The use of consumer data to optimize smart grids for electricity and district heating

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Abstract. Smart grids require a lot of data. Much of the policy discussions and related research on smart grids has been devoted to electricity grids. However, in some countries, such as Denmark and Sweden, district heating is a prominent part of the energy systems, and an important issue for the future concerns how the grids for heating and electricity can and should interact. The issue is further complicated by the fact that heating grids are changing, and the grids of the future will most likely run on lower temperatures. In order to estimate the potential for lowering temperatures in existing heating grids, several grid owners plan to collect and process user data.

In this contribution we analyze the legal issues related to consumer data collection, storage, and usage in electricity and district heating grids, and especially the concerns related to privacy and misuse of data. We also include a case study on legal issues in relation to collection of user data in district heating grids in Sweden. The methods employed are an analysis of law and policy documents, a focus group discussion with staff at a Swedish energy company, and two semi-structured interviews with experts on IT law. A main finding is that the collection of this data is legitimate but that several principles in the General Data Protection Regulation (GDPR) and national laws are relevant, which implies that certain measures should be taken to protect personal data, such as 'pseudonymization'. There is a need for further research on these issues, and especially how to handle data issues in integrated heating and electricity grids.

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1. Introduction and background

The legal framework for energy and climate issues is becoming increasingly complex. At the European Union (EU) level, the policy area referred to as the 'Energy Union' aims to provide all EU citizens and organizations with a secure supply of sustainably produced energy at a reasonable price.[1] However, there are many tensions between the various policies and rules related to the Energy Union, and it has proven difficult to develop a truly coherent, coordinated energy policy at the EU level.[2] Further, many EU rules are complex and their required transposition into national laws in the EU member states is a very complicated process.

In relation to the markets for electricity, gas and district heating, there are numerous rules that aim to integrate national, regional[3] and European markets, and increase the freedom of choice for consumers. There are also great expectations that 'prosumers' will increase their participation in the energy system. The term prosumer tend to include individual consumers and households that produce their own energy and/or in other ways participate on energy markets, for instance through energy storage solutions. Prosumers can also be public bodies that produce energy, such as hospitals that use the roof space for solar photovoltaics (PVs), or energy associations that make shared investments in renewable energy solutions.[4] The potential for prosumers to produce more energy is high[5] but their willingness to do so may be impeded by their (limited) access to reliable information about prices and other factors, and the risk they are exposed to when entering into complicated contracts with larger commercial actors.[6]

The desired transition to a sustainable energy system is politically challenging as it stands in the nexus of energy, politics, and markets.[7] EU has three types of objectives - and associated policies and laws - related to sustainable energy at the EU level: targets for greenhouse gas emissions; renewable energy; and energy efficiency improvements. Figure 1 outlines the targets and examples of EU and national policies.[8]

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[1] For an overview see European Parliament Research Service. (2015). Energy Union. New impetus for coordination and integration of energy policies in the EU. Briefing March 2015.

[2] Cf. María Dolores Sánchez Galera, M.D.S. (2017). The Integration of Energy and Environment under the Paradigm of Sustainability threatened by the Hurdles of the Internal Energy Market. European Energy and Environmental Law Review, 26(1), 13–25. For a discussion on relevant principles for energy law, see Heffron, R.J, A. Rönne m fl. (2018). A treatise for energy law. Journal of World Energy Law and Business 11, 34-48.

[3] For instance the Nordic electricity market Nord Pool; https://www.nordpoolgroup.com/

[4] See e.g. European Parliament Research Service. (2016). Electricity "Prosumers". Briefing Nov 2016.

[5] See e.g. Kampman, B., J. Blommerde and M. Afman. (2016). The potential of energy citizens in the European Union. Report, CE Delft.

[6] Cf. Lavrijssen, S. (2017). Power to the energy consumers. European Energy and Environmental Law Review Dec 2017, 172-187.

[7] Cf. Leal-Arcas, F. Lasniewska och F. Proedrou. (forthcoming). Smart grids in the European Union: Assessing energy security, regulations & social and ethical considerations. Forthcoming, Columbia Journal of Environmental Law.

[8] Note that an agreement in June 2018 stipulates that the renewables target should instead be 32 % until 2030; cf. http://europa.eu/rapid/press-release_STATEMENT-18-4155_en.htm

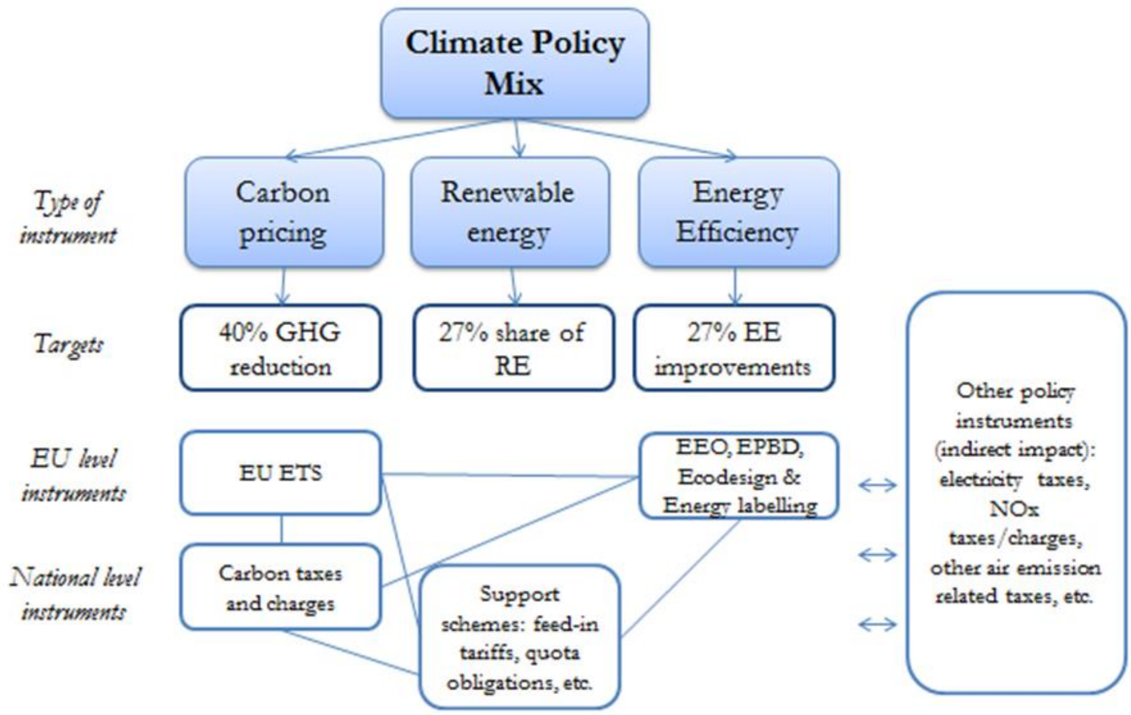

Figure 1. EU targets and policies in climate policy until 2030 (Based on European Council, 2014[9]). Source: Skolina, 2017.[10]

Though the overall targets are set at the EU level, policies are adopted both at the EU and national levels and increasingly also at regional and local levels. For instance, energy efficiency standards for products are set at the EU level to avoid restrictions to trade, whereas EU member states are free to choose national policies to reach targets for renewables.

One clear trend in climate policy in last decade is that more focus – and expectations of reduced greenhouse gas (GHG) emissions – is devoted to climate policies at the regional and local levels.[11] Even in countries with limited climate ambitions at the national level (e.g. the US), there are many regions and major cities who have set up ambitious climate targets, and sometimes also adopted progressive policies. For example, in Scandinavia, Copenhagen has set the objective to be carbon neutral by 2025[12], while Malmö has set a target of using 100 percent renewable energy by 2030 (out of which 15 percent shall be from locally produced solar energy).[13] Among policies, we find several progressive initiatives in the US, for instance the City of Portland's ban on building or expanding large fossil fuel storage facilities[14] and California's decision that homes built from 2020 onwards must install photovoltaic systems.[15] Around the globe we also see a lot of 'local experiments' to reduce GHG emissions, which

[9] European Council. (2014). Conclusions on 2030 Climate and Energy Policy Framework.
[10] Skolina, J. (2017). ETS & Ecodesign – Anything in Common? Assessment of the interactions between the EU Emission Trading Scheme and the Ecodesign Directive. Report, Lund University.
[11] See e.g. Bernstein, S. och Hoffmann, M. (2018). The politics of decarbonization and the catalytic impact of subnational climate experiments. Policy Science March 2018.
[12] See e.g. https://www.theguardian.com/environment/2013/apr/12/copenhagen-push-carbon-neutral-2025
[13] Environmental Program for the City of Malmoe 2009-2020 (Miljöprogram för Malmö stad 2009 – 2020) and preliminary budget 2019 with plan for the years 2020-2024, Municipal Assembly (Kommunfullmäktige) of the City of Malmoe 2018-06-19-20, § 168.
[14] See e.g. https://www.yaleclimateconnections.org/2018/04/portlands-fossil-fuel-ban/
[15] See http://www.energy.ca.gov/releases/2018_releases/2018-05-09_building_standards_adopted_nr.html

include: smart grids for electricity and district heating, smart cities and resource sharing, new energy storage solutions, energy efficient buildings and building renovations, and so on.

1.1 The Smart Cities Accelerator project

Smart Cities Accelerator (SCA) is an InterReg project[16] that involves Swedish and Danish municipalities and universities. The Malmö and Lund municipalities in Sweden are among the project partners. The aims are to develop new smart grid solutions, and optimize current grids for district heating and electricity.

The context of Sweden and Denmark is unique, for several reasons. The Nordic countries established one of the first common electricity markets, and this was accomplished despite the fact that the Nordic countries have quite different electricity mixes and different support schemes for renewables.[17] Notably, both Sweden and Denmark have a very high share of district heating; in Sweden more than 50 % of all facilities receive their heat from district heating.

Among the issues to be investigated in the project we find:

- *How to increase the uptake of solar PVs in cities.*
- *How to optimize current district heating grids, and improve the performance, by making changes in e.g. temperature, pressure, and the use of heat pumps – delivering heat and cooling just in time*. This process involves the design of new grids as low-temperature grids, but it may also be possible in some cases to convert existing grids into grids with lower temperatures (this is discussed later in this paper). This optimization will require access to user data, as grid owners need to process data on heat needs in order to optimize the grids, and potentially to offer new solutions for con summers (e g new district cooling solutions). A related challenge concerns how to make better use of waste heat from industries and research facilities for heating purposes. This is especially relevant in Lund where the new state-of-the-art research facilities MAX IV (a synchrotron radiation facility) and the European Spallation Source (ESS) will produce a lot of waste heat; these activities provide the basis for investing in new low-temperature grids (discussed later).
- *How to further develop the recently finalized pilot projects for 'smart grids' and 'smart buildings', and to integrate smart district heating grids with electricity grids*. Recent pilot projects have tested some innovative approaches and smart metering solutions. New methods will be used to further involve users and develop even better technologies and interfaces that allows for real-time information schemes, and the further possibilities to optimize energy use according to chosen parameters such as optimal GHG reductions or lowest cost. One conclusion in the smart grid project in Hyllie, Malmö, is that the great potential for better energy performance in residential buildings can be realized through integrated systems where district heating, district cooling and electricity interacts.[18] This situation does not necessarily apply everywhere in Europe, but is very relevant for Sweden where 90 per cent of the residential buildings are heated through district heating. The potential for the

[16] Homepage: https://smartcitiesaccelerator.eu/

[17] For an overview see Mundaca, L. T., C. Dalhammar, D. Harnesk. (2013). 'The Integrated Nordic Power Market and the Deployment of Renewable Energy Technologies: Key Lessons and Potential Implications for the Future ASEAN Integrated Power Market' in Kimura, S., H. Phoumin and B. Jacobs. (Eds.). Energy Market Integration in East Asia: Renewable Energy and its Deployment into the Power System. ERIA Research 2012-26, Jakarta: ERIA.

[18] Olin, M. (2017). Smarta nät mer än el. Second Opinion Web 17 April 2017. Available: http://second-opinion.se/smarta-nat-mer-el/

integration depends on several factors including the building itself, the measurements technology and the potential to use weather forecast data, and the involvement of users.

One Work Package in the SCA project deals with legal issues related to new energy solutions. The aim is to analyze legal barriers facing Swedish and Danish municipalities that may pose barriers to new energy solutions, and proposed changes to the legal frameworks. A recent study looked at legal barriers in Sweden. Based on a literature review and interviews with various stakeholders, several main issues were identified, cf. table 1.

Themes	Examples of legal and administrative challenges	Examples, relevant laws
Competition	While grid ownership and electricity provision are unbundled, smart grid projects involving the grid operator (DSO) may provide the DSO with competitive advantages also regarding energy sales; as they have more direct access energy users like households and property owners	Competition law Public law
Local ownership of energy companies	Cities that have not sold off their energy companies have greater opportunities to work with local energy solutions than cities that have sold off their companies; the latter are often unsure what they can (legally) do	Energy law Public law
Community planning and building permits	To what extent should community planning integrate considerations of future energy solutions, such as energy storage solutions in city districts? Building permits can influence incentives for investing in solar on roofs New energy solutions may negatively affect the aesthetics of the urban environment (e g solar PVs on historical buildings)	Community planning Energy planning Building codes and permits Heritage protection Impact assessments
New energy solutions' impacts on human health, the environment, fire & electrical safety	New energy solutions may negatively impact human health, the environment, and fire and electrical safety. Examples include risks to electrical safety from solar PVs, and increased risk for Legionella bacteria in low temperature district heating solutions	Environmental Code Rules on H&S, working environment etc. Rules on electrical installations
Energy solutions that require several permits and/or requires permits that the permitting authority have little experience of handling	Some energy solutions require several permits, which leads to a complex and time consuming process (for instance, some energy solutions may require water permits; such as sea based wind power and energy storage solutions that affects ground water) In the case of new technologies, permitting authorities may have limited or no experience of issuing permits, and not always be aware that other permits will also be required (e.g. water permits, concessions to carry out electrical grid operations, and permits required according to the Environmental Code)	The Environmental Code Rules on electrical installations
Rules for collection, processing and storage of user data	Smart grids require user data for grid optimization/balancing, and the development of new business offerings In order to make changes in existing district heating grids, data on energy use at various locations in the grid is required Integrating grids for district heating, district cooling and electricity requires user data The required data can be misused, and the integrity of users must be considered; thus measures to protect users are paramount	The GDPR and related rules The NIS Directive and related rules Public rules on handling sensitive information Rules on spatial information
Taxes and bureaucracy	Energy related taxes can reduce incentives to invest in renewables Rules that increase red tape and high transaction costs for users reduce willingness to invest	Tax laws Laws related to electricity production & concessions & grid feed-in Subsidy schemes etc.
Safe energy delivery	The involvement of prosumers and other actors in energy supply, provision and storage may negatively affect safe energy delivery; this means that more sophisticated systems for continuous monitoring of energy deliver and use need to be developed.	Rules on electricity, markets etc.
Public procurement and state aid	Rules on public procurement be a barrier when procuring new energy solutions Public investments in new energy solutions require substantial funds; these may not be allowed under state aid rules, or require administrative measures	Rules & guidelines on the Internal market, State aid and procurement

Table 1. Examples of legal barriers and conflicting legal areas in relation to new energy solutions at the local level. Source: Dalhammar and Hjärne (forthcoming)[19]

[19] Dalhammar, C. and A. Hjärne. (forthcoming). Behovet av systemsyn inom energirätten: exemplen utbyggnaden av solel och smarta nät för el och fjärrvärme (forthcoming book chapter).

A recent SCA study looked at legal barriers for solar PVs in urban environments, and found several barriers both for households and municipalities who are considering putting PVs on the roofs of municipally owned buildings.[20]

This paper is devoted to another important legal issue that has been discussed in the project: the use of consumer data in smart grids. This is important for several interrelated reasons:

- In order to evaluate the potential to lower the temperature in existing district heating grids, a lot of data about heating needs and patterns in different location in the grids are required.
- More generally, optimizing grids for electricity and district heating, allowing new actors (e g aggregators) to enter the systems, and offering new business models for heating, cooling and electricity to consumers, is dependent upon data.

Thus, data is required in order to realize the smart grids of the future. However, collecting use data raises several ethical issues, and also new regulations – most notably the GDPR[21] – sets out principles that needs to be followed.

1.2 Objective, methods and outline

The aims of this contribution are to provide an analysis of the legal issues related to consumer data collection, storage, and usage in electricity and district heating grids, and to discuss the implications of our analysis for grid owners that aim at optimizing the grids, with a special focus on district heating grids in Sweden.

The methods employed are:

1) An analysis of law and policy documents, reports, and relevant academic literature;
2) A focus group discussion with staff at a Swedish energy company, which owns several local grids for electricity and heating and also sell several kinds of energy carriers (the company is owned jointly by four Swedish municipalities), and;
3) Two semi-structured interviews with experts on IT law.

The focus group discussion concerned legal and practical issues related to data collection in district heating grids. The interview dealt with legal issues - and most notably consumer integrity issues - related to collection of energy data in district heating grids.

The next section will discuss digitalization in energy systems, the role of data in energy grids, and how the desired flexibility of future grids is not promoted by current energy/climate policies and policy objectives.

Section three outlines the main privacy and integrity issues related to data use in smart grids, the consumer perspectives, and EU and national regulations that deal with these concerns.

Section four outlines the main features of the Swedish energy system, and the planned developments in district heating systems.

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[20] Dalhammar, C. and A. Hjärne. (forthcoming). Behovet av systemsyn inom energirätten: exemplen utbyggnaden av solel och smarta nät för el och fjärrvärme (forthcoming book chapter).

[21] Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation).

In section five, we analyze the issue of collection, use and storage of consumer data in district heating systems, and the implications from GDPR and other relevant Swedish rules.

The paper ends with the conclusions, which also discuss the need for further research.

2. Digitalization of energy systems

2.1 Digitalization and data

Often, the word digitalization is used in general terms. Some actors outline two phases of digitalization.[22] The first phase, which is already happening and in some sector have progressed quite far, concerns the digitalization of information, methods, processes and channels. The second phase mainly concerns four emerging areas of technology: AI, advanced automation, IoT, and blockchain.

The IEA has stated that digitalization has three main elements:[23]

- Data: digital information
- Analytics: the use of data to produce useful information and insights
- Connectivity: exchange of data between humans, devices and machines (including machine-to-machine), through digital communications networks.

2.2 Digitalization of energy grids

Some of the main impacts of digitalization on the energy system, and how it may support smart grids, concerns its potential to:[24]

- support smart demand response through altering when households and appliances use energy from the grids;
- support integration of variable renewables e.g. by enabling grids to better match energy demand to times when the sun is shining and the wind is blowing;
- support roll-out of smart charging technologies for electric vehicles, and;
- facilitate the development of distributed energy resources, such as household solar PV panels and storage, by creating better incentives and making it easier for producers to store and sell surplus electricity to the grid.

Thus, digitalization offers a range of opportunities to electricity grids, and enables better grid utilization and new consumer offerings. More fundamentally, "*In the energy sector, digitalization is transforming the business architecture, redrawing boundaries and redefining relationships between consumers and utilities*."[25]

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[22] E.g. Löfblad, E. et al. (2018). Digital utveckling och möjligheter för energisektorn. Rapport 2018:501. Energiforsk.

[23] IEA (2017). Digitalization & Energy. OECD/IEA, 2017.

[24] IEA (2017). Digitalization & Energy. OECD/IEA, 2017.

[25] Eurelectric. (2016). The power sector goes digital - Next generation data management for energy consumers. Report.

For energy suppliers, digitalization provides opportunities for better services to consumers, and the development of personalized offers.[26] Suppliers can also go beyond energy, offering bundled packages that include home security services, appliance installation/maintenance/ insurance, broadband or TV etc.; either self-developed (electricity cables) or jointly operated with technology providers (ICT, telecommunications/media).Thus, suppliers are changing their traditional business models, based on pure delivery of kilowatt-hours, towards becoming full service providers. The challenges are however many. In order to succeed, data analytic competencies are required. Further, in the new smart grids energy suppliers will most likely have to compete with other sectors offering home solution, and even with consumers themselves (in their roles as prosumers, or collectively via cooperatives or community schemes).

When it comes to DSOs[27] (energy grid owners), these will have to play a coordinating role between all market participants, and facilitate markets and services provided through grids in a neutral and non-discriminatory manner.[28] Digitalization and big data can help DSOs drive new levels of operational efficiency and improve communication both internally (making processes more flexible and cross functional) and externally (with grid users such as generators, aggregators, households, SMEs, or public authorities). Where DSOs are responsible for meter operation and data exchange, digitalization may allow them to handle, manage, and analyze much more detailed data, as well as to explore new ways of collecting, storing and processing them (data analytics, complex event processing etc.). But the detailed regulation of DSOs means that these developments are heavily dependent upon the regulatory framework in each jurisdiction.

Digitalization solutions in the heat and cooling markets - related to heating and cooling grids - enable various actors to offer new kinds of customer offerings. There is a large potential for real-time steering of smart grids for heating and cooling that can support demand side flexibility and heat storage (in buildings and other storage media), allowing optimization in accordance with user patterns and price fluctuations. The heating grid is less flexible than the electricity grid, but this 'inertia' can actually be an advantage in many ways, as it allows for planning e.g. for heat storage over seasons and allow for storage in buildings (see also below).[29]

According to the IEA, digitalization carries three main cross-cutting risks for the energy sector, that need to be assessed and managed: cybersecurity, privacy and economic disruption.[30] It is recommended that policy makers finds a balance between privacy concerns

[26] Eurelectric. (2016). The power sector goes digital - Next generation data management for energy consumers. Report.
[27] Distribution systems operators.
[2828] Eurelectric. (2016). The power sector goes digital - Next generation data management for energy consumers. Report.
[29] Löfblad, E. et al. (2018). Digital utveckling och möjligheter för energisektorn. Rapport 2018:501. Energiforsk.
[30] IEA (2017). Digitalization & Energy. OECD/IEA, 2017.

and other objectives, which include promoting innovation in markets, operational needs of utilities and the wide-ranging potential of the digital transformation of electricity.[31]

A recent Swedish study on digitalization in the Swedish energy sector found that generally:

- The energy companies are very interested in digitalization, but there are few concrete developments so far. Most existing initiatives concern IoT, monitoring and maintenance of grids and utilities, and improved customer billings systems.
- The actors that are most progressive regarding digitalization see the benefits of further cooperation on data; this entails not just cooperation among suppliers, DSOs and consumers, but also cooperation among competitors. The companies currently have a lot of cooperation with a academia and smaller startups; these actors are not only providing know-how in the projects but are often necessary in order to move forward;
- Despite the many opportunities, many actors are wary about connecting data to Cloud services and various digital platforms, mainly due to concerns regarding data security and user integrity and privacy;
- There is a lack of awareness about data security, and lack of related knowledge, among many actors in the energy systems.

In the study many actors stated that they were willing to share information with other actors, if they could see that this will be mutually beneficial. New regulations such as the GDPR and the NIS Directive (discussed in section 3) have however caused uncertainty on how to treat data. Many companies do not want to use cloud services due to fears of being hacked which can cause safety breaches for facilities or lead to business secrets being leaked. However, some parts of the energy system have very little protection, most notably system components in many multi-story buildings. While some people interviewed in the study raised concerns regarding consumer integrity and privacy, other meant that if we have very high climate ambitions, and progressive targets for renewables, reduced consumer privacy may be a price we have to pay.

2.3 Types of data in energy grids and principles for how to handle data

In a Eurelectric report, a distinction is made between three types of data, cf. table.

Smart Meter Data Smart meter data covers consumption data (i.e. energy usage as well as historical consumption), production data (if a consumer also owns generation), and master data (i.e. point of delivery identification data). Smart meter data is under the control of the consumer and is usually collected at the consumer's premises. It gives more granular information to consumers than traditional metering data and is accessible to the market players who are allowed to process it either to fulfil their regulated obligations (supply, settlement, balancing, etc.) or - with consumer consent - to develop (additional) commercial services. **Smart Grid Data** Smart grid data covers all technical data (e.g. voltage, power quality, frequency etc.) collected by sensors in the network – including smart meters – allowing system operators to plan, operate and manage their networks. Such data - when referring to a specific consumer or to a small group - is generally anonymized. Smart grid data is needed for network monitoring and management (e.g. to predict or identify congestion) and network planning. It also provides the information needed to manage the interface between DSOs and Transmission System Operators (TSOs). Such data becomes more and more important in a decentralized energy system as it provides the foundations for a flexibility market.

[31] Löfblad, E. et al. (2018). Digital utveckling och möjligheter för energisektorn. Rapport 2018:501. Energiforsk.

Smart Market Data Smart market data is the most complex set of data to define. To create innovative services, market players enrich smart meter and smart grid data with data from other sources, e.g. from commercial energy contracts (e.g. price information, first day of supply, payment method etc.), from smart appliances (e.g.devices such as smart plugs, smart thermostats or electric vehicle charging set offered to a consumer, which can provide additional usage and service related data) or from external sources (e.g. meteorological/weather data, demography, social media).

Table 2. Three types of energy data. Source: Eurelectric 2016.[32]

The study also distinguishes between 2 types of data usage in the electricity sector, cf. table.

Regulated Obligations Any consumer is entitled to be connected to the grid (by the DSO), be supplied and billed (by a supplier) and be provided with high level of security of supply. To make this possible, DSOs need access to basic meter data from network customers and grid data from adjacent network operators (DSOs and/or TSOs), with the right level of granularity depending on the respective processes (e.g. supply, settlement, balancing etc.), while respecting data security and privacy. The same is true for other players in the energy value chain. Sometimes suppliers also carry out regulated tasks and must still follow a clear set of rules as well as implementing governance structures for customer data with regards to, inter alia, data privacy legislation. **New Commercial Services** The available data makes it possible to develop a range of new commercial services beside plain electricity supply. These include, for instance, demand response, energy audits, home management programs, etc., all of which are expected to generate new revenue avenues for market players. The development of new services is conditional upon consumers giving their consent to access their (smart) meter data on a more granular basis and/or to install additional meters or other devices.

Table 3. Two types of data usage. Source Eurelectric 2016. [33]

Regarding principles for data collection, Eurelectric has proposed general principles, cf. table.

Security and Privacy Consumers should always remain in control of their consumption data. This means that their consent is required before their data is collected and used for non-regulated purposes (i.e. additional commercial services). Moreover, consumers should always be able to know who uses their data and for what purpose. The right of data correction and deletion must be guaranteed. The storage of aggregated customer data must ensure quality and (cyber) security. **Neutrality** The metering data management company should not provide commercial services to final consumers. If consumers decide to retrieve their data from a web platform linked to the (centralized or decentralized) data hub, the platform should not provide data with commercial objectives attached such as customer behavior tips or similar. **Non-discrimination** The metering data management company should not discriminate against any energy player, be it a supplier, an aggregator, a system operator, or an energy services company. Such principle should apply to data access, but also to investment decisions by the data management entity. The metering data management company should provide the same level of service to all its customers, in line with existing legislation and regulations. If a service is available to one player, it should potentially be available to all players – given consumer consent. **Transparency** Consumers should be informed by their energy supplier about their rights regarding access to, and use of, their energy data. Consumers should be able to access their consumption data in an easily understandable and standardized format. The metering data management company should make the rationale for its decisions explicit to the NRA that regulates it.

[32] Eurelectric. (2016). The power sector goes digital - Next generation data management for energy consumers. Report.

[33] Eurelectric. (2016). The power sector goes digital - Next generation data management for energy consumers. Report.

The metering data company's costs and long-term investments must be made transparent and auditable by the energy regulator. **Cost-efficiency** Regulatory decisions should be fully based on prior cost-benefit analysis in the interest of consumers and society. If the metering data management entity is a regulated company and sells data to market participants, it should not make any extra profits from this activity. **High quality** At a time when ever larger sets of (energy) data are becoming available, ensuring high-quality processes is crucial. There are a number of quality components, including data accuracy and timeliness. Setting up a tool for automatic monitoring and data consistency checking at every stage of the process (data extraction, data exchange etc.) might be appropriate.

Table 4. Principle for data collection. Source Eurelectric 2016.[34]

It is argued that while the principles should be set at the EU level, there is no 'one size fits all' model applicable in all European countries for smart meter data management, and therefore each country needs its own rules.

2.4 Combining grids for electricity, heating and cooling

As regards the possibilities created by digitization, there are some clear differences between the heating and electricity grids.[35] Most notably, the complexity in the two systems is different. In grids for electricity, the main issue is to balance production and consumption, whereas thermal systems have an inherent inertia and more parameters to measure and analyze compared to electrical systems. The big amounts of data generated within e.g. district heating systems, on the other hand, benefit self-learning systems, which can provide more robust decision support over time when algorithms gain access to more data to work with (including data on heat systems, buildings, weather forecasts etc.).

While most of the research on smart grids has been devoted to electricity grids, in many countries the really 'smart' solutions can emerge when the electricity grid is combined with other grids, such as gas and heat grids.[36] And the number of cooling grids is increasing as well, adding more options for the future energy systems. Energy can be stored with different techniques. Electric power can be stored in batteries and hot water can be stored in storage tanks. Another way of storing energy is to utilize the thermal inertia found in the walls, ceilings and floors of buildings. This is a very cost-effective way of storing energy. A building of stone or concrete of the kind commonly found in cities has a thermal inertia which means that you can greatly change energy usage for up to eight hours without significantly affecting the indoor temperature. Combining this across a larger group of real estate using collaborative load management creates a 'smart energy network'.

In some cities, the key to optimizing the energy systems in the future, and to balance the grid, may lie in the effective combination of the different grids, and the involvement of not only consumers but also the property sector as buildings may be used to store energy in various ways. For cities that are have a quickly growing population, where it takes time to install new

[34] Löfblad, E. et al. (2018). Digital utveckling och möjligheter för energisektorn. Rapport 2018:501. Energiforsk.
[35] See e.g. Löfblad, E. et al. (2018). Digital utveckling och möjligheter för energisektorn. Rapport 2018:501. Energiforsk.
[36] Isacson, P. et al. (2016). "Räkna med fjärrvärmen i smarta näten". NY Teknik Opinion web 2016-09-02; Olin, M. (2017). Smarta nät mer än el. Second Opinion Web 17 April 2017.

transmission lines and grid capacity, and where it is difficult to quickly increase the local installment of renewables, the way forward is to optimize the current system including grids and buildings. Thus, both energy grids and buildings will need to become more flexible. In Malmö in southern Sweden, a new project aiming at finding such solutions have recently started.[37]

2.5 The current legal framework does not reward flexibility

While flexibility is an important feature of future smart grids, current policies do not necessarily reward such flexibility. A 2016 study from Northern Europe found that in the Nordic and Baltic countries energy system related objectives and policies tend to promote other aspects such as climate friendly energy production and energy security.[38] It was found that combined heat and power (CHP) and power-to-heat (P2H) are the most ideal technologies in the district heating-electricity interface, but that flexibility is not incentivized by energy policy, and only sometimes by market incentives. It was also found that unless prices have larger seasonal fluctuation, CHP and P2H may be in direct competition (e.g. due to low electricity prices supporting heat pumps), and thus will not support joint development of these systems. Barriers for the flexibility include stable, low electricity costs in countries like Sweden. Other barriers include the availability of local biomass, and current support schemes for renewables. Further, all countries in the study apply flat heat tariffs which may discourage flexible consumer demand, existing profit caps in some jurisdictions can discourage investment, and there are no support policies for heat storage solutions.

Several policy measures may increase flexibility, including creating level playing fields for all renewable energy sources, introduce tariff schemes that incentivizes flexibility among users, dynamic taxation of electricity, and abolish support for renewables during negative price periods.[39]

Further, in many countries the price and tariff schemes applied for DSOs in today's grids, and rules on cost coverages, provides very weak incentives for investments in smart grids.[40] Changes are needed in order to change the current state of affairs.

3. Privacy and integrity issues in smart grids

3.1 Consumers and digitalization

The issue of privacy in digital systems is one of the defining issues of our time. Personal data is increasingly becoming a 'currency' in its own right, and in an increasing 'digital ecosystem' - where data from various platforms are combined, and often used in ways, and by actors, that are not foreseen - the consumer protection interest may clash with other

[37] https://malmo.se/Bo-bygga--miljo/Miljoarbetet-i-Malmo/Malmo-stads-miljoarbete/Klimat-och-energi/Malmoeffekten.html
[38] Flex4RES. (2016). Framework conditions for flexibility in the district heating-electricity interface. Report.
[39] Flex4RES. (2018). Better policies accelerate clean energy transition. Policy Brief.
[40] Copenhagen Economics. (2017). Incitament för smarta elnät. Report.

interests.[41] The issue is however complex as consumers usually need to share their data in order to receive some of the benefits provided.

While data in energy systems are in many cases less sensitive from a privacy perspective than in other systems and ICT applications, consumers are often less aware of these processes in an energy context, and may feel that data collection in energy systems is an 'imposed' process. As stated by Eurelectric[42]: "*Whilst PCs, tablets or smartphones may generate much more personal data (for instance, through intentional online behavior and social networks) than smart meters, many citizens choose to share their own information on the Web whereas smart meters are generally 'imposed' on them by industry policy and regulatory choices whilst not always being perceived as useful. Suppliers and DSOs must, therefore, take the time to explain carefully why smart meters are needed, prove - through innovative services - the added-value they represent, how they will benefit consumers and, crucially, how/by whom the data generated by such meters will be used*."

3.2 The (lack of) consumer perspectives in energy markets

Smart grids and other future developments in energy markets are expected to generate a lot of opportunities for consumers, as these can generate their own electricity, take on new roles (e.g. aggregators), and reduce their energy bills by diverting energy use to times when the prices are lower. However, the developments do not only create new opportunities for consumers, but also entail risks: consumers who do not take the right decision may instead be subject to higher prices. Furthermore, some markets may suffer from poor competition, and price increases for suppliers and DSOs may then be transferred to consumers. Generally, the visions for smart grids often neglect to fully account for the complexities, interests, and behaviors of consumers; and assume that these want to be 'active'.[43] In a country like Sweden, where electricity prices are low and stable, many consumers are actually not very interested in lowering their electricity costs.[44]

Further, the opportunities may primarily come about for knowledgeable, connected consumers. Stressing the importance of the 'digital divide', it has been argued that:[45] "…*many of today's benefits such as access to more competitive energy tariffs or price comparison tools hinge on a stable and consistent internet connection. The 'digital divide' currently*

[41] Larsson, S. and J. Ledendal. (2017). Personuppgifter som betalningsmedel. Rapport 2017:4. Swedish Consumer Agency.

[42] Eurelectric. (2016). The power sector goes digital - Next generation data management for energy consumers. Report.

[43] Lavrijssen, S. (2017). Power to the energy consumers. European Energy and Env law Review Dec 2017, 172-187.

[44] This is evident in discussions we have had with staff at energy suppliers: many consumers do not change contract even when their energy bills state that they can reduce their costs straight away by signing up for a new contract, with no downsides.

[45] Eurelectric. (2016). The power sector goes digital - Next generation data management for energy consumers. Report.

works to the disadvantage of elderly/more vulnerable and/or less computer-numerate consumers."

We could imagine a future where all kinds of consumer services – whether related to energy, finance or IT services – become so complicated that a large share of citizens cannot in any way control or understand their interactions with these systems; while the user behavior is increasing monitored and steered by the systems in various ways.

Due to the many concerns, ACER[46] has outlined some necessary steps to ensure that the perspective of users/consumers/prosumers are taken into account in the development of future energy markets and the integration of different energy markets and the further development of the Internal Energy Market (IEM) in the EU.[47] Among proposed measures to strengthen the consumers on future markets we find:

- Ensure consumers rights are enhanced and that DSOs cannot undertake measures that distort the competition on markets for energy services;
- Develop key functions in consumer markets where energy suppliers, aggregators and other energy suppliers compete on equal terms;
- Clearly differentiate between markets with free competition and regulated markets and establish roles for the actors in these markets, such as TSOs, DSOs, data hub operators, suppliers etc.;
- Develop formats that enables consumers to easily change suppliers etc., and provide protection for vulnerable consumer groups;
- Over time, while protecting consumers on markets with limited competition, an objective is to remove fixed consumer prices, as these are not compatible with deregulated, flexible markets;
- Develop better information to consumers on how they can navigate markets, and how they can engage as prosumers;
- New services that contain offers not related to energy shall not be blocked by TSOs.

3.3 Concerns related to privacy and integrity in electricity and heating grids

The data collected from smart meters can often tell more about consumer behavior patterns than people think. For instance, data from smart electricity meters can tell what TV programs or movies users are watching. Greveler et al.[48] made a sample testing and found that:

"…sample rate does reveal what channel the TV set in the household was displaying. It is also possible to identify (copyright-protected) audiovisual content in the power profile that is displayed on a CRT, a Plasma display TV or LCD television set with dynamic backlighting. Our test results indicate that a 5 minutes-chunk of consecutive viewing without major interference by other appliances is sufficient to identify the content. Our investigation also

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[46] Agency for the Cooperation of Energy Regulators.

[47] ACER. (2014). Energiförordning: en bro till 2025 Slutsatsdokument (translated from English). ACER: Ljublana.

[48] Greveler, U et al. Multimedia Content Identification Through Smart Meter Power Usage Profiles. Avialbale: https://www.nds.rub.de/media/nds/veroeffentlichungen/2012/07/24/ike2012.pdf

reveals that the data transmitted via the Internet by the smart meter are unsigned and unencrypted."

In a UK survey of consumer concerns,[49] it was found that many consumers are aware of, and concerned about, data security issues. Most however considered these to be acceptable when seeing the benefits of smart meters and information for both private benefits and optimizing grids. A minority has however more negative attitudes to any kind of data sharing, though these concerns relates to all kinds of data handling and not grids specifically. Electricity consumption data collected by smart meters was not perceived as sensitive information by most participants, and this was a key reason underlying high levels of support overall for DNOs accessing this information. However, it was noted that *"…this attitude was expressed based on the assumption (made spontaneously by many participants) that consumption data is not linked to information about them as an individual - participants assumed, for example, that their consumption data would not be linked to their name, telephone number, bank account details or health data*."

In discussions with consumers, it was noted that many consumers have a hard time differentiating between DNOs (DSOs) and energy suppliers, and thus believe suppliers rather than DSOs would obtain consumer data: "…*some participants still had difficulties separating the DNOs from suppliers, and often diverted into thinking about the implications of suppliers accessing half-hourly data*."

The participants' views were categorized (cf. figure).

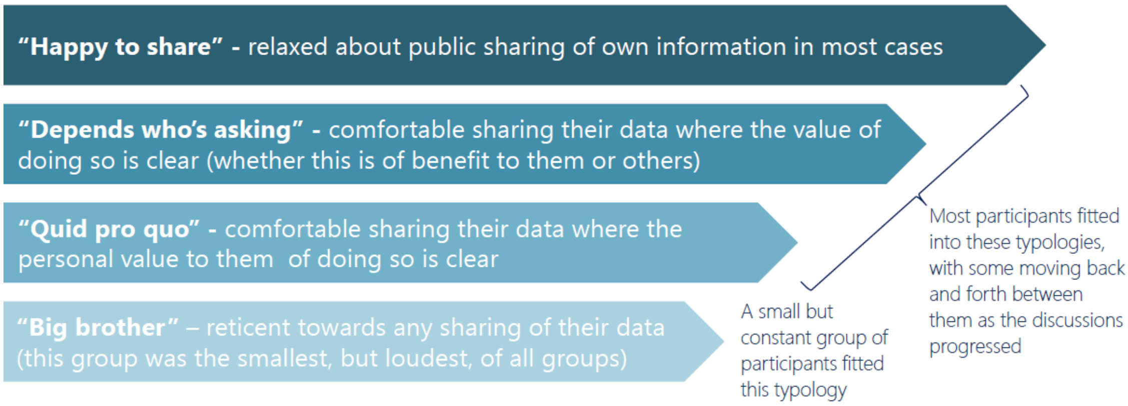

Figure 2. Differing viewpoints on data privacy. Source: Ipsos public affairs 2017[50]

Some main concerns from consumers were:

- Fear of differential pricing
- Cold-calling to sell products or services

[49] IPSOS Public Affairs (2017). Consumer attitudes to DNO access to half hourly electricity consumption data. Ipsos MORI research study report. IPSOS/ENA

[50] IPSOS Public Affairs (2017). Consumer attitudes to DNO access to half hourly electricity consumption data. Ipsos MORI research study report. IPSOS/ENA

- Concern that this data may be misused or sold to other private companies
- Hacking into the smart meter
- Linking of smart meter data to other personal sensitive information

One recommendation in the report was that "…*entirely overcoming fears held by some consumers around the risk of data hacking will be challenging for DNOs to overcome (given they are not related to the specific context of the DNO but rather the wider world). DNOs should be clear on their data protection processes as these are important but should avoid denying there is any potential risk - participants are suspicious of claims that any data can be kept completely safe and secure*."

Regarding aggregation of data, it is of course likely that DSOs will need to aggregate consumer data, and need to be careful with handling data from individual households. Most consumers however seem to think that individual property level data being used is reasonable, cf. figure.

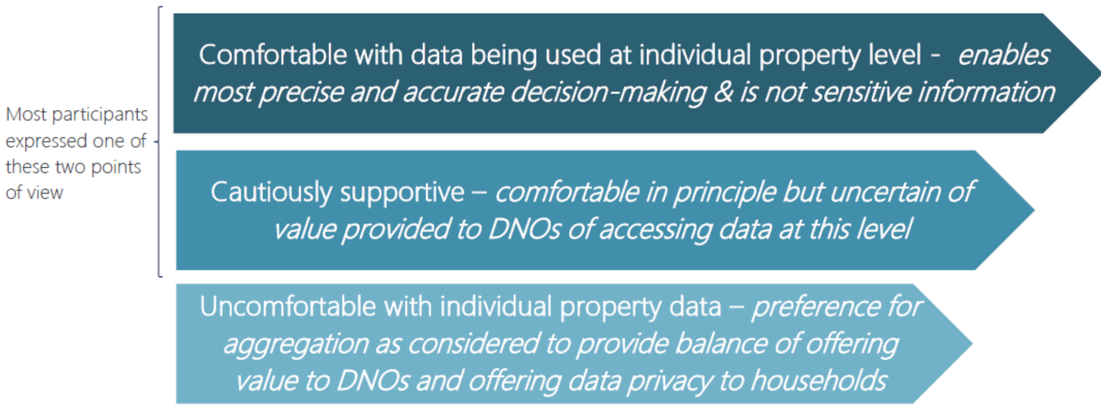

Figure 3. Consumer attitudes to data being used at individual property level[51]

The report further stated that: "*Most participants were either very or fairly comfortable with DNOs using half-hourly electricity consumption data at an individual property level. Participants understood this to mean that a property was identifiable through some kind of geographical marker on the network (including the precise address), but that this would not be linked to any information about the property's inhabitants (names, ages, household activities, financial information).*"

Data in district heating grids is often less intrusive; for instance it may be able to tell how often or when a person takes a shower, which is usually considered to be less intrusive than monitoring what movies he/she is watching. Thus, generally an electricity meter can create greater potential for privacy violations compared with the meters and monitoring systems located in district heating systems and water distribution systems. People in the energy sector also argue that the issue of consumer privacy and integrity is often less concerning in district

[51] IPSOS Public Affairs (2017). Consumer attitudes to DNO access to half hourly electricity consumption data. Ipsos MORI research study report. IPSOS/ENA

heating grids than in electricity grids.[52] Further, when it comes to district heating deliveries to large buildings - like multi-family houses and premises - dominate. It is then often difficult to identify the individual's or the household's heat use in these systems. But as Gadd states the issue is more complicated for single dwellings:[53]

"*The ownership of the meter readings is a non-issue at present. However, from an energy efficiency point of view it could be useful to make energy meter readings public. If energy meter readings were public, lack of energy efficiency competence at the building operators could be identified, and compensated for by energy efficiency experts who could analyse the energy use in buildings on a large scale to identify inefficiencies in order to sell energy efficiency services. But, fault detection in substations and secondary systems with high frequency meter readings not only reveals knowledge about customers' heat demand. It also reveals knowledge of behaviour. Analysis of companies' energy use patterns might reveal changes in production methods, a competitive advantage. Public meter readings could also risk trespasses on personal integrity. It might not be a problem in a multi-dwelling building with dozens of flats, but for a single dwelling building it would with a one-hour resolution metering be possible to identify working times. With increased resolution, it would be possible to see showers or even single hot water taps. This would certainly be a risk for trespass of personal integrity. High-resolution measurements could be of interest not only to take energy efficiency measures but for other purposes as well. Information about customers' use of domestic hot water could perhaps be of interest for companies selling shampoo, while information about hours people are away from their homes could be of interest to companies that sell security systems, or for burglars!*"

3.4 Legal approaches in the EU to address cybersecurity and privacy issues[54]

In general, the contours of the future energy systems can be discerned, which allows for some principles for future regulations to be discussed.[55] However, some flexibility is required as the future is far from certain. In an OFGEM paper it is stated that:[56] "*The regulatory framework will need to evolve to ensure consumers' interests are realised in the future energy system. While no-one can be certain about what the system will look like, we believe that we can best protect consumers' interests by adopting a flexible approach to regulation which relies on learning over time. Moving towards a regulatory framework based more on principles and outcomes seems likely to be more robust to future developments. At the same time, we will*

[52] Löfblad, E. et al. (2018). Digital utveckling och möjligheter för energisektorn. Rapport 2018:501. Energiforsk.
[53] Gadd, H. (2014). To analyse measurements is to know! Doctoral dissertation, Lund University.
[54] For more information see e.g. Leal-Arcas, F. Lasniewska och F. Proedrou. (forthcoming). Smart grids in the European Union: Assessing energy security, regulations & social and ethical considerations. Forthcoming, Columbia Journal of Environmental Law; Papakonstantinou, V. and D. Kloza. (2015).Legal Protection of Personal Data in Smart Grid and Smart Metering Systems from the European Perspective. In S. Goel et al. (eds.). Smart Grid Security, SpringerBriefs in Cybersecurity. Springer.
[55] Cf. ACER. (2014). Energiförordning: en bro till 2025 Slutsatsdokument (translated from English). ACER: Ljublana
[56] OFGEM. (2017). Local Energy in a Transforming Energy System. Paper, OFGEM future insights series., p 16.

need to ensure that regulatory arrangements enable the emergence of business models that are in the long-run interests of consumers."

When it comes to cybersecurity, EU has adopted the NIS Directive[57] which aims to create a culture of security across sectors which are vital for the economy and society and which rely heavily on ICTs, including the energy sector. Businesses in these sectors that are identified by the Member States as operators of essential services will have to take appropriate security measures and notify serious incidents to the relevant national authority. Also key digital service providers (search engines, cloud computing services and online marketplaces) will have to comply with the security and notification requirements under the Directive. The NIS Directive will not be discussed further in this contribution.

Policy makers must also ensure that consumers retain a wide market choice, and are not locked into using products that are only interoperable with other products from the same manufacturer or that are based on the same protocols. This includes guidance for standardization work.[58] Recent areas of standardization work by CEN/CENELEC include the development of standards for electricity and telecommunications networks, energy management systems, data formats for electronic invoicing, and qualifications in digital skills. Some of this work builds on legislation, while some anticipates future policy decisions by European governments.[59]

Currently some governments seek arrangements to access data from private firms in exchange for access to markets, e.g. the deal struck between the city of Boston and the ride-sharing company Uber. But policymakers are also increasingly concerned that the concentration of data collection and processing in the hands of a few large companies could have possible competition and anti-trust impacts.[60]

When it comes to privacy concerns, these have started to be addressed by different jurisdictions. Here will limit our main discussion to the EU and Sweden.

First, it should be pointed out that the solutions for dealing with consumer data privacy issues can be of different nature, including:[61]

- *Technical solutions*: Data can be made anonymous by means of aggregation, so private information cannot be attributed to a specific household. Another solution is to limit data granularity by adding a time lag. In Germany and France, the time lags are 15 and 10 minutes, respectively.

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[57] Directive (EU) 2016/1148 of the European Parliament and of the Council of 6 July 2016 concerning measures for a high common level of security of network and information systems across the Union

[58] European Smart Grids Task Force (2016). My Energy Data. Report by European Smart Grids Task Force, Expert Group 1: Standards and Interoperability.

[59] CEN-CENELEC (2017). Annual Report 2016.

[60] See e.g. OECD (2016). Big Data: Bringing Competition Policy to the Digital Era; IEA (2017). Digitalization & Energy. OECD/IEA, 2017.

[61] IEA (2017). Digitalization & Energy. OECD/IEA, 2017. Note also that the software techniques used for making data aggregated, pseudonymized or anonymized (cf. section 5) can be quite different in nature; this is not discussed in this paper

- *Balancing societal objectives*: Policy makers wanting to encourage the development of demand response markets will need to strike an appropriate balance between consumers' privacy concerns, promoting innovation in demand response markets, and the operational needs of utilities. A key issue is whether regulation should take an opt-in or an opt-out approach to customer authorization. Opt-in programs provide maximum protection and require affirmative customer authorization for certain data to be shared. Opt-out programs, on the other hand, are more likely to favor mass participation in demand response markets. In reality, customers could be given a range of confidentiality options.

The main EU law related to collection and handling of data in the EU is the General Data Protection Regulation (GDPR),[62] which was adopted in 2016 and came into full force in May 2018. It establishes an updated framework for personal data protection in the European Union. The GDPR requires data privacy and customer consent for any data collection or use to be designed into all business processes for products and services, including where foreign-based companies collect or process the data of EU residents. All data breaches must be reported to the relevant national authorities. A principle of "data portability" establishes a right to transfer personal data from one service provider to another. The GDPR means significant changes to business practices for many companies, also for the energy sector. It strengthens the consumer perspective in several ways, compared to previous rules including:[63] privacy policies will have to be written in a clear, straightforward language; the user will need to give an affirmative consent before his/her data can be used by a business; businesses will be able to collect and process data only for a well-defined purpose; business will also have to inform the user about new purposes for processing, and whether a decision affecting the user is automated through algorithms and give him/her a possibility to contest it; businesses will have to inform users without delay in case of harmful data breaches, and; the user will be able to move his/her data, for instance to another social media platform.

There are also rules on users' rights to access data on them, and rules on when a 'right to be forgotten' may apply. Furthermore, the GDPR has more stringent rules on compliance and penalties for non-compliance than previous rules. More details on GDPR in relation to data collection and use will be provided in Section 5.

Apart from EU rules, there are national rules of relevance for data collection, handling and use. Several interesting legal issues can arise in relation to different legal fields, including:

- Even if the GDPR protects fundamental rights and freedoms of natural persons, and in particular their right to the protection of personal data, it does not primarily relate to persons as consumers according to consumer law and contract law.[64] Consumers may

[62] Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation).
[63] European Commission. (n.d.). A new era for data protection in the EU. What changes after May 2018. Factsheet.
[64] Consumer laws and contract law in EU member states are regulated through a mix of EU rules and national rules and practices.

in the context of business relations agree to share their data with corporations, for specific purposes. This can be understood as a contractual relationship. If the collection and use of consumer data is not clearly communicated to the users, but can be considered 'implicit', the issue becomes more legally complex.[65]

- Furthermore, national rules on fair marketing practices can also affect the allowance of collecting and using consumer data.[66] In some cases, such practices can be 'unfair marketing' practices, or be performed in a way that mislead consumers. In some national marketing rules, there may also be a clause referring to other relevant rules, which may include GDPR-related ones. In that case, contacts that breach GDPR rules may be unlawful. In Sweden, there is currently very limited case law that can provide guidance for actors in these matters.[67]

- In some countries there may be specific rules that are important. In Sweden, the principle of public access to official records (offentlighetsprincipen) means that there is a fundamental right for all citizens to access public documents – also documents containing specific data on individuals; this is regulated in the Swedish Freedom of the Press Act.[68] Since the Act is part of the Constitutional framework, it has precedence over GDPR. The main rule is that all public documents are public and can be obtained by anyone if demanded, unless the information is secret according to law. The exceptions to public access are written in the Public and Privacy Act.[69] As many energy suppliers and DSOs are publicly owned corporation in Sweden (often owned by municipalities) the general rules on public access applies to them.[70] This means that all data concerning the customers can be obtained by anyone, unless the data is considered secret, according to the Public and Privacy Act. A recent judgement by an administrative appeal court in Sweden did not rule the data concerning individual clients as secret by law, and ordered an energy company to reveal the demanded data on payments, energy use, among other things. The court pointed out that the main purpose of the provision in question is to protect the business partners of the authorities, which a private person (individual) was not considered to constitute.[71] However, the purpose of the person who demanded to obtain the data is of great importance, since there is another provision in the Public and Privacy Act, saying that privacy applies to personal data, if it is assumed that the post-delivery task will be in violation of the GDPR – that is: there is good reason to suspect that the receiver of the data will use the data in violation of the GDPR.[72]

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[65] Larsson, S. and J. Ledendal. (2017). Personuppgifter som betalningsmedel. Rapport 2017:4. Swedish Consumer Agency.
[66] Ibid.
[67] Ibid.
[68] Tryckfrihetsförordningen (1949:105), second chapter.
[69] Offentlighets- och sekretesslagen (2009:400).
[70] Ibid, 2nd chapter 3 §.
[71] Judgement case no 3504-17, by the Administrative Court of Appeal (Kammarrätten) in Jönköping: The law on business secrecy in public organizations does not protect the individual customer of a municipal energy company from public access to his or hers data, as he or she could not be considered as have "... entered into a business relationship ..." with the company in the manner required to be protected by the confidentiality of Ch 31 Paragraph 16 of the Public and Privacy Act.
[72] Chapter 21 paragraph 7 of the Public and Privacy Act. See judgement by the Administrative High Court HFD 2014 ref. 66, and the proposal of the law: Proposition 2017/18:105 Ny dataskyddslag, pages 135 and 210.

- Of course, there are specific provisions concerning secrecy of personal data concerning healthcare and social services, crime prevention, etc. Concerning energy consumers that are not private persons, the provision of secrecy does not prevent access to information on energy delivery, as long as the information cannot reveal individual customers' data. Drawing conclusions from a judgement concerning secrecy provisions om Statistics in Chapter 24, Section 8 of the Public and Privacy Act: A cell must contain at least three objects, none of the objects can alone contribute > 50% of the total value and two objects may not contribute > 50% of the total. The purpose is to protect against the disclosure of individual customers, such as energy use. Thus, single company use of energy is protected data, but not data concerning groups of non-identifiable companies.[73]

Apart from legal provisions, other guidelines for handling data in smart grid projects exist. Most notably, the CEER guidelines[74] have had a large influence on ongoing smart electricity grid projects; for instance that consumers should have control over their data unless its required for grind functioning and vital functions. For instance, in one project related to a development of a local grid and market hub (gm-hub), it was stated that:[75] "*Consumers have full control over the access to their customer meter data, i.e. choose the way in which their metering data shall be used and by whom. The exception is technical data for grid management, which is controlled by the DSO to fulfil regulated duties, and consumption data for the consumer's retailer that is essential for electricity billing.*"

4. The Swedish Energy system

4.1 Climate and renewables policies

Through the introduction of a new climate framework in 2017 – with targets to 2030/2040 /2050, a Climate Act, and a Climate Council – Sweden has communicated that the national climate agenda is very ambitious. In order to reach set targets however, new policies are required, not least in the transport sector.

While there is a shared vision in Sweden, and some agreement among political parties, about the progressive climate ambitions, the need for more renewables and electric cars, and a development moving towards a smart electricity grid, there is less agreement on how to develop energy markets, the role of different policies (e.g. taxes) and the role different actors has in the transition. The Swedish Energy Agency has published a report outlining four different paths for the future.[76]

Sweden has a large share of renewables (mainly hydro, biomass and wind) and nuclear in the energy mix, and a high share of district heating for heating purposes. The main fuels used in the district heating system are bio fuels and waste. The main recent policies driving the uptake of renewables in Sweden include the carbon tax, the green certificate scheme (the scheme

[73] See SCB manual: Handbok i statistisk röjandekontroll, Sveriges officiella statistik, and judgement by the Administrative Court of Appeal in Stockholm, KamR Sthlm 2014-07-10, 1031-14.
[74] Most notably CEER. (2015). CEER Advice on Customer Data Management for Better Retail Market Functioning. Electricity and Gas.
[75] Bessa, R. et al. (2018). Grid and market hub: empowering local energy communities in INTEGRID. Proceedings from CIRED Workshop - Ljubljana, 7-8 June 2018.
[76] Energimyndigheten. (2016). Fyra framtider. Energisystemet efter 2020. Rapport.

applies to main producers and users of energy; the system is a joint initiative between Sweden and Norway), building codes, and to some extent the EU-ETS. These policies have been combined with policies that support biogas, public procurement, investment support programs for renewables, subsidy schemes for heat pumps and solar PVs, energy efficiency programs for industries, and information measures. The green certificate scheme has directed investments to the most cost-effective renewables, and therefore there is very little installed solar PV capacity in Sweden. Generally, the Swedish system has prioritized large actors, and this in combination with low energy prices means that there is limited prosumer activity. Recently, a Commission was appointed by the Swedish government; the Commission's task is to analyze the existing barriers for small actors that want to participate in electricity markets by undertaking actions for energy efficiency, energy production and energy storage.[77]

For households, initial subsides and low electricity prices have led to a strong, continuous uptake of heat pumps. These are mainly applied in smaller houses, but there is increasing interest in using heat pumps also in industry and in larger buildings. Whether district heating or heat pumps is the most cost-effective heating solution for a given building tends to depend upon several factors, most notably whether district heating infrastructure is in place at the location, the price of district heating in the city, and the pricing scheme[78] applied for district heating.[79]

A limited number of Swedish households have been interested in solar PVs, due to inter alia the lack of supporting polices, limited subsidies, and the low price of electricity[80] in Sweden. This is however changing, both because recent rule changes have provided tax reliefs and other support to micro producers, due to increasing subsidies for solar in households, and due to the rapid cost reductions for solar installations. Also, municipalities – mainly because of changes in cost for solar PVs and increasing public resistance towards wind power installations – are increasingly interested in solar PV installations. Several municipally owned energy companies are offering electricity from solar to consumers, and there is also an increasing number of solar parks where municipal companies – often in cooperation with other actors – offer households and companies the chance to invest in the own solar PVs through buying shares in the parks.

Sweden appointed an Energy Commission in 2015 where that major political parties could negotiate a joint vision for the future Swedish Energy system. The Commission has concluded that more micro production of electricity from small actors is required in order to realize the vision, as well as more elaborate energy transfer systems with elements of digitalization (i.e. smart grids).[81] The Swedish government has also stated that small actors like households,

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[77] Regeringens Kommittédirektiv 2017:77 Utredning om hinder för energieffektivisering och småskalig elproduktion och lagring för mindre aktörer.

[78] For instance, whether pricing is subject to seasonal changes, and whether the price is related to kWh delivered of the effect.

[79] Cf. Energimyndigheten. (2015). Värmepumparnas roll på uppvärmningsmarknaden Utveckling och konkurrens i ett föränderligt energisystem. ER 2015:09: Swedish Energy Agency, Stockholm.

[80] In fact, staff at energy suppliers that we have talked to state that many Swedish households are uninterested in their energy bills, and that they do not change contracts even when the suppliers offer better deals and state this on the bills sent to the consumers.

[81] See Regeringens Dir. 2017:77 and the reports at http://www.energikommissionen.se/.

farmers and private housing cooperatives must be provided with more incentives to take part in the energy transition. [82]

4.2 The Swedish markets for electricity and district heating

The Swedish electricity market is deregulated since 1996, and grid owners are not allowed to sell electricity, forcing companies to split their operations into grid ownership (distribution system operators, DSOs), and sales of electricity. [83] Many local energy companies –which had both grid ownership and energy production operations - where previously owned by municipalities. Today, some Swedish municipalities have kept ownerships over these operations, whereas some municipalities have sold off these operations to larger energy companies such as Fortum, EON and Vattenfall.

The market for electricity is completely deregulated and consumers can choose supplier freely.[84] The local grid is a so-called natural monopoly, but the prices set by grid owners are monitored by the Swedish Energy Markets Inspectorate (Energimarknadsinspektionen, Ei).

The Swedish district heating grids are however not deregulated to the same extent as the electricity grids. It is more complicated to open up these grids for different suppliers, and there are benefits with having integrated operations where the same company owns both the district heating grid and the production facilities. The district heating grids are natural monopolies where one company can usually produce heat at lower costs that if several companies are involved in the production. However, often actors with available waste heat (e.g. industries) are allowed to export their waste heat to local grids. Legislative proposals to mandate the grid owner to allow such access has however not been turned into binding law due to the various complexities involved. The heat sources in the Swedish district heating grids are primarily renewables, waste, and industrial waste heat.[85] Waste heat that are used in district heating grids in Sweden are exempt from energy tax. Instead, the tax is paid at the consumption stage.

4.3 Local energy initiatives

It is crucial to involve the regional and local levels in the necessary energy transition. The local level is critical as a lot of community planning, and infrastructure investments (energy, water and waste), happens at the city level.

Many Swedish municipalities have large ambitions in the climate area. In order to achieve these goals, a large number of climate initiatives and instruments have been initiated. Examples include:

- Smart grids: Several municipalities work with smart grid projects, [86] often in connection with the development of new urban areas, and often in cooperation with energy companies, property owners and users, who are able to test new solutions. In new neighborhoods, smart networks are often included as part of a larger 'package', which may include, for example, smart transport, sharing of resources, urban farming, etc. Projects are also under way or planned which will test synergies between different

[82] Regeringens Kommittédirektiv 2017:77 Utredning om hinder för energieffektivisering och småskalig elproduktion och lagring för mindre aktörer.
[83] As stated in 3 kap 1a§ ellagen (1997:857) (The Electricity Act).
[84] This is regulated in Chapter 11 kap ellagen (1997:857) (The Electricity Act).
[85] Svensk Fjärrvärme 2015-08-31, remissvar över Förslag till svensk tillämpning av nära-nollenergibyggnader (dnr 2015/2507/Ee)
[86] For example see http://www.swedishsmartgrid.se/projekt-och-resultat/projekt-inom-smarta-elnat/

types of energy such as electricity and district heating) and if these grids can be optimized in a coordinated manner, as well as how peak loads can be removed by, for example, energy storage in real estate.

- Low temperature district heating grids (see below*)*

- Support households' installation of solar PVs, e.g. through reduced red tape and better targeted information; or households' investment in solar PVs by offering solar electricity through municipal energy companies, or offering shares in solar parks.

4.4 Developments in Swedish grids for district heating

The district heating systems in Sweden face several challenges.[87] Deliveries to connected buildings are likely to shrink in the future due to expected energy efficiency improvements, while the possibility of establishing new connections is limited due to a saturated market and because access to today's dominant fuels - biomass and waste - may become limited in the future. Competition from heat pumps is also fierce.

Gadd and Werner[88] argue that there are two main ways to maintain the competitiveness of district heating in the future. One is to find other heat requirements, such as industrial needs. The second is to increase the system efficiency in district heating systems. Traditionally, the district heating system consists of three parts: production, distribution and district heating; but since the secondary systems of the buildings set boundary conditions for overall efficiency, they must also be included in optimization, from a system efficiency perspective. The product heat is not delivered until it has resulted in space and water heating, and therefore it should also include customer facilities and district heating systems in the optimization of the systems. This has been going on for many years in many district heating companies and is often referred to as 'energy services'.

Further, the temperatures in today's district heating system are about 15 ° C higher than they are theoretically supposed to be. An important reason for the current temperature is to compensate for quality faults in district heating and secondary systems. Future district heating systems are expected to have significantly lower distribution temperatures. Then the possibility of compensating errors with an increased temperature will not be possible, and therefore quality defects must be identified and remedied quickly.

A challenge is that while district heating networks are quite homogeneous from a thermal perspective, the connected buildings are heterogeneous. A correct heat flow pattern for one building is wrong for another. This is due to behavior patterns, but also because the secondary systems – i.e. the technical installations for heating, ventilation and hot water in the buildings - look different. In a measurement project, it was found that approximately 75 percent of all Swedish buildings' heat load has some kind of quality fault and that there are errors in approximately 6 percent of all district heating plants annually.[89] Then, it is necessary to have knowledge of each individual building's conditions in terms of activity and secondary systems. Further, errors appeared to be random and occur without patterns. In the analyzed district heating plants, all types of errors have been identified in all building categories. This in combination with the fact that heat flow patterns are individual makes the possibility of

[87] Gadd, H. and S. Werner.(2015). Framtida värmebehov, etapp två. Rapport 2015:107. Fjärrsyn/Energiforsk.
[88] Ibid.
[89] Ibid.

predicting faults difficult, if not impossible. In order to identify errors quickly, continuous monitoring must be introduced in combination with increased knowledge of the respective customer. For example, it would make it possible for service visits to be more demand-driven and not calendar-controlled as is commonplace today.

Despite the challenges for district heating, there is optimism that the heat grids can survive and prosper. A lot of expectations are connected to the development of the 'fourth generation' of district heating. The concept has no agreed definition, but there is some agreement that it entails:[90]

- Reduced network temperatures, which provide greater potential for integration of renewable energy sources - such as solar and geothermal energy - and different forms of residual heat with different temperatures, for example from industrial processes. It also allows for more efficient energy conversion in most production teams - such as cogeneration plants, flue gas condensation boilers and heat pumps - and lower losses in heat storage and distribution. Lower temperatures can also allow the use of cheaper pipe materials.

- A system where you can optimize energy use, increase flexibility and reduce power peaks by integrating grids for electricity, district heating and remote cooling. Heat pumps can also be used in such a system; for example, they can be used to produce heat when the electricity price is low or when the thermal heat production is disturbed. In such a system you can also store heat, electricity, etc. in buildings. A prosumer can partly produce his/her own heat through, for example, heat pumps and store any surplus heat in the district heating network; and then buy heat when required.

Currently, several new low-temperature networks are being built, for example, in the new city district of Brunnshög, City of Lund, where there is a lot of excess heat available from industries and research facilities. In these cases, you can already build networks adapted for lower temperatures. However, it is also possible to lower the temperature in existing networks, as well as linking district heating networks with different temperatures.

The new district heating networks raise a number of legal issues. These include the following:

Health issues: low temperature grids can increase the risk for increased growth of legionella bacteria. The Swedish building codes state that the water coming out of the tap shall be between 50 and 60 degrees Celsius.[91] It is possible to comply with these rules also in low temperature grids but this requires proper technical solutions and maintenance. There are also regulations on maintainance for the purpose of reducing the risk of health risks, for example legionella in water grids.[92]

- *Integration of grids*: The electricity market is deregulated, and all suppliers can sell electricity in the grids. This does not however apply to district heating; the same

[90] Lauenburg, P. (2014). Teknik och forskningsöversikt över fjärde generationens fjärrvärmeteknik. Lunds universitet; Olin, M. (2017). Smarta nät mer än el. Second Opinion web;
[91] BFS 2011:6 (BBR) 6:621.
[92] Paragraph 33 of the Regulation on environment and health (SFS 1998:899), on self-regulation in Chapter 26 19 paragraph of the Environmental Code and advisory regulations by the Public Health Agency of Sweden.

company who owns the grid tend to produce the heat, and all potential heat suppliers do not have right to use the grid. Often, the same company owns the grids (i.e. is the DSO) for both electricity (and increasingly, also district cooling). We will have a situation when an energy form that is deregulated is to interact with an energy form that is not. Furthermore, prosumers - which may include homeowners but also owners of multi-family houses and other facilities, and housing associations - may feed electricity into the grid through solar cells and feed heat into the district heating network through heat pumps. At the same time, other operators should be able to use the electricity grid to sell different energy services (storage, aggregation, etc.), while this may not be the case in the heating and cooling grids. Obviously, much work will be required about regulations and contracts in the future if the integration of grids is to be realized in practice. The fact that grids for cooling and natural gas can also be integrated adds to the complexities.

- *User data*: The integration of grids means that user data are required, potentially for several grids, and most importantly: the data from several grids may need to be analyzed together, which increases the likelihood that data contains sensitive information. In reality, within the first phases of smart grid projects the households/ tenants will have access to electricity-related services, while it will primarily be the owners of the large buildings who will have access to smart solutions for water and heat. Thus, in many cases information about heat/cooling will not relate to individual tenants/households, making it less concerning from a privacy perspective. But if grids become increasingly sophisticated, also here we will have more and more issues to deal with.

5. The use of data in existing district heating grids

We will now discuss one very specific aspect of data collection, which is of great practical importance for local energy companies: user data in existing heating grids.

5.1 Purposes of data collection and legal implications

At the moment several local grid owners in Sweden and Denmark are looking into the opportunities to lower the temperature in existing grids. Lower temperatures have several benefits (see previous section), and most notably it will reduce heat losses in the pipes. In order to evaluate the potential, a lot of data from geographical locations in the grids are required. This includes data from multi-story buildings, but in some cases also data from family houses (single dwelling buildings). In many cases universities do the modelling/ analytics, using data supplied to them by the DSOs. The outcome is inter alia a self-calibrating model for the district heating network that can indicate the potential for lowering temperatures in existing grids, and show where there may be a need to upgrade the network.

Data from family houses can be important for several reasons. For instance, when the grid temperature is lowered this improves the overall performance of the grid, but it is possible that some consumers do not get the heat required at certain times of the year. The DSO can then support these consumers through adding heat pumps instead.

The DSOs need to consider the privacy issues before handing out data to the universities. It may be possible to 'anonymize' the data before handing it over to universities, which would mean that there is no risk of breaches of privacy.[93] In that case GDPR (see below) does not apply. For data to be truly anonymized however, the anonymization must be irreversible. This may not be desirable in this case, as the DSO may want to actually be able to analyze the user data and collect it to personal data (most notably in this case, the specific location of users – including houses – in the grids) in the future. Then they may instead pseudonymize the data before handing it over to universities. According to article 4 in GDPR: "*pseudonymisation' means the processing of personal data in such a manner that the personal data can no longer be attributed to a specific data subject without the use of additional information, provided that such additional information is kept separately and is subject to technical and organisational measures to ensure that the personal data are not attributed to an identified or identifiable natural person*;"

This would mean that the data can later be combined with data on location etc.

Pseudonimyzation can be reversed, a process referred to as de-identification. This can be done e.g. through using a de-identification key. Such de-identification may be necessary once the modelling and analytics are completed, and the DSO considers options for lowering the temperatures in the grid, and how this affects various users in the grid. But then this should be done by the DSO using appropriate safeguards.

Personal data that has been encrypted or pseudonymised but can be used to re-identify a person however remains personal data and falls within the scope of the GDPR.

5.2 Legal issues to consider when handling data

In order to obtain input from relevant stakeholders, a group discussion with staff at a regional energy company was held in April 2018. The main purpose was to discuss requirements related to the GDPR, and the potential to collect and use data from the district heating system. In addition, two semi-structured interviews with experts on IT law took place in August 2018, to obtain more in-depth views on the legal issues to consider when collecting this data. The main takeaways from these discussions were:

- The actual collection of the data is no problem from a legal perspective; it can be justified both as a general interest and as a way to improve consumer offerings (see below). The key is to consider which data that is needed and why; data that is not needed should not be collected.
- The data from single dwellings should preferably be pseudonymised before processed. While the data as such is not very sensitive, all data that connects user patterns to location has the potential to be misused.
- Users should be informed about the data collection, and its uses. Today, it is common that consumers receive too much information, which is in itself a breach of the principles of the GDPR as it makes data inaccessible and non-transparent.[94] Thus, short and concise information should be provided. Further, a common mistake today is that consumers are provided with information on all kinds of potential future uses of

[93] For more information about pseudonymizing and anonymization see e g https://ec.europa.eu/info/law/law-topic/data-protection/reform/what-personal-data_en ; https://gdpr.report/news/2017/11/07/data-masking-anonymisation-pseudonymisation/

[94] In Art 12 GDPR it is stated that information should be provided "…in a concise, transparent, intelligible and easily accessible form, using clear and plain language…".

data. They should only be informed about actual planned use of the collected data at this point in time.

The main legal issues of concern related to the GDPR are outlined in the table below. The rules outlined in the table or not the only relevant GDPR rules, but the ones most important to consider.

Clearly, it should be allowed for the DSO to collect this type of data, but they need to consider how it is stored and used, and ensure pseudonimyzation especially when the data is used by 3rd parties for e.g. modelling and analytical processing.

Issues in GDPR	**Examples of requirements in legal text**	**Main implications when collection and handling user data**
Art. 5 Principles relating to processing of personal data	Data shall be collected for specified, explicit and legitimate purposes Data collection shall be limited to what is necessary in relation to the purposes for which they are processed ('data minimisation'); Data shall be kept in a form which permits identification of data subjects for no longer than is necessary for the purposes for which the personal data are processed Data must be processed in a manner that ensures appropriate security of the personal data, including protection against unauthorised or unlawful processing	The grid owner should not collect more data than necessary. Caution should be taken regarding how data is stored and processed. Measures should be taken so that data is not spread between the corporation's different platforms and registers.
Art 6 Lawfulness of processing	Processing shall be lawful only if and to the extent that at least one of the following applies: … processing is necessary for the performance of a contract to which the data subject is party or in order to take steps at the request of the data subject prior to entering into a contract; processing is necessary for compliance with a legal obligation to which the controller is subject; processing is necessary in order to protect the vital interests of the data subject or of another natural person; processing is necessary for the performance of a task carried out in the public interest or in the exercise of official authority vested in the controller; processing is necessary for the purposes of the legitimate interests pursued by the controller or by a third party…	The collection of user data in heating grids should be lawful both because it relates to a public interest (grid optimization and climate change objectives) and legitimate interests, but also because it aims to improve the customer offerings, and can be tied to the contractual relationship.
Pseudonymisation (definition in Art 4) (relevant for 'lawful processing' in Art 6)	Art 4, definition: 'pseudonymisation' means the processing of personal data in such a manner that the personal data can no longer be attributed to a specific data subject without the use of additional information, provided that such additional information is kept separately and is subject to technical and organisational measures to ensure that the personal data are not attributed to an identified or identifiable natural person	The company can use several techniques to pseudonymize data. For instance, data on energy use and geographical location can be kept separately. Most importantly, in cases where external parties (e g universities) does the modelling and analytics of data, the corporation should ensure

	Art 6: … the controller shall, in order to ascertain whether processing for another purpose is compatible with the purpose for which the personal data are initially collected, take into account, inter alia: … the existence of appropriate safeguards, which may include encryption or pseudonymisation.	that the external parties receive data on grid temperatures and anonymized user data. Thus, the energy use at certain locations shall not be processed together with user data on the same location.

Table 5. GDPR rules and collection of district heating data

There are also national rules of relevance. For instance, DSOs owned by municipalities must adhere to the principle of public access to official records (see section 3 above). Therefore, there could be reason to consider if private users' energy data needs special integrity protection in law.[95]

The aspect of integrity protection is also discussed in every proposal of law concerning the energy grids of the future. One example is discussions on forthcoming regulations on smart meters. Electricity meters are important in the development of smart grids. For DSOs, smart meters collecting of data can contribute to a more efficient network operation, decreased energy usage and improved possibilities for integration of micro production. Smart meters can also provide consumers with more detailed information about their energy consumption, providing possibilities for a more flexible use of energy and lower costs. Within the next few years, many of the current electricity meters in Sweden will be replaced, as they have reached the end of their economic lifespan. In November 2017, the Swedish Energy Markets Inspectorate (Ei) proposed to the Government new rules concerning minimum functional requirements for smart meters, based on the functionalities that Ei recommended previously.[96] After public consultation of the report, the referred authorities emphasized the need of protection of consumer data for integrity purposes and suggested a closer investigation on the matter – also suggesting exemptions for Swedish Security Services, the military, and similar public organizations.[97]

6. Concluding remarks

Technological development and an environmentally optimal energy system require ever-increasing amounts of privacy-sensitive data that must be protected as far as possible, while the laws on energy are based on the political view that competition and free access to data is paramount to promote the Internal Markets for energy and IT services. Obviously, it is a huge challenge for legislators and practitioners to sew this gigantic patchwork of rules and policy areas together. If the future power grids will be able to receive and deliver energy just in time, while integrating various different energy grids and optimize the system, simultaneously

[95] Cf. Judgement case no 3504-17, by the Administrative Court of Appeal (Kammarrätten) in Jönköping.

[96] Funktionskrav på elmätare – Författningsförslag, Energimarknadsinspektionens rapport Ei R2017:o8, Funktionskrav på elmätare (M20i7/02657/Ee) Funktionskrav på framtidens elmätare (Ei R2015:09)

[97] See for example the statement of opinion from the consultatives E.On Sverige AB, The Swedish Data Protection Authority (Datainspektionen) and Svenska Kraftnät (the authority responsible for ensuring the functionality of Sweden's transmission system).

managing to deal with huge amounts of personal data in an appropriate manner, many things need to be sorted out.

Generally, there is reason to be critical of the visions of an integrated grid, and more generally, how digitalization as a concept is perceived in the context of smart grids and smart cities.[98] Some people in the energy sectors have doubts that the grand visions for a smart grid for electricity will ever become reality. Furthermore, there can be reason to question if the current visions of smart grids constitute truly 'sustainable grids'? Maybe the current visions are based in a paradigm mixing scientific innovations, efficiency and markets whereas alternatives are possible.[99]

In this paper we have discussed the legal issues related to data management in smart grids. A main conclusion is that the rules are quite complex, and that DSOs will face many complex issues in the near future that needs to be resolved, for instance regarding data pseudonymisation when data is used for various purposes. In the case examined on district heating data, we found that both EU rules (most notably the GDPR) and national rules are relevant to consider.

Obviously, there are many avenues for further research, including:

- How do the potential integration of different power grids affect data management, and will new rules be required to handle such systems?
- How will the potential integration of large buildings – e.g. as producers and accumulators of energy – in future energy systems affect data management solutions?
- How shall we deal with data regulations micro grids, off-grids and other emerging solutions?

7. Keyword set

Energy Distribution, Energy Policy, Heat Innovation, Smart Energy

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[98] For a critique of the digitalization discourse in smart cities, see Granath, M. (2016). The Smart City – how smart can 'IT' be? Discourses on digitalization in policy and planning of urban development. Doctoral dissertation, Linköping University.

[99] For a discussion on this see Gellert, R. (2015). Redefying the smart grids' smartness: or why it is impossible to adequately address their risks to privacy and data protection if their environmental dimension is overlooked. Journal of Law, Information and Science 24(1), 34-55. For a discussion on alternative electricity futures see e.g. Hojčková, K. et al. (2018). Three electricity futures: Monitoring the emergence of alternative system architectures. Futures 98 (2018) 72-89.