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Co-creation in public utilities: The case of district heating networks

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Abstract

Public authorities are committing to the decarbonization of economies. Public utilities – especially district heating networks – could serve as critical levers for cutting carbon emissions. Heat production accounts for about fifty percent of the global energy consumption and is still heavily carbonized. Fossil-free and locally-based district heating systems are being promoted and implemented with the support of public authorities. These innovative systems raise challenges as they integrate a greater variety of stakeholders than conventional ones. To maximize the creation of public value, public authorities have been setting up co-creation processes with these stakeholders. This paper analyzes how co-creation processes are used in district heating projects, using a framework that revolves around three co-creation activities: *setting up a collaborative network*, *defining the collaborative governance* and *assessing and learning from project outcomes*. These activities are studied throughout the lifecycle of five projects: three innovative district heating networks and two conventional ones. Innovative projects are expected to demonstrate more articulated and elaborate forms of co-creation compared to conventional counterparts, including more activities and a greater diversity of stakeholders involved. The data comes from twenty-seven semi-structured interviews, informal discussions with project stakeholders, and an analysis of project documents – partly publicly available, partly confidential. The research findings focus on (1) demonstrating and explaining the use of co-creation within the selected cases and (2) discussing the critical limitations of and barriers to the integration of co-creation in the utility sector.

Keywords

Public value co-creation; utilities; district heating

1 Introduction

Over the past decade, at all levels – transnational, national, regional, local – and in all kinds of sectors – public, private, or otherwise – organizations have been increasingly committing themselves to decarbonizing their economies. Municipalities and urban agglomerations at large provide particularly relevant actor constellations and geographies when it comes to taking up this task. Well over 50 percent of the global population is now living in cities – a percentage that will continue to increase to almost 70 percent by 2050 (United Nations, 2018). It is cities that “consume two-thirds of the world’s energy and account for as much as 70 per cent of human-induced greenhouse gas emissions” (UNHabitat, 2020, p. 61), and so there are significant leaps to be made in taking up the decarbonization challenge.

The utility sector includes a pool of services and assets - e.g. water supply, wastewater management, energy infrastructures, waste recycling - that are up for cutting urban carbon emissions. Utilities are organizations that maintain and often operate the infrastructure for public services. They supply essential services like e.g., water, gas, electricity and communication systems. These utilities need to become more sustainable and resilient soon, yet also continue to provide permanent and affordable services to citizens (Corvellec et al., 2013). The expansion and renewal of existing utilities require extensive, long-term, and sunk investments (Lund et al., 2014). Within the utility sector, district heating networks form a particularly relevant branch of utilities in making sustainability transitions.

Heating is one of the primary services that utilities provide. Heat production takes up 50 percent of the global energy consumption and is dominated by fossil-fuels production (International Energy Agency, 2020). In many places, heating systems are planned by local governments (Euroheat & Power, 2020). Their operation can be done by the public entity itself or contracted out to private companies. In France, the usual way is writing and signing standardized contracts such as so-called public service delegation contracts (Fedene-SNCU, 2021). Practices vary from one country to the other. However, many national standard practices have recently been challenged: the push for decarbonization has instigated an appetite for innovative, often locally-anchored heating solutions – which are supposed to enhance public value creation – instead of centralized and fossil-based solutions. Consequently, new stakeholders have started becoming involved in heat production, thereby reconfiguring actors’ roles. The emergence of “prosumers” – e.g., through the increased use of citizen-owned heat

pumps or, at a larger scale, the integration of industrial surplus heat into a district heating system – is an illustration of this dynamic (Lund et al., 2014). In the context of new public concern (decarbonization), this reconfiguration of a complex stakeholders' network while attempting to create public value through utilities is considered an appropriate platform for value co-creation.

Public value co-creation is a relatively novel area of interest for scholars. It is based on the meeting of two concepts: co-creation and public value. Co-creation was historically defined as the involvement of the final consumer in the private creation of goods and services (Durugbo and Pawar, 2014). Public value is a multi-faceted concept that can go from a utilitarian vision of the sum of all individual satisfaction to a political one of an essential purpose for a collective (Moore, 2005). Public co-creation is a collective process of public problem-solving involving many stakeholders (Torfing et al., 2019).

To address this emerging field of concerns, we investigate to what extent and how co-creation is integrated into the development and operation of utilities. We take the case of district heating solutions, investigating how co-creation is set up in utility projects.

The paper is structured as follows. Section 2 discusses the core concept of this study, namely co-creation, and introduces district heating systems. This section also forms the basis for an analytical framework. Section 3 discusses the methodology of this research. Section 4 presents the empirical results of this study. In it, we focus on current levels of co-creation in the district heating sector. Also, we discuss the limitations and merits encountered by actors involved in these endeavors. Section 5 summarizes the empirical findings, discusses theoretical implications, and provides an outlook for further research.

2 Co-creation and district heating: a theoretical discussion

2.1 Public value co-creation: definitions and use

Co-creation as a concept was coined in the private sector to describe a process in which customers contribute to creating services or products that they eventually purchase (De Koning et al. 2016). It represents a shift from a single-organization innovation process to a distributed one (Durugbo and Pawar, 2014). Recently, public

management scholars have picked up co-creation as a topic of interest. An example is provided by Torfing et al. (2019), who see co-creation in the public sector as:

[A] process through which two or more public and private actors attempt to solve a shared problem, challenge, or task, through a constructive exchange of different kinds of knowledge, resources, competences, and ideas, that enhance the production of public value in terms of visions, plans, policies, strategies, regulatory frameworks, or services, either through a continuous improvement of outputs or outcomes or through innovative step-changes that transform the understanding of the problem or task at hand and lead to new ways of solving it. (Torfing et al., 2019, p. 802)

Co-creation in the public sector aims to generate public value (Moore, 1995 in Osborne, 2018; Farr, 2016). It expresses the solving of collective needs, such as water provision, health services, or education, by public managers (Dudau et al., 2019). According to Moore (2005), a way to create public value is through public-private partnerships (PPPs). For instance, it is argued that through a so-called long-term infrastructure contract that comprehends the lifecycle of a utility, better value-for-money may be achieved. In PPPs of this kind, a rationale of risk transfer, long-term thinking, and connecting construction decisions with maintenance considerations is applied to deliver better results for the public purse. However, these long-term infrastructure contracts have shown little – if any – connection to customers, and economic performance criteria rule. Despite these limits, a certain extend of public values co-creation can be realized through PPP. Dos Reis and Gomes (2022) point out four mechanisms that participate in public value creation through PPP: information sharing, the building of public and private capabilities, risk governance, and stakeholder orientation. Even though mainly centered on a few public and private partners, these mechanisms resonate with co-creation activities.

Co-creation for public value is a relatively novel area of research and goes further than PPP. It has recently gained traction in public management, with scholarly contributions that have linked it to several paradigms in public management, such as public service logic and new public governance (Osborne, 2018; Torfing et al., 2019). According to Torfing et al. (2019), co-creation can happen in several core functions of the public sector, including service provision (e.g., with parents involved in the running of child care facilities), public problem solving (e.g., projects to resolve homelessness)

and public regulation (frequently used in the field of water management). Scholars have tried to specify the differences between co-creation and other, related concepts, including co-production and collaborative governance. Co-production is generally considered a 'narrower' version of co-creation that focuses on collaborative initiatives in the production process, while 'real' co-creation also integrates implementation, assessment, and other phases and activities to enhance public value (Dudau et al., 2019; Sillak et al., 2021). As for collaborative governance, although it highlights the importance of collaboration, it does not explicitly consider public-sector innovation as a core subject of research – while co-creation does (Torfing et al., 2019).

Even though public value co-creation still represents many different models (De Koning, 2016; Dudau et al., 2019), scholars agree on a few features of the concept. First, all cases of co-creation are characterized by a *complex network* of stakeholders involved. The literature distinguishes between several categories of actors and groups of actors involved in co-creation processes. The basic categories of actors are the state, the market, the community, and the third sector (Sillak et al., 2021). Second, implementing public value co-creation requires that stakeholders adopt *new roles* (Torfing et al., 2019; Van Gestel et al., 2019). Third, the main goal of public value co-creation is to respond to a *public concern*, seeking to create public value creation. Even though co-creation historically emerged in the private sector through the integration of final consumers in the creation process, this integration of final consumers is not considered a necessary feature of co-creation in the public sector.

The literature indicates several expected benefits of public value co-creation, including better democratic deliberations, the empowerment of local actors, better public authority legitimacy, and the opportunities that co-creation creates for locally-efficient solutions (Torvinen and Ulkuniemi, 2016; Torfing et al., 2019; Sillak et al., 2021). Barriers to and problems of co-creation in the public sector have not been thoroughly discussed in the literature. They include the lack of participation or poor democratic representation, the difficulty in refining stakeholders' identities and role perceptions, and the large and expensive number of resources needed for the expertise building and practices implementation (Torfing et al., 2019; Suhari et al., 2022).

The concept of co-creation has been used in many areas – e.g., welfare, migration, energy, and policy development (Coggan et al., 2021; Farr, 2016; Geuijen et al., 2017; Itten et al., 2021; Sillak et al., 2021; Suhari et al., 2022; Van Gestel et al.,

2019). The design of appropriate dimensions, criteria, and indicators to evaluate co-creation has been an essential aspect of this research (Coggan et al., 2021; Schuck-Zöller et al., 2017; Sillak et al., 2021). However, little is known about co-creation in the utility sector, let alone their connection to existing arrangements like PPPs, which are also supposed to co-create public value¹.

2.2 District heating networks: opportunities and challenges

District heating is a collective heat distribution system that brings heating from a production unit to the end user's building. In this paper, we assume that utilities are owned by public-sector actors and operated by a district heating company, including private-sector actors. Most existing district heating systems are based on the technology of burning fossil fuel (gas, oil, coal) in centralized boilers to heat heating fluid (International Energy Agency, 2021). Public authorities usually own conventional district heating, and various organizations can be put in place to maintain and operate the network (Euroheat & Power, 2020). Due to the centralization of the network, a limited number of producers are part of the network. In France, arrangements between public and private actors are usually formalized through a public-private partnership (PPP), where the private company operating the network bears the risk of investments (Fedene-SNCU, 2021). These partnerships usually last for about 30 years, which is the typical lifespan of the production infrastructures.

Assumption 1a: In conventional PPP projects, we expect a predominance of public and private actors at the expense of other actors.

District heating systems are a predominant vector for heating decarbonization (International Energy Agency, 2021) as they can integrate multiple renewable sources into their heating mix (Lund et al., 2014; Morvaj, 2016; Schmidt, 2018). Literature on district heating generally has a technical focus: to decarbonize district heating, conventional systems have to be optimized (Morvaj et al., 2016) and transformed into

¹ Torvinen and Ulkuniemi (2016) have studied co-creation in PPPs with a focus on end-user engagement and Dos Reis and Gomes (2022) have studied public value creation in PPPs. Malacina et al. (2022) have recently proposed a literature analysis of value creation in public procurement through purchasing and supply chain practices. Our study contains an empirical assessment of co-creation practices in the lifecycle of utilities and complements the former studies.

so-called fourth-generation district heating systems (Lund et al., 2014). This shift demands new techniques for network optimization, for instance through the integration of thermal storage (Lesko et al., 2018). The sustainability of district heating has mainly been studied through technical modeling or financial lenses. The integration of new renewable resources can also threaten the economic equilibrium of the network. This statement led to a literature stream on price optimization to better integrate sustainable district heating into the heating market (Becchis et al., 2008; Odgaard and Djorup, 2020; Djorup et al., 2020).

Literature on sustainable district heating agrees on technical and economic challenges due to the decentralization and the integration of renewable resources, e.g., biomass, biogas, geothermal heat, or waste heat, into the heat production mix. However, this shift involves integrating a variety of stakeholders, which raises new concerns about the sharing of risks, responsibilities, and benefits (Lygnerud et al., 2019). Globally, there is a need to design appropriate business models for these new systems (Bolton and Hannon, 2016; Lygnerud, 2018). Moreover, the role of public authorities, as owners, planners, and sometimes investors, is challenged (Hawkey et al., 2013; Hvelplund and Djorup, 2019). Several challenges regarding collective action can be pointed out:

- How to ensure the creation of value for all involved actors and keep them committed to the system?
- How to secure the value despite the uncertainty of the system operation?
- How to align the time frames of all the stakeholders with the system's timeframe?
- Who will invest in and own the new infrastructures needed for district heating decarbonization?
- What partnerships and contracts to put in place?
- What performances are to be monitored during the system lifecycle?

Assumption 1b: Due to the integration of various stakeholders in innovative projects, we expect more stakeholders to be involved in co-creation activities compared to conventional projects.

To our knowledge, no contribution to the academic literature studies specifically the way of working with multiple stakeholders for sustainable utilities. This is arguably a striking observation given the specificity of the utility sector and the aforementioned

collective action challenges due to network decentralization and increased stakeholder integration.

2.3 Analyzing co-creation in the utility sector: some expectations

Attempt to theorize co-creation have often focused on stakeholders' identification (Ranjan and Read, 2021; Sillak et al., 2021) and defining a model, typology or phases for co-creation (Durugbo and Pawar, 2014; De Koning et al., 2016; Sillak et al., 2021). In this article, we want to assess the co-creation processes set up in district heating projects. We build on co-creation activities discussed in the literature on co-creation and collaborative governance and business models literature when relevant (Table 1).

Type of activities	Activities	Literature
Processes for cross-sector collaboration	Forging initial agreements Building relationship Building legitimacy Building trust Managing conflict Planning	Bryson et al., 2006
Steps for value proposition co-creation	Identifying the stakeholders Determining the core values Facilitating dialogue and knowledge sharing Identifying value co-creation opportunities Co-creating stakeholder's value propositions	Frow and Payne, 2011
Co-creation activities	Co-creation involvement strategy Co-creation technique selection Co-creation dialogue	Durugbo and Pawar, 2014
Co-creation activities	Forming groups and networks for interactive discussion Distributing information Training users Measuring user satisfaction Evaluating risks of user proposals Building trust and personal relationships	Torvinen and Ulkuniemi, 2016
Operationalizing collaborative business models	Managing incentives Building relationships Creating accountability and decision-making processes Reporting	De Man and Luvison, 2019
Activities that foster transformative power	Articulation and alignment of expectations Social learning Resource acquisition Assessment and evaluation	Sillak et al. 2021
Co-creation activities	Knowledge and idea-sharing Creation of interdependence Power-sharing and engagement Interaction and dialogue	Ranjan and Read, 2021
Collaborative "building blocks"	Identifying need and articulating intent to collaborate Identifying and selecting partners Aligning partners on shared purpose	Brown et al., 2021

	Developing structural and procedural governance Defining collaborative value capture model	
Actions to govern collaborative networks	Aligning Mobilizing Organizing Integrating Arbitrating Monitoring	Wegner and Verschoore, 2021

Table 1 Literature review of co-creation activities

We clustered these activities and distinguished three main co-creation activities that can be applied to public projects: (1) setting up a collaborative network; (2) defining the collaborative governance; (3) assessing and learning from project outcomes (Table 2).

First, setting up a collaborative network corresponds to the gathering of stakeholders into a network where they build relationships and exchange information. Here, we understand this activity as a first step to gather stakeholders around a common purpose and for collaborative problem-solving.

Second, defining collaborative governance is a process through which different stakeholders agree on sharing the resources, roles within the network, and the related risks and responsibilities. One example of this could be the co-construction of a contract clarifying the commitment of each stakeholder.

Third and finally, assessing and learning from project outcomes corresponds to the co-design of performance criteria the project should be evaluated on and the joint assessment of these criteria throughout the lifecycle. From this evaluation, expertise can be built at the actor and network levels.

Main co-creation activities	Co-creation activities	Literature
Setting up a collaborative network	Co-creation involvement strategy Identifying and selecting partners Building trust and personal relationships Building relationships Building legitimacy Aligning partners on shared purpose Identifying need and articulating intent to collaborate Articulation and alignment of expectations Determining the core values Forming groups and networks for interactive discussion Knowledge and idea-sharing	Bryson et al., 2006 Frow and Payne, 2011 Durugbo and Pawar, 2014 Torvinen and Ulkuniemi, 2016 De Man and Luvison, 2019 Sillak et al. 2021 Brown et al., 2021 Ranjan and Read, 2021 Wegner and Verschoore, 2021

	Distributing information Co-creation dialogue Interaction and dialogue	
Defining the collaborative governance	Defining collaborative value capture Developing structural and procedural governance Arbitrating model Creation of interdependence Identifying value co-creation opportunities Forging initial agreements Power-sharing and engagement Resource acquisition Evaluating risks of user proposals Managing incentives	Bryson et al., 2006 Frow and Payne, 2011 Torvinen and Ulkuniemi, 2016 De Man and Luvison, 2019 Sillak et al. 2021 Brown et al., 2021 Ranjan and Read, 2021 Wegner and Verschoore, 2021
Assessing and learning from project outcomes	Training users Social learning Creating accountability and decision-making processes Measuring user satisfaction Monitoring Reporting Assessment and evaluation	Torvinen and Ulkuniemi, 2016 De Man and Luvison, 2019 Sillak et al. 2021 Wegner and Verschoore, 2021

Table 2 Construction of the four main co-creation activities

We use these four main co-creation activities to discuss their (potential) use and concomitant challenges in cases that revolve around district heating. The different co-creation activities can be based on formal processes, such as procurement, or more informal ones, depending on the stakeholders involved (Torvinen and Ulkuniemi, 2016; Malacina et al., 2022). The co-creation activities can rely on a variety of methods: living labs, workshops, mapping tools, or design thinking (Mulder, 2012; Short et al., 2013; Durugbo and Pawar, 2014; Breuer and Lüdeke-Freund, 2017; Itten et al., 2021, Pulselli et al., 2021).

Assumption 2: We expect a higher informality in innovative cases compared to conventional cases, as processes are designed differently and formalized sparingly.

Next to the fact that co-creation activities come in different sorts, they can be applied in different phases of the lifecycles of utilities. Hueskes et al. (2017) distinguish four phases in this lifecycle: *project identification, preparation, procurement, and operation*. Looking at the lifecycle of a utility allows for a processual co-creation approach. This processual approach is paramount as literature presents co-creation as a process that continues throughout the lifecycle of a utility.

Assumption 3: We expect more co-creation activities in the early stages of innovative projects than conventional ones. More is to be collectively discussed and created in innovative projects, and no process exists.

Given the nature of the utility sector, we expect to see several examples of challenges with co-creation in district heating projects that we have formulated in our assumptions. Overall, we expect to see a higher level of co-creation – in the number of stakeholders and activities involved – in innovative projects compared to conventional ones.

3 Methods

This paper reports on a multiple case study (Pettigrew, 1990; Yin, 2018) of district heating networks. We selected three “innovative” cases that focused on co-creation from the outset, next to two “conventional” cases that will be considered reference-class cases. The “innovative” cases are recent cases presenting a clear ambition of the public actor to implement innovations, create public value or act on their utilities’ decarbonization. These cases are not necessarily full-fledged PPP contracts (like the case we investigated in Ottawa) but can also be cases of experimentation (Hornsyld) or early brainstorming on future decarbonization projects (Helsinki). Unlike these “innovative” cases, the selected “conventional” cases date back further, are in the operational phase, and are based on a PPP contract. In these cases, actors have now turned to decarbonization, but this was not the plan when creating these PPPs (Besancon and Dunkirk). Choosing various cases helped us take into account the different contexts and objectives of district heating networks across different settings: from the operation of conventional systems and the renewal of PPPs for existing networks to transitions from public to private management of state-of-the-art experimentations on district heating.

The access to the data was part of a data collection process for an ongoing Ph.D. As parts of the data are confidential, and not all projects have the same level of development, not all steps of the project could be studied for each case. Table 3 provides basic information on the cases studied.

Case study	Type of case	Characteristics	Milestones	Phases studied
Dunkirk (France)	Conventional	Use of industrial waste heat (integration of a	1985: creation of the district heating	Project operation

		third party from the beginning of the PPP); PPP (concession)		
Besancon (France)	Conventional	Based on waste heat recovery and biomass; PPP (leasing)	1968: creation of the district heating Renewal every 6 years Last renewal in 2019	Procurement, project operation
Ottawa (Canada)	Innovative	Lots of resources dedicated to the procurement process by the Government of Canada; co-creation of a decarbonization roadmap for the district heating; PPP (concession)	The public management was transformed into a PPP in 2020	Identification, detailed preparation, procurement, project operation
Hornsyld (Denmark)	Innovative	“Thermo-road” experimentation research project based on cross-sector integration; partners included a research institute, a private company, a municipality and consulting engineers	2019: submission of the project for funds (accepted in December) 2020-2021: setting up of the system	Identification, detailed preparation
Helsinki (Finland)	Innovative	Energy challenge launched by the municipality of Helsinki for the future of their heating network; anyone could answer the challenge (e.g., students, private companies, research institutes, consortiums)	2020: application phase (February-September) Co-creation phase for finalists (November) 2021: Award ceremony (March)	Identification phase

Table 3 Presentation of the case studies.

Data were gathered through 27 semi-structured interviews with stakeholders of the partnerships, several informal conversations within utility companies, and an analysis of grey literature, mainly project files. Eleven semi-structured interviews were conducted with the stakeholders of the Besancon case; eleven with the ones of Dunkirk; and five for the Hornsyld case. The interviewees represented the diversity of stakeholders surrounding the district heating system, e.g., district heating owners, district heating operators, members of local governments, suppliers, and regional state representatives. Informal conversations with a private operator complemented these interviews. The interviews were primarily exploratory in the Besancon and Dunkirk

cases, with open questions on, e.g., the technical system, the history of the network, its governance and the involved stakeholders, the latest innovations implemented, and the performance criteria. Questions on the stakeholders’ network and its governance gave some insights into the co-creation process, but no explicit mention of co-creation was made. For Hornsyld, the stakeholders highlighted the importance of the collaborative process during the interviews, leading to results in the implicit co-creation process setup. The Ottawa and Helsinki cases were studied through documents (e.g., bidding documents and contracts) and informal discussions. For Ottawa, a focus was put during the discussions on the co-creation strategy set up by the Government of Canada.

From the data, various co-creation methods were extracted (Table 4). In each stage of a utility’s lifecycle, co-creation practices can be based on specific methods and techniques. The literature does not provide a comprehensive list of co-creation methods – all the more as some may be implicit – yet they were recognized as such if they (1) gathered multiple stakeholders to (2) participate in the design of a utility and the production of public value.

Case study	Project	Stage of the lifecycle	Description of the co-creation method	Formal / informal	Quote	Data	Stakeholders	Remarks

Table 4 Data collection framework

From the description of the co-creation method was extracted a “co-creation activity,” which was then coded according to the co-creation activities found in the literature (see an example extracted from the operation phase of the Besancon case study in Table 5).

Stage of the lifecycle	Case study	Project	Description of the co-creation method	Formal / informal	Stakeholders	Code 1 (co-creation activity)	Code 2 (literature)	Code 3 (main co-creation activity)

operati on	Besan con	histori cal DH	Continuou s dialogue between the oeprator and the owner to solve problems, follow the performan ce of the network and discuss the future investment s	inform al	DH owner, DH operator	Discussion s for colective problem- solving	Co- creation dialogue	Setting up a collabora tive network
operati on	Besan con	histori cal DH	The DH owner forces the DH operator to engage with the consumers through different communic ation channels	formal	DH owner, consumer s, DH operator	Communica tion to final users on the DH network	Distributi ng informati on	Setting up a collabora tive network
operati on	Besan con	histori cal DH	Annual meeting to analyze the performan ce of the DH network	formal	DH owner, DH operator	Debriefing on the DH network performanc es	Assessm ent and evaluatio n	Assessin g and learning from project outcome s
operati on	Besan con	histori cal DH	Local problem- solving to adapt national regulations to specific context	inform al	DH owner, regional agency for environme nt, housing and agriculture	Negotiation s to define local framing	Arbitratin g model	Defining the collabora tive governan ce

Table 5 Coding process

This inductive and focused coding process (Emerson et al., 2011; Gioia et al., 2012) gave an overview of implementing the three main co-creation activities, their repartition between the innovative and the conventional projects, and the stages of the projects in which they were used.

4 Results – Findings from the case studies

Our analysis highlighted different patterns depending on the cases. The result is threefold. First, we analyze the extent of implementation of the co-creation process in “conventional” cases. Then, we explain how co-creation was applied in “innovative” cases. Finally, we draw some common conclusions from all the cases studied.

4.1 Difficulties to achieve public value co-creation in “conventional” district heating networks

Co-creation was limited in conventional PPP contracts for district heating. First, in the two conventional cases analyzed in this study, co-creation mainly occurred between two stakeholders (a public authority and a private operator). In the Dunkirk case, where an industrial actor was integrated from the outset, this actor was considered a technical supplier rather than a partner. Second, when collaborative problem-solving was implemented, PPPs mainly committed to a basic level of co-creation aimed at setting up collaborative discussions without further formalizing collaborative methods.

Within the context of a public market and its routines, little space was left for stakeholders to engage in various co-creation methods during the procurement and implementation phases. Some activities which could be completed in co-creation, such as distributing risks and responsibilities or assessing project outcomes, were already set through common ways of setting up PPP contracts. No resources were allocated to innovate on this. Spaces for collaborative discussions, such as monthly reports and follow-up discussions or general assemblies with consumers, did not become arenas of co-creation but merely opportunities to distribute information to consumers.

Despite this frame, co-creation arenas were found throughout the project’s lifecycle: at each new project – e.g., contract renewal in Besancon, district heating extension in Dunkirk – collaborative discussions took place to frame the project and its outcomes, giving opportunities to implement co-creation activities. Depending on the partnerships between the actors, the type of co-creation activities differed: from formal processes, sometimes supported by informal discussions for actors engaged in contractual relationships, to more informal and collaborative discussions where the partnership was less formalized (for instance, between the district heating owner and the operator before the contract renewal, or between the district heating owner and the secondary network operators).

4.2 Public value co-creation in the development and operation of “innovative” district heating networks

We noticed a wide variety in applying co-creation methods in the “innovative” cases. For instance, in the cases of Ottawa and Helsinki, parts of the processes were formalized, and an explicit focus on co-creation was visible in project documents. On the contrary, in the Hornsyld case, the co-creation process relied heavily on informal methods and trust links between stakeholders.

In all “innovative” cases, it was during the early project stages (preliminary and detailed preparation phases) that the co-creation process was more robust and involved a wide range of stakeholders. These were also the first two phases where various methods and co-creation activities were implemented. For instance, the preliminary phase involved many resources in Ottawa through multiple visits to different operators, preliminary discussions, and studies. Similarly, in the Helsinki case – which focused on the preliminary phase – the challenge method that was used pushed the involvement of a great variety of global stakeholders. Here, a co-creation phase was designed for the finalists, which included more discussions and a boot camp. In the Hornsyld case, the co-creation process was launched during the detailed preparation phase, when multiple meetings between all the stakeholders were conducted, with open discussions on implementing the solution.

The very beginning of the identification phase is usually led by a single stakeholder, who then integrates others into the process. For instance, in the Helsinki case, decarbonization was a municipal concern, and the City of Helsinki imagined this global challenge to co-create solutions for this public problem. In the Danish research project, the project identification phase was led mainly by a single research stakeholder who had the technical expertise to imagine the heating solution.

4.3 Public value co-creation in district heating networks

In all the cases studied, collaborative and co-creation activities were set up. *Setting up a collaborative network* was the most represented activity (45 codes out of 70), followed by *defining collaborative governance* (15 codes) and *assessing and learning from the project outcomes* (10 codes). The predominance of *setting up a collaborative network* indicates that co-creation activities often focus on aligning the core actors around shared values and governance processes. Where formal processes were usually followed, the activities were often supported by informal collaborative

discussions that enabled actors to build a relationship outside the formally established partnership. Several arenas for collaboration and co-creation emerged, also in formal partnerships, especially during project preparation.

We observed different networks of collaboration and co-creation in single projects. For instance, in Besancon, a strong collaboration network between the public authority and the district heating operator was set up. In parallel, collaboration was set up between biomass suppliers and with the district heating operator. Similarly, in the Hornsyld case, a collaborative network was set up between the core actors of the project (e.g., researchers, geothermal company, public authority, and its consultants), and another one was set up for the operation between all the contractors. These networks followed different rules – e.g., different governance, different leadership – but interacted in co-creation activities.

Several stakeholders addressed a lack of collaborative and co-creation activities, including difficulties in identifying and aligning all relevant actors (e.g., services inside a public authority, contractors) to support the development of the network. In the case of Besancon, tools and communication for joint planning between the urban and energy services were lacking, making it difficult to size the district heating network correctly and to ensure its economic and technical optimizations. In both Dunkirk and Besancon, the technical expertise of actors was mentioned as a critical point in engaging in co-creation activities.

5 Conclusion and discussion

Co-creation is considered a promising solution to resolve concerns faced by utilities – and take up the global challenge of decarbonizing the world's economies. Also, district heating is seen as a potentially welcoming platform for co-creation – both in current utility services and future ones. However, the literature does not provide an integrated framework to analyze co-creation processes, let alone provide significant empirical evidence on whether and how co-creation occurs.

The theoretical contribution of this paper is the development of an analytical framework for studying co-creation in the utility sector, based on three main co-creation activities: (1) setting up a collaborative network, (2) defining a collaborative governance, (3) assessing and learning from the project outcomes. Its empirical contribution is in applying the analytical framework to a multiple case study of three allegedly innovative and two conventional cases of district heating.

Literature on district heating led us to formulate three assumptions regarding the implementation of co-creation activities in this sector, which we analyzed empirically. *Assumption 1: More stakeholders are involved in innovative projects' co-creation activities compared to conventional ones.* Our study showed that conventional district heating projects often focused on collaboration between the district heating owner and its operator. In the “innovative” cases, more stakeholders participated in the co-creation activities.

Assumption 2: There is a higher number of informality of co-creation activities in innovative projects than in conventional ones. In all cases, co-creation activities were supported by informal discussions between the stakeholders, enabling them to build networks of trust. Several co-creation activities were embedded in formal processes in the “conventional” and “innovative” cases. The Hornsyld case stood out with a high informality throughout the project preparation.

Assumption 3: A higher number of co-creation activities set up in innovative projects compared to conventional ones. If co-creation activities were a basis for the “innovative” projects, the study highlighted several arenas of co-creation in “conventional” projects. Co-creation process is more embedded in “innovative” cases throughout their lifecycle, while it happens mainly during the implementation of new projects in the “conventional” cases.

This study has several limitations. Due to the limited access to data, not all phases of utilities' lifecycles could be considered, leading to partial results. A more thorough and perhaps more confrontational study of cases would be needed to put the results in perspective. Also, the conventional cases investigated were all PPPs due to the choice of the country studied. It would be interesting to apply our analytical framework to other types of utilities and test its relevance in different contexts and within different contractual frames. Moreover, no assessment of co-creation outcomes in the projects was made, neither in terms of success in creating instruments or criteria nor in terms of positive public value created thanks to co-creation. Building on the existing framework, an assessment framework of co-creation could be designed to properly analyze the level of co-creation in the projects and confront it to public value outcomes. Finally, the role reconfigurations could be specifically studied with dedicated case studies, e.g., with an enhanced description of the roles of stakeholders as stated by official documents and their role perceptions when engaged in co-creation for utilities.

6 References

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