



HAL
open science

13th century Paris. Energy constraints and institutional arrangements

Mathieu Arnoux

► **To cite this version:**

Mathieu Arnoux. 13th century Paris. Energy constraints and institutional arrangements. XIX World Economic History Congress 2022, International Economic History Association, Jul 2022, Paris, France. hal-03826886

HAL Id: hal-03826886

<https://hal.science/hal-03826886v1>

Submitted on 24 Oct 2022

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

XIX World Economic History Congress (Paris, 2022)

Session: *What are renewable energy systems? Economic history approaches to a technological problem*
(July 27th, bâtiment Recherche Nord, room 004)

13th century Paris. Energy constraints and institutional arrangements.

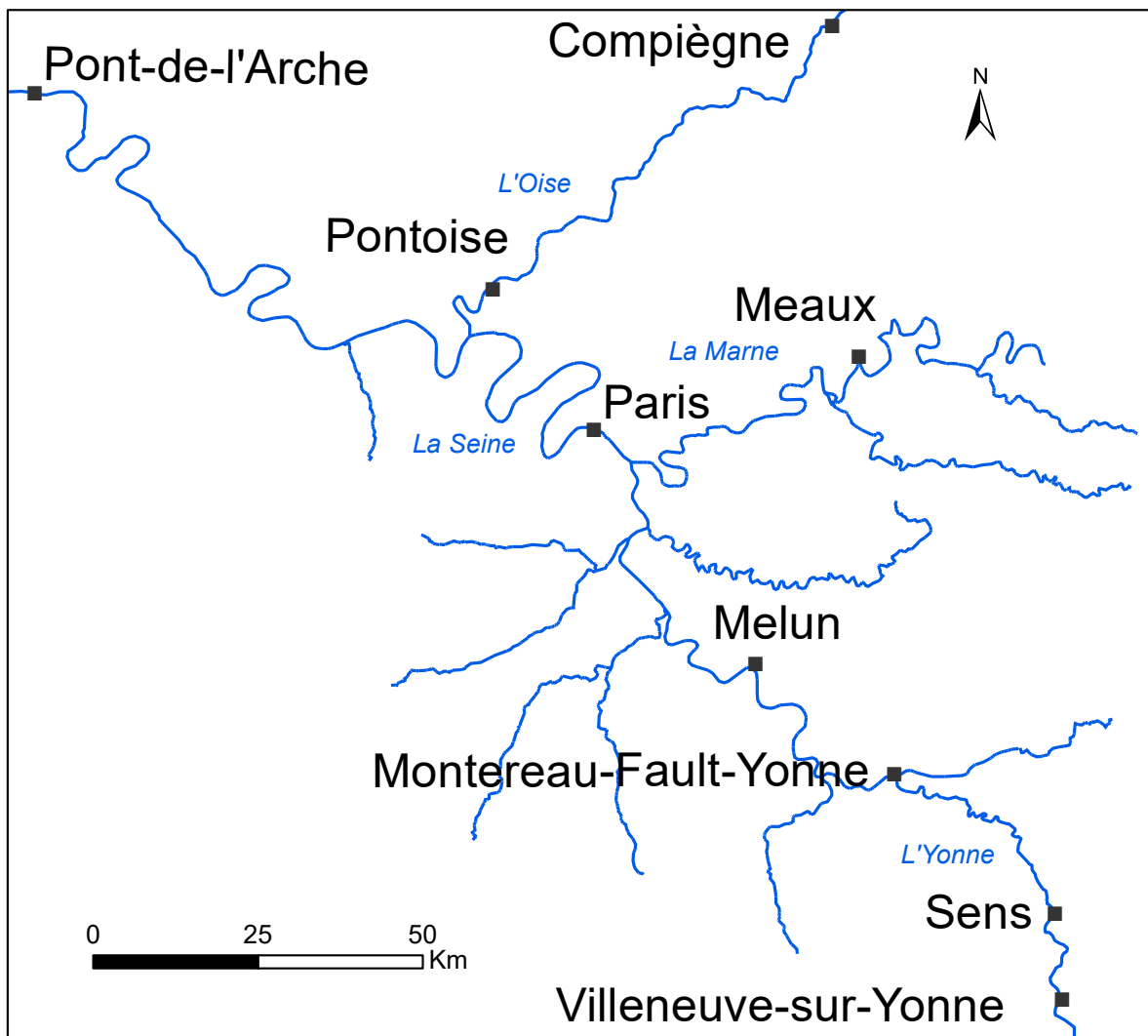
Mathieu Arnoux, Université Paris Cité and EHESS

These are problems that cannot be solved here, obviously. But they have to be borne in mind as we proceed. For the *fact* of this economic expansion is of essential importance if we want to understand the whole dynamic of medieval society in these central centuries, and indeed later; but when it is explored here, it must be recognize how far basic data and interpretations are missing. Some general points are clear: the fact that Paris and the Paris basin became unusually economically active in the twelfth century, for example, is a basic context for the growth of the Paris Schools and, later, university (for there was no point attracting students if there were no infrastructure to feed them) as well for the capacity of Philipp II of France, with only a restricted territory under his direct control, to match the resources of John of England in their wars in the early thirteenth century, and also for the concentration of resources which produced the striking density of very expensive new gothic cathedral in every city of northern France. But, having said that, we must be honest and admit that we do not really understand how the economy of the Paris region worked in this period. (Chris Wickham, *Medieval Europe*, 2016, p. 121)

The city of Paris probably had 100,000 inhabitants at the beginning of the 13th century, at least 200,000 around 1300 and about 250,000 when the king's officers counted 62,000 households paying the royal tax. This figure, now accepted by the community of historians, is impressive: in 2022, the capital city of Philip the Fair would be one of the 10 largest cities in France. Between the middle of the 13th and the middle of the 14th century, and probably in the following century, it was the largest city in Europe. For any urban, economic or technical historian, this observation is not self-evident. The concentration of such a large population in one place for a long period of time requires a capacity for supply, organisation and maintenance of order that is considerably greater than that required by cities of 20,000 to 50,000 inhabitants found elsewhere in Europe. In the absence of the modern means of transport and conservation that fossil fuels allow, the question arises as to how the inhabitants of the city were able to sustain themselves and reproduce.

From this perspective, the metropolitan growth of Paris is a borderline case of what is possible with an entirely renewable socio-technical system. The following pages will attempt to

shed light on the functioning of the urban metabolism of the capital, by showing that technical solutions cannot be separated from the economic and social conditions of their implementation.



The Paris area of Supply (13th-14th century)

The renewable nature of the socio-technical system is the starting point for reflection. By this I mean a system that is entirely (or almost entirely) based on the use of resources derived from the great natural cycles, mainly those of water, nitrogen and carbon. In order to stabilise the habitat and grow the population, the material and energy flows induced by these cycles must be converted into stocks of potential and consumable materials. In the long run, the population figure determines not only the extent of the supply area necessary for the stability of the city, but also the nature and organisation of the subsistence stocks.

One of the political capitals of ancient Gaul and then of the Frankish kingdom, Paris was probably not the most populous city in Europe before the 11th century: depending on the period, Rome, Arles, Milan and Aachen may have had more inhabitants. But from the 12th century onwards, its pre-eminence in its regional area and in the Capetian kingdom and the exceptional character of its growth are not disputable. Although no precise figures are available, it is likely that in less than two centuries its population increased fourfold or more, from a maximum of 50,000 during the 11th century to more than 200,000 after 1300. This long period of growth, for a city that was not a seaport, implied an exceptional demographic dynamic on the part of the surrounding regions, since it had to feed the growth of the capital through immigration and produce food for the Parisians and those who supplied them.

It is therefore impossible to study the growth of the capital without also examining the evolution of its countryside. The historical sources, which are very abundant from the second third of the 12th century onwards, show that a real system was then put in place, linking agrarian choices, technology, the organisation of space and power. The extraordinarily favourable nature of the environment, in terms of the fertility of the soil and the ease of access to the town, by water or by road, has often been emphasised. It does not explain everything. Similarly, there is no stream of sectorial innovation, which can explain the growing efficiency of the technologies used in this area. In the case of Paris, it is the construction of a territorial system in which the technical, economic and political aspects are inseparable that explains the success of the metropolitan construction. Parisian growth is built in the long term on the basis of a mix of energies, resources and institutions, the originality of which must be highlighted.

As was the case for most large cities in antiquity and the Middle Ages, grain was the basis of the Parisian subsistence diet. Until the industrial revolution, white wheat bread was the staple diet of city dwellers, while country dwellers consumed large quantities of leguminous plants, minor cereals (rye, spelt and winter barley) or even chestnuts. The food of the inhabitants, but also their peacefulness, depended on the capacity, ensured by the royal power, to produce the necessary quantity of bread every day. It is therefore not surprising that the sources contain information on the supply of charcoal to the city, which arrived on the Seine from the forests located upstream of the city, and on the flour produced in the numerous mills set up in the arches of the bridges between the Ile de la Cité and the right bank of the capital. The grain used was produced in the countryside to the north, as far as the borders of Picardy, and to the south, towards Chartres.

It is in these areas that the most spectacular changes can be observed from the end of the 11th to the middle of the 13th century. The main characteristics of this movement have long

been highlighted and are part of a very heterogeneous process: it has a strong component of demographic growth and agrarian growth, which come together in the clearing of land and the appearance of new habitats. But it can also be explained by the appearance of new actors, in particular the monastic orders, whose rise is primarily due to the diffusion of the Gregorian ecclesiastical reform. Finally, it reflects the expansion of the king's power of control and command at the expense of that of the old Carolingian aristocracy, a process that testifies to social changes within the dominant group and to the transformation of the monarchic institution. The literature on these three areas is considerable, but it does not take into account a massive fact, the progressive construction of a metropolis whose expansion imposed a profound restructuring of the entire regional space.

These distinctions allow an analytical approach to the overall process. A more careful consideration of the diversity of places shows that the processes mentioned above do not occur in the same way everywhere. For example, the two banks of the Seine downstream from Paris, which for centuries have been one of the largest vineyards in Europe, have been entrusted to very large ecclesiastical institutions since Merovingian times (bishoprics of Paris and Rouen, abbeys of Saint-Germain des Prés, Saint-Martin des Champs, Jumièges, Saint-Wandrille, Saint-Amand of Rouen) which ensured peace on this major commercial axis, even in periods of conflict between the Capetian kings and their vassals, the dukes of Normandy and kings of England. On the other hand, on the plateaux to the north and south of the city, where the land was fertile but heavy and difficult to cultivate, the new regular orders, the Cistercian monks and Premonstratensian canons, found a space for development where they expanded to the detriment of the more established Benedictine monks. However, when we consider these regional dynamics as components of a single process, two elements become clear: on the one hand, the general diffusion of a triennial agrarian system based on the succession of wheat-oats-fallow and the use of the horse-drawn plough, and on the other hand, the gradual structuring of the agrarian space around new establishments, the barns.

The first element is not new: the plough, the three-year rotation with fallow and the use of horses have been attested in Europe for at least half a millennium. What appears in the sources at the end of the 11th century is its integration into a territorial system that included an essential part of seigniorial power and aimed at providing the capital with a constant supply capacity. The word *grange* (in Latin *granchia* or *grangia*), appeared at the same time, around 1080 in Île-de-France, Burgundy and Normandy. It is the Latin form of a word of northern French vulgar language. It probably already referred to a particular method of direct management of seigniorial land, a place for collecting certain levies, especially tithes, and a particular type of

building. It was only later that it came to designate the annexed farms of the Cistercian and Premonstratensian communities. Here again, we should not be mistaken about what constitutes the innovation: the large buildings built of frameworks over a double row of posts have existed in northern Europe since the Neolithic period. What is new is the functional construction that combines a set of cultivated lands, a place to exercise power and a building to store and valorise the harvested fruits.

There are more than a dozen 13th century barns preserved in the countryside around Paris. They belonged to the bishopric of Paris (Wissous), to ancient establishments such as Saint-Germain-des-Prés (Samoreau), Saint-Denis (Tremblay-en-France), or Saint-Martin-des-Champs (Écouen), to nunneries such as those of Montmartre (Barbery), or to Cistercian abbeys such as Châalis (Vaulerent and Fourcheret) or hospital institutions (St-Lazare of Beauvais). These constructions, identical in size (50m long by 20m wide and 25m high), appear to be very well adapted to the storage of fruit at harvest time and to its valorisation by sieving and threshing. The sources show that these installations, whether they belonged to Parisian communities or to communities established outside the city on roads leading to the capital, were linked to other barns located inside Paris. The extremely large number of these Parisian barns shows that the ecclesiastical seigneuries played a major role in supplying the capital, perhaps more so than the markets, which seem to have an essential function of local redistribution.

The accounting records of several barns of the Cistercian abbey of Les Vaux-de-Cernay, south of Paris, for the years 1296-1297 show both the astonishing productivity of the crops (yields are up 9 to 10 grains per 1 in the Beauce) and their close connection with the abbey's Parisian barn, located in the heart of the University district. The solidity of the link established between the capital and cereal-growing areas 20 to 40 km away helps to understand the city's ability to feed its numerous inhabitants. But another factor must be taken into account: the royal involvement at all stages of the system. The sources show that the royal administration very carefully monitored all flows of materials and energy, regulating the circulation of charcoal, the distribution of mill sites, roads and waterways. Even more decisively, they show that the creation of the new monastic communities, which played a leading role in this system, constituted a crucial stage, from the 1130s onwards, in the transformation of the regional aristocratic group, which was encouraged, or forced, to participate in this process.

The weight of royal power is also evident in another aspect of this system: the importance of serfdom. Important research, from Marc Bloch to Ghislain Brunel, has shown that serfdom around Paris is not a residual legacy of ancient or early medieval practices, but a component of the seigneurial system. For peasants in bondage, the pressure exerted on them by the *seigneurie*,

even though their economic condition was prosperous, was a very strong incentive to increase their productivity in order to accumulate the sums necessary for their emancipation. The hundreds of pounds spent for an individual emancipation, or the thousands of pounds paid by certain communities, reflect the capacity of farmers to produce more than is locally necessary. At the same time, it can also be hypothesised that the servile constraint also played a role in encouraging the migration of rural populations to the capital. Both literary sources, such as the poems of Rutebeuf or the Miracles of Saint Louis, and fiscal sources from the last years of the 13th century, show that an essential part of Parisian wage earners came from villages close to Paris with a large servile population.

At this point in our journey, it is worth pausing. The unreasonable pages that a famous American medievalist, Henry Adams, devoted to the rise of Gothic architecture can serve as a starting-point here. A complex mind, combining extreme open-mindedness with radical anti-Semitism, the Harvard medievalist wanted to think about the course of history in the light of Willard Gibbs and James Maxwell's physical theories of, and Karl Pearson and Henri Poincaré's mathematics. Adams' assumptions were not adopted by his colleagues. The famous pages he devoted to the alternative "Virgin and the dynamo", as well as those relating to Chartres Cathedral, were written during a visit to the 1900 Universal Exhibition. Exalted as they are, they do not seem so meaningless to those who wonder about the technologic and energetic foundations of medieval growth.

Like all great churches, that are not mere storehouses of theology, Chartres expressed, besides whatever else it meant, an emotion, the deepest man ever felt, — the struggle of his own littleness to grasp the infinite. You may, if you like, figure in it a mathematic formula of infinity, — the broken arch, our finite idea of space; the spire, pointing, with its converging lines, to unity beyond space; the sleepless, restless thrust of the vaults, telling the unsatisfied, incomplete, overstrained effort of man to rival the energy, intelligence, and purpose of God. Thomas Aquinas and the schoolmen tried to put it in words, but their Church is another chapter. In act, all man's work ends there; — mathematics, physics, chemistry, dynamics, optics, every sort of machinery science may invent, — to this favour come at last, as religion and philosophy did before science was born. All that the centuries can do is to express the idea differently: — a miracle or a dynamo; a dome or a coal-pit; a cathedral or a world's fair; and sometimes to confuse the two expressions together. The world's fair tends more and more vigorously to express the thought of infinite energy; the great cathedrals of the Middle Ages always reflected the industries and interests of a world's fair (Henry Adams, *Mont-Saint-Michel and Chartres*, 1912, p. 96).

The sources we have used do not provide any clues that link Parisian growth to one or more technical innovations. Mills and baking ovens, grain storage facilities and farming practices are part of a centuries-old technical landscape that is that of the European countryside, from the

river Elbe to Scotland. The same cannot be said of the institutional construction of the capital and the organisation of its territory. Here we can observe, carried to an unprecedented level, a characteristic of metropolitan processes that can be observed at the same time elsewhere in Europe, in London for example or in Flanders: the quest for more power and the pursuit of more concentrated resources. In the case of Paris, it was the success of this quest that explained, at the beginning of the 13th century, why the kingdom that Philip-Augustus governed, notwithstanding how limited in surface area it was, finally defeated apparently more powerful coalition principalities in 1204 and 1214. There is an important energy aspect to this search for power, which opens up interesting perspectives on medieval growth.

We must be clear about what it means to seek power in a society that ignores the notion of energy. What is at stake is the technical practices of optimisation, not representations or artefacts. The question of mills provides a good illustration. The devices for converting the energy of watercourses into the rotary movement of grain millstones have been known since Antiquity. The Parisian specificity, based perhaps on some mechanical innovations whose origin we do not know, consists in using the bridges of the city to collect the energy of a river changing in its pace and its level. Recent research by Pierre Marchandin shows a complex chronology, which led to the end of the 13th century to reduce this system of milling, whose remarkable efficiency in terms of energy conversion led to an excessive amount of the river's energy being concentrated on the piers and arches of the bridges in the event of flooding. On several occasions at the end of the 13th century, the river washed away the bridges, forcing some of the mills to move upstream and to other rivers, including the Marne. In this case, the deliberate attempt to concentrate the river's energy led to the creation of a power system similar to a penstock, the control of which was beyond the control of the technical devices or local administration, and required a complete reorganisation of the system.

One element that has so far remained outside our observation is the demand for metal in the growth of Paris, and in particular for iron. The agrarian model put into practice around Paris and the systems for transporting subsistence and milling grain that accompanied it were particularly iron-intensive. Surveys carried out in France at the end of the 18th century on arable farms show that the annual expenditure on iron on farms can range from one to several kilos of iron/steel per hectare under cultivation. These figures, which are similar to those established by Paul Bairoch for the following centuries, can serve as an order of magnitude for the medieval period. The annual iron consumption of the Parisian countryside in terms of horseshoes, ploughshares, wheels, carts and tools of all kinds, necessary to cultivate some 1.5 million hectares

and to bring their production to Paris, can hardly have been less than 1,000 tons per year, coming from Champagne, Burgundy and Normandy.

This problem is important for two reasons, both related to the energy mix. 1. Iron, a mineral from the ground, however abundant, is not a renewable resource. 2. In the indirect metal production process, the only one used around Paris until the last years of the 13th century, the ore is reduced and the metal worked at a temperature that varies between 900 and 1300°C. This is not a very high temperature, but it requires a concentrated energy fuel such as charcoal, which the forests can only produce in limited quantities. The water hammer appears to have been used by the Cistercians in the first third of the 13th century, but it was not until the beginning of the 15th century that what was to become the blast furnace spread across Europe in the following century. The cycle of innovations that would later lead to the industrial revolution was therefore not a condition of medieval growth, but one of its aspects.

In the case of the Île-de-France, iron and the demand for the energy power induced by its production and work are not only linked to agriculture. They are deeply involved in the cycle of innovation giving rise to Gothic architecture, which emerged precisely in the Paris region in the second third of the 12th century, half a century ahead of other European regions. The debate is not yet over the definition of what was then called "French art" (*opus francigenum*), the first example of which, the abbey church of Saint-Denis, has also been defined as "the last great Romanesque pilgrimage church" (Lindy Grant). More than the stylistic elements, which refer to Romanesque monuments under construction in various European regions at the time, it is the stretching of the space upwards by lengthening the pillars and windows that constitutes the innovative element. Metals play an essential role here: iron to link the columns, walls and windows and to frame the stained glass windows, lead and tin for the latter.

In the decades following the construction of Saint-Denis and then Notre-Dame de Paris, the movement reached its first limit with the Sainte-Chapelle, a building entirely structured by iron elements, a large part of which is made up of stained glass. Through the choice of materials and the constraints of their design, the Sainte-Chapelle, but also Amiens Cathedral and, even more so, Beauvais Cathedral, anticipated the constructions of the industrial era. This is even more obvious if we take into account the amount of concentrated energy required to build its elements.

It is now appropriate to conclude. The hypothesis presented previously is that the extreme case presented by the growth of Paris, which made the Capetian capital the largest city in Europe, cannot be explained by technological innovations, which would have made it possible to

concentrate a very large population within the city walls. This was first and foremost the product of a much more wide-ranging territorial project, which placed the resources of an exceptionally fertile region at the service of the capital. If innovation took place in the first phase of the city's growth, it was through the conjunction of processes that were separate in other regions: demographic growth, ecclesiastical reform and the political construction of the Capetian monarchy.

In a limited regional space, these dynamic processes resulted in the joining and strengthening of the most relevant elements of pre-existing economic and social systems. However, a key role was played by the social constraint of serfdom in the countryside, which encouraged peasants to increase the productivity of their labour, and of social inequality in the city, which provided the economy with an exceptionally large and docile mass of low-cost wage labour. In a context where the stability of the regional economy had to be ensured, the growing place of iron within the technical system must be underlined: it shows that in a pre-industrial system, not all elements are necessarily renewable.

The search for energy intensity to process iron and other metals in large quantities was bound to run up against environmental constraints, particularly in terms of access to wood: it is not impossible that this was one of the causes of the 14th century depression. In the first instance, it allowed the monarchy to push the limits of the local ecosystem and to develop innovative processes. Gothic architecture is an early example. This process, which was brought to an end by the crisis that accompanied the pandemic of 1348, allowed the inhabitants of Paris to experiment for a century with the technical and social changes that the switch to fossil fuels and the industrial revolution would make permanent four centuries later. The issue of the Anthropocene must be studied in the light of these ancient experiences.

Mathieu ARNOUX, Université Paris Cité et EHESS,
Laboratoire Interdisciplinaire des Énergies de Demain (UMR CNRS 8236),

