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ENERGY DATA ACROSS EUROPEAN CITIES

—Divergences and convergences in sharing methods and uses of urban energy data

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Introduction

The ecological crisis and the Russian invasion of Ukraine are major contemporary threats that put into question our use of energy. If we want to live sustainably, we need to reduce our energy consumption and convert to renewable energy sources. As our ways of life became increasingly energy-intensive in the past decades, understanding energy dynamics is crucial to overcome the obstacles of today and face the challenges of tomorrow. Simultaneously, another dimension of the evolutions of our society is the growing importance of digital information and communication technologies. Local public services are increasingly becoming digital, and information exchanges happen online. The Covid-19-induced lockdowns only accelerated a previously established trend. Considering the importance of the energy transition, and the potential added value of digital information, the following paper will focus on one of the links between these two challenges: energy and data. More specifically, we are going to analyze the ways in which energy data is shared and used, to better understand local energy data governance dynamics. The purpose of this study is therefore double. First, we will look at these methods of sharing energy data. Second, we will analyze how actors utilize this data. Doing so, we will also explore, most importantly, the links between the ways actors share energy data and the ways they use it.

To get a deeper understanding of the issues at stake, we think it is important to situate several contextual elements. First, as mentioned above, the current ecological crisis calls for urgent actions. Energy is at the heart of any form of transition. This fact can take on a variety of forms: we can find it in the fuel we use for transportation, the electricity necessary to heat our buildings, or even in the food we eat. Rethinking energy will inevitably lead to many questions, debates, and choices. To try to go in a good direction, we need to understand the stakes with precision. We have therefore tried to embed our research in a twofold attitude. We look at energy issues with an open mind: whatever the actors, the scales and the projects and whatever the type of energy, we carefully look at it and take it into account. Our goal is therefore to have the broadest overview possible: since energy is almost everywhere, we need to open our horizons. Yet at the same time we need to dive into the specifics, to be able to understand the particular dynamics of what we look at. This double approach will hopefully allow us to have a detailed panorama of energy issues, in the context of our research.

Second, another key evolution of our world is the digital transformation of our societies. This affects many parts of our lives and we can see constant and impressive innovation. From the internet of things to new forms of communication, the digital revolution is changing the way we live. If we focus on what matters here, *i.e.* energy data, we can see that energy and digital tools are closely intertwined. Everything that is digital requires energy to function and many energy issues are currently being *digitized*. For example, the 'smart homes' that are being invented heavily rely on energy supply. And at the same time, the heating of our buildings is increasingly controlled by smart meters or other technologies of this kind. The point we want to make here is that understanding energy data requires a combined form of research: getting a deep understanding of energy issues on the one hand and mastering the brand new digital innovations on the other. This is what we attempt to do in the following report.

Energy is also a profoundly political issue. From the 'gilets jaunes' events in France to the fear of energy cuts during winter, energy is in fact a central question on the political stage. The way we deal with energy relies on our political choices, visions and aspirations. The war in Ukraine, on the matter of energy, has had massive consequences in Europe, adding to various existing economic and political issues. Such geopolitical events disrupting energy are not rare. Moreover, our very relationship with energy raises philosophical debates that go beyond the scope of this study. We need to have this specific context in mind when talking about energy, in order not to get lost.

The regulatory framework is another key element to remember here. Regarding the ecological transition, it is crucial to keep in mind that the European Union aims to be climate neutral by 2050. This is the core of the European Green Deal, in line with the Paris Agreement, and all actors involved in the European energy data sector, from local authorities to energy providers, must abide by this objective. Furthermore, data related regulation unfolds in two overlapping directions: there is on the one hand regulation of energy and on the other regulation of data, with some regulation on energy data. Furthermore, regulations are here of a multilevel nature, with many public actors involved in the field, from the European Union to very local actors. To understand energy data projects, we need to grasp the complexities, challenges and dynamics of these regulations.

Moreover, it is important to underline the importance of the EU legal framework as a general background for all the projects we will analyze. This background can be best described in the following way, with three key elements. First, the European Union is very active in the field of the digital revolution. The recent 'European Commission Digital Strategy' is a good illustration of the broadness of Europe's digital ambitions, ranging from business to policymakers (Communication to the Commission). Second, this strong interest of the EU in the digital tools translates in the making of various legal instruments, progressively shaping the European legal landscape in that regard. Among the most important ones that exist or are underway, affecting our research on energy data, we can note the European Data Governance Act, the Data Act, or the famous GDPR (General Data Protection Regulation). Third, on the specific issue of energy data, the Communication of the European Commission titled 'A European Strategy for Data', is particularly insightful (European Commission, 2022). The 'Common European energy data space' is a reality that is explained with the following elements: "[i]n the energy sector, several Directives establish customer access to and portability of their meter and energy consumption data on a transparent, non-discriminatory basis and in compliance with data protection law. The specific governance frameworks are to be defined at the national level. Legislation also introduced data-sharing obligations for electricity network operators" (p. 31). It is furthermore added that "[t]he availability and cross-sector sharing of data, in a secure and trustworthy manner can facilitate innovative solutions and support the decarbonisation of the energy system" (p. 31). There is thus a legal obligation set by the European Union (notably by the INSPIRE Directive from 2007) for local authorities to make certain data readily available online, usually on open data platforms.[1]

Energy data is thus a non negligible tool to help understand and tackle ongoing global disruptions. Following the introduction of the politico-economic and legal dimensions to energy data, we will now present the research prompt of our study, conducted for the Digital Cities Chair of the Urban School of Sciences Po Paris. The aim is to conduct a comparative study, pointing out convergences and divergences in the sharing and use of energy data, in order to subsequently provide recommendations to the various actors involved in these policies, for the digitization of the energy sector. Based on this prompt, and following some preliminary research, we developed the following research question: *How is energy data used and shared with other actors in cities in the European Union? What are the challenges and opportunities of existing models?*

In order to answer this research question, we develop a taxonomy of energy data sharing and usage based on an analysis of a few dozen projects and initiatives across European cities. We then evaluate our taxonomy based on a few selected cases. The following paper will firstly give a brief and broad overview of the relevant literature, followed by a section detailing our methodology and presenting our taxonomy. Our taxonomy is then explored on various levels of analysis: a description of broad trends is followed by an elucidation of select cases, succeeded

1 For further details, consult Directive 2007/2/EC of the European parliament and of the Council of 14 March 2007 establishing an Infrastructure for Spatial Information in the European Community (INSPIRE).

by a case study of energy data governance models in Vienna, Austria. Finally, we discuss our findings and give policy recommendations, before concluding.

Literature review

As information has increasingly gone digital, social scientists across disciplines started to analyze the implications of digitization in their respective fields. As data has a very wide scope and its potential uses may be limitless, an increasing number of scholars focused on the effective management and shepherding of data. It thus follows that scholarly debates on data governance models, as well as models of the usage and sharing methods of energy data are highly relevant to our research endeavor, focusing on the urban environment as our main level of analysis. It must however also be acknowledged that significant research on data governance is produced outside academia. It is therefore important to limit the scientific gaze on the subject matter, and critically reference the work of private companies, public authorities, as well as civil society, in order to gain a complete overview on urban energy data governance. As a matter of fact, the work produced outside academia may potentially be more pertinent, as its publication lag is much shorter, making its findings more relevant in the constantly evolving energy data environment. Thus, the following section will present a brief overview of the state of research—academic but not only, and with a focus on the energy sector where possible—on uses of urban (energy) data by and in cities, and data governance, with reference to taxonomies or classification models.

Uses of data by and in cities

With current projections pointing towards an increasingly urban environment and ever-growing global disruptions and challenges posed by the effects of climate change, the term *transition* has gained significant traction. It is in this context that urban data governance has increasingly gained scholarly interest with the emerging abundance of new, modern and alternative city types, such as “eco cities,” “smart cities,” “sustainable cities,” “digital cities,” etc. (de Jong et al., 2015). In this plethora of utopian city types, the role of information communication technologies (ICTs) cannot be understated. "Smart" technologies are data-driven and thus data collection, distribution, and analysis inevitably plays an essential role in the city of the future, and certainly must be analyzed critically by urban scholars (Bibri, 2020).

Furthermore, as *transitions* are cross-sectoral they involve all aspects of urban life, a significant one being energy. Energy is an essential property, as without it human life would not be possible. Energy determines human life, as it is the vital property of food, light, heat, mobility, communications, etc.[2] However, with increasing urbanization, there is a global challenge of ensuring sufficient energy for all. Despite the apt philosophical discussion on energy and its relation to humans and the natural environment, for the purposes of our study we limit our understanding of energy to the property that is used to generate electricity and heating—two vital services that are necessary to urban life. It is widely accepted that the "production," storage and distribution of these services has severe environmental implications, making energy a salient sector in need of *transition*.

Furthermore, scholars have developed energy roadmaps with a focus on energy data processing (Pincetl, 2020), or assessed the current state of the energy data landscape in national environments (Seim et al. 2019). International institutions are already more prone to publish on the subject matter. For example, the World Bank displayed the potential offered by the use of open data for the energy sectors, mainly with regards to increased transparency (Leica, 2015), whereas the International Energy Agency developed ideal policy frameworks for the energy sector that include the use of digital tools (International Energy Agency, 2021). It highlighted that the main challenge is the accessibility and expertise to acquire and process granular energy data to develop "policies that are broad enough to effect change on a large scale and targeted to meet the needs of (...) diverse groups" (IEA, 2021). Finally, a report by the International Renewable Energy Agency describes the different types of urban energy data that can be collected.

2 See for example Broto, 2019 for an in-depth analysis of urban energy landscapes.

They identify data on energy demand and consumption; energy and fuel production, availability and supply; urban energy infrastructure (including energy transport network efficiency); energy technology (for instance, costs, performances, future projections); as well as data on the microclimate and weather patterns (IRENA, 2020). Public, private, as well as public-private projects from the field also regularly publish reports on their findings, for instance the C4S published a report assessing their progress of a project on improving local energy management, highlighting the importance of stimulating local competition in the energy sector, as well as using standardized approaches to increase transparency (Imana & Chapman, 2020). Besides, a plethora of civil society, private actors and other stakeholders are also involved in the analysis of urban energy data, with their findings not always being freely accessible. Still, this plethora of data needs to be organized, steered, and managed, thus calling for data governance.

Data governance: a very broad overview

Although there is no consensus on the exact definition of data governance, scholars tend to converge around a similar understanding of the term. As Nielsen presents in his overview, data governance is commonly understood as "a framework for decision rights and accountabilities to encourage desirable behavior in the use of data." (2017). Furthermore, scholars emphasize the importance of the actors involved in the governance process, whose contributions finally lead to formal or informal collectively binding decisions for the actors involved (Micheli et al., 2020). Interestingly, instances of governance can thus be observed at many different levels of analysis and be initiated from both, private as well as public sector.

Governance models may be pursued for an array of reasons. Weill and Ross found that private actors "with effective IT governance have profits that are 20% higher than other companies pursuing similar strategies" due to the well-defined accountability processes (2004). Furthermore, effective data governance can improve transparency and, more importantly, efficiency, as the actors involved all align their positions on data and thus have the same understanding of the issues at hand (Nielsen, 2017), easing policy implementation processes (OECD, 2019). Relevant actors here are plentiful. There are the various public authorities acting at different levels (local, regional, national), companies providing energy services as well as network operators (that can sometimes be owned by public actors), private actors such as companies specializing in the analytics of energy data or that use energy data to provide auxiliary services, civil society groups forming energy communities, for example, as well as academia and other experts.

Thus governance contains both a descriptive as well as a normative dimension, as Micheli et al recognize (2020). Indeed, it maps all actors involved in a process, justifying why their participation is important, and critically explaining decisions, outcomes and identifying what actors finally hold accountability. There is no right or wrong model, and it is necessary that governance models are always adapted to the local, national and sectoral context, taking all specificities into account (OECD, 2019). Governance therefore also refers to a form of rule-making, ranging from laws, to standards and informal agreements, often embracing a shift towards decentralization and bottom-up approaches (Micheli et al., 2020), highlighting subsidiarity and the need to involve local actors in decision-making processes.

Finally, one attempt to clearly and successfully illustrate and classify data governance models is through taxonomies. Methodologies aiming to construct taxonomies produce clear overviews, allowing to differentiate between diverging approaches to the same or similar issue. Such approaches are often used by scholars concerned with data governance, as it allows to differentiate between the varying degrees of specific variables, such as the openness of data (Gelhaar et al., 2021) and its intended uses. According to Nickerson et al., typologies are constructed by starting simultaneously at the conceptual and the empirical level and attempt to connect the two with trial and error until the ending conditions are met (2013). Below, we explain our methodology, developing our own approach towards the construction of an energy data taxonomy for the purposes of analyzing the governance of urban energy data.

Data collection and analysis

When we ask how energy data is used and shared in EU cities, we are interested both in collecting novel empirical data on the state of the energy data ecosystems, as well as attempting to observe more general patterns and tendencies. Thus, our research is divided into several phases, in which the collection and analysis of data is tightly entangled. The first phase consists mainly of desk research, to develop our theoretical and empirical understanding of energy data governance in a few dozen EU cities. This knowledge is used to develop our taxonomies of energy data sharing methods and its ensuing usage. The second phase consists of more in-depth, case-based research that attempts to further illustrate our taxonomy while offering insights into some of the archetypal challenges and opportunities that various models may give rise to. Based on our results in the first two research phases, the third and final phase encompasses an in-depth case study of the energy data governance in the Austrian capital, Vienna.

Taxonomies for energy data sharing and usage

The primary aim of the first phase of our research consists of the creation of a taxonomy of energy data sharing and usage methods. By developing a taxonomy, we hope to arrive at a systematized understanding of energy data ecosystems that will offer us the theoretical foundations to subsequently investigate the challenges and opportunities each model presents. As referenced in our literature review, building a taxonomy requires a simultaneous appreciation of both the empirical and conceptual dimensions of a subject. As such, in this first phase of the project we worked iteratively, moving between case-based empirical research and the theoretical literature.

CITY	COUNTRY	CITY	COUNTRY
Amsterdam	Netherlands	Lisbon	France
Antwerp	Belgium	Ljubljana	Slovenia
Athens	Greence	Lyon	France
Barcelona	Spain	Madrid	Spain
Berlin	Germany	Paris	France
Brussels	Belgium	Rennes	France
Bucarest	Romania	Rotterdam	Netherlands
Dublin	Ireland	Stockholm	Sweden
Grenoble	France	Tallinn	Estonia
Copenhagen	Denmark	Turin	Italy
Hamburg	Germany	Vienna	Austria
Helsinki	Finland	Warsaw	Poland

Figure 1: Preliminary selection of EU Cities in alphabetical order.

With regard to the empirical dimension, we selected a group of 25 cities in the European Union (see Figure 1), chosen to offer the largest diversity with regards to geographic, political and economic profiles. Naturally, some level of arbitrariness in the case selection cannot be excluded. We conducted online text-based research into the various energy data sharing/usage systems we could find, attempting to note down recurring patterns and points of interest. Regarding the conceptual dimension, we conducted numerous semi-structured interviews (see Annex) following a pre-set guideline with academics and experts in the field, as well as reviewing the theoretical literature dealing with the development of taxonomies of other (non-energy) data ecosystems. Our general method can thus be enumerated in the following way: 1) as grounded in our theoretical research, we developed a first draft of a provisional taxonomy before 2) researching our chosen cities with an eye our taxonomy's dimensions, followed by 3) adjusting our taxonomy to better reflect the newfound challenges of the field before lastly 4) returning to the empirics and beginning this process anew. At all times, we attempted to note any difficulties we had and any reflections on the relevance of our taxonomy. *What do we feel like we missed by only focusing on our chosen dimensions? Did the categories we derived for each feel relevant? Do we need more specificity? Less?* In line with post-positivist approaches, we attempted to maintain a reflexive disposition throughout, constantly trying to balance all the factors at play while remaining aware of what the necessary sacrifices precluded. It was decided that we would develop two separate taxonomies—one relating to data sharing and the other to data usage—as we found it difficult to collapse all relevant dimensions in a single framework.

As a result, given the cyclical nature of this research program it is hard to disentangle a discussion of the *results* of this first phase from a discussion of *how we proceeded*. Nevertheless, we will first describe in more detail the specifics of the provisional taxonomy we arrived at, before moving to a presentation of our findings regarding its relationship to the current state of EU energy data ecosystems in the next section of this paper.

Developing a taxonomy of energy data sharing methods

Sharing Methods	Open	Limited	Closed
Voluntary	Method O/V	Method L/V	Method C/V
Hybrid	Method O/H	Method L/H	Method C/H
Mandated	Method O/R	Method L/R	Method C/R

Figure 2: A taxonomy of urban energy data sharing methods.

Figure 2 represents the provisional taxonomy we arrived at with regards to energy data sharing methods. Horizontally, we plot the *accessibility of energy data*: i.e., is it an open-access data commons (open), a data-lake with access granted only to certain types of actors (limited), or a platform/arrangement specifically for the exchange of data between two specified actors (closed)?

Vertically, we plot the *impetus* behind the sharing of energy data with reference to regulatory frameworks. Is the data being shared voluntarily, independent of any governmental requirement? Or, is the data being shared as a result of, and within the framework of, some form of regulation? Alternatively, are we actually seeing a mix of these two—data sharing that incorporates both regulatory requirements as well as voluntary motivations?

These two dimensions, impetus and accessibility, were arrived at because, as informed by our interviews and case-based research, we believe them to be two of the underlying variables at play when evaluating the state of energy data sharing and they do not appear to be correlated in any apparent way (open data ecosystems were just as likely to be voluntarily established as they were to be governmentally mandated, for example). As such, we believe that they offer an analytically powerful way to distinguish between different energy data ecosystems and construct an abstracted understanding of energy data governance contexts. More specifically, we were initially inspired by Open Data Institute's "Data Spectrum" (ODI, 2022), which is an established framework for assessing the openness or accessibility of a given data platform, while our conversations with researcher Marina Micheli underlined for us the importance of the regulatory environment in shaping the challenges of a given data ecosystem.

Developing a taxonomy of energy data uses

Data Uses	Public	Private	Public–Private	Civil Society
Objective #1 (i.e. profit)	Use 1/Pub	Use 1/Priv	Use 1/PP	Use 1/Civ
Objective #2 (i.e. consumption reduction)	Use 2/Pub	Use 2/Priv	Use 2/PP	Use 2/Civ
Objective #3… (etc…)	Use 3/Pub	Use 3/Priv	Use 3/PP	Use 3/Civ

Figure: A taxonomy of urban energy data sharing methods.

Horizontally, we plot the ***actors*** involved in a given use-case for energy data. Some projects are led by a single actor, such as a city for example. Others are involving partnerships, such as public-private partnerships, or more complex arrangements, involving civil society actors for example. Our taxonomy reflects this diversity, with categories representing the various actors or partnerships.

Vertically, we plot the ***objectives*** a given use-case is designed to achieve. These objectives are varied and can range from profit-making to energy transition or energy consumption reduction. When a project has multiple objectives, we take each of them into account.

Potential purpose and analytical value

The purpose of these two taxonomies is to facilitate a comparative study of energy data sharing and usage across the EU, while simultaneously allowing us a reference point with which to study the various challenges and opportunities presented by varying energy data ecosystems. The first taxonomy will hopefully allow us to general identify trends in *how* and *why* energy data is shared. Of interest here is the way in which these findings can be mapped in relation to our second typology, which allows us to identify trends with regards to *who* is using energy data and *why* they are doing so. By observing the use-cases most frequently associated with a given sharing method (or the sharing methods most frequently underpinning a given use-case), we can observe patterns in the relationship between sharing and usage, see for example Figure 4 below.

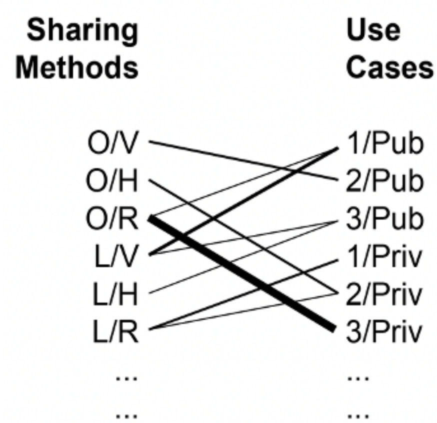

Figure 4: A depiction of potential taxonomy-derived insights.

Phase one –
— Preliminary survey of energy data usage and sharing

The first phase of the research, consisting in mapping out a preliminary overview of the different sharing methods and uses of energy data across EU cities, proved at the same time both encouraging as well as challenging. While some cities present an accelerating and dynamic ecosystem, with both municipalities and private entities pursuing different opportunities that involve the sharing of energy data, others lag far behind with, at times, very few identifiable projects. Where projects were identified, sharing methods defined in terms of accessibility and regulatory situation were diverse, as were the uses defined in terms of actors and the motivations.

Mapping Sharing Methods and Data Uses Across Identified Projects

City	Project	Sharing		Usage	
		Accessibility	Regulatory situation	Actors	Motivations
Paris	EnerSIG	Open	Mandated	Public, Private, Civil	Consumption reduction, renovation
Tallinn	Estfeed	Open	Hybrid	Public, Private, Civil	Market facilitation
Warsaw	"GPI" Power Market Data	Open	Mandated	Public	Market facilitation
Stockholm	Tibber	Open	Voluntary	Private	Profit, consumption reduction
Madrid	Acciona	Open	Mandated	Public, Private	Energy efficiency
Madrid	Municipality	Open	Mandated	Public	Analytics
Lisbon	Solis	Open	Voluntary	Private	Energy transition
Amsterdam	Energy Atlas	Open	Mandated	Public	Energy efficiency
Rotterdam	GridMaster HIC	Open	Mandated	Public	Energy transition
Rennes	Rudi (Data Lake)	Open	Voluntary	Public, Private, Civil	Better services
Lyon	Smarter Together Project	Open	Voluntary	Public, Private, Civil	Energy efficiency, energy transition, analytics
Grenoble	ALEC	Open	Mandated	Public	Analytics
Hamburg	Hamburg Energie	Open	Mandated	Public	Analytics
Berlin	Energy Atlas	Open	Mandated	Public	Analytics
Copenhagen	EnergyData Hub DK	Closed	Voluntary	Public, Private	Analytics, consumption reduction
Milan	CityLife	Closed	Hybrid	Private	Real estate
Vienna	Municipality	Open	Mandated	Public	Analytics
Tilos	Battery and others	Closed	Voluntary	Public, Private	Energy transition, grid management
Kranj	Homes smart meters	Open	Voluntary	Public, Private, Civil	Consumption reduction
Brussels	Prod. of data by public authority	Limited	Mandated	Public, Civil	Consumption reduction
Brussels	Prod. of data by public agency	Open	Mandated	Public, Civil	Energy transition

Brussels	Prod. of data by private company	Closed	Mandated	Public, Private, Civil	Energy transition, grid management
Antwerp	Neighborhood (Zuid)	Closed	Voluntary	Public, Private, Civil	Energy transition, consumption reduction, grid management
Barcelona	Asesor Energético Virtual	Open	Mandated	Public	Analytics
Turin	Energy Community	Closed	Mandated	Private	Consumption reduction
Helsinki	Digital Twin	Open	Mandated	Public	Analytics

Figure 5: Projects and typology.

The diverse sharing methods and uses of energy data across the 25 chosen EU cities were mapped out according to the developed taxonomy. Figure 5 is a condensed version of the results, where the different projects are depicted alongside their respective characteristics.

Whilst certain characteristics, such as the sharing methods, were properly defined at the onset of our research, some new terms also came to figure in the usage motivations of data sharing. In the context of our research, these terms must be appropriately defined and we do so as follows:

1. Consumption reduction: reducing the consumption of energy in all its forms.
2. Renovation: thermal renovation of buildings.
3. Market facilitation: smoothing of the exchange of information between actors on the market, to facilitate their decision-making process.
4. Analytics: production and provision of data for further analysis. Often this data is produced for its own sake, with no specific primary objective in mind.
5. Energy efficiency: reduction of energy use through efficiency.

6. Energy transition: transition from non-renewable sources of energy to renewable ones.

Discussion

The preliminary results from our first research phase shown in Figure 5 reveal that there are, at the same time, both convergences and divergences in the share and use of energy data across the 25 preselected EU cities. On the one hand, there is a somewhat equal divide between projects where accessibility to data appears to be open (available to the public), and closed, (shared only amongst relevant actors), while only two identified instances where data sharing appeared to be limited. Moreover, there was also an equal divide amongst regulatory frameworks where projects were at times mandated and at other times voluntary. On the other hand, in every project with the exception of two particular cases, the public sphere was a primary actor, at times even operating alone. Of course, there is a significant level of arbitrariness that needs to be addressed, as public projects tend to be more accessible to desk-based research than projects with solely private actors. Nevertheless, similarities between the motivations of the data sharing projects were found. Motivations such as the provision of data for analytics, energy transition, energy efficiency, or consumption reduction appeared most frequently. Other uses, such as real estate, market facilitation, and the bettering of services were also found, albeit with lesser frequency.

As expected (and as previously discussed in the preliminary results), different methods of sharing were combined with different uses in a manner that may, on the surface, appear random. For this reason, and in order to better understand the ecosystems in which these data sharing projects currently operate across Europe, we conducted a more detailed analysis of our results to identify trends across our typology. To identify general trends more easily, we developed a set of flowcharts, designed to show the links, in practice, between the several dimensions of our typology.

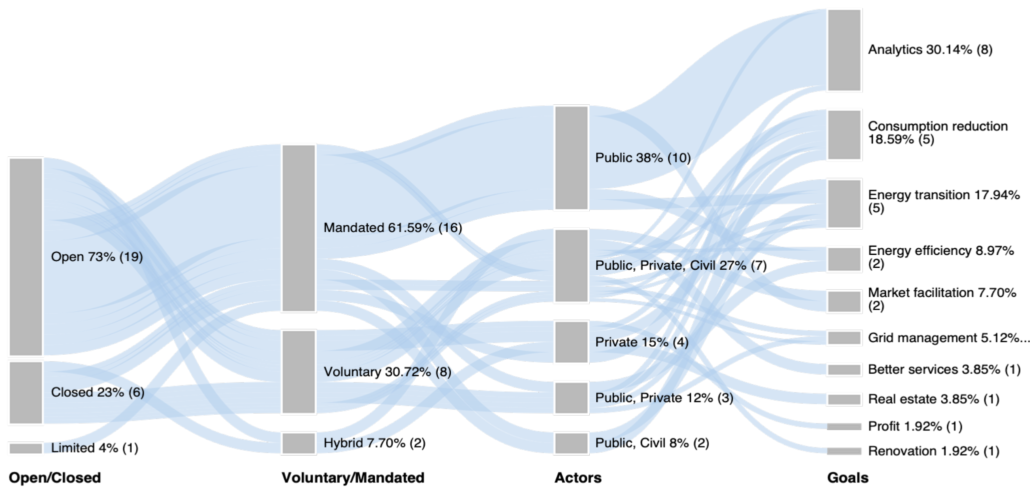

FIGURE 6: FLOWCHART OF THE TYPOLOGY IN PRACTICE.

Before beginning our analysis, it is worth reiterating that our sample size is obviously limited, and our selection of cases contains a degree of arbitrariness. However, we think some insights can be gained from this exercise, even if they should be confirmed by further research. Four general insights into energy data sharing and usages arise.

1. Public actors are omnipresent, yet the narrative they want to empower is still very abstract.

The biggest trend that can be observed—in dark blue in Figure 6a—is that a significant part of the projects we studied have the same nexus: they are open-data, mandated, involving public actors only, and focused on broad and blurry goals that can be described as 'analytics.' This relates to a key finding of our research: there is a strong narrative, among public actors, about open data, and its possibilities, even though these possibilities are often not yet materialized. Public actors use their coercive powers to mandate such open-data schemes, yet these remain analytical tools without any baked-in or pre-designed concrete use. We can also see—considering dark blue and light blue in the graph—that most projects regarding energy data are directly linked to at least one public actor. Only 15% of the projects are led by another actor alone (i.e. private actors).

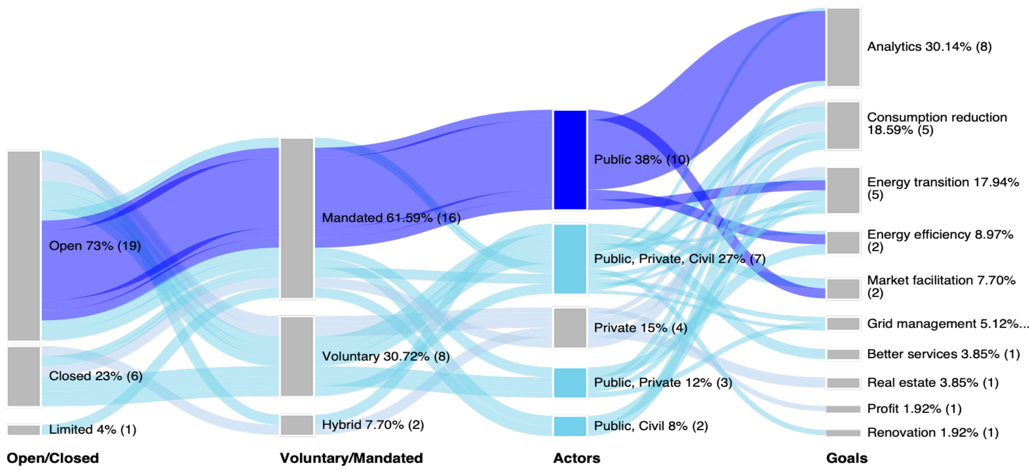

FIGURE 6A: PUBLIC ACTORS.

2. Voluntary schemes are appealing to private actors.

Figure 6b shows that voluntary projects are all related to private actors, whether in partnership with other actors or not. This seems to support the hypothesis that voluntary projects are appealing for private actors, and set up with this in mind. Furthermore, we can see that these voluntary schemes can be equally open or closed, and reach most types of uses of energy data.

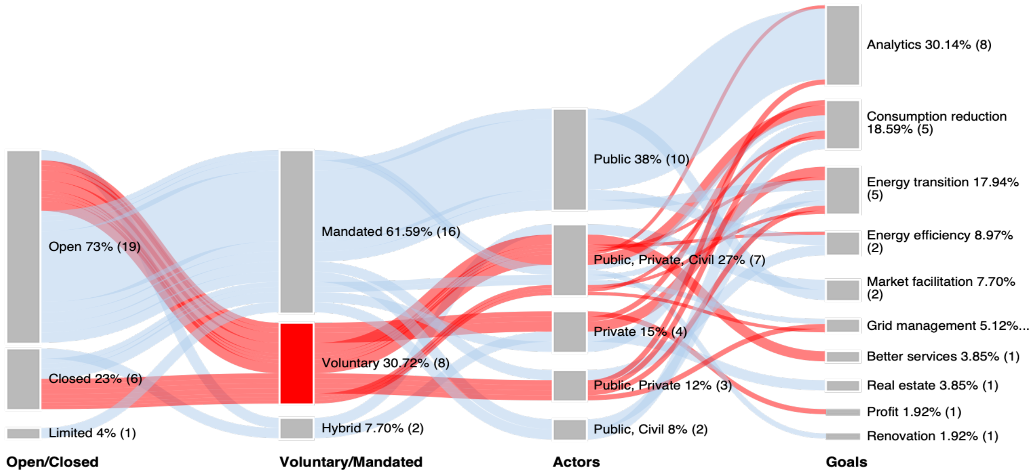

FIGURE 6B: VOLUNTARY SCHEMES.

3. Closed schemes are appealing to private actors

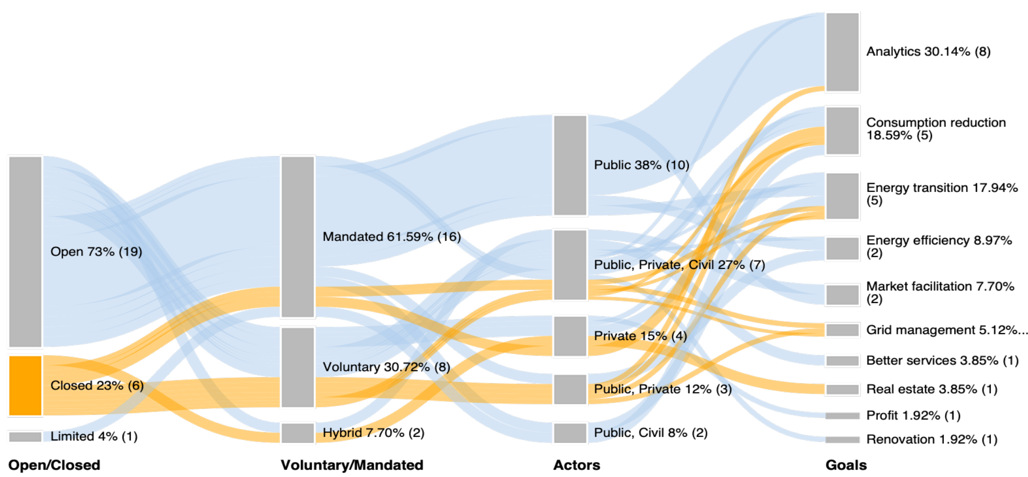

FIGURE 6C: CLOSED SCHEMES.

Figure 6c shows a similar insight, this time regarding the degree of openness/ closedness of the energy data. Indeed, all closed data schemes involve private actors, who would appear to be interested in this kind of project. This echoes business protection concerns, regarding access to information and data, that we encountered in our research and interviews.

4. The ecological transition encompasses our typology without distinctions

Another interesting insight, that can be seen in the next graph, Figure 6d, is that the ecological transition, considered through the prism of four of the uses of energy data we identified (consumption reduction, energy transition, energy efficiency, and renovation), encompasses all of the other dimensions of our typology. Indeed, it can be found similarly often in (1) open, closed, or limited access data schemes, (2) mandated or voluntary projects, and (3) all types of projects regarding the actors involved.

Two hypotheses can be made. Either the ecological transition is now an all-encompassing problem regarding energy data, or some trends of differentiation can be observed regarding this specific purpose but these are not shown in our typology. Likely, there is some truth in both these hypotheses, but only further research could shed light on this issue.

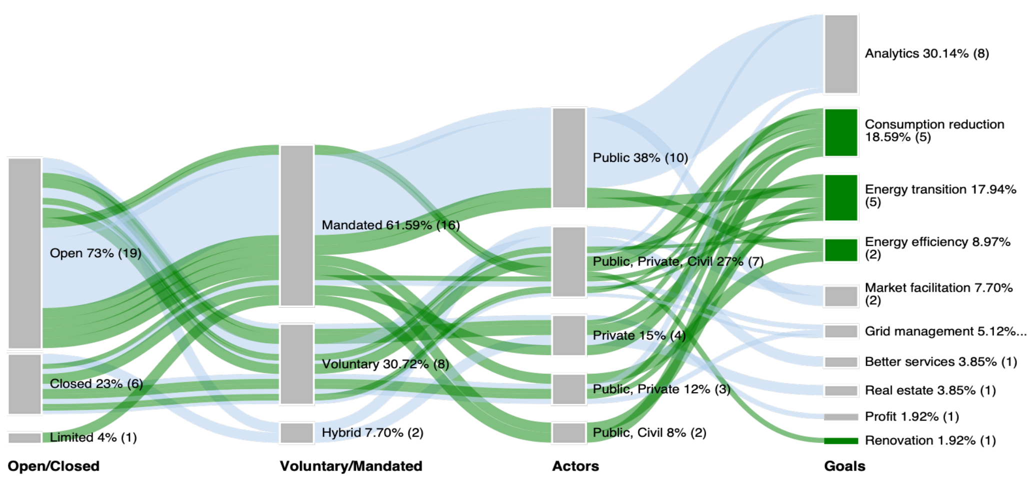

FIGURE 6D: ECOLOGICAL TRANSITION.

To conclude, our typology, when compared to the projects we studied in Europe, proved to be insightful in several ways. To begin with, public actors are omnipresent yet their narratives about open data still often lacks concrete realizations. Additionally, closed, voluntary systems of sharing data seem to be appealing to private actors. Finally, the ecological transition is cross-cutting concern in our typology, with no specific trend with regards to a bias in favour of open, closed, private or public arrangements. Further research could be conducted to confirm all these results and inquire into the questions they raise. In the second phase of our research, we now turn to analyze four case studies in more detail.

Phase two –
— Divergences and convergences across specific case studies

The pinpointing of some pertinent case studies should allow for a better analysis and identification of certain divergences and convergences in energy data sharing and usage across Europe. This is the aim of the second research phase. By conducting interviews with key stakeholders from the public and private sector, as well as academia and civil society groups across different EU cities from our initial selection, we identified a set of case studies defined primarily by their conformity to three of the large actor-focused categories observed in our typology: public, public-private, and civil society.[3] These case studies, indeed, then provide insightful information with regards to the opportunities and challenges of energy data sharing along these different streams and the implications that these then have on the governance of urban energy data.

3 It is worth briefly noting that the lack of in-depth data on exclusively private ventures constitutes a key limitation of our research. In conducting our research and attempting to schedule interviews we found these actors to be reticent with regards to sharing information and engaging with our project. Those private actors that were willing to speak with us were engaged in work with public authorities, hence our focus instead on the dynamics of public–private partnerships. We suggest that future research would benefit greatly from successfully accessing these more private actors (in both senses of the term).

Public

As has been previously discussed, because of legal obligations set by the European Union (chiefly in the INSPIRE Directive from 2007), cities are increasingly making energy data accessible to all through open data portals. This requires important public efforts to manage energy data. Thus, in the years following 2007, many European cities started to work on or launch their own energy data on their respective open data portals. The cases of Vienna, Austria (detailed below) and Lyon, France, in this context, provide many insights. Indeed, as many other cities, Lyon has been publishing the city's energy data on their open data platform since 2010. Together with the city of Rennes, they were one of the first French cities to do so. The city's ambition was to create more openness and transparency, as well as internal and external visibility, around energy consumption (Interview with Chief Data Officer, Lyon). This being said, more than a decade later, it remains questionable whether the project was able to fulfill this ambition. Indeed, as an interview with the Chief Data Officer of the city of Lyon revealed, it still remains that it is "not evident whether the information is advantageous or useful" (Interview with Chief Data Officer, Lyon). In many ways, it was seen that these sorts of open data public platforms offer a vast array of opportunities but that there needs to be wider support to accompany communities, not only in the creation of these platforms, but also in promoting a link between them and other actors, be they private businesses or ordinary citizens (Interview with Chief Data Officer, Lyon). Such was also particularly relevant with the effort to share data regarding the consumption of energy by neighborhood and the potential for solar panel implementation, amongst others, where its availability was not communicated to the public, and where reuse then did not take place (Interview with Chief Data Officer, Lyon). The main overarching challenges revealed by the case of Lyon were thus as follows: a stronger goal or supporting ambition would have better ensured that the energy data serve a purpose; a stronger effort at national level with regards to energy data sharing would have helped delineate the purpose and use of such data; and finally a standardized method of energy data sharing would have better ensured shareability of this data across actors in the energy sector in France.

Public–Private

While the case of Lyon is extremely insightful in understanding the challenges behind the public sharing of energy data, some attempts have been made to remedy the missed opportunity that such data represents. Indeed, what our research revealed was that an important part of energy data sharing activity involved the collaboration of public and private actors. This is visible both in our results table, as well as, more clearly, in the analytical figures previously presented. In this context, the cooperation of public and private actors allows for energy data to have a more clearly-defined meaning or a use, and for the outsourcing of expertise, often by actors in the energy sector, to look at, understand, and derive conclusions from it. This interaction was made most clear through our case study research of Acciona in Madrid and of NexQT in Paris and Copenhagen. In both cases, there was a mandate for the outsourcing of energy data analysis by the public authority. In the case of Acciona, interviews with key stakeholders revealed that it was the municipality of Madrid which had called for bids for energy companies to work on measuring energy efficiency across municipal buildings (Interviews conducted with Actors from the Energy Sector in Madrid who wish to remain anonymous). In the case of NexQT, it was the European Union who had organized a bid for a research and development project that would use artificial intelligence technology to help accelerate decarbonization. The NexQT project was selected by both Paris and Copenhagen through such a bid to fill the gap between energy data and the public by making energy and CO2 emissions data more visible by mapping it on a building and city level, identifying hotspots that may signal a need for renovation development, and other such policies. Yet, while both of these projects represent case studies where energy data sharing has been successful in being attached to a purpose or a use, and not just for analytics as is often the case with publicly managed energy data, in neither case was the data entirely publicly available and diffusible. In many ways this can stand as a challenge for the potential of energy data as it limits the ability of other, auxiliary actors to access it and develop new uses. At the heart of this is the fact that laws concerning energy data currently prioritize privacy and personal data protection over the value or potential of energy data, as became clear across a variety of interviews conducted with stakeholders.

Civil Society

A final trend that was identified, albeit found in much lesser frequency, is the role that civil society can play. The aims of civil society groups working with energy data is usually the reduction of fossil fuel consumption and the promotion and or production of renewable energy to ensure the ecological transition. In this context, the case of Amsterdam is extremely insightful. Indeed, civil society groups in Amsterdam identified the potential for solar panel production on the city's rooftops. Today, the energy cooperative Energiecoöperatie Zuiderlicht provides cheap renewable solar energy to its members, producing 1.4 MWh of electricity in 2022 (Energiecoöperatie Zuiderlicht, 2023). The energy cooperative shares aggregated energy data with its members on an open and voluntary basis to create transparency with its members and encourage interested people to participate. It also shares data with municipal authorities—as this also allows it to access subsidies for renewable energy producers—as well as the network operator, as the solar energy that is produced also flows into the grid.

Phase three –
— The case of energy data governance in Vienna, Austria

As already mentioned above, our exploration led to the selection of the Austrian capital, Vienna, as an apt in-depth case study to illustrate and understand the governance of energy data and its challenges. Although differences in energy data governance exist, as outlined in the previous section, our research in our second phase hinted towards Vienna as an ideal case which would best illustrate relevant convergences. Fieldwork, consisting of interviews with experts, civil servants, and academia were complemented with site visits to better understand the development of Vienna's energy data ecosystem and the challenges it is facing today.

Vienna's energy ecosystem is embedded in its national context, which is dominated by the public sector (Interview conducted with an independent industry expert). Austria imports about double the amount of energy it produces within its territory, amounting to around 526 Petajoules in 2021, according to the Federal Ministry for Climate Action, the Environment, Energy, Mobility, Innovation and Technology. Its main imports are oil and natural gas, which, in terms of production, only play negligible roles domestically, while most of the electricity produced in Austria, around 80%, comes from renewable sources. The energy market was under strict state control until the end of the 20th century, when the first waves of privatization pushed the Austrian government to allow for the partial privatization of energy businesses and the opening of the European energy market by the European Union in 1996.[4] In 2010, with the EIWOG 2010, the latest domestic legislation regulating the energy market and enshrining the European visions for an open energy economy (thus, entailing the disentanglement

4 For further details, consult Directive 96/92/EC of the European Parliament and of the Council of 19 December 1996 concerning common rules for the internal market in electricity.

of energy producers and distributors, an independent public regulatory body, etc.) entered into force.[5] Since then, the domestic energy market is regulated by a public company, the Austrian E-Control. Nevertheless, the privatization efforts were insufficient in fully opening the energy market to wholly private firms. Fully private companies are negligible in the Austrian energy market, which in terms of production and distribution, is still strongly dominated by the public sector (Strauch, 2022). The federal government, as well as regional governments and in some cases local municipalities control the majority of most Austrian energy companies, either directly or indirectly through holding companies. Figure 7, created by the regulatory agency E-Control, illustrates the ownership structure of Austrian energy companies, where the green boxes represent fully public bodies, turquoise foreign and light green domestic private bodies (often however, with partial public ownership). The blue boxes represent regional (light) and nation-wide (dark) energy distribution companies (E-Control, 2020).

5 For further details consult Bundesgesetz, mit dem die Organisation auf dem Gebiet der Elektrizitätswirtschaft neu geregelt wird (Elektrizitätswirtschafts- und -organisationsgesetz 2010 – ElWOG 2010.

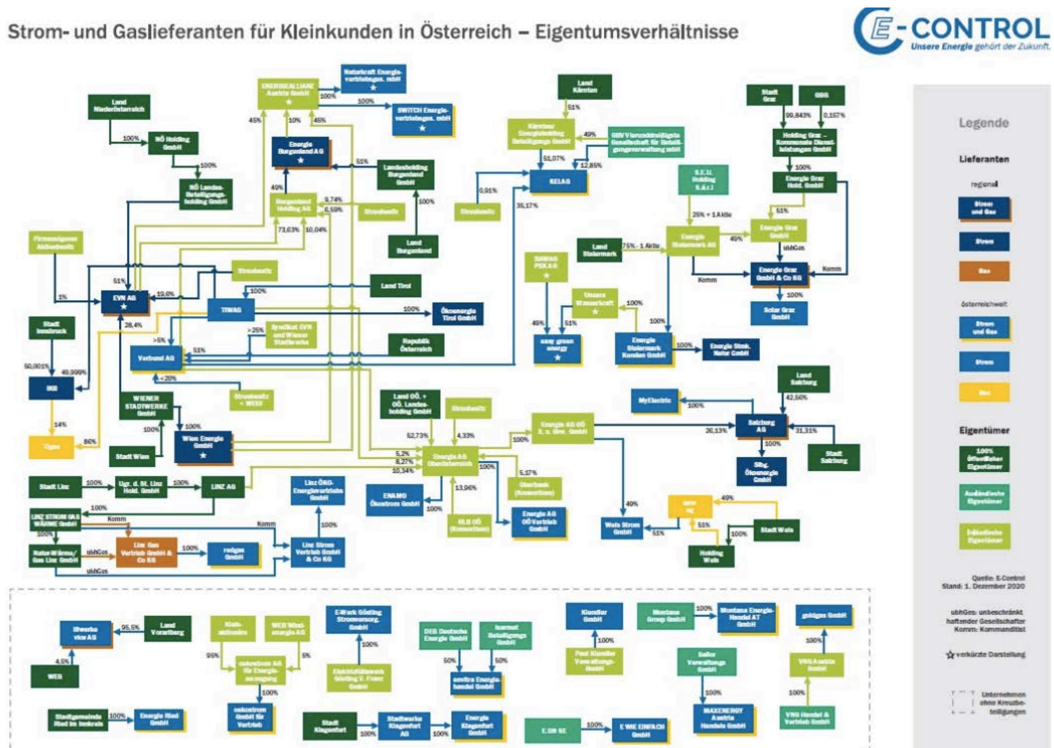

FIGURE 7: OWNERSHIP STRUCTURE OF THE AUSTRIAN ELECTRICITY AND GAS COMPANIES (E-CONTROL, 2020).

The most important player in the Austrian energy ecosystem is Verbund. Active on a national level it is also Austria's largest producer of electricity, with a majority of shares controlled by the federal state. The various regional companies under control of the regional governments, such as Wien Energie in the capital Vienna (in Vienna the state and municipal level are merged), wholly owned by the city's infrastructure service provider holding company also play an important role in the Austrian energy production and distribution market. Vienna also has minority stakes in the EVN group, another energy production and distribution company active in a dozen European countries, whose majority of shares is owned by the regional government of Lower Austria. Other important actors are Oesterreichs Energie, the lobbying organism of the Austrian energy companies, as well as Austrian Power Grid, a subsidiary of Verbund, which manages and controls the frequency of the national grid. In Vienna, the local distribution is managed by Wiener Netze, the local grid operator, also a subsidiary of the city's infrastructure service provider holding company.

The important role of the public sector is also relevant with regards to the local energy data ecosystem in the Austrian capital. The city of Vienna is a unique case, as the local administration has a department that is solely dedicated to local energy planning—the Magistratsabteilung 20: Energy Planning (MA 20). The city of Vienna set the ambitious political aim of becoming carbon neutral by 2040, ten years ahead of the deadline set by the EU. In order to achieve this goal, the MA 20, created in the early 2010s, plays a crucial role. This department works on the development of urban energy plans and the coordination of its implementation, as well as the coordination. It also coordinates the various funds that are allocated mostly around transitioning towards renewable energy sources as well as communicating the importance of renewable energy to the citizens. Notable projects spearheaded by the MA 20 revolve around the discontinuation of fossil fuel infrastructure in new buildings, as well as a photovoltaic offensive to push for the production of solar energy where possible.

In order to achieve its ambitious goals and successfully transition to a carbon neutral city, Vienna needs to develop holistic strategies, and these rely on good data, as a civil servant explained to us (Interview conducted with a deputy head of department of the City of Vienna). The MA 20, in order to fulfill its tasks, mainly works with energy data and is thus the major player in the local energy data governance. Below, the energy data lifecycle used by MA 20 will be detailed.

In order to understand urban challenges related to energy and develop plans accordingly, the city needs a whole array of data, not only energy-related ones. For the most part, the MA 20 works with data that is collected and aggregated by the local energy service provider Wien Energie and the local energy distribution network operator Wiener Netze (both owned by the local infrastructure service holding company owned by the City of Vienna). Naturally, as energy data, especially personal consumption data contains very sensitive information (by tracking individual consumption data one can determine for instance when a person wakes up and takes a shower, or cooks, etc.) the data is given to the local authorities in an aggregated manner (Interview conducted with civil servants from MA 20). Critics may argue that this aggregated data is not precise enough to develop specifically targeted policies. Nevertheless, the data provided gives enough understanding to the local officials to understand the energy related challenges, especially with regards to insulation and heating (as most energy in urban areas is consumed by heating in the winter, and not electricity consumption). This exchange happens in a closed system, of course. Later, this data can be processed and combined with building material information, the analysis of energy data is therefore crucial to develop successful and impactful energy planning strategies.

Furthermore, there is a legal obligation of cities to publish their aggregated consumption data and make it readily available to their citizens. Similar to Lyon, Vienna also publishes a range of relevant datasets onto its open government data portal. All energy related energy data is treated by the MA 20. One major step, and a fairly successful dataset was the publishing of a solar cadastre, showing the potential of PV production on Vienna's roofs (see data.gv.at, 2023). This dataset is the fruit of the collaboration of a range of municipal departments. Citizens can now freely access data telling them the potential of solar energy production on their own roofs.[6] However, as lamented by experts and researchers in interviews conducted in previous research phases, all stakeholders in Vienna confirmed to us that open data is often not used by the ordinary citizen. Academia, primarily,

6 However, it cannot go unsaid that over three quarters of Vienna's population rents and is therefore not the owner of his or her residence. Thus, even if citizens can now freely check the potential of solar energy production on their roofs, the decision to invest in solar panels lies with the landlord. Additionally, as Lukas Kranzl pointed out in an interview, it must be noted that not all roofs that have PV potential can actually be used for solar energy production, due to various reasons such as building material, safety, etc.

benefits from the open access to these large datasets, but they remain obscure and unknown to the regular person. An expert confirmed to us that regrettably, a lot of very good data that is published on the open government websites falls under the radar (Interview conducted with an energy expert at UIV).

MA 20 also collaborates and provides data in a limited framework to Urban Innovation Vienna (UIV), a local and publicly owned agency for urban development. The energy consulting department within UIV works with energy data that is provided by MA 20 to consult with important local actors to ensure the energy transition and the achievement of the city's carbon goals by 2040. Due to limited capacity, UIV focuses on the collaboration with actors that can have large multiplier effects, such as private businesses that own buildings with a lot of rooftop space, to counsel them on the potential benefits of solar energy production, for example (Interview conducted with an energy expert at UIV). Moreover, and similar to other EU cities analyzed above, there are other actors, such as start-ups, that are developing services that rely on the open availability of energy data in order to develop their services. These services are usually aimed at individual energy consumption reduction and use algorithms to estimate personal energy consumption based on the openly available data (as the start-up itself obviously does not have access to real individual energy data, due to data protection laws).

One interesting take away from the interviews conducted in Vienna, was that civil society groups do not seem to be very interested in energy data. Although there are an innumerable number of grassroot groups tackling climate change and the ecological transition, they tend not to be interested in urban energy data. Energy communities such as the one explored in Amsterdam are not known to exist in Vienna, although they are present in rural parts of Austria.

Overall, based on our taxonomy, the City of Vienna publishes open data, as required by EU regulations. This data originates from local energy companies that share aggregated consumption data in a closed framework, but also from the city itself. Furthermore, this data can be used to better understand energy related challenges and to develop urban development strategies accordingly. Urban energy data also serves other stakeholders, such as UIV, who receives energy data according to its mandate, or other actors such as academia or start-ups who rely on open data. Sometimes, upon request, academia can also work with other, more precise datasets, but will never have access to the raw data collected by the energy companies Wien Energie and Wiener Netze, as researcher and energy expert Lukas Kranzl explained to us.

It is important to outline some of the challenges and warnings with regards to the sharing methods and ensuing use of energy data in Vienna. Firstly, Vienna is able to have such an effective and efficient urban energy governance due to a political decision establishing a department that is solely dedicated to energy data analytics and planning little more than a decade ago. Cities need expertise if they want to use energy data to better understand their related challenges. Only large cities have the capacity to develop and employ such experts internally. In smaller municipalities, where there may be less than a handful of civil servants tasked with working on energy and the environment, effective energy data governance will unlikely be a priority. Not only sufficient manpower, but also expertise is needed. Furthermore, the open availability of precise energy data does not have any impact if citizens or other stakeholders do not benefit from it and actively use it to inform themselves or better, change their energy related behavior. Also, Vienna does not exist in an isolated environment, and although the administrative capacity of the city is limited by a boundary, the energy ecosystem of Vienna is interlinked with that of its surrounding region and this is not taken into account by local energy data (Interview conducted with a deputy head of department of the City of Vienna).

Finally, it is also crucial to keep in mind that data represents only a part of a more complex reality. Although energy production and consumption can be quantified, such data does not give a full picture of the patterns at hand. Further, social and economic variables both qualitative and quantitative must be considered when working with energy data in order to develop efficient and effective policies that have an impact on the ecological transition. For example, the MA 20 also works a lot with building and infrastructure datasets in order to develop its rollout of district heating (Interview conducted with a deputy head of department of the City of Vienna).

Phase four –
— Synthesis of findings and policy recommendations

Across the three phases of our research, we have aimed to identify convergences and divergences in energy data sharing and usage in European cities. The aim of this section is to synthesize these similarities and differences in the challenges and opportunities faced by urban actors in effectively engaging with energy data. In doing so, a normative assessment of existing practices becomes possible. We then use this assessment to provide a set of policy recommendations, both with specific regard to the actors who may be implicated, as well as regarding energy data projects as a whole. For the sake of clarification, when we speak of 'challenges' on the one hand and 'opportunities' on the other, we are assessing the efficacy of energy data usage and sharing as a *tool for facilitating a just ecological transition.* This means we are interested not only in the degree to which a given strategy may be conducive to realizing the stated goals of an actor, but also whether these goals themselves are efficacious with regards to the execution of a socially inclusive and environmentally sustainable transition.

Divergences

As phases one and two of our research make clear, we observed a diverse array of challenges and opportunities arise depending on the position a given energy data project occupies in our taxonomy. Whether a project is open or closed or mandated or voluntary, for example, will implicate novel barriers and openings to the project's success. This said, when beginning a normative assessment of the stakes arising from these divergences, we have chosen to focus on the consequences of the *actor(s)* behind a given project. This is because, in view of proposing a set of recommendations, it feels most logical to target these recommendations on the basis of who it is that would actually be capable of implementing them.

Firstly, when observing energy data projects driven primarily by public actors, a set of particularities become clear. Namely, the predominant focus on analytics identified in Figure 6a leaves a large gap to action. By orienting a project towards the production of information for information's sake, analytic energy data projects presuppose the existence of other eager actors who can make use of the information provided. Our research has shown, however, that this cannot be taken as a given—the skills and knowledge required to engage with energy data are poorly distributed, and the focus of public actors on data for analytics only goes a small part of the way towards making use of this information for a just transition. Effective engagement with the relevant stakeholders is at stake here—open access data lakes may be liable to languishing, underutilized by a disengaged and underskilled public. Relatedly, cities themselves are often confronted with limitations regarding their technical and staffing capacities: public-driven projects are constrained by the degree to which cities are prepared to invest in the training and development required to effectively engage with energy data. Simultaneously however, it must be noted that the regulatory power held by public authorities (even if weaker at the municipal level) offers a compelling lever for the mandatory procurement of data, as well as ensuring its implementation.[7] Likewise, with regards to social inclusivity, the dimension of accountability afforded by public-driven projects poses a unique benefit.

Energy data projects originating in civil society mitigate some of the challenges regarding participation that have been mentioned above. While engagement with a broader public may still pose a challenge, by definition a civic project must attract enough attention and engagement if it is to get off the ground in the first place. These projects may offer powerful ways to engage urban residents with questions of energy data at the micro level. This said, it is important to avoid a form of 'survivorship bias' here. On the whole, far less projects originating in civil society were observed than those in the private or public spheres, suggesting that the challenge of civic engagement is present even at the grassroots level. In addition, it is evident that the lack of financial or political power held by these initiatives invariably limits the scope and depth of civil society-driven projects. The lack of know-how and manpower felt by public actors is equally a problem here, constraining the potential efficacy of civic-led initiatives.

Lastly, public–private partnerships present their own unique challenges and opportunities. Across the projects surveyed, it became clear that public–private partnerships are more likely to be geared towards the production of a closed energy data ecosystem. This has its benefits (regarding the tendency towards more specific and applied uses of energy data) but it also poses notable drawbacks regarding the visibility and accessibility of (at least in part) publicly funded projects that deal with questions of public interest. Questions of accountability must be raised. As the data these projects engage with is, in a sense, publicly produced by urban residents, what level of access should this public have to their own data? Simultaneously, in our research on Vienna another drawback of the partnership approach was highlighted. By engaging with private partners on a

7 Nonetheless this is often under utilized. As our research in Vienna demonstrated—even in a context where most energy companies are publicly-owned—it can remain challenging to coordinate sharing given patchwork regulations and strategic interests.

contractual basis to outsource energy-data related needs, cities may be prone to neglecting the development of the internal capacity necessary to ensure the continued implementation and maintenance of data-driven policy. One-time deals with private actors may work well in the short term, but can build a dynamic of dependency that inhibits the long-term viability of a given project. The other side of this, of course, is that public–private partnerships would appear to offer the unique benefit of harmonizing regulatory authority and technical expertise. As stated, this can prove singularly effective with regards to specific short-term use cases.

Convergences

While the actor-based divergences in the challenges and opportunities to effective energy data sharing and usage in European cities have been developed above, it is important to note also that certain trends were found across most projects, *regardless of their taxonomic position.* We proceed by observing the convergences in the *enjeux* of energy data sharing projects for each axis of our taxonomy: actors, regulatory status, accessibility, and motivations.

Regarding the similarities observed in energy data sharing initiatives across all actor types, it became clear that cooperation and inter-actor collaboration is critical to the success of a given project. Regarding civil society-driven projects, our research on Amsterdam illustrated the inextricable manner in which grassroots organizations must engage with external actors to ensure the viability of their projects. Setting up a solar-powered micro grid requires authorizations and access to public (and/or private) infrastructure, this invariably involves interaction with municipal, regional or state authorities, and potentially private parties. Likewise, funding must be secured. While in the case of Amsterdam a co-operative model was adopted, civil society organizations may equally wish to find private-backing or public subsidies for their bottom-up energy projects. In both cases, effective collaboration is critical to the success of these initiatives. Regarding partnerships between public and private actors, it has been demonstrated that there may be benefits in terms of short term and project-oriented efficacy. This is, in large part, a result of the collaborative approach baked-in to such a strategy; each actor can compensate for the weaknesses of the other. This said, the *nature* of collaboration must also be assessed. Actors must be careful to ensure an adequate alignment of goals and motivations—coherence in collaboration is critical. Lastly, even when collaborations arise between public and private actors, engagement with civil society may further strengthen the effects of such an approach. While our interviews revealed that the capacity and appetite to engage with energy data is sparse in civil society, many of the experts interviewed equally expressed their concerns that this apparent lack was also a result of an existing failure to engage civic actors, posing a chicken-and-egg situation. The apparent lack of current demand for engagement should not be taken as an indication that such engagement is futile; rather that adequate conditions must be built to cultivate it.

With regards to the convergences observed related to the regulatory situation of energy data projects, our findings are less clear. Nonetheless, it would appear that mandates for data accessibility may benefit from being strengthened as well as clarified. By clarification, we refer to the way in which existing regulations at the level of the EU are often (perhaps strategically) ambiguous, allowing for a wide range of domestic, regional and municipal interpretations. In multiple interviews it was highlighted that this patchwork quality of regulation and mandates may pose challenges to effective project development. Strengthening the depth and scope of data accessibility requirements may also be a strategy, although such an approach must be carefully balanced with concerns over privacy and data sovereignty. Regardless, if such a strengthening of data sharing and publishing requirements takes place in a context of unaltered capacity for engagement, this development would be unlikely to have much of an effect. Here, voluntary projects (more likely to be privately oriented) may partially escape this trap, as the uncoerced publication of energy data suggests an existing interest and ability to work with said data amongst the implicated parties.

With reference to the dimension dealing with accessibility in our taxonomy—whether a data sharing arrangement is open, limited or closed—it would equally appear that a given project's position along this axis has little relationship to its efficacy. Successful data energy initiatives, as we have noted, are more contingent on the skills and motives of the ecosystem energy data is introduced into. Moreover, the different affordances of each access method renders them more or less conducive to the achievement of particular targets. This is to say, openness for opennesses sake was not found to be a meaningful strategy for effectiveness. Rather, the sharing method employed will be most conducive to success when considered in context. Furthermore, our research revealed that the *type* of data that is shared may be a more relevant consideration. Raw numbers are, for most actors, functionally useless detritus. What is important is that the data which is shared must be adequately parseable as *information*—it must be situated in context with a set of references that allow it to become meaningful to an interpreter. Here a note on the *materiality* of data is also relevant. Beyond the human skills required to make use of energy data, there are physical infrastructural requirements to storing, transmitting and manipulating data (Diguet & Lopez, 2019). These can generate frictions that are costly to overcome. Accordingly, with regards to data accessibility, a more pertinent discussion may instead focus on the 'openness' or accessibility of *that which is shared*, as opposed to the sharing method itself.

To finish, certain trends regarding motivation were identified across most projects. That is, effective energy data initiatives were often distinguished by the *clear sense of purpose* they presented. Having a specific and clearly articulated direction and raison d'être underpinning a project would appear to facilitate implementation and engagement. This sense of purpose can be achieved in a variety of ways, both economic and political. Regarding private actors, the profit motive offers a clear and straightforward objective that can coordinate action. In the case of private–public partnerships, public authorities can find ways to harness this drive to notable effect—this became apparent in our discussions with NexQT and Acciona. Nonetheless, political clarity can also serve this function. Our research on Vienna and the MA 20 revealed that the coherence and urgency of the municipal agenda on energy efficiency and transition facilitated targeted action and capacity development. The lesson here appears to be that specificity of intent in the development of energy data usage and sharing methods is an asset. This is not necessarily to say that more sweeping general programs should be avoided, but rather could benefit from being broken down into their constituent case-specific objectives and developed accordingly.

Policy recommendations

In light of this assessment, we wish to offer the following list as a set of potential guiding policy recommendations. We first outline some that are relevant for public and civil society actors, as well as for public-private partnerships, before delineating further recommendations that may be relevant to all actors concerned by urban energy data.

For public actors:

1. Move beyond analytics. Data for data's sake is liable to going unused—target specific uses and design programs accordingly;
2. Understand the constraints of capacity—match project ambitions to existing skillsets in the urban environment *or,* pair project development with capacity development, be prepared to spend what it takes;
3. Leverage regulatory power. In the procurement of data and and their implementation in services, public actors possess unique legal levers with which to pursue a just transition. Use them.

For civil society actors:

1. Prioritize a collaborative relationship with both public and private actors. When harnessed, their political and economic power can open new pathways for transition;
2. Find ways to leverage the creativity of an engaged community—a unique asset.

For public–private partnerships:

1. Find ways to engage with civil society. This may also involve stimulating demand for engagement itself, but civic participation will strengthen the legitimacy and staying-power of any effort;
2. For public authorities, be careful not to let the ease of outsourcing distract from the need for internal capacity building—critical in the maintenance phase of any project.

The following are a set of recommendations derived from our study of the convergences in energy data sharing and usage and can be relevant to all actors:

1. Don't fall into the openness trap. The level of accessibility of the sharing method should be coherent with the aims of the project. Sometimes this calls for open data, other times closed or limited;
2. Simultaneously, recognize that the accessibility of the informatic quality of data is different from the accessibility of its brute material. Prioritize the 'openness' or accessibility of *that which is shared*, as opposed to the sharing method itself;
3. Strengthening data-sharing mandates can only go so far. Focus equally on clarifying or harmonizing existing regulations and practices;

4. Prioritize collaboration and multi-sector engagement. This is a cheap way to strengthen capacity and expand the reach of a project;
5. Most notably, work to build a clearly articulated sense of purpose for any energy data initiative. This can be accomplished by introducing other actors into the fold and aligning their respective aims, or by capitalizing on existing demands and pressures. Data is a tool, and must accordingly be *put to use.* Expecting actors to put themselves to the use of data is a mistake.

Conclusion

A successful ecological transition to a more sustainable urban environment entails a reduction in consumption and the greening of our energy systems. To achieve this in the digital age, extensive information in the form of data is needed by all stakeholders. This paper, guided by the following research questions, *How is energy data used and shared with other actors in cities in the European Union? What are the challenges and opportunities of existing models?*, set out to better understand contemporary urban energy governance models, in accordance with following the definition of Nielsen (2017), and provide recommendations to the relevant actors. This was achieved through the development of a novel taxonomy of urban energy data sharing methods. This valuable contribution to the field aids scholars, students, experts and practitioners alike, in mapping (urban) energy data governance across the sharing methods and the ensuing intended data usage. This normative framework was developed using a mostly qualitative approach organized in three research phases that firstly relied on interviews with experts, scholars and practitioners, the superficial and descriptive examination of relevant projects across 25 cities in the European Union, and the development of visualizations (flowcharts) to identify patterns across the previously selected projects. Secondly, semi-structured qualitative interviews allowed us to enshrine these patterns through the analysis of specific actor-centered case studies allowing us to recognize divergences and convergences in urban energy data sharing and usage. Finally, an in-depth case study involving fieldwork and aimed at the analysis of projects and experiences in the Austrian capital Vienna, illustrates the best practices of the governance of energy data, as well as its challenges. This three step and multilevel methodology allows us to synthesize our findings across two dimensions—convergences and divergences—and provide applicable policy recommendations.

Nevertheless, it is crucial to briefly evaluate the limits to our findings based on our selected method. Firstly, our findings are based on a selection of projects and experiences regarding urban energy data in 25 cities of the European Union. Although these cities were selected taking various variables into account, a certain amount of arbitrariness cannot be excluded. Furthermore, the impossibility of considering all relevant projects in a selected city must also be highlighted. A plethora of institutions and actors—not only urban—work with urban energy data, and thus there is an abundance of relevant projects that may have been considered for our study. In fact, it is likely impossible to study *all* relevant projects in the European Union. We thus attempted to diversify our cases to the greatest extent possible, however, again, some arbitrariness cannot be excluded. Our interviews in the second and third research phase were semi-structured, meaning that we developed an interview guideline to ensure coherence in our data collection and took place both online and in person. Notwithstanding our meticulous preparation, and the reality that we always talked to experts and practitioners from the field, some interviewer effects potentially altering our answers cannot be excluded. Finally, some limits to our taxonomy. The ontological limit of all taxonomies is intrinsically linked to its benefit. Taxonomies are helpful as they allow scholars to classify cases and types. However, the reverse is also true, as taxonomies force classifications when sometimes the lines between for instance the relevant actors or energy data uses are in reality much more blurred. Further empirical research is needed in order to ground our taxonomy as a useful tool for scholars, students and experts alike.

Still, our research endeavor explored a highly relevant but profoundly underexploited topic by scholars and contributed to the creation of a novel taxonomy to better understand energy data sharing methods and usage by actors in cities of the European Union. Our research led us to uncover a plethora of features of urban energy data governance. The most relevant will be re-stated below. Firstly, when public actors are involved, energy data is often made readily available to citizens on open government platforms due to European Union obligations. However, publishing data for the sake of publishing it, with no additional intent, nor any communication campaigns is not very fruitful. Academia, as well as specific private actors benefit from open access to this data, but as this data needs to be aggregated so as to respect privacy laws, it is not granular enough to conduct specific examinations or analyses in the absence of specially developed algorithms. We found that public-private partnerships exchanging energy data to pursue a specific goal proved to be much more advantageous. Specificity of intent is fundamental. Furthermore, civil society organizations, although often concerned with the ecological transition, are not very present in the urban energy data governance landscape, and when they are they face various challenges to access relevant databases and ensure cooperation with public and private partners, leading to a contradiction where although the ecological transition is voiced by many public actors as a priority, a concrete and coherent energy data landscape—essential to the energy transition—ensuring access to all interested and relevant actors, is usually lacking. We found that no matter the actors involved, successful projects necessitate inter-actor collaboration. Based on these findings we were able to develop a set of policy recommendations for the digitization of the energy sector in cities of the European Union to a range of relevant actors.

In conclusion, the findings and policy recommendations of this paper are based on and, in return, inform our taxonomy. We explored and approached our topic from a pluridisciplinary social science perspective. Nonetheless, further empirical research across disciplines is needed to enshrine our findings and test the robustness of our taxonomy. With the development of our taxonomy and our empirical analysis we hope to have contributed to a highly specialized but nonetheless crucial field and opened various avenues for further research to the increasingly relevant topic of urban energy data, how this data is shared and subsequently used.

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Annex

Interviews conducted for general insights in research phase one.

Interviewee	Organisation
Bruno Carballa	Joint Research Centre - European Commission; B6: Digital Economy
Michel Bena	RTE
Marina Micheli	European Commission

Simon Chignard	Sciences Po Paris
Dominique Bouiller	Sciences Po Paris
Quentin Derumaux	Julhiet Sterwen

Interviews conducted for specific case studies in research phases two and three.

Interviewee	Organisation
Laia Canavaggia	Sciences Po Paris
Employees (wish to stay anonymous)	Acciona Madrid
David Leicher Auchapt	Grand Lyon CDO
Fouzi Ben Khelifa	NexQT
Aukje van Bezeij	Energiecoöperatie Zuiderlicht (AMS)
Ursula Heumesser	Vienna MA 20
Alexander Harrucksteiner	Vienna UIV
Herbert Wagner	Independent, for Verbund - Kraftwerk Freudenau
Lukas Kranzl	Technical University Vienna
Rainer Hauswirth	City of Vienna