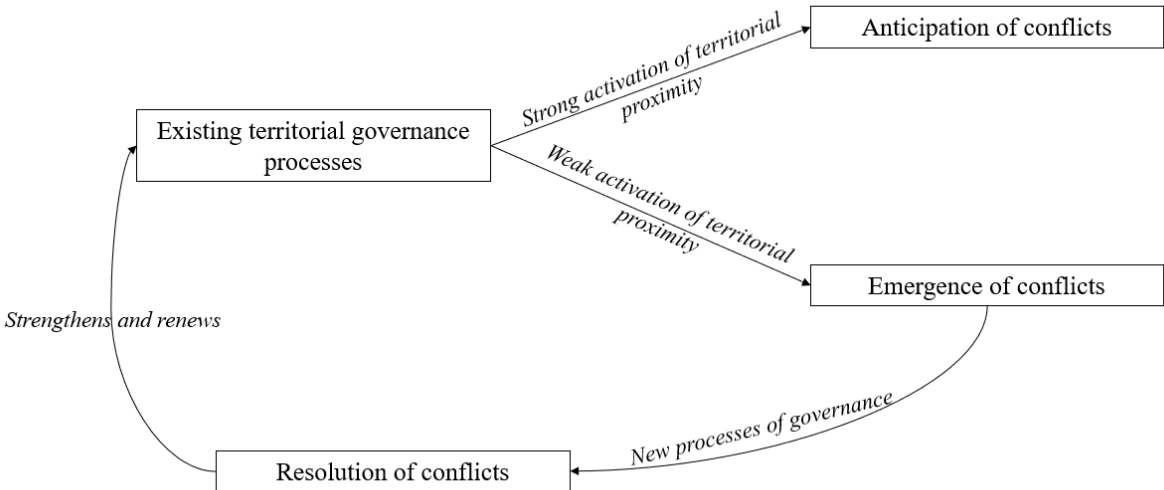


Figure 56: conflicts as both failures of governance processes and opportunities to improve them. (Source: own graph).

3. The necessity of a multi-actor analysis of territorial governance processes

In Chapter 3, we exposed that the literature insisted in the importance of governance processes over time, for the continuity and sustainability of territorial projects (Bourdin & Maillefert, 2020). We indeed observed, for all of our case studies, the role of territorial governance both to anticipate the emergence of conflicts throughout the life of the biogas plants, and to solve conflicts that had emerged years after the beginning of the valorization of digestates. In addition, we observed that the territorial governance mechanisms activated to solve these conflicts were often based on previous processes of governance, i.e., they depended on already-existing proximities, that were activated to mobilize the already-existing territorial

capital, and especially its organizational, institutional and cognitive & technical dimensions (see the governance mechanisms activated through the APIEME for Terragr'eu, for instance, or through the cooperation between the SATEGE / MUAD and State services for Bionerval).

There is, therefore, the necessity to mobilize the existing structures and mechanisms of territorial governance to support the activities of valorization of digestates, and to make them evolve when necessary, to solve potential conflicts, or, otherwise, there is the need to create new structures dedicated to the valorization of digestates, when the territories lack structures that can deal with this issue. For instance, we highlighted the need to create new structures of governance for BioQuercy, in the form of participatory observatories, but, we observed, again, the same challenges for these structures than for existing structures (the PNRCQ, for instance) and especially issues with a lack of financial capital. In this perspective, we can validate the claim made by Niang et al. (2021; 2022) that biogas projects are a test to existing local and regional coordination (see Chapter 3).

Also, we can come back to Chevalier & Pola (2014), and we validate their idea of a continuity in the mobilization of the territorial capital, and a continuity in the challenges that affect this capital. Therefore, although the mobilization of the territorial capital can be discontinuous, with periods of time where some dimensions are less mobilized, the activities of valorization of digestates are definitely embedded in a timeline of activation of the specific resources of their territory. This is very much in line with the French-speaking understanding of territorialisation we explained previously. The success of the valorization of digestates, and the resolution of conflicts, lie on the mobilization of the specific resources of the territories.

We also explained, in Chapter 3, that the literature on territorial governance had highlighted the role of an intermediary, and even, a “territorial intermediary”, to activate territorial proximity, help federate local agents and support the design of innovative governance mechanisms (Bourdin & Nadou, 2020; Carrière, 2018; Niang et al., 2022). We indeed observed the role intermediaries, but not only of one intermediary per territory, but of several intermediaries or central actors. We also observed their role at different spatial scales: local and regional (including department scale, watershed, regional park, impluvium), and we are therefore in line with Torre (2011) that talked about the increasing number of spatial levels of governance, and of the agents involved (Chapter 3). Moreover, in line with what we explained above, these intermediaries are often organizations that already played a role in previous territorial governance processes, i.e., they already benefit from credibility and networks, and resources, i.e., they already have the capacity to mobilize the territorial capital. In this, we are in line with Niang et al. (2021, 2022) that insisted on the importance of existing networks to

guarantee the success of biogas projects. The identity of these intermediaries and central actors can be very diverse, such as the Chamber of agriculture, State services, consultancies, PNRCQ and municipalities. Their intervention depends on the history of the territory, i.e., on the structure of its territorial capital, and especially the organizational, institutional and cognitive dimensions, and it depends on the challenge addressed (need to activate cognitive resources to produce information, need to transfer information to farmers, need to discuss with opponents...), and on the spatial scale. We therefore challenge the idea of “one central agent” as proposed in the literature (Bourdin, Colas, et al., 2019; Bourdin, Nadou, et al., 2019; Bourdin & Nadou, 2020; Niang et al., 2021), and we would rather talk of several central agents.

In addition, we exposed in Chapter 3 the claim made by the literature that this intermediary is most often a “local public authority” that is supposed to be “neutral” and inspire confidence (Bourdin, Colas, et al., 2019; Bourdin, Nadou, et al., 2019; Bourdin & Nadou, 2020; Niang et al., 2022). In our result, this role was played sometimes by public authorities, including State services a lot, but we also identified other agents, such as private companies and consular bodies. In addition, the neutrality of these public agents can also be questioned, such as the PNRCQ for BioQuercy, or State services for Kastellin. Public authorities do not always possess this aura of neutrality and this trust from other agents, and they can lose it when they fail to manage a crisis, which, in this sense, is in line with Gobert & Brullot (2018), and Niang et al. (2022). But, however, we confirmed the claim made by Gilly & Perrat (2003) about the role of the State as an important discussion partner, no matter the characteristics of local territorial governance processes. We can therefore validate the claim made by (Bourdin, Colas, et al., 2019) in reference to Kortsh et al (2015), about the need to adopt a multi-actor analysis of territorial governance processes, to fully capture the roles played by the different agents involved. The literature on biogas plants also insisted on the necessary involvement of many different agents to legitimize a project (see Chapter 3, (Bourdin, Colas, et al., 2019; Chodkowska-Miszczuk et al., 2019; Depoudent et al., 2020; Niang et al., 2022), and we add to that the necessity of the involvement of many different agents in the governance processes throughout the lifetime of the plants, in the organization of the valorization of digestates, to anticipate and solve conflicts.

4. Direct interactions and intermediation to solve situations of information asymmetry and shared uncertainty

We showed, in this Chapter, that one of the main roles of intermediaries is to facilitate the transfer of information in situations of information asymmetry, which is in line with previous literature on biogas plants (Bourdin, Colas, et al., 2019) and also to facilitate the collective production of knowledge in situations of shared uncertainty, which is our original finding. We explained, in Section 3 of Chapter 3, that the literature on biogas plants highlighted that conflicts and oppositions often come from a lack of information and communication (Bourdin, Colas, et al., 2019; Bourdin et al., 2020; Bourdin, Nadou, et al., 2019) i.e., from information asymmetry. In line with the literature, we observed the necessity, for biogas plants, to build trust through transparency, honesty and communication towards many different agents, including farmers, elected officials, state services and local inhabitants. We observed both direct communication between agents, and through the intermediation of central agents, at different spatial scales. In both cases, the activities of information and communication, as defined by Torre (2011) and (Bourdin, Nadou, et al., 2019) implied the activation of at least organizational proximity, often completed by geographical proximity, and sometimes by social proximity too. However, we challenge the previous literature that considers that information and communication are always beneficial, as we observed that some agents consider communication to be ambiguous, because of cognitive distance between agents. Ensuring cognitive proximity seems therefore necessary too to ensure beneficial activities of information and communication.

For what concerns situations of shared uncertainty, we observed the necessary role of an intermediary to activate territorial proximity in its different dimensions, i.e., to bring agents together through the activation of organizational and geographical proximity, as well as to involve some agents capable of bringing cognitive & technical resources, in order to help creating cognitive proximity between all the parties. However, the identity of the intermediary and the spatial scale for the production of knowledge is often source of debates, but, at least, our results were often in line with the claim made by Carrière (2018) on the central role of regional public powers in the production of knowledge. The new structures and processes of governance launched, and chaired, by the regional intermediaries, allow for the other stages of interactions described by Torre (2011), i.e., consultation of the opinions of all parties and opponents, dialogue with all parties, concertation on the impacts of digestates, and negotiation about the future of the sector. As a consequence, in line with our previous results, the resolution

of conflicts linked to shared uncertainty allows for the transformation and the strengthening of territorial governance mechanisms.

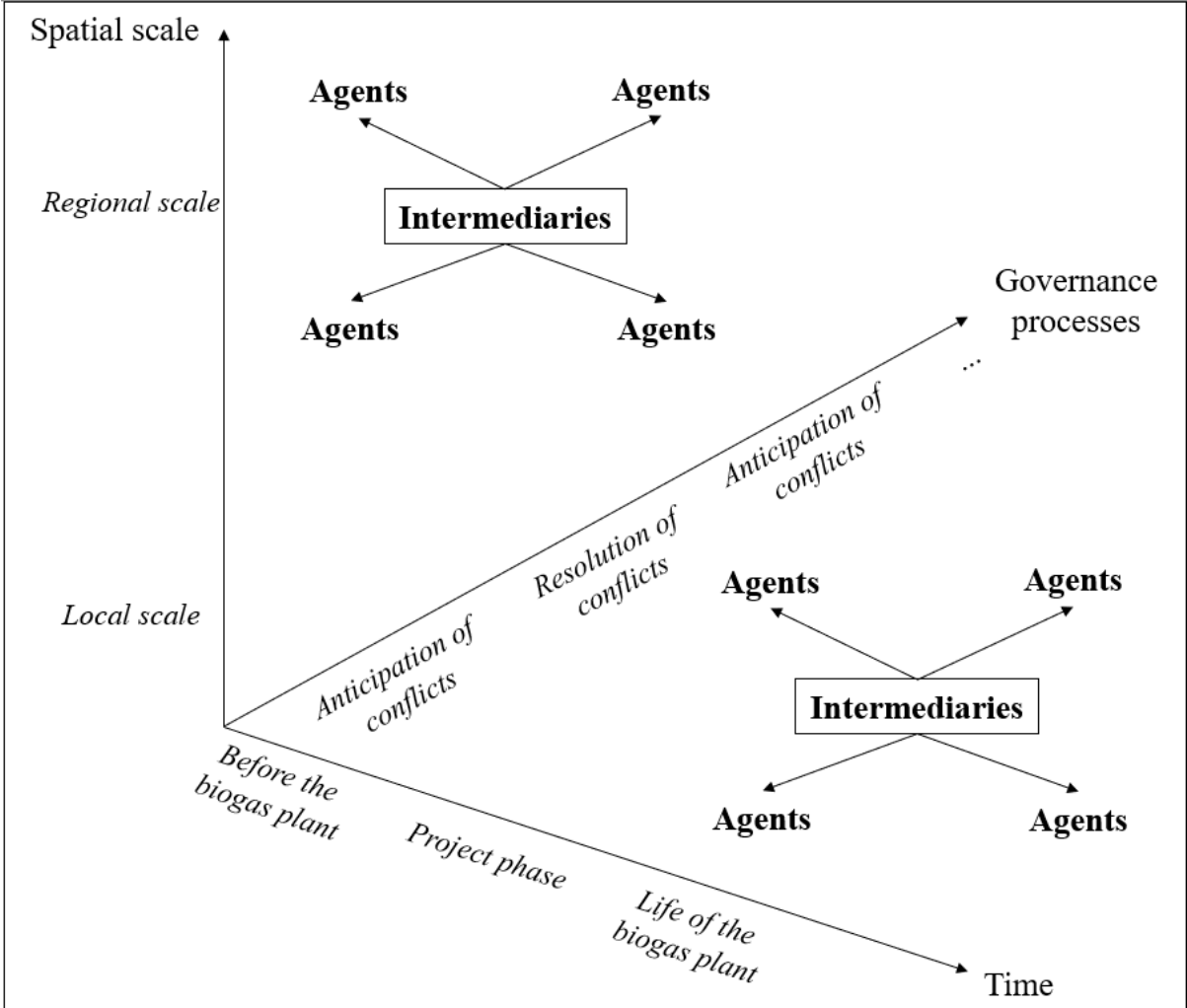


Figure 57: the role of intermediaries in territorial governance processes. Different intermediaries intervene at different spatial scales, through time, to activate proximities between agents, in order to anticipate and resolve conflicts. (Source: own graph)

Conclusion of Section 3

In this section, we first discussed and validated our assumption of Section 1 of Chapter 3, about the necessity of both the French-speaking and the English-speaking understandings of territorialisation, to ensure the anticipation and the resolution of conflicts linked to the valorization of digestates. We discussed the important role of the State in territorial governance, through the implementation of control, coercive and regulatory actions, and therefore in ensuring institutional proximity between all the stakeholders of the sector. We also confirmed again the need to build a sector adapted to the unique territorial capital of each territory, in line with what we already demonstrated in Chapter 5.

We then discussed the role of conflicts in territorial governance processes, and we confirmed the claims made in the literature, about conflicts being both a failure in governance processes, and being a source of innovation, evolution and strengthening of the governance process (Section 2 of Chapter 3). We observed the emergence of conflicts following a weak activation of territorial proximity, or at least, of organized proximity, whereas a strong activation of territorial proximity, including an often-strong activation of geographical proximity, allows for the anticipation and the resolution of conflicts.

We also discussed the role of territorial intermediaries that we explained in Section 2 of Chapter 3. We validated the claims made about the necessity to adopt a multi-actor analysis of territorial governance processes, as we witnessed the role of many different central agents and intermediaries in the activation of organized proximities, or even territorial proximity, and therefore in the anticipation or resolution of conflicts. We challenged the claims of the literature on public agents being the most adequate territorial intermediaries, because we observed the role of territorial intermediation played by private agents too, and we agreed with some authors that challenged the idea of an aura of neutrality and credibility of public agents. Neutrality and credibility must be gained and can be lost.

We also confirmed our assumptions of Chapter 3 about the existence of different spatial scales of governance, involving different agents, but we showed that the governance processes aiming at anticipating and solving the conflicts often rely on previous processes of territorial governance. If these processes are missing, there is the need for territorial intermediaries to launch new structures and processes of governance, notably to produce and transfer information, and especially to solve situations of shared uncertainty, which is an original finding of our research, compared to the results of the literature on the biogas sector.

Conclusion of Chapter 6

In this Chapter, we presented the second part of our results (first part is in Chapter 5), and we discussed these results. We, highlighted, at first, a potential general lack of consideration of digestates in the mechanisms of coordination of agents around projects of biogas plants. This lack of consideration should be addressed in future projects, to avoid potential issues. We then showed that the anticipation of potential conflicts, at the local level, implies to build trust between the biogas plant and the other local agents, through communication and information, about the qualities and impacts of digestates, facilitated by the activation of territorial proximity. However, we challenged the generalized assumption that communication and information are always beneficial. When the cognitive proximity between agents is too weak, communication can potentially be detrimental and create fears or even conflicts.

We also witnessed two types of interactions between local agents: direct interactions, and interactions through the intermediation of another central agent, whose identity can be very diverse, depending on the territorial context and the challenge or the conflict addressed. This territorial intermediary activates territorial proximity and therefore facilitates communication and dialogue, to anticipate conflicts or to solve them. At the regional level, the role of territorial intermediary appears to be even more important, to federate agents at the regional scale, and for three main goals: to facilitate the transfer of existing information, through structures of governance such as the site monitoring commissions, to produce and acquire knowledge in situations of shared uncertainty, through the setting up of participative observatories for instance, and to develop a shared vision of the development of the biogas sector. Again, at the regional level, the identity of the intermediary can be very diverse, and regional coordination implies the inclusion of an important diversity of agents, especially the opponents to the sector. Finally, depending on the conflict or challenge addressed, there can be several different intermediaries or central agents, operating at different spatial scales, and at different periods of time, in a dynamic perspective.

We also highlighted the almost inevitable and central role of the State in the processes of territorial governance, both as a territorial intermediary capable of federating the agents, or/and as the holder of authority whose role is to ensure the minimum production of negative externalities by the sector by means of controls and coercive actions. The role of the State seems to arise from its support of the development of the sector, and its coercive powers regarding environmental threats.

Consequently, our observations will lead us, in Chapter 7, to propose recommendations

of governance to the agents of the sector, in order to help them anticipating and solving conflicts on the valorization of digestates.

Chapter 7: Recommendations to the stakeholders for the governance of the biogas sector

Introduction

This chapter sums up the main results of our doctoral research that we would like to bring to the attention of the stakeholders of the biogas sector. It is intentionally brief and concise, in order to popularize the results to a wide and non-scientific audience. This chapter is made available in both French and English. In the first place, we sum up the objectives and method of our study. Then, we describe the nature of the conflicts we observed. And finally, we make recommendations of governance. The version transmitted to the stakeholders of the biogas sector is available in annex n°7.

Objectives and method

The biogas sector has been experiencing a very important growth in the last decade, in France and in Europe, thanks to the strong support of public powers. About 20 000 biogas plants are recorded in the European Union, and half of them are located in Germany, the world leader of the sector. In France, less than 200 biogas plants existed in 2013, while more than 1 700 biogas plants were operating in the end of 2022, and more are being constructed. According to an optimistic scenario of the European Biogas Association, the sector could cover 30 to 40% of the gas consumption of the EU by 2050. The boom of the sector leads to an increasing production of digestates: between 222 and 258 Mt of digestates may have been produced in 2021, and it is estimated that the production of digestates could double and reach between 455 and 492 Mt in 2030, and that a production of between 1.145 and 1.334 Mt of digestates could be reached by 2050.

However, the number of local conflicts, oppositions, and rejection of new biogas plants increases too, and it is estimated that up to 30% of projects fail to start because of local conflicts. The objectives of our 3-year research was therefore **to study these conflicts, to understand their nature, and to identify solutions to anticipate and solve these conflicts**. We focused on **centralized, industrial and territorial biogas plants**, and on the downstream stages of the sector, i.e., **the valorization of digestates**, because these stages too often lack the necessary consideration.

We compared the situation in France and in Germany, to gain experience from the world leader. We conducted interviews with experts and stakeholders of the sector, across different territories in France and in Germany, and we reviewed many different documentary sources.

The nature of the conflicts

The conflicts we observed were mainly related to the following issues:

a) Issues with infrastructures and equipment

-Undersized storage capacities of digestates,

-Congestion of roads, and especially around the biogas plant (from and towards the biogas plant where trucks collect digestates), and during certain period of time (periods of land application),

-Inadequacy of some pathways (municipal pathways, agricultural pathways) with the size of the spreading equipment,

-Degradation of public infrastructures (dirt on roads, rutted pathways).

b) Threats caused to the environment

Many different threats are usually mentioned, but the main one, far surpassing the other ones:

-Threats to water resources, both in terms of quantity and quality of water.

-About quality: fears of nitrates pollution if there is a leakage of digestates during storage, transportation or land application. These fears are aggravated because in many territories, water resources are already submitted to nitrates pollution.

-About quantity: fears of an additional use of water to cultivate crops for the biogas plants, and fears that in case of pollution / contamination of water sources (rivers, catchments...) during periods of droughts, no other water source would be available, depriving local people from drinking water.

c) Unpleasant smells

Very unpleasant smells are very often reported, in different places: at the biogas plant, at remote storages, and at land application worksites. These smells are often the source of a lot of complaints addressed to state services.

d) Cultural and political tensions

Biogas plants, and their digestates, often crystallize territorial conflicts about the agricultural model the sector supports (a more or less industrial model for instance), about the vision of the ecological and energy transition (and the role of the different renewable energies), and about the meaning of the circular economy. Conflicts also arise on the development of the sector itself, and especially around the opposition between industrial vs agricultural biogas production.

e) Global lack of skills and attractiveness

A lack of technical skills to operate properly biogas plants and to handle digestates has been widely reported, as well as the difficulty to attract qualified workers. Above all, a lack of skill about risk management is emphasized. This lack of skills concerns all the actors of the sector, including operators and managers of biogas plants state services, consultancies and consular bodies. This lack of skill can be sources of accidents and generate conflicts.

f) Lack of knowledge and hindsight

Many scientific uncertainties remain on the impacts of the biogas sector and digestates on the environment, including water quality, soil quality, biodiversity, human and animal health, carbon footprint... This lack or absence of knowledge, especially about the long-term consequences, generates fears, and fears generate oppositions and conflicts.

Recommendations to the stakeholders of the biogas sector

First of all, a general lack of consideration for digestates during the conception phase of biogas plants is reported. The first advice is therefore to pay much more attention, for new projects, to the issues related to digestates.

Then, the three first issues we mentioned can be anticipated and solved at the local level.

a) Issues with infrastructures and equipment

-During the conception phase of the biogas plant: a particular attention must be granted to the storage capacity of digestates, both on-site, and at the remote storages. Sufficient storage capacity must be ensured, and it often depends on local agricultural practices.

-A collective thinking about the adequate storage capacity might involve all the stakeholders capable of rightly estimating storage capacity, i.e., farmers, chambers of agriculture, consultancies...

-Storages should also be sufficiently secured to avoid leakages.

-To discuss preferential routes for transporting digestates with local authorities: town halls, department, potentially state services. The biogas plant should ensure to remedy to the potential damages and dirt provoked as fast as possible.

-To discuss and adapt the size of the spreading equipment with local authorities.

-If possible, to record the routes during the transportation of digestates. If issues are reported, the recording allows to check collectively if the biogas plant is responsible or not for these issues.

b) Threats caused to the environment

-A very careful and particular attention to the situation of water resources in the territory should be paid during the design phase of the project. The biogas plant should be designed and conceived in order not to be seen as an additional threat to water resources, but as a way to better protect the water resources (thanks to a better management of land applications and a better valorization of livestock effluents).

-To associate to the design of the project the local institutions, organizations and associations responsible for protecting water resources in the territory (mixed unions, state services, local water commission, even associations of speleology in some territories with a lot of fragile underground water resources...).

c) Unpleasant smells

-To implement as soon as possible the equipment that prevents the smells (covered storages, filters, adequate spreading equipment...), to be careful of the direction of the winds during land application, and of the proximity of housing.

-To allow for direct contacts between the complainants and the biogas plant, or through an intermediary such as town halls that collect the complaints and direct them to the biogas plant. This is usually made possible through the implementation of a dedicated hotline. It is important to give complainants the feeling to be heard.

-To check as quickly as possible the source of the smells and verify the responsibility of the biogas plant. It appears important to come back to the complainants once the problem is identified and solved.

-To record the complaints over time, in order to check improvements in the smell.

-If necessary, there is the possibility to federate local inhabitants into an observatory of smells, to monitor smell issues with the biogas plant.

For the following issues, solutions cannot be implemented at the local level, and higher spatial levels of coordination are requested (region, department, watershed, regional natural park...).

d) Cultural and political tensions

-To anticipate and solve the conflicts linked to cultural and political oppositions, the smallest relevant spatial level seems to be the level of the PCAETs and of “projects of territory”. The elaboration of these development schemes can allow to collectively define the types of agriculture, energy and ecological transition wanted in the territory, and therefore, the place of biogas production and digestates.

-At a higher spatial level (department, region, watershed, regional natural park...), there is the need for a central agent capable of bringing all stakeholders at the table, to cooperate, to define a shared vision of the development of the biogas sector. The identity of this central actor depends on the history of cooperation of the territory.

e) Global lack of skills and attractiveness

-To ensure the skill building of all the stakeholders within the sector: state services, consular bodies, consultancies, operators... through the implementation of relevant training. This is a

policy that should be supported at the national level, and be made effective at smaller spatial levels.

f) Lack of knowledge and hindsight

-To keep funding and supporting research on the impacts of digestates, and especially across different territories, to capture the diversity of digestates, of soils, sub-soils and agricultural practices.

-To widely publicize the results of local experimentations when they come from non-academic sources (experiments of Chambers of agriculture, or from collective of farmers for instance).

-To allow, if agents feel necessary, for the collective production of knowledge, through participatory studies or observatories including all parties and opponents, and chaired by a central regional agent.

Chapitre 7 : Recommandations de gouvernance à l'attention des acteurs de la filière méthanisation

Introduction

Ce chapitre résume les principaux résultats de nos recherches, que nous souhaitons porter à la connaissance des acteurs de la filière méthanisation. Il est volontairement bref et concis, afin de vulgariser les résultats auprès d'un public large et non scientifique. Ce chapitre est disponible en français et en anglais. En premier lieu, nous résumons les objectifs et la méthode employée pour réaliser nos recherches. Ensuite, nous décrivons la nature des conflits que nous avons observés. Et enfin, nous proposons des recommandations de gouvernance afin d'anticiper et résoudre les potentiels conflits autour de la filière et de la valorisation des digestats. La version diffusée auprès des acteurs de la filière se trouve en annexe n°8.

Objectifs et méthodes

La filière méthanisation connaît une croissance très importante depuis environ une décennie, en France et en Europe, grâce au fort soutien des pouvoirs publics. Environ 20 000 méthaniseurs sont actuellement recensés dans l'Union européenne, dont la moitié en Allemagne, leader mondial du secteur. En France, alors qu'on dénombrait moins de 200 méthaniseurs en 2013, plus de 1 700 méthaniseurs étaient en fonctionnement fin 2022, et plus encore sont en construction. Selon un scénario optimiste de l'Association Européenne du Biogaz, la filière pourrait couvrir 30 à 40% de la consommation de gaz de l'UE d'ici 2050. L'essor de la filière conduit à une production croissante de digestats : entre 222 et 258 Mt de digestats auraient été produites en 2021, et on estime que la production de digestats pourrait doubler et atteindre entre 455 et 492 Mt en 2030, et qu'une production comprise entre 1,145 et 1,334 Mt de digestats pourrait être atteinte d'ici 2050. Cependant, le nombre de conflits locaux, d'oppositions et de rejets des nouveaux méthaniseurs augmente également, et on estime que jusqu'à 30 % des projets échouent à démarrer en raison de ces conflits locaux. L'objectif de nos recherches, menées sur 3 ans, étaient donc d'étudier ces conflits, de comprendre leur nature, et d'identifier des solutions permettant d'anticiper et de résoudre ces conflits. Nous nous sommes concentrés sur les méthaniseurs centralisés, industriels et territoriaux, et sur les étapes aval de la filière, à

savoir les différentes étapes de valorisation des digestats, car ces étapes sont souvent peu prises en compte dans les recherches. Nous avons comparé les conflits en France et en Allemagne, pour bénéficier de l'expérience du leader mondial du secteur. Nous avons mené des entretiens avec des experts et des acteurs du secteur, sur différents territoires en France et en Allemagne, et nous avons collecté et étudié de nombreuses sources documentaires (presse, documents officiels...).

La nature des conflits

Les conflits que nous avons observés sont principalement liés aux problèmes suivants :

a) Problèmes liés aux infrastructures et aux équipements

- Capacités de stockage des digestats sous-dimensionnées,
- Congestion des routes, notamment autour des méthaniseurs (trafic routier important depuis et vers le méthaniseur où les camions viennent collecter les digestats), et à certaines périodes (périodes d'épandage notamment),
- Inadaptation de certaines routes (routes communales, chemins agricoles) avec la taille des équipements d'épandage,
- Dégradation des infrastructures publiques (routes salies, chemins défoncés).

b) Craintes pour l'environnement

De nombreuses craintes différentes sont généralement mentionnées, mais la principale crainte évoquée, surpassant de loin toutes les autres, est la suivante :

- Menaces sur les ressources en eau, tant en termes de quantité que de qualité de l'eau,
- A propos de la qualité de l'eau : craintes de pollution par les nitrates en cas de fuite de digestats lors du stockage, du transport ou de l'épandage. Ces craintes sont aggravées dans de nombreux territoires par une pollution déjà importante des ressources en eau et des écosystèmes déjà dégradés,
- A propos de la quantité : craintes d'une utilisation supplémentaire de l'eau pour cultiver les intrants des méthaniseurs (CIVE irriguées notamment), et craintes qu'une pollution/contamination des sources d'eau (rivières, captages...) pendant les périodes de

sécheresse, où aucune source d'eau de secours ne serait disponible, prive les populations locales d'eau potable.

c) Odeurs désagréables

Des odeurs très désagréables sont fréquemment signalées, à différents endroits : sur le site du méthaniseur, autour des stockages déportés, et lors des chantiers d'épandage. Ces odeurs sont à l'origine de la plupart des plaintes adressées aux services de l'Etat.

d) Tensions culturelles et politiques

Les méthaniseurs, et la valorisation de leurs digestats, cristallisent souvent des conflits territoriaux préexistants, à propos des modèles agricoles dans lesquels la filière s'insère (et notamment autour de l'aspect industriel de certains modèles agricoles), autour de la vision de la transition écologique et énergétique (et de la place accordée aux différentes énergies renouvelables), et sur le sens donné au concept d'économie circulaire. Des conflits surgissent également autour du développement de la filière elle-même, et notamment autour de l'opposition entre méthanisation industrielle vs agricole.

e) Manque global de compétences et d'attractivité

Un manque de compétences techniques nécessaires au bon fonctionnement des méthaniseurs et à la gestion des digestats nous a été largement signalé, ainsi qu'une difficulté à attirer des employés qualifiés dans le secteur. Un manque de compétence en matière de gestion des risques a été particulièrement souligné. Ce manque de compétences concerne tous les acteurs de la filière, incluant les opérateurs et gestionnaires de méthaniseurs, les services de l'Etat, les bureaux d'études et les organismes consulaires. Ce manque de compétence peut être source d'accidents et générer des conflits.

f) Manque de connaissances et de recul

De nombreuses incertitudes scientifiques subsistent sur les impacts de la méthanisation et des digestats sur l'environnement, notamment sur la qualité de l'eau, la qualité des sols, la biodiversité, la santé humaine et animale, l'empreinte carbone... Ce manque ou cette absence

de connaissances, notamment sur les conséquences à long terme, génère des peurs, et les peurs génèrent des oppositions et des conflits.

Recommandations de gouvernance

Tout d'abord, nous avons observé un manque généralisé de considération pour les digestats lors des phases de réflexion et de conception des projets de méthaniseurs, la production de gaz primant sur les autres considérations, dans l'écrasante majorité des cas. Notre première suggestion consiste donc à accorder beaucoup plus d'attention, pour les nouveaux projets, à la gestion des digestats, afin d'anticiper les problèmes identifiés ci-dessus.

Ensuite, les trois premiers problèmes que nous avons évoqués peuvent être anticipés et résolus au niveau local.

a) Problèmes d'infrastructures et d'équipements

-Pendant la phase de conception du méthaniseur : une attention particulière doit être accordée à la capacité de stockage des digestats, tant sur site qu'avec les stockages déportés. Une capacité de stockage suffisante doit être assurée, et elle dépend souvent des pratiques agricoles locales.

-Il semble adéquat d'impliquer en amont tous les acteurs capables d'estimer correctement la capacité de stockage, c'est-à-dire les agriculteurs, les chambres d'agriculture, les bureaux d'études... afin de mener une réflexion collective sur la capacité de stockage nécessaire.

-Les stockages doivent également être suffisamment sécurisés pour éviter les fuites.

-Elaborer des itinéraires préférentiels de transport des intrants et des digestats avec les autorités locales : conseils municipaux, communautaires et départementaux, éventuellement services de l'Etat. Le méthaniseur doit également s'assurer de remédier le plus rapidement possible aux éventuels dommages et salissures provoqués.

-Discuter et adapter la taille du matériel d'épandage avec les autorités locales.

- Si possible, enregistrer les itinéraires lors du transport des digestats. Si des problèmes sont signalés, l'enregistrement permet de vérifier collectivement si le méthaniseur est responsable ou non de ces problèmes.

b) Craintes pour l'environnement

-Porter une attention très attentive et particulière à la situation des ressources en eau sur le territoire lors de la phase de conception du projet. Le méthaniseur, et l'usage des digestats, doivent être pensés et conçus de manière à ne pas être considérés comme une menace supplémentaire pour la ressource en eau, mais comme un moyen de mieux protéger cette ressource (par exemple, en permettant une meilleure valorisation des effluents d'élevage et une meilleure gestion de l'azote).

-Associer à la conception du projet les institutions, organismes et associations locales chargées de la protection de la ressource en eau du territoire (syndicats mixtes, services de l'Etat, commission locale de l'eau, voire associations de type association de spéléologie dans certains territoires disposant de ressources en eau souterraines très fragiles ...).

c) Odeurs désagréables

-Mettre en place, au plus tôt, les équipements limitant les odeurs (stockages couverts, filtres, matériel d'épandage adéquat...), et faire attention à la direction des vents lors de l'épandage, et à la proximité des habitations.

-Permettre des contacts directs entre les plaignants et le méthaniseur, ou via un intermédiaire tel que les mairies, qui recueillent les réclamations et les transmettent au méthaniseur. Ces interactions sont généralement rendues possible grâce à la mise en place d'une ligne téléphonique dédiée. Il est important de donner aux plaignants le sentiment d'être écoutés et entendus.

-Vérifier le plus rapidement possible la source des odeurs, et vérifier la responsabilité du méthaniseur. Il apparaît important de revenir vers les plaignants une fois le problème identifié et résolu.

-Garder trace des plaintes, afin de contrôler l'amélioration des odeurs dans le temps, et de pouvoir transmettre cette information aux autres acteurs du territoire.

-Si nécessaire, il est possible de fédérer les riverains autour d'un observatoire des odeurs, afin qu'ils coordonnent, avec le méthaniseur, l'amélioration des odeurs.

Pour les problématiques suivantes, les solutions ne peuvent pas être mises en œuvre au niveau local, et des niveaux spatiaux supérieurs de coordination sont demandés (région, département, bassin versant, parc naturel régional...).

d) Tensions culturelles et politiques

-Pour anticiper et résoudre les conflits liés aux oppositions culturelles et politiques, le plus petit échelon spatial pertinent semble être celui des PCAET et des « projets de territoire ». L'élaboration de ces schémas de développement peut permettre de définir collectivement les modèles agricoles, énergétiques, et le type de transition écologique souhaités sur le territoire, et la place de la méthanisation et des digestats dans ces modèles.

-A une échelle spatiale supérieure (département, région, bassin versant, parc naturel régional...), nous avons observé la nécessité qu'un acteur central soit capable de réunir tous les acteurs de la filière et de les amener à coopérer, afin de définir une vision et des objectifs partagés du développement de la filière méthanisation. L'identité de cet acteur central dépend de l'histoire du territoire et des structures de coopération déjà existantes.

e) Manque global de compétences et d'attractivité

-Il semble très important d'assurer dès aujourd'hui la montée en compétence de tous les acteurs de la filière : services de l'Etat, organismes consulaires, bureaux d'études, opérateurs... par la mise en place de formations adaptées. Il s'agit d'un objectif qui devrait être soutenu au niveau national et rendu effectif à des échelles spatiales plus petites.

f) Manque de connaissances et de recul

-Il apparaît plus que nécessaire de poursuivre voire d'intensifier le financement et l'accompagnement de la recherche autour des impacts des digestats et de la méthanisation sur l'environnement et la santé, en étudiant notamment ces impacts dans des différents territoires, afin de capter la diversité des digestats, des sols, des sous-sols, des pratiques agricoles et des écosystèmes.

-Diffuser largement les résultats des expérimentations locales lorsqu'elles proviennent de sources non académiques (expérimentations par les chambres d'agriculture, ou par des collectifs d'agriculteurs par exemple). De nombreuses connaissances sont acquises, au travers de l'usage des digestats, mais demeurent cantonnées à l'échelle locale faute de diffusion.

- Permettre, si les acteurs de la filière le jugent nécessaire sur leur territoire, la production collective de connaissances, par le biais d'études ou d'observatoires participatifs incluant tous les parties prenantes, y compris les opposants, et pilotés par un acteur central (préfecture, PNR, conseil régional...).

Conclusion

To conclude our manuscript, we will first go back to our research problem, and to the research questions we presented in chapter 2, in order to summarize the answers to these questions we elaborated thanks to our investigations. Then, we will present the limits of our work and our results, and then we will formulate some perspectives for future research work.

1. The role of territorial governance in anticipating and solving conflicts

In the first chapter of this manuscript, we presented the dynamism of the biogas sector in Europe, and particularly in France and in Germany, our fields of investigation. But we also detailed the heterogeneity and the diversity of the sector, due to the diversity of the resources used, of the technical processes, and of the administrative and management organizations. This observation first introduced the interest of adopting a territorial approach in our research, to capture this diversity across space.

In chapter 2, we exposed the controversies and the local conflicts around the development of the biogas sector, and it led us to identify the research question that had been left unaddressed, or partly addresses, by previous research. Among the questions left unaddressed, there was the role of the valorization of digestates in the emergence of conflicts, because previous research focused on the conflicts that emerged before the biogas plants were built, i.e., on ex-ante conflicts, although acknowledging that digestates could be a source of conflicts too. In parallel, the literature insisted on the need of territorial governance to anticipate and solve the ex-ante conflicts, but the literature also highlighted the necessity to complement and go further the existing studies on the topic. This led us to formulate our research problem by combining the two aforementioned knowledge gaps, i.e., to research how territorial governance could anticipate the emergence, and / or, solve the conflicts around the valorization of digestates, or in other words, to anticipate and solve ex-post conflicts. From this research problem, we formulated research questions that correspond to our research aims: 1) to identify the nature of the conflicts, and the territorial dimensions affected by these conflicts, 2) to describe how agents coordinate around the valorization of digestates and how it impacts the emergence and the resolution of conflicts, 3) to understand how imperfect information on the impacts and qualities of digestates could impact coordination.

To answer these questions, we first reviewed the literature, in chapter 3, and based on the literature, we formulated assumptions that we then tested in our field investigations. First, the literature highlighted the necessity for the biogas sector to be *territorialized* to avoid the emergence of conflicts. However, we observed two different meanings behind the concept of *territorialisation*. The first meaning, found in the English-speaking literature, considers territorialisation as the role of an authority to control, monitor, and orientate the use of local resources to allow economic development (top-down approach). The second meaning, in the French-speaking literature, considers territorialisation as the mobilization of the inner resources of a territory, by local agents to develop adapted economic activity (bottom-up). We therefore assumed the need for a combination of both approaches to ensure a conflict-free development of the sector, i.e., the necessity for local agents to mobilize the inner resources of their territory to valorise digestates, and the need for control and monitoring actions from a local authority, to supervise and frame the development of the activity.

We then mobilized the concept of territorial capital, to understand the mobilization of these inner resources. Based on the literature, we assumed the necessity to adequately mobilize all the dimensions of the territorial capital to ensure a conflict-free valorization of digestates. We identified the following dimensions that must be mobilized for the valorization of digestates: the natural capital, the organizational capital, the infrastructural & equipment capital, the cognitive & technical capital, the cultural & political capital, the financial capital and the institutional capital. We also highlighted the dual nature of the territorial capital, i.e., if wrongly mobilized, conflicts emerge.

Then, we highlighted the need for the coordination of agents, through the activation of proximities, to mobilize the territorial capital. We mobilized the framework of the French school and of Boschma, to detail the five dimensions of proximities: organized proximity, divided into organizational, social, cognitive, and institutional proximities, and geographical proximities. According to the literature, a weak activation of organized proximity, combined to unwanted geographical proximity, leads to an inadequate mobilization of the territorial capital, and therefore to conflicts. To the contrary, the strong activation of territorial proximity, i.e., the strong activation of organized proximity combined to a wanted geographical proximity should allow for a conflict-free valorization of digestates. The activation of territorial proximity may be facilitated by the intervention of a local intermediary, that very often is, according to the literature, a local public authority. We therefore assumed to observe this role of *territorial intermediation* in our field investigations. The role of this intermediary is very important in territorial governance processes, as it federates very different local agents pursuing different

aims, and it creates the framework for discussion and cooperation. However, the literature also pointed out the important role that other local agents can play, such as the Chambers of Agriculture in France, to avoid the emergence of conflicts around projects that have an agricultural dimension. We therefore assume to observe multi-actor governance mechanisms around the valorization of digestates. The governance mechanisms are supposed to allow for a good transfer of information, from the producers of digestates, to other local agents, in order to solve situations of asymmetric information, supposedly responsible for conflicts. The literature insisted on the need for transparency and very good communication. But, based on the Economics of Quality, we assumed both the existence of situations of information asymmetry, and situations of shared uncertainty on the qualities and impacts of digestates, and we assumed the existence of different governance mechanisms to solve the conflicts induced by these issues.

In chapter 4, we presented our method of investigation for our field work. In the next section, we will go back to chapter 4, to discuss the limits of our method and our results.

In chapters 5 and 6, we present the results of our field investigations and we discussed them. We first described the different territorial contexts into which our case studies are embedded, and how, for each case, the different dimensions of the territorial capital are mobilized by local and regional agents. It allowed us to enrich the framework of the territorial capital we had identified in our literature review. The valorization of digestates involves the mobilization of: the natural capital, the agronomic capital (agricultural practices and activities), the economic capital (including the financial capital, and the human resources), the cultural & political capital, the cognitive & technical capital, infrastructural & equipment capital, the organizational capital, and the institutional capital. We confirmed the dual nature of the territorial capital, as their adequate mobilization can provide local opportunities for the valorization of digestates, while conflicts emerged from their inadequate mobilization.

We identified that the emergence of conflicts is mainly linked to the deterioration, or the fears of deterioration of the natural capital (and especially, the water resources), the inadequacy of the infrastructural & equipment capital (roads, storages, spreading machines...), and the cultural & political capital (too many local and regional divergent opinions on digestates). We also observed that conflicts emerge at different spatial scales: at the local scale, i.e., the scale of biogas plants, municipalities, land application worksites and infrastructures, at the regional scale, i.e. the scale of regions and large watersheds, and the sub-regional scale, i.e. the scale of departments, smaller watersheds, natural regional parks. These conflicts involve many different categories of local, regional and sub-regional agents: farmers, local inhabitants, local and supra-local associations, local, regional and sub-regional public powers, local

authorities, private companies and consular bodies. We also observe that conflicts emerge at different time scales: there are punctual conflicts, as well as long-term conflicts that often derive from previous territorial conflicts that were crystallized by the new biogas plant and by the valorization of its digestates.

Based on our observations, we proposed a sequence of events that lead to the emergence of conflicts: first, local and regional organizations are not used to communicate and coordinate (low organizational proximity), and local agents are not used to talk and coordinate (low social proximity). It leads to difficulties to create a shared institutional environment (shared norms, shared values) (low institutional proximity), and there is not enough interactions to share cognitive resources (low cognitive proximity). This low activation of proximities leads to an inadequate mobilization of the territorial capital, and combined to unwanted geographical proximity with the activities of the biogas plants, lead to the emergence of conflicts.

Therefore, to anticipate and solve conflicts, there is the necessity to activate proximities at the local, regional and sub-regional levels. We observed, at the local level, that there can be direct interactions between local agents, to coordinate, exchange information, and solve situations of asymmetric information, when they are capable of activating territorial proximity by themselves. Otherwise, we observed the necessary intervention of one, or several territorial intermediaries to activate territorial proximity. The identities of these local intermediaries are not simply that of public authorities, but they can also be private companies and consular bodies. At the regional and sub-regional levels, we observed that there is always the need for a regional intermediary to bring the different agents together and coordinate, to exchange information and solve situations of asymmetric information, to develop a shared vision of the sector, but also to create spaces for the production and acquisition of new knowledge in case of situations of shared uncertainty.

In parallel to coordination, we observed the necessity of the coercive and control role of the State in case of conflicts, and in case of damage to the environment or to the quality of life. This role relies on the responsibility of the State in supporting the development of the sector, that creates a responsibility to ensure that the environment is protected and that some groups of agents are not penalized by the negative externalities of the sector. This coercive power can be mobilized to force the transfer of information in case of a situation of asymmetric information, but the responsibility of the State in the development of the sector also leads it to endorse the role of territorial intermediary, in situations of shared uncertainty where agents need to cooperate to acquire new knowledge. Consequently, the anticipation and resolution of conflicts

around the biogas sector require to mobilize both the French-speaking and English-speaking approaches of territorialisation.

2. Limits of the method and the results

We explained, in chapter 4, the usefulness of the qualitative case study method for investigating our topic, and we present here the limits we encountered.

First of all, this method does not aim at producing results that can be statistically generalized, but it aims at formulating propositions that can be again tested, validated or invalidated in different contexts and different case studies. Therefore, other types of conflicts around the valorization of digestates may exist, in other cases, that we haven't encountered in our cases, and that we therefore haven't be able to describe. Similarly, other mechanisms of coordination may be implemented. As we carried out applied research, the scope of our results is to highlight some conflicts that future biogas projects might face, and to encourage stakeholders to pay a particular attention to certain issues. But stakeholders may also not face any of the issues we observed, if their territorial context is different enough to not produce these issues. Also, we highlighted some mechanisms of governance that help anticipating and solving conflicts, therefore we encourage stakeholders to consider the implementation of these mechanisms in their territory. However, as we explained in chapter 2 and 4, in our constructivist and relativist epistemological framework, we did not attempt, through our research, to reach the absolute truth about governance, as we believe the absolute truth about a socially constructed object does not exist. Stakeholders might therefore experience other governance processes to anticipate and solve conflicts. Our applied aim was formalized in chapter 7, through the recommendations of governance we formulated: our results led to recommendations that are tools that can help stakeholders anticipating and solving conflicts. They describe certain aspects of the reality of the valorization of digestates, in France, and in Germany, and they contribute to bridging the knowledge gap on the topic.

While applying our method, we also faced limitations on the ground. Some stakeholders refused to be interviewed, and therefore we missed some potentially important opinions. It was particularly true for our German-Polish case, where local stakeholders were very unwilling to be interviewed, and they were particularly suspicious. This explain the low number of interviews we conducted for this case, compared to our French case. In addition, in France and in Germany, we were dealing with a very hot topic, as we were questioning stakeholders about

local and regional conflicts that were often still on-going. Some stakeholders admitted to give us only partial answers to our questions, and that they were not willing to tell everything about the local situation, because of the implications their words could have on local relations. Especially, when governance relies on trust, stakeholders were afraid that being implied in research could break the trust with other stakeholders or worsen conflicts. We therefore had to rely on what people were willing to tell us, but of course, we complemented the interviews with the analysis of the press and of documents, to collect more information.

Finally, for ethical reasons, we remained very transparent with interviewees about our position as PhD students, and about the identity of our funding partners, i.e., the ADEME and Avril Group. Depending on the interviewee, some did not express any concern about our partners, some had sympathy for our partners, which increased their willingness to talk to us, and some expressed dislike, although we assure them that our partners had no interference in the research. This could have influenced the answers of some stakeholders, that is why we said we could capture a certain aspect of this socially constructed reality.

3. Perspectives for future research

One of the original points of our research was to underline the influence of shared uncertainty on the relations between stakeholders of the biogas sector. We would therefore recommend, for future research on the biogas sector, and more generally, for research on the circular bioeconomy, to carefully consider the impacts of situations of shared uncertainty related to the use of new technologies and products, or by-products. We suggest to dive into the governance mechanisms at work to produce knowledge about these new products and by-products, at the territorial scale.

In addition, we highlighted the importance of the cultural and political dimension behind the conflicts around the biogas sector, both at the regional and the local scale. We would therefore suggest to compare the national and European official speeches on the biogas sector, and on the circular bioeconomy, and the representations and desires that local agents have about these sectors, to check their compatibility and to understand how to bridge potential gaps.

Finally, thanks to the information we collected through our qualitative research, we see the possibility to engage into quantitative research, through surveys for instance, especially to verify how extended the issues and conflicts we identified are. Future research could, through surveys, statistically estimate how many biogas plants faced inadequate storage capacity, or

unpleasant smells. Depending on the results, the sector could engage into generalized technical and organizational improvements.

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References

- ADEME. (2015a). *LE CADRE RÉGLEMENTAIRE ET JURIDIQUE DES ACTIVITÉS AGRICOLES DE MÉTHANISATION ET DE COMPOSTAGE*.
- ADEME. (2015b). *Méthanisation. Fiche technique*.
- ADEME. (2016). *Méthanisation. Les avis de l'ADEME*.
- Agency for Renewable Resource. (2017). *Barrieren für die Nutzung von Gülle in Biogasanlagen*. Deutsches Biomasseforschungszentrum.
<https://www.dbfz.de/projektseiten/chinares/forschung/barrieren-fuer-die-nutzung-von-guelle-in-biogasanlagen>
- AILE. (2015). *Compost de fraction solide de digestat*.
- Appel, F., Ostermeyer-Wiethaup, A., & Balmann, A. (2016). Effects of the German Renewable Energy Act on structural change in agriculture – The case of biogas. *Utilities Policy*, 41, 172-182. <https://doi.org/10.1016/j.jup.2016.02.013>
- Arnsperger, C., & Bourg, D. (2016). Vers une économie authentiquement circulaire : Réflexions sur les fondements d'un indicateur de circularité. *Revue de l'OFCE*, N° 145(1), 91-125. <https://doi.org/10.3917/reof.145.0091>
- ATEE. (s. d.). *Carte des unités de méthanisation en France*. Consulté 26 septembre 2023, à l'adresse <https://atee.fr/energies-renouvelables/club-biogaz/carte-des-unites-de-methanisation-en-france>
- ATEE. (2020). *Observatoire du biogaz en France*. Association technique énergie environnement. <https://atee.fr/energies-renouvelables/club-biogaz/observatoire-du-biogaz-en-france>
- Baškarada, S. (2014). Qualitative Case Study Guidelines. *The Qualitative Report*. <https://doi.org/10.46743/2160-3715/2014.1008>
- Bassett, T. J., & Gautier, D. (2014). Regulation by Territorialization : The Political Ecology of Conservation & Development Territories: Introduction. *EchoGéo*, 29. <https://doi.org/10.4000/echogeo.14038>
- Baxter, P., & Jack, S. (2008). Qualitative Case Study Methodology : Study Design and Implementation for Novice Researchers. *The Qualitative Report*. <https://doi.org/10.46743/2160-3715/2008.1573>
- Berthe, A., Fautras, M., Grouiez, P., & Issehnane, S. (2020). Les formes d'unités de méthanisation en France : Typologies et scénarios d'avenir de la filière. *Agronomie, environnement et sociétés*. <https://doi.org/10.54800/utm105>
- Bianchi, F., van Beek, C., de Winter, D., & Lammers, E. (2020). *Opportunities and barriers of circular agriculture : Insights from a synthesis study of the Food & Business Research Programme*.

Bioenergy Insight. (2022, juillet 15). *German Farmers criticise EEG amendment amid gas shortages*.

BMEL. (2021). *BMEL - Bioeconomy and renewable resources—National Bioeconomy Strategy*. Federal Ministry of Food and Agriculture.

<https://www.bmel.de/EN/topics/farming/bioeconomy-renewable-resources/national-bioeconomy-strategy.html>

BMUV. (2023). *Waste Policy*. Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection. <https://www.bmu.de/WS585-1>

Bogner, K., & Dahlke, J. (2022). Born to transform ? German bioeconomy policy and research projects for transformations towards sustainability. *Ecological Economics*.

Boons, F., & Howard-Grenville, J. A. (2009). *The Social Embeddedness of Industrial Ecology*. Edward Elgar Publishing.

Boschma, R. (2005). Proximity and Innovation : A Critical Assessment. *Regional Studies*, 39(1), 61-74. <https://doi.org/10.1080/0034340052000320887>

Bourdeau-Lepage, L., & Huriot, J.-M. (2009). Proximités et interactions : Une reformulation. *Géographie, économie, société*, 11(3), 233-249. <https://doi.org/10.3166/ges.11.233-249>

Bourdin, S. (2020a). Concertation, localisation, financements Analyse des déterminants du déploiement de la méthanisation dans le Grand-Ouest français. *Économie rurale*, 373, 61-77. <https://doi.org/10.4000/economierurale.8043>

Bourdin, S. (2020b). Concertation, localisation, financements Analyse des déterminants du déploiement de la méthanisation dans le Grand-Ouest français. *Économie rurale*, 373, 61-77. <https://doi.org/10.4000/economierurale.8043>

Bourdin, S., Colas, M., & Raulin, F. (2019). Understanding the problems of biogas production deployment in different regions : Territorial governance matters too. *Journal of Environmental Planning and Management*, 63(9), 1655-1673. <https://doi.org/10.1080/09640568.2019.1680158>

Bourdin, S., Colas, M., & Raulin, F. (2020). Understanding the problems of biogas production deployment in different regions : Territorial governance matters too. *Journal of Environmental Planning and Management*, 63(9), 1655-1673. <https://doi.org/10.1080/09640568.2019.1680158>

Bourdin, S., Jeanne, P., & Raulin, F. (2020). Dossier « L'économie circulaire : Modes de gouvernance et développement territorial » – « La méthanisation, oui, mais pas chez moi ! » Une analyse du discours des acteurs dans la presse quotidienne régionale. *Natures Sciences Sociétés*, 28(2), 145-158. <https://doi.org/10.1051/nss/2020030>

Bourdin, S., & Maillefert, M. (2020). Dossier « L'économie circulaire : Modes de gouvernance et développement territorial » – Introduction – L'économie circulaire : modes de gouvernance et développement territorial. *Natures Sciences Sociétés*, 28(2), 101-107. <https://doi.org/10.1051/nss/2020033>

- Bourdin, S., & Nadou, F. (2020). The role of a local authority as a stakeholder encouraging the development of biogas : A study on territorial intermediation. *Journal of Environmental Management*, 258, 110009. <https://doi.org/10.1016/j.jenvman.2019.110009>
- Bourdin, S., Nadou, F., & Raulin, F. (2019). Les collectivités locales comme acteurs intermédiaires de la territorialisation de la transition énergétique : L'exemple de la méthanisation. *Géographie, économie, société*, 21(4), 273-293. <https://doi.org/10.3166/ges.2019.0016>
- Brémond, U., Bertrandias, A., Steyer, J.-P., Bernet, N., & Carrere, H. (2021). A vision of European biogas sector development towards 2030 : Trends and challenges. *Journal of Cleaner Production*, 287, 125065. <https://doi.org/10.1016/j.jclepro.2020.125065>
- Brulot, S., Junqua, G., & Zuideau, B. (2018). Écologie industrielle et territoriale à l'heure de la transition écologique et sociale de l'économie: *Revue d'Économie Régionale & Urbaine*, Décembre(5), 771-796. <https://doi.org/10.3917/reru.175.0771>
- Calvin, K., Dasgupta, D., Krinner, G., Mukherji, A., Thorne, P. W., Trisos, C., Romero, J., Aldunce, P., Barrett, K., Blanco, G., Cheung, W. W. L., Connors, S., Denton, F., Diongue-Niang, A., Dodman, D., Garschagen, M., Geden, O., Hayward, B., Jones, C., ... Péan, C. (2023). *IPCC, 2023 : Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, H. Lee and J. Romero (eds.)]. IPCC, Geneva, Switzerland.* (First). Intergovernmental Panel on Climate Change (IPCC). <https://doi.org/10.59327/IPCC/AR6-9789291691647>
- Carrière, Jean-Paul. (2018). La région, une échelle pertinente pour la « mise en territoire » de l'économie circulaire ? Réflexions à partir du cas français. *Lucrările Seminarului Geografic « Dimitrie Cantemir »*, 46(1), 3-22. <https://doi.org/10.15551/lsgdc.v46i1.01>
- Chenon, P., Thevenin, N., Benbrahim, M., & Merle, S. (2012). *Programme VALDIPRO. Guide pour la mise en marché des digestats.*
- Chevalier, P., & Pola, P. (2014). *Développement économique local et capital territorial en France et en Hongrie : Une approche institutionnaliste.* 9.
- Chodkowska-Miszczuk, J., Martinat, S., & Cowell, R. (2019). Community tensions, participation, and local development : Factors affecting the spatial embeddedness of anaerobic digestion in Poland and the Czech Republic. *Energy Research & Social Science*, 55, 134-145. <https://doi.org/10.1016/j.erss.2019.05.010>
- CPE. (2020). *Unités de méthanisation : Epanchage des digestats. Guide méthodologique.* Conférence Permanente des Epanchages.
- da Graça Carvalho, M. (2012). EU energy and climate change strategy. *Energy*, 40(1), 19-22. <https://doi.org/10.1016/j.energy.2012.01.012>
- Dabert, P., Berger, S., Couturier, C., Béline, F., & Trémier, A. (2013). *State of the art of digestates in France and of their agronomic value.* 3.

Dahlin, J., Herbes, C., & Nelles, M. (2015). Biogas digestate marketing : Qualitative insights into the supply side. *Resources, Conservation and Recycling*, *104*, 152-161. <https://doi.org/10.1016/j.resconrec.2015.08.013>

Dahlin, J., Nelles, M., & Herbes, C. (2017). Biogas digestate management : Evaluating the attitudes and perceptions of German gardeners towards digestate-based soil amendments. *Resources, Conservation and Recycling*, *118*, 27-38. <https://doi.org/10.1016/j.resconrec.2016.11.020>

Daly, H. E. (1974). The Economics of the Steady State. *The American Economic Review*, *64*(2), 15-21.

Damiano, A., Haumont, A., & Lencauchez, J. (2015). *Comparaison des réglementations européennes sur le digestat*. AILE.

Darby, M. R., & Karni, E. (1973). Free Competition and the Optimal Amount of Fraud. *The Journal of Law & Economics*, *16*(1), 67-88.

Davies, S., Griestop, L., Vironen, H., Bachtler, J., Dozhdeva, V., & Michie, R. (2016). *Case studies of national bioeconomy strategies in Finland and Germany*.

Delfosse, P. (2010). *MICROBIOLOGIE DE LA DIGESTION ANAEROBIE*.

Depoudent, C., Anzalone, G., Boudes, P., & Mazaud, C. (2020). *METHANISATION TERRITORIALE : FACTEURS SOCIAUX DE REUSSITE*.

Dermine-Brullot, S., & Torre, A. (2020). Dossier « L'économie circulaire : Modes de gouvernance et développement territorial » – Quelle durabilité pour le développement territorial ? Réflexions sur les composantes spatiales de l'économie circulaire. *Natures Sciences Sociétés*, *28*(2), 108-117. <https://doi.org/10.1051/nss/2020034>

DIRECTIVE 2001/77/EC. (2001). *DIRECTIVE 2001/77/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 27 September 2001 on the promotion of electricity produced from renewable energy sources in the internal electricity market*. Official Journal of the European Communities.

DIRECTIVE 2009/28/EC. (2009). *DIRECTIVE 2009/28/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC*. Official Journal of the European Union.

DIRECTIVE 2018/2001. (2018). *DIRECTIVE (EU) 2018/2001 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 11 December 2018 on the promotion of the use of energy from renewable sources*. Official Journal of the European Union.

Dollhofer, M., & Zettl, E. (2017). *Quality assurance of compost and digestate. Experiences from Germany*. German Environment Agency.

Domingo, L. (2021, septembre 22). *Économie circulaire : Gare aux solutions trop faciles*. The Conversation. <http://theconversation.com/economie-circulaire-gare-aux-solutions-trop-faciles-165495>

Donner, M., Gohier, R., & de Vries, H. (2020). A new circular business model typology for creating value from agrowaste. *Science of the Total Environment*.

Dornburg, V., van Vuuren, D., van de Ven, G., Langeveld, H., Meeusen, M., Banse, M., van Oorschot, M., Ros, J., Jan van den Born, G., Aiking, H., Londo, M., Mozaffarian, H., Verweij, P., Lysen, E., & Faaij, A. (2010). Bioenergy revisited : Key factors in global potentials of bioenergy. *Energy & Environmental Science*, 3(3), 258.
<https://doi.org/10.1039/b922422j>

Dubresson, A., & Jaglin, S. (s. d.). *Gouvernance, régulation et territorialisation des espaces urbanisés : Approches et méthode*.

EBA. (2022b). *European Biogas Conference*. European Biogas Association.
<https://www.europeanbiogas.eu/european-biogas-conference-2022/>

EBA. (2022c). *European Commission and industry leaders launch Biomethane Industrial Partnership to support the 35 bcm target on biomethane by 2030*. European Biogas Association. <https://www.europeanbiogas.eu/european-commission-and-industry-leaders-launch-biomethane-industrial-partnership-to-support-the-35-bcm-target-on-biomethane-by-2030/>

EBA. (2022a). *The REPowerEU puts forward a Biomethane Action Plan to scale-up the sector by 2030 | European Biogas Association*. European Biogas Association.
<https://www.europeanbiogas.eu/the-repowereu-puts-forward-a-biomethane-action-plan-to-scale-up-the-sector-by-2030/>

EBA. (2014). *New German Renewable Energy Act (EEG) shoots biogas in Germany*. European Biogas Association.

EBA. (2018). *EBA statistical report 2018* (p. 18). European Biogas Association.

EBA. (2020). *EBA Statistical Report 2020*. European Biogas Association.

EBA. (2021). *EBA Statistical Report 2021*. European Biogas Association.

EBA. (2022a). *EBA Statistical Report 2022*. European Biogas Association.

EBA. (2022b). *Digestate as driver of the agroecological transition in Europe | European Biogas Association*. <https://www.europeanbiogas.eu/digestate-as-driver-of-the-agroecological-transition-in-europe/>

European Commission. (2022a). *COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE EUROPEAN COUNCIL, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS REPowerEU Plan*.

European Commission. (2022b). *REPORT FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS EU Bioeconomy Strategy Progress Report European Bioeconomy policy : Stocktaking and future developments*.

European Commission. (2012a). *COMMUNICATION FROM THE COMMISSION TO THE COUNCIL, THE EUROPEAN PARLIAMENT, THE EUROPEAN ECONOMIC AND SOCIAL*

- COMMITTEE AND THE COMMITTEE OF THE REGIONS *Energy Roadmap 2050*. European Commission.
- European Commission. (2012b). *Renewable Energy : A Major Player in the European Energy Market*. European Commission.
- European Commission. (2017). *COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS The role of waste-to-energy in the circular economy*. European Commission.
- European Commission. (2018). *Bioeconomy -The European way to use our natural resources : Action plan 2018*.
- European Commission. (2019a). *Clean Energy for All Europeans*. European Commission.
- European Commission. (2019b). *Digestate and compost as fertilisers : Risk assessment and risk management options* (Final report; p. 463).
- European Commission. (2022a). *COMMISSION STAFF WORKING DOCUMENT IMPLEMENTING THE REPOWER EU ACTION PLAN: INVESTMENT NEEDS, HYDROGEN ACCELERATOR AND ACHIEVING THE BIO-METHANE TARGETS*. European Commission.
- European Commission. (2022b, mai 18). *REPowerUE: A plan to rapidly reduce dependence on Russian fossil fuels and fast forward the green transition* [Text]. European Commission Press Corner. https://ec.europa.eu/commission/presscorner/detail/en/ip_22_3131
- European Commission. (2023). *European Green Deal : Sustainable use of natural resources* [Text]. European Commission - European Commission. https://ec.europa.eu/commission/presscorner/detail/%20en/ip_23_3565
- FAO Action Plan 2022–2025 for the implementation of the FAO Strategy on Climate Change*. (2023). FAO. <https://doi.org/10.4060/cc7014en>
- Fleuret, S. (2015). *Questionner la territorialisation de la santé en France*. 11.
- Fourcroy, E., & Drejerska, N. (2019). AGRICULTURAL EMPLOYMENT TRANSFORMATION IN FRANCE. *Annals of the Polish Association of Agricultural and Agribusiness Economists*, XXI(2), 59-68. <https://doi.org/10.5604/01.3001.0013.2070>
- French Senate. (2021). *RAPPORT D'INFORMATION FAIT au nom de la mission d'information (1) sur « la méthanisation dans le mix énergétique : Enjeux et impacts »*.
- Fruhner-Weiß. (2018). *Biogas in Germany—Aspects of organic waste digestion*. German Biogas Association.
- Gallaud, D. (2018). « *Proximités géographiques et organisées et innovation* ».
- Gallaud, D., & Laperche, B. (2020). *Economie circulaire et développement durable : Écologie industrielle et circuits courts*.
- GBA. (2018). *Digestate as Fertilizer*. German Biogas Association.

- GBA. (2022). *Feedstocks for biogas*. German Biogas Association. <https://www.biogas.org/edcom/webfvb.nsf/id/en-feedstocks-for-biogas>
- Geissdoerfer, M., Savaget, P., Bocken, N. M. P., & Hultink, E. J. (2017). The Circular Economy – A new sustainability paradigm? *Journal of Cleaner Production*, 143, 757-768. <https://doi.org/10.1016/j.jclepro.2016.12.048>
- Georgescu-Roegen, N. (1979). *La décroissance (entropie, écologie, économie)*. <https://biosphere.ouvaton.org/de-1970-a-1979/496-1979-la-decroissance-entropie-ecologie-economie-de-nicholas-georgescu-roegen->
- Gilly, J.-P., & Perrat, J. (2003). La dynamique institutionnelle des territoires : Entre gouvernance locale et régulation globale. *Cahier du GRES*, 2003-5.
- Ginelli, L., Candau, J., Girard, S., Houdart, M., Deldrève, V., & Noûs, C. (2020). Écologisation des pratiques et territorialisation des activités : Une introduction. *Développement durable et territoires*, Vol. 11, n°1. <https://doi.org/10.4000/developpementdurable.17272>
- Giuliano, A., Gioiella, F., Sofia, D., & Lotrecchiano, N. (2018). Chemical Engineering Transactions, vol 18, 2009 main web page. *Chemical Engineering Transactions*, 18. <https://doi.org/10.3303/CET0918000>
- Gkartzios, M., Gallent, N., & Scott, M. (2022). A capitals framework for rural areas : ‘Place-planning’ the global countryside. *Habitat International*, 127, 102625. <https://doi.org/10.1016/j.habitatint.2022.102625>
- Gobert, J., & Brulot, S. (2018). La mobilisation du capital territorial pour le développement d’une logique d’Écologie industrielle et territoriale: *Revue d’Économie Régionale & Urbaine*, Décembre(5), 881-904. <https://doi.org/10.3917/reru.175.0881>
- GRDF. (2022). *GRDF - Projet Méthanisation | La dynamique du marché*. projet-methanisation. <https://projet-methanisation.grdf.fr/>
- Greene, P. (2016, novembre 10). *Managing Digester Feedstocks*. BioCycle. <https://www.biocycle.net/managing-digester-feedstocks/>
- Große, A. (2014). *Approval procedures for biogas plants and the protection of neighbours’ rights in Germany*.
- Guilayn, F., Rouez, M., Crest, M., Patureau, D., & Jimenez, J. (2020). Valorization of digestates from urban or centralized biogas plants : A critical review. *Reviews in Environmental Science and Bio/Technology*, 19(2), 419-462. <https://doi.org/10.1007/s11157-020-09531-3>
- Hjort-Gregersen, K. (2015). *Market overview micro scale digesters*. BioEnergy Farm.
- Hofmeier, K. (2022). *Support schemes and legal framework for Bioenergy in Germany*. German Environment Agency.
- Icart, L. (2020, novembre 16). *Épandage : Le digestat restera-t-il une affaire de paysans ?* Gaz d’aujourd’hui. <https://www.gazdaujourd’hui.fr/epandage-le-digestat-restera-t-il-une-affaire-de-paysans/>

- Inrae. (2021). *La méthanisation au coeur des territoires*. INRAE Institutionnel. <https://www.inrae.fr/actualites/methanisation-au-coeur-territoires>
- Jimenez, J., Wallrich, A., Guilayn, F., Ollivier, D., Patureau, D., & Houot, S. (2020). *Digestats de méthanisation : Typologie en fonction des intrants et réglementation*. INRAE.
- Kanellakis, M., Martinopoulos, G., & Zachariadis, T. (2013). European energy policy—A review. *Energy Policy*, 62, 1020-1030. <https://doi.org/10.1016/j.enpol.2013.08.008>
- Kant, E. (1781). *Critique de la raison pure*. Ladrance.
- Kenneth Boulding. (1966). *The Economics of the Coming Spaceship Earth*.
- Khanal, S. K., Tirta Nindhia, T. G., & Nitayavardhana, S. (2019). Biogas From Wastes. In *Sustainable Resource Recovery and Zero Waste Approaches* (p. 165-174). Elsevier. <https://doi.org/10.1016/B978-0-444-64200-4.00011-6>
- Korhonen, J., Nuur, C., Feldmann, A., & Birkie, S. E. (2018). Circular economy as an essentially contested concept. *Journal of Cleaner Production*, 175, 544-552. <https://doi.org/10.1016/j.jclepro.2017.12.111>
- Koszel, M., & Lorencowicz, E. (2015). Agricultural Use of Biogas Digestate as a Replacement Fertilizers. *Agriculture and Agricultural Science Procedia*, 7, 119-124. <https://doi.org/10.1016/j.aaspro.2015.12.004>
- Lancaster, K. (1966). A new approach to consumer theory. *Journal of Political Economy*, 74(2), 132-156.
- Le Boulch, G. (2001). *Approche systémique de la proximité : Définitions et discussion*.
- Le Guen, G., & Damiano, A. (2013). Le développement de la méthanisation dans l'Ouest de la France: *Sciences Eaux & Territoires, Numéro 12(3)*, 30-33. <https://doi.org/10.3917/set.012.0030>
- Leipold, S. (2021). *Transforming ecological modernization 'from within' or perpetuating it? The circular economy as EU environmental policy narrative*.
- Leloup, F. (2010). Le développement territorial et les systèmes complexes : Proposition d'un cadre analytique: *Revue d'Économie Régionale & Urbaine, octobre(4)*, 687-705. <https://doi.org/10.3917/reru.104.0687>
- Leloup, F., Moyart, L., & Pecqueur, B. (2005). La gouvernance territoriale comme nouveau mode de coordination territoriale ? *Géographie, économie, société*, 7(4), 321-331. <https://doi.org/10.3166/ges.7.321-331>
- Levasseur, P., Rugani, A., & Marcon, M. (2010). Déshydratation des digestats de méthanisation Analyse économique de 4 procédés. *TechniPorc*, 33(5).
- Levasseur, P., Toudic, A., Bonhomme, S., & Lorinquer, E. (2017). *Gestion et traitement des digestats issus de méthanisation*.
- Livian, Y. (2018). *Enseigner la recherche qualitative en sciences économiques et de gestion*.

- Logan, M., & Visvanathan, C. (2019). Management strategies for anaerobic digestate of organic fraction of municipal solid waste : Current status and future prospects. *Waste Management & Research: The Journal for a Sustainable Circular Economy*, 37(1_suppl), 27-39. <https://doi.org/10.1177/0734242X18816793>
- Lupton, S. (2001). Sécurité environnementale et sanitaire : Les biens controversés. *Économie rurale*, 262(1), 3-18. <https://doi.org/10.3406/ecoru.2001.5228>
- Lupton, S. (2002). *Incertitude sur la qualité et économie des biens controversés. Le marché d'épandage des boues de stations d'épuration urbaines.*
- Lupton, S. (2005). Shared quality uncertainty and the introduction of indeterminate goods. *Cambridge Journal of Economics*.
- Lupton, S. (2011). *Économie des déchets Une approche institutionnaliste* (De Boeck Supérieur).
- Lupton, S. (2017). Markets for waste and waste-derived fertilizers. An empirical survey. *Journal of Rural Studies*, 55, 83-99. <https://doi.org/10.1016/j.jrurstud.2017.07.017>
- MAAF. (2014). *La gestion des digestats*. Ministère de l'agriculture, de l'agroalimentaire et de la forêt.
- Marshall, B., Cardon, P., Poddar, A., & Fontenot, R. (2013). Does Sample Size Matter in Qualitative Research? : A Review of Qualitative Interviews in is Research. *Journal of Computer Information Systems*, 54(1), 11-22. <https://doi.org/10.1080/08874417.2013.11645667>
- Martel, S., & Desmeules, X. (2013). *Valorisation agronomique des digestats de méthanisation*. Agrinova, recherche et innovation en agriculture.
- Mason, J. (2002). *Qualitative Research*. SAGE Publications.
- MEAE. (2015). *Rencontre entre la bioéconomie allemande et américaine à Berlin*. France Diplomatie - Ministère de l'Europe et des Affaires étrangères. <https://www.diplomatie.gouv.fr/fr/politique-etrangere-de-la-france/diplomatie-scientifique-et-universitaire/veille-scientifique-et-technologique/Allemagne/article/rencontre-entre-la-bioeconomie-allemande-et-americaine-a-berlin>
- MEDE, & MAAF. (2013). *Le plan Energie Méthanisation Autonomie Azote*.
- Messad, P. (2022, septembre 14). *European Parliament backs 45% renewable energy goal for 2030*. Wwww.Euractiv.Com. <https://www.euractiv.com/section/energy-environment/news/european-parliament-to-adopt-a-45-renewable-energy-goal-for-2030/>
- Millar, N., Mclaughlin, E., & Börger, T. (2019). The Circular Economy : Swings and Roundabouts? *Ecological Economics*, 158, 11-19. <https://doi.org/10.1016/j.ecolecon.2018.12.012>
- Moletta, R. (2015). *La méthanisation*. Lavoisier.
- Monlau, F., Sambusiti, C., Ficara, E., Aboulkas, A., Barakat, A., & Carrère, H. (2015). New opportunities for agricultural digestate valorization : Current situation and perspectives. *Energy & Environmental Science*, 8(9), 2600-2621. <https://doi.org/10.1039/C5EE01633A>

- MTE. (2021). *Accidentologie du secteur de la méthanisation*. Ministère de la Transition Ecologique.
- MTE. (2022). *Biogaz | Chiffres clés des énergies renouvelables*. Chiffres clés des énergies renouvelables - Édition 2021. <https://www.statistiques.developpement-durable.gouv.fr/edition-numerique/chiffres-cles-energies-renouvelables-2021/18-biogaz.php>
- Nelles, M. (2016). Waste Management in Germany – Development to a Sustainable Circular Economy? *Procedia Environmental Sciences*.
- Nelson, P. (1970). Information and Consumer Behavior. *JOURNAL OF POLITICAL ECONOMY*.
- Niang, A., Bourdin, S., & Torre, A. (2020). L'économie circulaire, quels enjeux de développement pour les territoires ? *Développement durable et territoires, Vol. 11, n°1*. <https://doi.org/10.4000/developpementdurable.16902>
- Niang, A., Torre, A., & Bourdin, S. (2021). Territorial governance and actors' coordination in a local project of anaerobic digestion. A social network analysis. *European Planning Studies*, 1-20. <https://doi.org/10.1080/09654313.2021.1891208>
- Niang, A., Torre, A., & Bourdin, S. (2022). How do local actors coordinate to implement a successful biogas project? *Environmental Science & Policy, 136*, 337-347. <https://doi.org/10.1016/j.envsci.2022.06.019>
- Njie, B., & Asimiran, S. (2014). Case Study as a Choice in Qualitative Methodology. *IOSR Journal of Research & Method in Education (IOSRJRME)*, 4(3), 35-40. <https://doi.org/10.9790/7388-04313540>
- Nkoa, R. (2014). Agricultural benefits and environmental risks of soil fertilization with anaerobic digestates : A review. *Agronomy for Sustainable Development, 34(2)*, 473-492. <https://doi.org/10.1007/s13593-013-0196-z>
- Pappalardo, G., Selvaggi, R., Bracco, S., Chinnici, G., & Pecorino, B. (2018). Factors affecting purchasing process of digestate : Evidence from an economic experiment on Sicilian farmers' willingness to pay. *Agricultural and Food Economics, 6(1)*, 16. <https://doi.org/10.1186/s40100-018-0111-7>
- Pecqueur, B. (1987). *De l'espace fonctionnel à l'espace-territoire : Essai sur le développement local*. Grenoble 2.
- Pecqueur, B., & Zimmermann, J.-B. (2004). *Economie de proximités* (Hermès Lavoisier). <https://www.eyrolles.com/Entreprise/Livre/economie-de-proximite-9782746208551/>
- Peshkin, A. (1993). The Goodness of Qualitative Research. *Educational Researcher, 22(2)*, 23-29. <https://doi.org/10.2307/1176170>
- Pin, C. (2023). *L'entretien semi-directif*. Science Po. <https://sciencespo.hal.science/hal-04087897/>
- Plana, P. V., & Noche, B. (2016). A review of the current digestate distribution models : Storage and transport. 345-357. <https://doi.org/10.2495/WM160311>
- PRN. (2019). *La méthanisation. Vademecum réglementaire*. Préfet de la région Normandie.

- Richter, S., Szarka, N., Bezama, A., & Thrän, D. (2022). *What Drives a Future German Bioeconomy? A Narrative and STEEPLE Analysis for Explorative Characterisation of Scenario Drivers*.
- Rigby, H., & Smith, S. (2011). *New Markets for Digestate from Anaerobic Digestion*. WRAP.
- Saveyn, H., & Eder, P. (2014). *End-of-waste criteria for biodegradable waste subjected to biological treatment (compost & digestate) : Technical proposals (JRC Scientific and Policy reports, p. 312)*. European Commission.
- Scarlat, N., Dallemand, J.-F., & Fahl, F. (2018). Biogas : Developments and perspectives in Europe. *Renewable Energy*, *129*, 457-472. <https://doi.org/10.1016/j.renene.2018.03.006>
- Scarlat, N., Dallemand, J.-F., Monforti-Ferrario, F., Banja, M., & Motola, V. (2015). Renewable energy policy framework and bioenergy contribution in the European Union – An overview from National Renewable Energy Action Plans and Progress Reports. *Renewable and Sustainable Energy Reviews*, *51*, 969-985. <https://doi.org/10.1016/j.rser.2015.06.062>
- Schroeder, L., & Jeonghyun, K. (2019). *GERMANY'S WASTE MANAGEMENT POLICY DEVELOPMENT A Focus on Municipal Solid Waste*. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH.
- Schumacher, K., Krones, F., McKenna, R., & Schultmann, F. (2019). Public acceptance of renewable energies and energy autonomy : A comparative study in the French, German and Swiss Upper Rhine region. *Energy Policy*, *126*, 315-332. <https://doi.org/10.1016/j.enpol.2018.11.032>
- Schumacher, K., & Schultmann, F. (2017). Local Acceptance of Biogas Plants : A Comparative Study in the Trinational Upper Rhine Region. *Waste and Biomass Valorization*, *8*. <https://doi.org/10.1007/s12649-016-9802-z>
- Selvaggi, R., Chinnici, G., & Pappalardo, G. (2018). *ESTIMATING WILLINGNESS TO PAY FOR DIGESTATE: EVIDENCE FROM AN ECONOMIC EXPERIMENT FROM SICILIAN FARMERS*.
- Selvaggi, R., Pappalardo, G., Pecorino, B., & Vecchio, R. (2021). Factors influencing farmers' decision to enter digestate market. *Journal of Cleaner Production*, *321*, 128961. <https://doi.org/10.1016/j.jclepro.2021.128961>
- SOLAGRO, & IRSTEA. (2015). *Etat de l'art des digestats et de leurs procédés de post-traitement* (p. 76).
- Soland, M., Steimer, N., & Walter, G. (2013). Local acceptance of existing biogas plants in Switzerland. *Energy Policy*, *61*, 802-810. <https://doi.org/10.1016/j.enpol.2013.06.111>
- Teiu, C.-M., & Juravle, D. (2011). *A PRACTICAL APPROACH ON MAKING USE OF CASE STUDY RESEARCH IN ECONOMICS*.
- Terrier, C. (1989). Recherche d'un espace de référence pour l'économie régionale—D'un concept de territoire à un concept de réseau. *Revue d'Economie Régionale et Urbaine*, *3*.

- Theuerl, S., Herrmann, C., Heiermann, M., Grundmann, P., Landwehr, N., Kreidenweis, U., & Prochnow, A. (2019). The Future Agricultural Biogas Plant in Germany : A Vision. *Energies*, 12(3), 396. <https://doi.org/10.3390/en12030396>
- Thisse, J.-F. (2011). Geographical Economics : A Historical Perspective. *Recherches Économiques de Louvain*, 77(2), 141. <https://doi.org/10.3917/rel.772.0141>
- Thrän, D., Schaubach, K., Majer, S., & Horschig, T. (2020). Governance of sustainability in the German biogas sector—Adaptive management of the Renewable Energy Act between agriculture and the energy sector. *Energy, Sustainability and Society*, 10(1), 3. <https://doi.org/10.1186/s13705-019-0227-y>
- Torre, A. (2002). Réflexions sur la proximité. *NTIC et Territoires*.
- Torre, A. (2011). Les processus de gouvernance territoriale. L’apport des proximités: *Pour*, N° 209-210(2), 114-122. <https://doi.org/10.3917/pour.209.0114>
- Torre, A. (2014). Proximity relations at the heart of territorial development processes : From clusters, spatial conflicts and temporary geographical proximity to territorial governance. In A. Torre & F. Wallet (Éds.), *Regional Development and Proximity Relations*. Edward Elgar Publishing. <https://doi.org/10.4337/9781781002896.00009>
- Torre, A., Aznar, O., Bonin, M., Caron, A., Chia, E., Galman, M., Lefranc, C., Melot, R., Guérin, M., Jeanneaux, P., Paoli, J.-C., Salazar, M. I., Thinson, P., & Kirat, T. (2006). Conflits et tensions autour des usages de l’espace dans les territoires ruraux et périurbains. Le cas de six zones géographiques françaises: *Revue d’Économie Régionale & Urbaine*, août(3), 415-453. <https://doi.org/10.3917/reru.063.0415>
- Torre, A., & Filippi, M. (2005). *Proximités et changements socio-économiques dans les mondes ruraux* (INRA Editions). <https://www.quae.com/produit/206/9782759214679/proximites-et-changements-socio-economiques-dans-les-mondes-ruraux>
- Torre, A., Kirat, T., Melot, R., & Pham, H. V. (2016). LES CONFLITS D’USAGE ET DE VOISINAGE DE L’ESPACE. BILAN D’UN PROGRAMME DE RECHERCHE PLURIDISCIPLINAIRE. *L’information géographique*, 80(4).
- Torre, A., & Zuindeau, B. (2009). Dossier « Économie de la proximité » – Les apports de l’économie de la proximité aux approches environnementales : Inventaire et perspectives. *Natures Sciences Sociétés*, 17(4), 349-360. <https://doi.org/10.1051/nss/2009062>
- Torrijos, M. (2016). State of Development of Biogas Production in Europe. *Procedia Environmental Sciences*, 35, 881-889. <https://doi.org/10.1016/j.proenv.2016.07.043>
- Trombin, G., Kayser, K., & Gruszkos, T. (2017). *IBBK Fachgruppe Biogas GmbH*. 67.
- Turley, D., Hopwood, L., Burns, C., & Di Maio, D. (2016). *Assessment of digestate drying as an eligible heat use in the Renewable Heat Incentive*. NNFCC The Bioeconomy Consultants.
- United Nations. (2015). *Paris Agreement*.

- Vivien, F.-D., Nieddu, M., Befort, N., Debref, R., & Giampietro, M. (2019). The Hijacking of the Bioeconomy. *Ecological Economics*, 159, 189-197. <https://doi.org/10.1016/j.ecolecon.2019.01.027>
- Wallace, W. (1971). *The Logic of Science in Sociology*. Routledge. <https://doi.org/10.4324/9781315132976>
- WBA. (2019). *Market Report Germany*. World Biogas Association.
- WRAP. (2012). *Market expectations and requirements for digestate*. The Waste and Resources Action Programme.
- WRAP. (2013). *Digestate distribution models. Final report*.
- Yang, X., Liu, Y., Wang, M., Bezama, A., & Thrän, D. (2021). Identifying the Necessities of Regional-Based Analysis to Study Germany's Biogas Production Development under Energy Transition. *Land*, 10(2), 135. <https://doi.org/10.3390/land10020135>
- Yin, R. (2003). *Case Study Research : Design and Methods*. SAGE Publications.
- Yin, R. K. (2009). *Case Study Research : Design and Methods*. SAGE.
- Zemo, K. H., Panduro, T. E., & Termansen, M. (2019). Impact of biogas plants on rural residential property values and implications for local acceptance. *Energy Policy*, 129, 1121-1131. <https://doi.org/10.1016/j.enpol.2019.03.008>
- Zimmermann, J.-B. (2008). Le territoire dans l'analyse économique. Proximité géographique et proximité organisée. *Revue française de gestion*, 34(184), 105-118. <https://doi.org/10.3166/rfg.184.105-118>

Annexes

Annex n°1: List of press articles reviewed for the case studies

Case	Press articles
Bionerval	« Oise, l'usine de méthanisation mise en demeure après les odeurs nauséabondes » Le Parisien, 08-08-2020
BioQuercy	« De l'eau dans le biogaz à Gramat dans le Lot », Touleco green, 31-03-2017
	« Méthanisation : les scientifiques ont la parole. Après la Bretagne polluée par le lisier, attention pour le Lot avec le digestat » ActuLot, 22-09-2017
	« Méthaniseur de Gramat : deux paysans lotois convoqués à la gendarmerie », La Dépêche du Midi, 29-03-2018
	« Unité de méthanisation de Gramat : une réduction très significative des nuisances est signalée », ActuLot, 16-11-2018
	« Ces alarmes que personne n'entend sur la méthanisation », Médiapart, 30-01-2019
	« Lot : les habitants d'un village infestés par des odeurs pestilentielles à cause d'une usine de méthanisation », La dépêche du Midi, 06-02-2019
	« Les dangers de la méthanisation pointés du doigt en France, y compris dans le Lot », France Bleu Occitanie, 14-02-2018
	« BioQuercy : l'appel pressant de V. Labarthe », La Dépêche du Midi, 05-12-2018
	« Méthanisation dans le Lot : l'épandage de digestat brut liquide suscite de vives inquiétude », ActuLot, 18-04-2019
	« Rapport sur les conditions d'exploitation du méthaniseur de Gramat. Rien n'empêche, mais tout de même... », ActuLot, 19-11-2019
« Méthanisation dans le Lot : 11 associations s'interrogent après les conclusions du rapport commandé par le préfet » ActuLot, 28-11-2019	
« Associations et collectifs ont épluché le rapport d'experts », La Dépêche du Midi, 06-12-2019	

	« Le tribunal administratif de Toulouse tranche en faveur de BioQuercy », La Dépêche du Midi, 06-12-2019
	« BioQuercy officiellement réhabilité. Capel sort du silence et appelle à la raison », ActuLot, 14-12-2019
	« Feu vert de la justice pour la remise en route de l'unité de méthanisation de BioQuercy », France 3 Occitanie, 15-12-2019
	Communiqué de presse, La Dépêche du Midi, 17-01-2021
	« Le méthaniseur de Gramat mis en demeure par la préfecture du Lot », La Dépêche du Midi, 28-04-2021
	« Méthanisation dans le Lot, le grand emmerdement », Reporterre 05-10-2021
	« Lot : l'observatoire de la méthanisation au point mort » La Dépêche du Midi, 10-11-2021
	« Conférence à Gramat, le point sur le développement de la méthanisation », ActuLot, 12-05-2022
Kastellin	« Finistère : la fuite d'une cuve de méthanisation à l'origine d'une pollution de l'Aulne » France 3 Bretagne, 20-08-2020
	« Pollution de l'Aulne : des bouteilles d'eau seront distribuées aux habitants jusqu'à un retour à la normale » France 3 Bretagne, 21-08-2020
	« Finistère. De la fumée s'échappe de l'usine de méthanisation responsable de la pollution de l'Aulne », Ouest-France 23-08-2020
	« Quel intérêt et quelle fiabilité pour les méthaniseurs ? L'avis d'un chercheur rennais », France 3 Bretagne 25-08-2020
	« Agriculture. La méthanisation agricole à la française inquiète », Ouest-France 26-08-2020
	« Après la pollution de l'Aulne, la mobilisation contre les méthaniseurs », France 3 Bretagne 30-08-2020
	« Pollution de l'Aulne : l'usine de méthanisation autorisée à redémarrer », France 3 Bretagne 08-10-2020
	« REPORTAGE sur la Centrale Biométhane de Kastellin 2018 - VOL-V et GRTgaz », YouTube video, 11-07-2018

	« Accident du méthaniseur de Châteaulin : Cash investigation dévoile un rapport accablant pour Engie », France 3 Bretagne 12-11-2021
	« Méthaniseur de Châteaulin : un élu demande à consulter le rapport d'enquête », France Bleu 16-11-2021
	« Méthanisation. 18 mois après l'incident de Châteaulin, le courrier du procureur inquiète », Ouest-France 11-02-2022
	« L'UDSEA veut un moratoire sur la méthanisation », Paysan-Breton 27-08-2020
	« Lecornu inaugure une centrale biométhane à Châteaulin », Geo 31-05-2018
	« Châteaulin. En 2015, deux unités de méthanisation sur pied », Ouest-France 07-11-2013
	« Méthanisation. L'usine de Vol-V met les gaz à Châteaulin », Le Télégramme 15-06-2016
	« Pollution de l'Aulne en 2020. Un an après, que l'incident a-t-il permis ? », Ouest-France, 23-08-2021
	« Bretagne : Engie va-t-il échapper à un procès après la pollution du méthaniseur de Châteaulin ? », 20 minutes, 11-02-2022
	« Bretagne : Engie devant la justice après la pollution de son méthaniseur », 20 minutes, 08-03-2020
	« Demande du report du procès du méthaniseur de Châteaulin, « une fumisterie » pour un plaignant », Ouest-France, 08-03-2020
	« Le procès du méthaniseur de Châteaulin renvoyé au 28 septembre 2023 », Ouest-France, 09-03-2023
	« Le procès de l'accident du méthaniseur de Châteaulin reporté au 28 septembre 2023 », Le Télégramme, 09-03-2023
Terragr'eau	« Evian sécurise sa ressource en eau avec la méthanisation », Les Echos, 01-04-2015
	« L'ambition carbone d'Evian », L'Usine nouvelle, 16-11-2017
	« GIEE : les premiers collectifs d'agriculteurs reconnus », Actu-environnement, 23-02-2015

	« Danone protège sa ressource en eau d'Evian en finançant un méthaniseur au bord du lac Léman », France 3 Auvergne-Rhône-Alpes, 16-10-2015
	« Méthanisation : Un épandage collectif des digestats avec la Sica Terragr'Eau », Réussir Lait, 25-01-2021
	“Evian’s journey to become the first global carbon neutral brand”, Beverage Daily, 02-11-2017
	« Vinzier : le méthaniseur Terragr'eau répond aux enjeux de développement durable du territoire », Thonon Alpes radio, 16-04-2021
	« Méthaniseur du Gavot : Danone ne semble pas prêt à mettre la main à la poche », Le Messenger, 23-06-2022
	« Méthanisation : Un épandage collectif des digestats avec la Sica Terragr'Eau », Réussir Lait, 25-01-2021
Zittau	« Zittauer Biogasanlage wird erweitert », Sächsische, 26-11-2020
	„EIN PROSIT AUF DIE TECHNIK: NEUER BIOGAS-CONTAINER SPART BRAUEREI ENERGIE!“, Tag.24, 13-02-2022
	„Śmierzący interes“, Przegląd Lubanski
	„Kolejny problem ze smrodem”, zgorzelec.info, 19-04-2013
	“spor o zbiornik na bioodpady”, wroclaw.tvp.pl, 18-04-2013
	„Będzie happy end w Skrzydlicach?”, old.chronmycklimat.pl, 19-09-2013
	„Wizyta w biogazowni w Zittau”, sulikow.pl, 14-02-2014
	„Odpady z Niemiec... na polską ziemię”, Radio Wroclaw, 01-05-2014
	„Sprawa "Laguny" w Skrzydlicach tematem obrad sesji”, Zinfo, 18-04-2014

Annex n°2: List of documents and websites reviewed for the case studies

Case	Documents
Bionerval	Prefectoral Decree for the 2 nd land application plan (2015)
	Application for the 3 rd land application plan (2018)
	Prefectoral Decree for the 3 rd land application plan (2019)
	Announcement public survey for the 3 rd land application plan (2019)
	Observations from the inhabitants for the extension of the spreading plan (2019)
	Conclusions of the public inquiry (2019)
	Opinion of the MRAE ⁵⁸ (22-10-2018)
	Answer to the demand of Environment Authority (2018)
	Answer to the demand of Environment Authority (2019)
	« Vers une démarche qualité de la filière biogaz », ATEE (2015)
	Prefectoral Decree creating the site monitoring commission (2013)
	Site monitoring commission 2018 report
	Site monitoring commission 2019 report
	Letter from the ROSO to the Prefecture of the Oise (2014)
BioQuercy	BioQuercy.fr
	Lot.confederationpaysanne.fr
	« Lettre du Comité départemental de Spéléologie du Lot et du Comité de Spéléologie Régional de Midi Pyrénées à la préfète du Lot », 18-02-2017
	« Conditions d'exploitation du méthaniseur de Gramat : expertise et pistes d'avenir », Report of the French Ministry for the Ecological Transition, September 2019
	« Quelques remarques sur le rapport des inspecteurs du CGEDD concernant BioQuercy », 20-01-2020
	Complementary prefectoral Decree, February 2020
	Prefectoral Decree, 19-11-2022
	Prefectoral Decree, 19-12-2022
	« Epanchage des digestats de BioQuercy, un double intérêt agronomique et économique », Lot.chambre-agriculture.fr 27-11-2020
	« Méthanisation, le retour de la raison », Solagro.org
	« Méthanisation, l'impasse de l'agriculture industrielle » loicprudhomme.fr
	« La MESE, une mission d'expertise et d'accompagnement au service des collectivités et des agriculteurs »
Kastellin	« Inauguration de la Centrale Biométhane de Kastellin », Vol-v.com

⁵⁸ MRAE = Regional Mission of the Environmental Authority

	Opinion of DDTM to extension land application plan, 18-04-2018
	ICPE request, 05-2018
	Press review, Vol-V Biogaz, 31-05-2018
	Note DDTM, 12-06-2018
	Decree for the opening of the public survey for the extension of the land application plan, 05-07-2018
	Observations from the public survey, 2018
	Response to the public survey, 09-2018
	ICPE report, 19-08-2020
	Note of the EPAGA to the DREAL, 20-08-2020
	Prefectoral decree, 22-08-2020
	Prefectoral decree, 25-08-2020
	Internal note EPAGA, 28-08-2020
	“Manifesto for a moratorium on the development of biogas plants in Brittany and the reinforcement of the control of existing units”, 09-2020
	Prefectoral decree, 08-10-2020
	« Retours d’expérience : méthanisation », l’ADEME en Bretagne, bretagne.ademe.fr
	« Mise à jour de l’étude préalable à la valorisation agricole des digestats issus du processus de méthanisation », SET for Vol-V, 05-2018
	Communiqué de presse, confederationpaysanne.fr, 28-10-2020
	« Méthanisation : nos positions » confederationpaysanne.fr
	« Un vrai procès pour la pollution du méthaniseur de Châteaulin », eau-et-rivieres.org, 13-10-2022
	cc-peva.fr
Terragr’eau	« Terragr’eau : un projet agricole territorial à dimension économique, sociale et environnementale », Auvergne-Rhône-Alpes Energie et Environnement, 2017
	« TERRAGR’EAU : Une vision collective et durable », Grdf.fr, 17-06-2021
	« Visite du méthaniseur Terragr’Eau de Vinzier », geoparc-chablais.com, 10-09-2019
	« Installation : Terragr’eau : SUIVI TECHNIQUE, ECONOMIQUE, ET SOCIAL D’INSTALLATIONS DE METHANISATION » ADEME, 02-2019
	« Un projet exemplaire mais pas forcément transposable », DREAL Rhône-Alpes, 9-10-2015
	« PRATIQUES AGRICOLES, BIODIVERSITÉ ET QUALITÉ DE L’EAU SUR L’IMPLUVIUM DES EAUX D’EVIAN », MAAF, 2015
	« INSTALLATION DE MÉTHANISATION Sur le territoire des communes de FÉTERNES et VINZIER par la SAS TERRAGR’EAU », ATEE, 2018
	Opinion of the Environmental Authority, 13-01-2015

	Prefectoral Decree, 25-08-2015
	Prefectoral Decree, 18-01-2019
	« SICA Terragr'Eau : Gérer collectivement les effluents pour préserver la qualité des eaux d'Evian », Chambre d'agriculture Savoie Mont-Blanc, 31-01-2021
	« Pratiques agricoles, biodiversité, et qualité de l'eau sur l'Impluvium des Eaux d'Evian (Haute Savoie) », SICA Terragr'eau, 03-02-2015
Zittau	« Ökostrom durch Biomethan. European Energy Award. Zittau », Sächsische Energieagentur, 04-10-2022
	„Erfahrungsaustausch zur Verbesserung der Energieeffizienz zwischen Stadt und Hochschule, European Energy Award. Zittau“, Sächsische Energieagentur, 04-10-2022
	„Dossier de références“, France Biogaz, 17-05-2018
	Certificat Afnor, 02-08-2022
	« Installations de méthanisation. Technologies et procédés modernes », Strabag, 28-10-2015
	North.data
	Stadtwerke-zittau.de
	Energieportal-sachsen.de
	« Biomethan-anlage Zittau », Biomethan Zittau GmbH, 13-09-2022
	zittau.de
	Vonschieszl.com
	« Referncje », Biomethan Zittau, 21-09-2018
	„Anlage zum Haushaltsplan für das Haushaltsjahr 2022“, Zittau, 13-09-2021
	“Referenzen 1998 – 2015“, Malmberg, 09-10-2015
	Enso.de
	„Beteiligungsbericht 2017 Jahresabschlüsse 2017 der Unternehmen der Landeshauptstadt Dresden“, Dresden, 19-12-2018
	„Biogasanlage Zittau“, YouTube video, 02-05-2012
	„Biogasanlage Zittau“, Strabag, 18-10-2010

Annex n°3: Summary of our interviews

Categories of agents	Structures / organisations	Countries / case studies	Dates of interviews
Experts	AILE & AAMF (1)	France	07/01/2021
	Private company building and managing biogas plants (1)	France	06/01/2021
	German Biogas Association (1)	Germany	03/03/2021
	German Federal Environmental Agency (1)	Germany	12/12/2022
	European Biogas Association (1)	Brussels	07/04/2021
	Private companies providing technologies for digestate management (2)	France	11/01/2021 & 20/01/2021
	Private companies providing technologies for digestate management (1)	Germany	11/01/2021
	Consultancies (2)	France	07/01/2021 & 19/05/2022
	ATEE (1)	France	04/01/2021
	Bank financing biogas plants (1)	France	04/01/2021
	German Biogas Research Centre (1)	Germany	18/11/2022

	Polytechnical Institute UniLasalle (2)	France	27/04/2022 & 29/04/2022
	INRAE (4)	France	03/05/2022, 18/05/2022, 20/05/2022 & 24/05/2022
Managers / owners of biogas plants	Ferti-NRJ (1)	Bionerval	25/10/2021
	Bionerval / SARIA (3)	Bionerval	30/11/2021 & 05/01/2022
	Fonroche Biogaz / TotalEnergies (1)	BioQuercy	07/02/2022
	SERFIM (2)	Terragr'eau	19/05/2022 & 20/05/2022
	SachsenEnergie (2)	Zittau	01/11/2022 & 30/01/2023
State services	DREAL Oise (1)	Bionerval	02/12/2021
	DDT Oise (2)	Bionerval	19/11/2021
	DREAL Finistère (1)	Châteaulin	09/06/2022
	DDTM Finistère (1)	Châteaulin	22/06/2022
	DDPP Haute-Savoie (1)	Terragr'eau	05/04/2022
	Provincial Inspectorate for Environmental Protection (1)	Zittau	06/12/2022
Farmers	Farmers (2)	Bionerval	12/01/2022 & 18/01/2022
	Farmers (2)	BioQuercy	24/02/2022 & 28/02/2022
	Farmer (1)	Châteaulin	22/09/2022
	Farmer (1)	Terragr'eau	04/04/2022

Consular bodies and government agencies	Agricultural Chamber Oise (1)	Bionerval	21/11/2021
	SATEGE Somme (1)	Bionerval	09/02/2022
	Water Agency Artois-Picardie (1)	Bionerval	14/01/2022
	Agricultural Chamber Lot (1)	BioQuercy	31/01/2022
	MESE Occitanie (1)	BioQuercy	01/01/2022
	AILE (2)	Châteaulin	16/05/2022 & 10/06/2022
	Agricultural Chamber Finistère (1)	Châteaulin	25/05/2022
	EPAGA (1)	Châteaulin	19/09/2022
	MESE Haute-Savoie (1)	Terragr'eau	05/04/2022
	Agricultural Chamber Savoie- Mont-Blanc (1)	Terragr'eau	23/05/2022
Local public powers and territorial entities	Municipality of Chiry-Ourscamp (1)	Bionerval	24/01/2022
	Municipality of Gramat (1)	BioQuercy	25/02/2022
	Communauté de Communes Cauvaldor (1)	BioQuercy	02/03/2022
	PNRCQ (2)	BioQuercy	04/02/2022 & 01/07/2022
	Municipality of Châteaulin (1)	Châteaulin	13/09/2022

	Communauté de Communes PEVA (2)	Terragr'eau	07/04/2022
Environmental and local residents' associations	ROSO (2)	Bionerval	15/11/2021 & 18/11/2021
	GADEL (1)	BioQuercy	07/02/2022
	Collectif citoyen Iotois (1)	BioQuercy	08/02/2022
	Bretagne Vivante (1)	Châteaulin	09/06/2022
Local companies	SARL Cadet (1)	Bionerval	01/12/2021
	GES (1)	Bionerval	14/01/2022
	Société des Eaux d'Evian (1)	Terragr'eau	27/04/2022
	SICA Terragr'eau (1)	Terragr'eau	04/04/2022

Legend: (1) = number of people interviewed within a structure

Annex n°4: Anonymised list of experts

Expert number	Institution
Expert 1	AILE
Expert 2	Consultancy
Expert 3	ATEE
Expert 4	Bank
Expert 5	Consultancy
Expert 6	Private company
Expert 7	Private company
Expert 8	Private company
Expert 9	European Biogas Association
Expert 10	Consultancy
Expert 11	DBFZ
Expert 12	Polytechnical Institute UniLaSalle
Expert 13	German Biogas Association
Expert 14	INRAE
Expert 15	German federal environmental agency
Expert 16	INRAE
Expert 17	INRAE
Expert 18	Polytechnical Institute UniLaSalle
Expert 19	INRAE

Annex n°5: Interview guides

Managers & owners of biogas plants:

Themes	Dunning questions
Presentation: Can you present yourself, the biogas plant and its history?	
Theme 1: how is the management and the valorisation of digestates organised, and who is involved in these operations?	Why did you choose this mode of management and valorisation?
	How did you convince farmers to use your digestates?
	How did you convince local agents to accept the use of digestates on the territory?
	Have you been supported / accompanied by other agents?
	How, and how often do you meet with other agents to organise the management and valorisation activities?
Theme 2: have you faced obstacles, challenges and / or conflicts over the management and the use of digestates?	What were the reasons why the obstacles / challenges / conflicts emerge?
	Who were the agents involved in the conflicts?
	Have the conflicts been solved? If yes, how, and by who? If no, how is it planned to solve them, and with who?
Theme 3: how do you produce and transfer information about the properties and impacts of digestates?	Are you accompanied by other agents to produce and acquire information on your digestates?
	Are you accompanied by other agents to transfer and communicate information on your digestates?
	Who do you communicate your information with, and how?
Final question: do you want to add anything you think relevant and that has not been discussed during this interview?	

Farmers:

Themes	Dunning questions
Presentation: Can you present yourself, your farm and your productions?	

<p>Theme 1: how is the management and the valorisation of digestates organised, and how are you involved in these operations?</p>	How did you hear about the biogas plant, and why did you get involved in the biogas plant?
	How did you hear about digestates, and why were you interested in using them?
	Did you have any fears or concerns about digestates? Which ones? What and who made you feel reassured?
	Have you been supported / accompanied by other agents in the use of digestates? How?
<p>Theme 2: have you faced obstacles, challenges and / or conflicts over the management and the use of digestates?</p>	What were the reasons why the obstacles / challenges / conflicts emerge?
	Who were the agents involved in the conflicts?
	Have the conflicts been solved? If yes, how, and by who? If no, how is it planned to solve them, and with who?
<p>Theme 3: how do you get informed about the properties and impacts of digestates?</p>	Did you or do you lack information on some properties and impacts of digestates? With what consequences?
	Who provides information and how? Do you trust this information? Why or why not?
	Are you involved in the production and acquisition of information, and how?
	Who do you exchange this information with and how?
<p>Final question: do you want to add anything you think relevant and that has not been discussed during this interview?</p>	

State services

Themes	Dunning points
<p>Presentation: Can you present yourself, your service and its missions?</p>	
<p>Theme 1: what is the role of your service in the management and the valorisation of digestates?</p>	Who do you interact with to carry out your missions? And how often?
	Did or do you have any fears or concerns about digestates? Which ones? Do you feel reassured and why or why not?
<p>Theme 2: have you observed obstacles, challenges and / or conflicts over the management and the use of digestates?</p>	What were the reasons why the obstacles / challenges / conflicts emerge?
	Who were the agents involved in the conflicts?

	Have the conflicts been solved? If yes, how, and by who? If no, how is it planned to solve them, and with who?
	Are these obstacles / challenges / conflicts specific to this biogas plant, or to the region?
Theme 3: what is your role in the production and transfer of information about the properties and impacts of digestates?	Did you or do you lack information on some properties and impacts of digestates? With what consequences?
	Who provides information and how? Do you trust this information? Why or why not?
	Are you involved in the production and acquisition of information, and how?
	Who do you exchange this information with and how?
Final question: do you want to add anything you think relevant and that has not been discussed during this interview?	

Consular bodies and government agencies

Themes	Dunning points
Presentation: Can you present yourself, your organisation and its missions?	
Theme 1: what is the role of your organisation in the management and the valorisation of digestates?	Who do you interact with to carry out your missions? And how often?
	Did or do you have any fears or concerns about digestates? Which ones? Do you feel reassured and why or why not?
Theme 2: have you observed / did you get involved into obstacles, challenges and / or conflicts over the management and the use of digestates?	What were the reasons why the obstacles / challenges / conflicts emerge?
	Who were the agents involved in the conflicts?
	Have the conflicts been solved? If yes, how, and by who? If no, how is it planned to solve them, and with who?
	Are these obstacles / challenges / conflicts specific to this biogas plant, or to the region?
Theme 3: what is your role in the production and transfer of information about the properties and impacts of digestates?	Did you or do you lack information on some properties and impacts of digestates? With what consequences?
	Who provides information and how? Do you trust this information? Why or why not?

	Are you involved in the production and acquisition of information, and how?
	Who do you exchange this information with and how?
Final question: do you want to add anything you think relevant and that has not been discussed during this interview?	

Local public powers and territorial entities

Themes	Dunning points
Presentation: Can you present yourself, your organisation and its missions?	
Theme 1: what is the role of your organisation in the management and the valorisation of digestates?	How did you hear about the biogas plant? Why did you get involved in the interactions around the biogas plant, and how?
	How did you hear about digestates? Why did you get involved in the interactions around their management and use, and how?
	Did or do you have any fears or concerns about digestates? Which ones? Do you feel reassured and why or why not?
Theme 2: have you observed / did you get involved into obstacles, challenges and / or conflicts /, over the management and the use of digestates?	What were the reasons why the obstacles / challenges / conflicts emerge?
	Who were the agents involved in the conflicts?
	Have the conflicts been solved? If yes, how, and by who? If no, how is it planned to solve them, and with who?
	Are these obstacles / challenges / conflicts specific to this biogas plant, or to the region?
Theme 3: what is your role in the production and transfer of information about the properties and impacts of digestates?	Did you or do you lack information on some properties and impacts of digestates? With what consequences?
	Who provides information and how? Do you trust this information? Why or why not?
	Are you involved in the production and acquisition of information, and how?
	Who do you exchange this information with and how?
Final question: do you want to add anything you think relevant and that has not been discussed during this interview?	

Environmental and local residents' associations

Themes	Dunning points
Presentation: Can you present yourself and your association?	
Theme 1: what is the role of your association in the management and the valorisation of digestates?	How did you hear about the biogas plant? Why did you get involved in the interactions around the biogas plant, and how?
	How did you hear about digestates? Why did you get involved in the interactions around their management and use, and how?
	Did or do you have any fears or concerns about digestates? Which ones? Do you feel reassured and why or why not?
Theme 2: have you observed / did you get involved into obstacles, challenges and / or conflicts over the management and the use of digestates?	What were the reasons why the obstacles / challenges / conflicts emerge?
	Who were the agents involved in the conflicts?
	Have the conflicts been solved? If yes, how, and by who? If no, how is it planned to solve them, and with who?
	Are these obstacles / challenges / conflicts specific to this biogas plant, or to the region?
Theme 3: what is your role in the production and transfer of information about the properties and impacts of digestates?	Did you or do you lack information on some properties and impacts of digestates? With what consequences?
	Who provides information and how? Do you trust this information? Why or why not?
	Are you involved in the production and acquisition of information, and how?
	Who do you exchange this information with and how?
Final question: do you want to add anything you think relevant and that has not been discussed during this interview?	

Local companies

Themes	Dunning points
Presentation: Can you present yourself, your company and its activities?	

Theme 1: how is the management and the valorisation of digestates organised, and how are you involved in these operations?	How did you hear about the biogas plant? Why did you get involved in the interactions around the biogas plant, and how?
	How did you hear about digestates? Why did you get involved in the interactions around their management and use, and how?
	Did or do you have any fears or concerns about digestates? Which ones? Do you feel reassured and why or why not?
Theme 2: have you faced obstacles, challenges and / or conflicts over the management and the use of digestates?	What were the reasons why the obstacles / challenges / conflicts emerge?
	Who were the agents involved in the conflicts?
	Have the conflicts been solved? If yes, how, and by who? If no, how is it planned to solve them, and with who?
	Are these obstacles / challenges / conflicts specific to this biogas plant, or to the region?
Theme 3: what is your role in the production and transfer of information about the properties and impacts of digestates?	Did you or do you lack information on some properties and impacts of digestates? With what consequences?
	Who provides information and how? Do you trust this information? Why or why not?
	Are you involved in the production and acquisition of information, and how?
	Who do you exchange this information with and how?
Final question: do you want to add anything you think relevant and that has not been discussed during this interview?	

We also discussed the **same three themes with the experts**, but in a more general way, for the whole biogas sector, and not just for the case studies. We discussed with them how the management and valorisation of digestates is usually organised, what types of challenges, obstacles, conflicts they witness / are aware of around the management and the use of digestates, and what type of information is missing on digestates and how do they contribute to the production and transfer of information.

Annex n°6: Example of an interview (interview with Ferti-NRJ)

Can you present yourself, the biogas plant and its history?

I think we can say we were quite pioneer in this field. We were one of the first centralized biogas plant in France. I had made a feasibility study with the ADEME and SOLAGRO that covered the whole north of Paris. In Picardy, the farming sector has completely lost animal breeding, there are just cereals and crops, there is no more land application of manure and slurry. There is an important decrease in the carbone content of soils so farmers apply residual products such as poultry manure. Therefore, Ferti-NRJ was welcomed on these topics. I met a lot of agri-food companies. The ComCom of Noyon offered the location in Passel, that was at the barycenter of the source of feedstock, with Nestlé, potatoes, sugar beetroots, and many industries of the first and second transformation. It was an industrial project. I then asked Cérésia to enter the capital because they had farmers that owned lands and could valorize the digestates. The group of farmer Innov'Aisnes also joined the capital. They wanted to invest in wind farming but they struggled so they joined Ferti-NRJ. We had some subsidies from the Seine-Normandy Water Agency because we digested WWTP sewage sludges, and the Agency had a say on the land application plan. The Artois-Picardy Agency gave us some problems but nothing serious. They just feared that our mix could dilute the pollutants. We had very good contacts with the SATEGE.

How did you organize the management and the valorization of digestates, and who was involved in these operations?

We asked many neighboring farmers for the land application plan. We found a group of dynamic farmers at 20km from the site, so a bit far, but they had a lot of hectares and they were interested a lot by the digestates. Ferti-NRJ continued to produce compost and digestates. We were lucky to find this group of farmers. Ferti-NRJ paid the transportation and the land application but the farmers paid the digestates. We set a price of digestates 30 to 40 euros cheaper than their fertilizing equivalents. The prices were attractive for the farmers but the digestates presented some inconvenient. But the land applications went very well. The land applications were carried out before the sowing of beetroots and potatoes of March-April and after the harvest, so before the sowing of wheat of August, September and October. We brought around 25-30 m³ by hectare. The farmers liked the digestates, there was no impurity in it. We contracted with the ETA CADET. They worked well, I was very happy with them. The second land application was being set up in 2015.

Have you faced obstacles, challenges and / or conflicts over the management and the use of digestates?

At the beginning of the project, the DREAL requested that we produced only compost. So, we separated the phases, we had the liquid phase recirculate to dilute the substrates and we composted the solid phase. We mixed the solid phase with horse manure and we composted it. The first project of land application plan was refused by the DREAL because the DREAL did not want digestates, but only compost. Unfortunately, the Belgians came to collect all the inputs from Bionerval, they took the waste at zero against a positive price for Fertinrj, so Fertinrj took other, more liquid wastes, then we had to send digestates to the treatment station, which created a lot of costs. So, we contacted the DREAL again to have a land application plan. The problem

was that we didn't master neither the upstream stages nor the downstream stages. The wastes were managed by big companies and the digestates were considered as wastes because of the land application plan. That is why the biogas plant was sold to Bionerval, we had no choice, we had financial difficulties because we couldn't make any benefit neither in the downstream stages nor in the upstream stages. We also had the problem that digestates were in high competition with other residual products such as poultry manure. At the beginning, we also had smell problems and some complaints from local inhabitants.

Have the conflicts been solved? If yes, how, and by who? If no, how is it planned to solve them, and with who?

We launched the site monitoring commission but we didn't have many meetings. I only attended two or three meetings. Otherwise, we set up a phone number in 2016, no, we set it up in 2012-2013 already. We also set up a weather station to track if we were responsible for the smell when we got a call. But the mayor of Passel understood that we were not robbers, not thieves. We were invited a lot by neighboring mayors. We show them when we had problems. At the beginning, there were threats from neighbors to set up associations against the biogas plant, but I was able to calm things down, and I asked for time to rectify the problems. I was able to show that the company was rolling up its sleeves. I also contacted the ROSO at the beginning of the project. I went to see the president of the ROSO at the beginning. And the ROSO voted for the project.

How did you produce and transfer information about the properties and impacts of digestates?

We invited a lot of farmers and we produced booklets. The first group of farmers already knew the biogas plant for the compost, therefore it was easy to approach them for the digestates. We organized meetings and we offered a very attractive price including the land application, so that they had no additional work. We also held a lot of meetings in the town halls, and with all the town halls included in the land application plan. We gave many details about the digestates, we provided samples, and I wanted to reassure the local inhabitants and the local elected officials in the area as much as possible and show that the nuisances associated with spreading were very limited, and we explained that we buried the digestates with a dribble bar to avoid the volatilization of the ammonia. We communicated a lot, communication with the farmers was a major axis of the project. The farmers were amazed by the absence of smell, compared to manure and slurry. And for many town halls, local inhabitants fear the smell. Finally, no town hall refused the land application plan.

Were you accompanied by other agents to produce and acquire information on your digestates?

We participated to a big research project to improve the valorization of digestates, with UniLaSalle and INRA, and some cooperatives such as Vivescia, but it didn't work because the costs involved to improve the valorization were too high.

Do you want to add anything you think relevant and that has not been discussed during this interview?

It's a double-edged communication, being transparent, but too much transparency causes people to worry sometimes. You have to reassure, to master your topic very well, but you must

use words that people can understand but not misinterpret. And today, I favor agricultural projects that use digestates in their vicinity. Digestates must be valorized in a short perimeter.

Annex n°7: Recommendations to the stakeholders