WORKING PAPER

Smart metering interoperability issues and solutions: taking inspiration from other ecosystems and sectors

Valerie Reif and Leonardo Meeus

European University Institute

Robert Schuman Centre for Advanced Studies

Florence School of Regulation

Smart metering interoperability issues and solutions: taking inspiration from other ecosystems and sectors

Valerie Reif and Leonardo Meeus

Robert Schuman Centre for Advanced Studies

The Robert Schuman Centre for Advanced Studies, created in 1992 and currently directed by Professor Brigid Laffan, aims to develop inter-disciplinary and comparative research on the major issues facing the process of European integration, European societies and Europe's place in 21st century global politics.

The Centre is home to a large post-doctoral programme and hosts major research programmes, projects and data sets, in addition to a range of working groups and *ad hoc* initiatives. The research agenda is organised around a set of core themes and is continuously evolving, reflecting the changing agenda of European integration, the expanding membership of the European Union, developments in Europe's neighbourhood and the wider world.

For more information: http://eui.eu/rscas

The EUI and the RSC are not responsible for the opinion expressed by the author(s).

The **Florence School of Regulation - FSR Energy & Climate** is a centre of excellence for applied research, policy dialogue and executive training, with the purpose to enhance economically and socially sound energy and climate regulation in Europe and worldwide.

Founded in 2004 by three European regulators in the energy sector, the FSR has been providing a unique forum where regulators, utilities, policy-makers and academics meet, discuss and get trained.

The FSR sits as a programme of the Robert Schuman Centre for Advanced Studies of the European University Institute in Florence, Europe's intergovernmental institution for doctoral and postdoctoral studies and research.

Florence School of Regulation - European University Institute
Via Boccaccio 121,
I-50133 Florence, Italy
FSR.Secretariat@eui.eu

+39 055 4685 878

Abstract

Interoperability in the context of smart electricity metering is high on the European policy agenda but its essence has been challenging to capture. In this paper, we look at experiences in other ecosystems (electromobility and buildings), other sectors (healthcare and public administration) and at the national level (the Netherlands and the UK). We show that the definition of interoperability depends on the context, that there are common solutions to different issues across sectors and that cross-sectoral factors must be increasingly considered. We recommend adopting a broader view in smart metering that goes beyond the interoperability of devices, considering solutions that have worked in other sectors and exploiting synergies across sectors. Our analysis of experiences provides a comparison that can help to move the debate at the EU level forward.

Keywords

1. Introduction[*]

Interoperability of energy services in the context of smart metering was recognised in the Clean Energy for all Europeans Package (CEP) as a prerequisite for customer empowerment and to promote competition in national electricity retail markets.[1] More recently, the Energy System Integration Strategy and the European Data Strategy have respectively reaffirmed the importance of interoperability for a future decarbonised and integrated energy system and a European single market for data that fosters data-driven innovation (European Commission, 2020a, 2020b). The three aims are intertwined as innovative energy services can come from other ecosystems closely related to smart metering such as electromobility and buildings, and the data relevant for the creation of such services needs to be accessible by eligible parties.

The CEP requires Member States to facilitate the full interoperability of energy services within the Union. To this end, the European Commission is enabled to adopt implementing acts laying down interoperability requirements and non-discriminatory and transparent procedures for access to (smart) metering and consumption data and the data required for customer switching, demand response and other services.[2] These implementing acts not only have a sector-specific role to strengthen the internal energy market but are also likely to have a cross-sectoral enabling function to create a citizen-centred integrated energy system and contribute to the decarbonisation goal of the Green Deal. Moreover, the acts are important for the development of an EU-wide common interoperable data space for energy to overcome legal and technical barriers to data sharing among organisations.

In this paper, we show what interoperability means and how it can be approached to achieve these aims. Since the electricity sector is not the only one that is dealing with interoperability questions, we were inspired to look at experiences in other ecosystems, other sectors and at the national level to identify issues and solutions that can help move the debate at the EU level forward.

The contributions of this paper are threefold. First, using examples from the smart electricity metering, electromobility and buildings ecosystems, we show that interoperability has different meanings depending on the context. To this end, we refer to van der Kam and Bekkers (2020) for electromobility and Eastman et al. (2008) for buildings. We chose these ecosystems because electric vehicles (EVs) and buildings can, via smart metering, provide services that support a flexible decarbonised integrated energy system. In other words, the smart meter acts as the gateway for the active consumer who lives in or owns a building, owns an EV and offers the flexibility of these assets to the energy system.[3]

Second, in the examples of smart electricity metering and the healthcare and public administration sectors we show that, although the specific interoperability issues may be

[1] A definition of energy services is provided in Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC (European Parliament and Council, 2012).

[2] See Articles 23 'Data management' and 24 'Interoperability requirements and procedures for access to data' of Directive (EU) 2019/944 of the European Parliament and of the Council of 5 July 2019 on common rules for the internal market for electricity and amending Directive 2012/27/EU (recast) (European Parliament and Council, 2019).

[3] There are also other ecosystems that can contribute to a decarbonised integrated energy system through the provision of energy services via smart metering, for example, the industry or (smart) electrical home appliances.

different, there are similar solutions that have been applied. We chose the latter sectors because, like the electricity sector, they are transforming into more citizen-centred data-driven sectors. All three sectors seek to overcome traditional data silos and fragmented information and communication technology (ICT) landscapes to enable cross-organisation, cross-sector and cross-border data sharing. The experiences in these sectors have been documented by several authors, whom we refer to in this paper. For the electricity sector, we rely on Schütz et al. (2021), who compare different methods for achieving interoperability in the energy sector, Gopstein et al. (2021), who focus on smart grid interoperability standards, and Papaioannou et al. (2018), who developed a method for interoperability profiling and testing. For the public administration sector, we refer to Wimmer et al. (2018), who review interoperability governance models at the EU and national levels in the public administration and healthcare sectors, and Gottschalk (2009), who proposes a maturity model for interoperability in digital government. For the healthcare sector, we refer to Kouroubali and Katehakis (2019), who discuss the interoperability frameworks used in the sector, and Noumeir (2008), who discusses a method for implementing and testing standards-based interoperability in healthcare. Finally, we were inspired by Gottschalk et al. (2018), who provide a proof of concept for transferring this method from the healthcare to the electricity sector.

Third, using the national examples of the Netherlands and the UK, we observe that interoperability is increasingly becoming a cross-sectoral topic. We picked these experiences because they are the only countries that we found to have recently published dedicated high-level institutional strategies for cross-sectoral data sharing that are currently being implemented. These developments are so recent that we have not been able to find publications that document these experiences, so we have relied on publicly available information and experts that are close to these developments.

The remainder of the paper is structured as follows. Sections 2 to 4 cover the three contributions, section 5 provides a discussion and section 6 concludes the paper.

2. How interoperability is defined depends on the context (smart metering, electromobility, buildings)

Interoperability is not only challenging to pronounce; it is also challenging to comprehend as a concept. Many different definitions of it exist, which vary not only across but also within sectors. The eHealth Network (2015) and Gottschalk (2009) explain that a general distinction can be made between a narrow and a broad understanding of interoperability. The former is located at the level of devices and used to describe technical systems. It typically covers interoperability among information and communication technology (ICT) systems. The latter is instead located at the level of organisations and considers that political, legal, regulatory, organisational and social factors influence technical systems and their performance. It takes the view that interoperability among ICT systems enables the interoperability of organisations, which means it enhances the ability of organisations to collaborate more efficiently and effectively.

Table 1: Definitions and scope of interoperability in the contexts of smart electricity metering, electromobility and building information models

In the context of building information models (BIMs), interoperability is the *"ability of BIM tools from different vendors to exchange building model data and operate on that data. Interoperability is a significant requirement for team collaboration."* (Eastman et al., 2008)

"*In the context of EV [electric vehicle] roaming, seamless interoperability means that, ultimately, a user (an EV driver) can charge at any public charge station, regardless of the CPO [charge point operator] of that station and regardless of the MSP [mobility service prover] the user has selected for mobility services and payment.*" (van der Kam and Bekkers, 2020)

In the context of smart metering, interoperability means "*the ability of two or more energy or communication networks, systems, devices, applications or components to interwork to exchange and use information in order to perform required functions.*" (Directive (EU) 2019/944 of the European Parliament and Council (2019)).
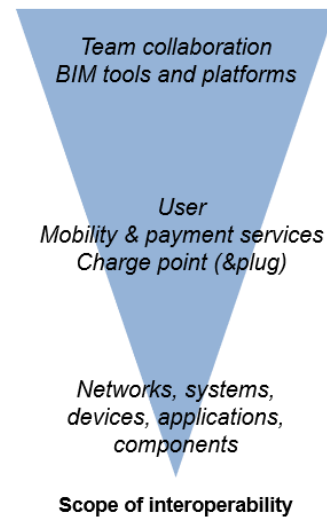
Interoperability definitions are typically context-dependent. Moreover, how a definition is formulated can give hints as to which understanding of interoperability dominates in a certain ecosystem and which issues are perceived to be most pressing.

In the context of smart electricity metering, the definition of interoperability that was introduced in article 2(24) of Directive (EU) 2019/944 takes a narrow view that focuses on the interoperability of devices and their ability to exchange information to perform certain functions, as is shown at the bottom of Table 1. This view may seem logical since smart meters are devices that support the performance of functions such as data collection, sharing etc. Indeed, until recently, the debate was focused on technicalities, for example the data format to apply (SGTF EG1, 2016a) and standards and interfaces for the roll-out of smart metering systems (SGTF EG1, 2016b, 2015). However, metering is also a service that is performed by an organisation and which is required by law and regulation to consider the users' interests and facilitate, for example, switching between suppliers or the provision of demand-side flexibility. Following the adoption of the Clean Energy Package, the focus of the debate switched to 'service provision,' differentiating between traditional retail services (e.g. billing, supplier switching), emerging services based on consensual sharing of historical or near real-time consumption data and future demand response/demand side flexibility services based on real-time data (SGTF EG1, 2019). This brings in interoperability issues and requirements that go beyond the technicalities of information exchange, because there is a need for, *inter alia*, regulatory and legislative alignment, alignment of different business processes (including across borders), agreement on roles and responsibilities, and common solutions for mechanisms such as customer authentication and consent.

In the context of electromobility, van der Kam and Bekkers (2020) present a more differentiated understanding of interoperability, as is shown in the middle of Table 1, namely in terms of the hardware and software that together enable services which are requested (or offered) by users.[4] The authors show that the issues that the EV ecosystem is facing and that hinder seamless interoperability of EV charging infrastructure are related to the interoperability of charge points and plugs, of payment systems and of charge point information exchange systems (van der Kam and Bekkers, 2020). Moreover, the European Commission (2020a) still

---

4   In simple words, EV roaming means that any EV driver can charge at any charging station.

sees large barriers regarding seamless cross-border electromobility, adequate customer information and efficient integration of EVs in the energy system.

In the context of building information models, the perceived scope of interoperability is even broader.[5] As is shown at the top of Table 1, interoperability of digital (building information model) tools and platforms is understood to be an essential prerequisite not only for data to move seamlessly between these tools and platforms but also for the ability of teams to collaborate in pursuit of a commonly defined goal, such as the construction and operation of a building. Interoperability issues in the building ecosystem can be broadly categorised as arising in the planning, construction and operation phases of a building. During the planning and construction phases, issues can arise from a lack of interoperability of intelligent building information systems. During the operation phase, the issue is how to effectively integrate buildings as active participants in the wider energy system. Related issues can also stem from the fragmentation of various certificates such as energy performance or smart readiness certificates and their availability in accessible databases (European Commission, 2020c).

Several of the initiatives that have been published under the umbrella of the EU Green Deal acknowledge that interoperability issues exist within these ecosystems and provide a high-level vision of how to tackle them. For example, the Energy System Integration Strategy (European Commission, 2020a) foresees a Digitalisation of Energy Action Plan that is expected to accelerate the implementation of the common European energy data space by making use of the interoperability requirements and access procedures laid down in the implementing acts. In the electromobility ecosystem, the upcoming revision of Directive 2014/94/EU on the deployment of alternative fuel infrastructure (AFID) is foreseen to strengthen interoperability requirements, ensure adequate customer information, cross-border usability of charging infrastructure and seamless cross-border payments, and increase the deployment of smart charging infrastructure (European Commission, 2020a). In the building ecosystem, the Renovation Wave Initiative aims at deploying digital building logbooks for deep renovations, contemplates the use of the European Building Observatory as a central European repository for available data on buildings and their performance, and suggests updating the Energy Performance Certificates framework by including technical provisions on data formats and access rules (European Commission, 2020c). The Green Deal also aims to accelerate the efficient integration of electric vehicles and buildings in the electricity system. However, concrete solutions to address this aim are lacking.

3. EU-level solutions to interoperability issues in different sectors (smart metering, public administration, healthcare)

In this section, we show which solutions have been applied in sectors that have long-standing experiences with interoperability. The idea is twofold. First, the other sectors have experiences that could inspire the adoption of additional solutions in the context of smart metering. Second, if the three sectors are successful in deploying certain solutions, they could also be applied in a cross-sectoral environment to address the aims of the EU Green Deal.

We have presented the interoperability issues that the electricity sector is facing in the context of smart metering in section 2.

---

[5] A building information model system is used to create, collect and manage data during a building's design, construction and operation phases. It enables real-time collaboration among different teams and crafts by integrating multi-disciplinary data in a detailed digital representation of the building.

In the public administration sector, for more than 20 years the European Commission has been driving interoperability initiatives for the benefit of European citizens and businesses.[6] The motivation is to reduce the risk of Member States opting for incompatible solutions to deliver public services. Therefore, a systematic approach to governing interoperability at the EU level has been deemed important and responsibilities are typically shared between the European Commission and Member States (European Commission, 2017a).

In the healthcare sector, the European Commission has developed targeted policy initiatives to foster the adoption of interoperable eHealth services since the first eHealth Action Plan in 2004.[7] The aim is to enable a seamless exchange of health information across Europe and make dispersed public health data and patient information accessible securely and quickly (European Commission, 2004). In healthcare, a large part of the activities related to interoperability are typically done at the national level, often supported by European networks.

Over the years, many solutions to address interoperability issues have been put in place in the three sectors, as is shown in Table 2. They can be grouped into commonly and individually applied solutions. In what follows, we first describe the solutions that have been commonly applied across the three sectors. Afterwards, we discuss the solutions that have only been applied in individual sectors.

---

[6]   A graphic overview of the EU initiatives concerning interoperability among public administrations is provided in European Commission (2017c).

[7]   eHealth means the "use of ICT in health products, services and processes in combination with organisational change in healthcare systems and new skills. […] eHealth covers the interaction between patients and health-service providers, institution-to-institution transmission of data, or peer-to-peer communication between patients and/or health professionals" (European Commission, 2012).

Table 2: EU-level solutions to interoperability issues in the electricity, public administration and healthcare sectors

Solution	Smart electricity metering	Public administration	Healthcare
Stakeholder engagement activities	• European Technology Platform • European Smart Grids Task Force • Implementing acts following Directive (EU) 2019/944, incl. a potential 'competent authority'	• ISA² committees and working groups	• eHealth Network • eHealth Stakeholder Group and eHealth Task Force
Tools and knowledge sharing	• H2020 BRIDGE initiative (incl. use case repository); Horizon Europe call for an 'Interoperability Community'	• Joinup platform • European Interoperability Reference Architecture and European Interoperability Cartography	• Large-scale European pilot projects (e.g. epSOS, Antilope)
Standardisation initiatives	• European standardisation mandates (e.g. M/490) • CEN-CENELEC-ETSI work (incl. Smart Grid Architecture Model (SGAM))	• Rolling Plan for ICT standardisation	• European standardisation mandates (e.g. M/403) • eHealth standardisation activities
Monitoring and reporting		• Compliance monitoring in the context of ISA² and reporting mechanism for National Interoperability Frameworks (NIFs)	
Interoperability profiling and testing			• *Integrating the Healthcare Enterprise (IHE) process to implement and test standards-based interoperability**

Note that IHE is not an EU-level initiative, but several IHE profiles were recognised by the European Commission to be used in public procurement (European Commission, 2015)

3.1 Solutions that are commonly applied across the sectors

We have identified three types of solutions that have been applied across sectors. The first is stakeholder engagement activities. In the context of smart metering, current engagement activities are mainly carried out in the form of advisory expert groups under the umbrella of the European Smart Grids Task Force, which was created in 2009. Another activity was the establishment of a European Technology Platform for smart grids in 2005 (E.DSO, n.d.). In the

future, centralisation of certain competences for interoperability may take place with the support of the relevant stakeholders in an 'EU competent authority' for interoperability following the adoption of the implementing acts under Directive (EU) 2019/944.

In the public administration sector, financial support for interoperability is provided through the dedicated ISA² funding programme (European Parliament and Council, 2015) and more general funding programmes such as the Connecting Europe Facility (CEF) and the Digital Europe Programme, which are made available to public administrations (European Commission, 2020d). ISA² has its own governance structure including committees and working groups, which also serve as fora for Member States to share their experiences (Wimmer et al., 2018).

In the healthcare sector, Directive 2011/24/EU (European Parliament and Council, 2011) foresaw the creation of a voluntary 'eHealth Network' connecting the national authorities responsible for eHealth. The Network is the main strategic and governance body at the EU level to develop and coordinate common requirements and specifications to improve the cross-border exchange of health data and achieve interoperability between national eHealth systems (European Commission, 2012). Other expert groups working on eHealth are the eHealth Stakeholder Group, first set up in 2012, which includes all European umbrella organisations and associations, and a temporary eHealth Task Force that consists of health care professionals, patient representatives, delegates from the medical, pharmaceutical and ICT industries, legal experts and policymakers (European Commission, 2021a).

The second solution is tools and knowledge sharing. In the electricity sector, much activity has lately come out of European research and innovation projects, notably under the umbrella of the H2020 BRIDGE initiative (BRIDGE, 2020). The working groups of the BRIDGE initiative are also setting up common tools like a repository of use cases that facilitates their re-use in other European projects. The activities coming out of the research and innovation projects may cumulate in the setting up of an 'interoperability community' under the Horizon Europe framework.

In the public administration sector, several tools have been developed to facilitate cooperation among European public administrations as required under the ISA² programme (European Parliament and Council, 2015). One example is the European Interoperability Reference Architecture (EIRA), which defines a set of architectural building blocks needed to build interoperable e-government systems and deliver digital public services across borders and sectors (Joinup, 2021a). Another example is the European Interoperability Cartography, which is a repository of interoperability solutions that are presented in a common format and comply with specific re-usability and interoperability criteria (Joinup, 2019). A third example is the collaborative Joinup platform, which was set up by the European Commission (2021b) to facilitate experience sharing among Member States.

In the healthcare sector, the groundwork for cross-border health data exchange and interoperability together with an extensive exchange of knowledge among Member States has been carried out through large-scale European pilot projects such as epSOS (European Commission, 2021c) and Antilope (Antilope, 2015).

The third solution is standardisation initiatives. These types of solutions are mainly relevant to technical interoperability issues at the level of devices. However, standards can also support the documentation of business processes across organisations in an agreed way with commonly accepted methodologies. In the electricity sector, in 2011 the European Commission issued standardisation mandate M/490 to the European Standardisation Organisations (ESOs) to support European smart grid deployment, which has led to the development of the Smart Grid Architecture Model (SGAM) framework (SGCG, 2012a). The

ESOs also established a working group to address legal propositions that are relevant to standardisation coming out of the Clean Energy Package (CGSEG, 2018).

In the public administration sector, an overview of current priorities for ICT standardisation is provided in the annual Rolling Plan for ICT Standardisation (Joinup, 2021b), which aims to facilitate a convergence of standardisation efforts towards achieving EU policy goals. Note that the Rolling Plan also addresses, among many other things, the eHealth and smart grids/smart metering domains.

In the healthcare sector, in 2007 the European Commission issued European standardisation mandate M/403 to the ESOs. This included a requirement to agree on implementable standards, technical reports, guidelines and methods in the domain of eHealth (European Commission, 2007).[8]

3.2 Solutions that are only applied in individual sectors

We have identified two solutions that have only been applied in one sector. The first is monitoring and reporting. In the public administration sector, activities are mostly carried out at the level of national administrations but are governed and facilitated by European instruments. One reason is that administrative structures have evolved in different ways and responsibilities for setting digital public administration and interoperability policies have been distributed across EU Member States (European Commission, 2020d). A solution that helps to ensure alignment is the European Interoperability Framework (EIF) (European Commission, 2017b, 2010). This framework exists to help raise awareness and to organise concepts and relevant terminology so that interoperability issues can be identified, discussed and prioritised, and to support the identification of key elements for successful implementation (Kouroubali and Katehakis, 2019). The EIF represents the common basis of interoperability policies in Europe, based on which the Member States are required to develop national interoperability frameworks and strategies that they can tailor to their specific needs. A National Interoperability Framework Observatory (NIFO) was set up under the ISA² programme, through which the European Commission monitors, evaluates and reports on the implementation of the EIF in the Member States. More specifically, a monitoring mechanism composed of 68 key performance indicators (KPIs) exists to assess the 47 recommendations in the EIF (European Commission, 2020d). EU Member States (and other European countries) report on the implementation of the EIF via their national interoperability initiatives (NIFO, 2021a). The results are publicly available on annually created digital public administration factsheets (DIGIT, 2020; NIFO, 2021b).

The second solution is interoperability profiling and testing. This activity is related to the use of (communication) standards, which are a fundamental building block for interoperability. However, the selection of the relevant standards and their implementation are not straightforward due to the multitude of existing standards and their rather general nature. One solution is to develop a structured approach to assess and select standards and specifications, evaluate them, monitor their implementation, check compliance and test their interoperability.

---

[8] Generally, the landscape of organisations and projects that are organising activities relevant to standardisation is broad and cannot be captured in this paper. For smart grids, including smart metering, it covers international, European and national standardisation organisations and involves general standardisation bodies like ISO and CEN, electrotechnical standardisation bodies like IEC and CENELEC, and telecommunication standardisation bodies like ITU and ETSI. Moreover, standardisation user groups like the CIM user groups, the UCA user groups, and DLMS-related user groups play an important role. Other relevant parties at the EU level are the industry-led European Technology and Innovation Platforms, the Joint Research Centre, the BRIDGE initiative and the European Commission. For the healthcare sector, an overview of the standardisation landscape is provided in the report on standardisation developments in eHealth by JASEHN (2017).

In healthcare, such a process has been operated by the private non-profit organisation Integrating the Healthcare Enterprise (IHE) for more than 20 years. IHE has been running a harmonised multi-step process on several continents that brings together users and developers of healthcare information technology on a voluntary basis with the aim of achieving interoperability of healthcare systems (IHE, 2019).[9] Noumeir (2008) identifies three main reasons for the success of IHE, namely collaboration between vendors and care providers, the yearly cycle and time constraints that are applied, and the testing process. The approach is based on the development of interoperability profiles ('integration profiles') that each solve a specific integration problem by proposing an integration solution through a combination and restriction of existing standards (Henderson et al., 2001). The European Commission (2015) identified 27 IHE profiles as ICT specifications eligible for referencing in public procurement. Note that the benefits of interoperability profiling and testing have also been recognised in the energy sector (Gopstein et al., 2021; Schütz et al., 2021; SGCG, 2012a, 2012b) and related methods have been researched and demonstrated (Gottschalk et al., 2018; Papaioannou et al., 2018).

4. Interoperability is increasingly becoming a cross-sectoral challenge (national examples)

At the EU level, the debate on interoperability and data sharing is gaining cross-sectoral momentum. It is driven by the vision of an integrated energy system and a European single market for data that the European Commission is working to implement to avoid Member States increasingly legislating on data-related issues in uncoordinated ways. Horizontal governance structures are envisaged to enable a coordinated approach to cross-sectoral data sharing, pooling and use, which are complemented by domain-specific common European data spaces in strategic sectors, including energy, health and public services (European Commission, 2020b).

The concrete implementation ideas at the European level are still vague but could be inspired by initiatives at the national level that are already more advanced. In the following, we illustrate with the examples of the Netherlands and the UK how institutional visions of cross-sectoral interoperability and data sharing are being followed-up with concrete implementation efforts.

4.1 The Netherlands

In the Netherlands, there is a data governance programme to enable energy sector-specific and cross-sectoral data sharing and data-driven services based on three drivers. The first are the requirements of European Directive (EU) 2019/944 regarding customer data management and interoperability. The second is a new Dutch Energy Act that transposes the CEP provision to the national level and takes account of the overall ambition to build a digital economy based on data sharing and re-use (EZK, 2020, 2019). The third is the energy regulator's vision of data governance in the commercial domain, which aims to give consumers control over their measurement data and determines which market parties have access to which measurement data (Autoriteit Consument & Markt, 2019).

Specific organisational structures and processes covering both the cross-sectoral and energy-specific dimensions are planned to be set up. First, the cross-sectoral dimension is

---

[9] To avoid ambiguity, note that IHE is not a standards body and IHE integration profiles are not standards (Channin, 2001). IHE provides a context in which the implementation and testing of standards-based interoperability can be carried out.

covered by the ministry-facilitated collaborative 'data sharing coalition' initiative. This aims to enable cross-sector and cross-domain data sharing and re-use by combining existing and new sector-specific data sharing initiatives (Data Sharing Coalition, 2020a).[10] To enable interoperability between these initiatives, generic agreements on, for example, technical standards, data semantics, legal issues and digital identities should be adopted in an iterative use case-based process. A first attempt to specify where and what type of common agreements are needed resulted in the creation of a 'Harmonisation Canvas' (Data Sharing Coalition, 2020b). The idea is that these agreements are ultimately captured in a generic trust framework and are governed by a common governing body that replaces the coalition.[11] One of the first cross-sectoral use cases brings together the energy and financial sectors to develop a concept for green mortgages.

Second, the energy sector-specific dimension is covered by the new Dutch Energy Act, which is driven by the CEP, and in which a new data exchange entity is defined. This will be set up as a legal entity that is responsible for data exchange within the energy sector and federates with the data sharing coalition on cross-sector data exchanges. The responsibility to operate this legal entity is given to the collective TSO/DSOs but will be separate from their existing grid operator business. The focus of the first phase is planned to be on use cases that cover data needs for energy market facilitation processes.

4.2 The UK

In the UK, a national data strategy has been published that aims to make the UK a world-leading data economy and brings together the many data-related actions that have been initiated across government (DCMS, 2020). An important element is Smart Data initiatives, which have been set up in multiple sectors to enable the secure and consensual sharing of customer data with authorised third-party providers, the most advanced initiative being in open banking (BEIS, 2020). In 2019, the UK government decided to expand Smart Data, with an initial focus on several regulated sectors, including energy. An important objective is to leverage synergies between sectoral initiatives addressing common challenges, such as the development of consent mechanisms, to avoid a lack of interoperability resulting from divergent approaches (BEIS, 2020). A new cross-sectoral expert group called the 'smart data working group' should facilitate these efforts and coordinate across the sectoral initiatives, government and relevant regulators while drawing on academic and industry expertise.[12]

Moreover, the UK is advancing standardisation efforts to enable the direct involvement of consumers in the electricity system. The British Standards Institution (BSI) notes in a recent report that the landscape of standards relevant to effective demand side response is large, complex and fragmented, with standards at different levels of granularity, scope and applicability (British Standards Institution, 2018). The same report finds that standardisation activities regarding EV charging and other smart appliances (for example, related to heating, ventilation and air conditioning (HVAC), cold and wet appliances, and battery storage) are evolving in parallel despite at least some common demand side response functionalities. To avoid duplication and leverage synergies, the BSI announced that it will look into opportunities for convergence of standards related to EV charging points and smart appliances, and seek

---

[10] In the context of the data sharing coalition, a domain is "flexibly defined as any number of organisations collaboratively working together to share data to achieve a shared purpose" (Data Sharing Coalition, 2020b).

[11] A trust framework "*enables many-to-many data sharing through business, legal, operational, functional and technical agreements, tools and processes which facilitate cross domain data sharing*" (Data Sharing Coalition, 2020b).

[12] The original proposal included a new cross-sector body called 'Smart Data Function' with responsibilities such as setting standards and managing the accreditation of third-party providers (BEIS, 2020).

better collaboration between stakeholders in the design and manufacture of smart appliances and EV charging points (British Standards Institution, 2020). It has recently published two new standards (PAS 1878 and PAS 1879) that aim to support the manufacture and use of secure and interoperable smart energy appliances.

5. Discussion

In the following, we provide discussions of the contributions we have made in this paper. How interoperability is defined depends on the context, which can be different for different ecosystems or different sectors. The definitions already point to the issues that a certain sector or ecosystem perceives as the most pressing. However, looking at the definitions used in other ecosystems or sectors helps understanding that definitions may also lock in a certain (narrow) perspective of interoperability. Using the examples of smart metering, electromobility and buildings, we showed that how the definition is formulated gives information about the perceived scope of interoperability in one ecosystem or sector. Adopting a broader perspective is important because the interoperability of devices requires organisations to agree on it as an objective and collaborate to reach it. A broad notion of interoperability has emerged, for example, in the context of building information models. In the context of electromobility, it was also acknowledged that interoperability needs to be tackled at several levels, including hardware, software and services, and needs to consider the perspective of the user. In the case of smart metering, a more technical device-oriented notion of interoperability has so far prevailed but needs to be challenged. Moving towards a consumer-centric electricity sector requires taking into account the viewpoint of consumers as need-owners. Consumers are need-owners because they want to consume energy services and easily switch between service providers, and not be locked into one solution or have to bother with changing the hardware in the case of a switch.

EU-level solutions are often similar, although interoperability issues across sectors are slightly different. The electricity sector is not the only sector that is discussing interoperability. We looked at two other sectors that have long-standing experiences with interoperability at the EU level and are also moving towards a more citizen-centred approach, namely public administration and healthcare. We identified three types of solutions that have been applied across all sectors (stakeholder engagement, tools and knowledge sharing, and standardisation initiatives) and two types of solutions that have only been applied in individual sectors (monitoring and reporting, and interoperability profiling and testing). In the context of smart electricity metering, monitoring and reporting and interoperability profiling and testing are currently lagging. This paper does not suggest copying the approaches used in the public administration and healthcare sectors. Instead, by looking at those experiences, the electricity sector may be able to leapfrog certain steps in the learning process and catch up faster. Learning can happen in multiple ways. It can mean better aligning interoperability efforts at the EU and the national levels by developing an integrated framework for monitoring, assessing and reporting national progress, as in the public administration sector. It can also mean developing a common structured transparent approach, including suitable processes to assess and select standards and specifications, to evaluate them, to monitor their implementation, to check compliance and to test interoperability. At the same time, some of these solutions that have been successfully applied across sectors could also be applied in a cross-sectoral environment.

Interoperability is increasingly becoming a cross-sectoral challenge. Silo thinking may lead to certain (sector-specific) solutions faster but will not deliver the big solutions that are needed to implement a citizen-centred interoperable and decarbonised energy system. Interoperability needs to be tackled both at the sectoral and the cross-sectoral levels: on the one hand, to ensure that adequate solutions for sector-specific issues are found; on the other hand, to avoid

duplications when issues are similar across sectors and common solutions can be leveraged to move forward faster. At the national level this realisation has already in some cases led to the deployment of solutions to tackle common interoperability challenges. In both the Dutch and UK cases, the long-term vision is moving beyond an energy sector-specific perspective towards a cross-sector one with a view to leveraging synergies to address interoperability and related standardisation challenges. In the Netherlands, the high-level institutional vision is already starting to be implemented through a governance framework that has both cross-sectoral and sector-specific dimensions. The UK is currently focussing more on collecting evidence through a new advisory board, while also looking for sector convergence in standardisation. At the EU level, a horizontal governance mechanism in a cross-sectoral framework seems to be the spirit of new EU policies and legislation, but practice has so far been mainly vertical, which means sector-specific. It is an open question to what extent it is necessary to deploy dedicated cross-sectoral solutions. The right balance will need to be found between leveraging synergies to drive progress faster and maintaining a sectoral focus to address specific needs.

6. Conclusions

Interoperability in the context of smart electricity metering is high on the European policy agenda and a legislative initiative is already being taken to create implementing acts that define interoperability requirements and procedures for access to (smart) metering and consumption data, and data for customer switching, demand response and other services. These implementing acts are not only important for the completion of the internal energy market but they are also seen as a key measure to sustainably integrate the energy system in Europe and develop a single market for data that fosters data-driven innovation. Despite the high importance of the topic, the essence of what needs to be debated has been challenging to capture due to the broad notion of the concept of interoperability.

In this paper, we have empirically analysed experiences in other ecosystems (electromobility and buildings), other sectors (public administration and healthcare) and at the national level (the Netherlands and the UK) which can help to move the debate at the EU level forward.

We have shown that the definition of interoperability is context-dependent and reveals a broad (at the level of organisations) or narrow (at the level of devices and systems) understanding of the concept. Definitions also hint at the issues that a certain ecosystem perceives as the most pressing.

We have also shown that EU-level solutions to interoperability issues are often similar across sectors despite different issues. The electricity sector could be inspired by the solutions that have been successfully implemented in other more advanced sectors. Moreover, the use of similar solutions in several sectors suggests that these solutions could also work in a cross-sectoral setting.

Finally, we have shown that the cross-sectoral momentum that is increasingly present in EU-level discussions has already taken off in several countries. The magnitude of the interoperability challenge in the light of the EU decarbonisation goals means that we cannot afford to overlook the cross-sectoral aspects. However, how to align the national and the European initiatives and how to prioritise between the sector-specific (completion of the internal energy market) and the cross-sectoral (the decarbonisation aims of the Green Deal) challenges remain open issues.

References

Antilope, 2015. Antilope Project [WWW Document]. URL https://www.antilope-project.eu/front/index.html (accessed 5.4.21).

Autoriteit Consument & Markt, 2019. Visie datagovernance energie. ACM/INT/384185.

BEIS, 2020. Next steps for Smart Data. Putting consumers and SMEs in control of their data and enabling innovation.

BRIDGE, 2020. The BRIDGE initiative and project fact sheets. Cooperation between Horizon 2020 Projects in the fields of Smart Grid, Energy Storage, Islands, and Digitalisation.

British Standards Institution, 2020. The Energy Smart Appliances Programme. An Overview. A programme implementing recommendations from the Standards Landscape Report on smart appliances and electric vehicle chargepoints.

British Standards Institution, 2018. Secure and interoperable use of smart appliances and electric vehicle smart charge points through standards. Standards landscape research.

CGSEG, 2018. CEN-CENELEC-ETSI Coordination Group on Smart Energy Grids (CG-SEG), Final Report of the Working Group Clean Energy Package (WG-CEP).

Channin, D.S., 2001. Integrating the Healthcare Enterprise: A Primer Part 2. Seven brides for seven brothers: The IHE integration profiles. Radiographics 21, 1343–1350. https://doi.org/10.1148/radiographics.21.5.g01se391343

Data Sharing Coalition, 2020a. Response to the European Data Strategy by the Data Sharing Coalition.

Data Sharing Coalition, 2020b. Harmonisation Canvas v0.1.

DCMS, 2020. National Data Strategy (GOV.UK) [WWW Document]. URL https://www.gov.uk/government/publications/uk-national-data-strategy/national-data-strategy (accessed 3.19.21).

DIGIT, 2020. D04.03: Digital Public Administration and Interoperability 2020 – Summary Slide Deck. ISA[2] action 2016.21: NIFO – National Interoperability Framework Observatory.

Eastman, C., Teicholz, P., Sacks, R. and Liston, K., 2008. BIM Handbook: A Guide to Building Information Modeling for Owners, Managers, Designers, Engineers, and Contractors, BIM Handbook. John Wiley & Sons, Inc., Hoboken, NJ, USA. https://doi.org/10.1002/9780470261309

E.DSO, n.d. European Technology Platform (ETP) SmartGrids [WWW Document]. URL https://www.edsoforsmartgrids.eu/policy/eu-steering-initiatives/smart-grids-european-technology-platform/ (accessed 7.21.21).

eHealth Network, 2015. Refined eHealth European Interoperability Framework.

European Commission, 2021a. eHealth experts. eHealth Stakeholder Group and eHealth Task Force [WWW Document]. URL https://digital-strategy.ec.europa.eu/en/policies/ehealth-experts (accessed 5.4.21).

European Commission, 2021b. Joinup [WWW Document]. URL https://joinup.ec.europa.eu/ (accessed 5.11.21).

European Commission, 2021c. Cross-border health project epSOS: What has it achieved? Shaping Europe's digital future [WWW Document]. URL https://digital-strategy.ec.europa.eu/en/news/cross-border-health-project-epsos-what-has-it-achieved (accessed 5.4.21).

European Commission, 2020a. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of Regions. Powering a climate-neutral economy: An EU Strategy for Energy System Integration. COM(2020) 299 final.

European Commission, 2020b. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. "A European strategy for data" COM(2020) 66 final.

European Commission, 2020c. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. A Renovation Wave for Europe – greening our buildings, creating jobs, improving lives. COM(2020) 662 final.

European Commission, 2020d. State-of-play report on digital public administration and interoperability 2020.

European Commission, 2017a. Annex 1 to the Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. European Interoperability Framework – Implementation Strategy. Interoperability Action Plan. COM(2017) 134 final Annex I.

European Commission, 2017b. New European Interoperability Framework. https://doi.org/10.2799/78681

European Commission, 2017c. European Interoperability Timeline poster, ISA[2] [WWW Document]. URL https://ec.europa.eu/isa2/publications/european-interoperability-timeline-poster_en (accessed 7.21.21).

European Commission, 2015. Commission Decision (EU) 2015/1302 of 28 July 2015 on the identification of 'Integrating the Healthcare Enterprise' profiles for referencing in public procurement.

European Commission, 2012. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. eHealth Action Plan 2012-2020 – Innovative healthcare for the 21st century. COM(2012) 736 final.

European Commission, 2010. Annex 2 to the Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of Regions "Towards interoperability for European public services." COM(2010) 744 final. Annex II.

European Commission, 2007. Standardisation mandate addressed to CEN, CENELEC and ETSI in the field of Information and Communication Technologies. M/403 EN.

European Commission, 2004. Communication from the Commission to the Council, the European Parliament, the European Economic and Social Committee and the Committee of the Regions. e-Health – making healthcare better for European citizens: An action plan for a European e-Health Area. COM(2004) 356 final.

European Parliament, Council, 2019. Directive (EU) 2019/ 944 of the European Parliament and of the Council of 5 June 2019 on common rules for the internal market for electricity and amending Directive 2012/27/EU (recast).

European Parliament, Council, 2015. Decision (EU) 2015/2240 of the European Parliament and of the Council of 25 November 2015 establishing a programme on interoperability solutions and common frameworks for European public administrations, businesses and citizens (ISA 2 programme) as a means for modernising the public sector.

European Parliament, Council, 2012. Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC. Official Journal of the European Union.

European Parliament, Council, 2011. Directive 2011/24/EU of the European Parliament and of the Council of 9 March 2011 on the application of patients' rights in cross-border healthcare.

EZK, 2020. Nederlandse Digitaliseringsstrategie 2020.

EZK, 2019. Dutch Digitalisation Strategy. Dutch vision on data sharing between businesses.

Gopstein, A., Nguyen, C., O'Fallon, C., Hastings, N. and Wollman, D., 2021. NIST framework and roadmap for smart grid interoperability standards, release 4.0. Gaithersburg, MD. https://doi.org/10.6028/NIST.SP.1108r4

Gottschalk, M., Franzl, G., Frohner, M., Pasteka, R. and Uslar, M., 2018. From integration profiles to interoperability testing for smart energy systems at connectathon energy. Energies 11, 1–26. https://doi.org/10.3390/en11123375

Gottschalk, P., 2009. Maturity levels for interoperability in digital government. Government Information Quarterly 26, 75-81. https://doi.org/10.1016/j.giq.2008.03.003

Henderson, M., Behlen, F.M., Parisot, C., Siegel, E.L. and Channin, D.S., 2001. Integrating the Healthcare Enterprise: A Primer Part 4. The Role of Existing Standards in IHE. RadioGraphics 21, 1597–1603.

IHE, 2019. Integrating the Healthcare Enterprise (IHE) International, Incorporated. Principles of Governance.

JASEHN, 2017. Report on Standardisation Developments in eHealth.

Joinup, 2021a. European Interoperability Reference Architecture (EIRA) [WWW Document]. URL https://joinup.ec.europa.eu/collection/european-interoperability-reference-architecture-eira/about#eia (accessed 5.11.21).

Joinup, 2021b. Rolling Plan for ICT Standardisation 2021 [WWW Document]. URL https://joinup.ec.europa.eu/collection/rolling-plan-ict-standardisation/rolling-plan-2021 (accessed 5.11.21).

Joinup, 2019. European Interoperability Cartography (EIC) [WWW Document]. URL https://joinup.ec.europa.eu/collection/cartography/solution/european-interoperability-cartography-eic (accessed 5.11.21).

Kouroubali, A. and Katehakis, D.G., 2019. The new European interoperability framework as a facilitator of digital transformation for citizen empowerment. Journal of Biomedical Informatics 94. https://doi.org/10.1016/j.jbi.2019.103166

NIFO, 2021a. National Interoperability Initiatives [WWW Document]. URL https://joinup.ec.europa.eu/collection/nifo-national-interoperability-framework-observatory/national-interoperability-initiatives (accessed 5.11.21).

NIFO, 2021b. Digital Public Administration factsheets – 2020 [WWW Document]. URL https://joinup.ec.europa.eu/collection/nifo-national-interoperability-framework-observatory/digital-public-administration-factsheets-2020 (accessed 5.11.21).

Noumeir, R., 2008. Integrating the healthcare enterprise process. International Journal of Healthcare Technology and Management 9, 167–180. https://doi.org/10.1504/IJHTM.2008.017371

Papaioannou, I., Tarantola, S., Lucas, A., Kotsakis, E., Marinopoulos, A., Ginocchi, M., Olariaga Guardiola, M. and Masera, M., 2018. Smart grid interoperability testing methodology.

Schütz, J., Uslar, M. and Meister, J., 2021. A case study research on interoperability improvement in Smart Grids: state-of-the-art and further opportunities. Open Research Europe 1, 33. https://doi.org/10.12688/openreseurope.13313.1

SGCG, 2012a. CEN-CENELEC-ETSI Smart Grid Coordination Group – Smart Grid Reference Architecture [WWW Document]. URL ftp://ftp.cencenelec.eu/EN/EuropeanStandardization/HotTopics/SmartGrids/Reference_Architecture_final.pdf

SGCG, 2012b. Sustainable Processes.

SGTF EG1, 2019. Towards Interoperability within the EU for Electricity and Gas Data Access & Exchange European Smart Grids Task Force Expert Group 1.

SGTF EG1, 2016a. "My Energy Data." Report by the European Smart Grids Task Force Expert Group 1.

SGTF EG1, 2016b. Interoperability of interfaces for the large scale roll out of smart metering systems in EU Member States. European Smart Grids Task Force Expert Group 1.

SGTF EG1, 2015. Interoperability, Standards and Functionalities applied in the large scale roll out of smart metering. European Smart Grids Task Force Expert Group 1.

van der Kam, M., Bekkers, R., 2020. Comparative analysis of standardized protocols for EV roaming. Report D6.1 for the evRoaming4EU project.

Wimmer, M.A., Boneva, R. and di Giacomo, D., 2018. Interoperability governance: A definition and insights from case studies in Europe, in ACM International Conference Proceeding Series. Association for Computing Machinery, New York, USA, pp. 1-11. https://doi.org/10.1145/3209281.3209306

Author contacts:

Valerie Reif (corresponding author)

Florence School of Regulation

Robert Schuman Centre for Advanced Studies, European University Institute

Via Boccaccio 121

I-50133 Florence

Italy

Email: valerie.reif@eui.eu

Leonardo Meeus

Florence School of Regulation

Robert Schuman Centre for Advanced Studies, European University Institute

Via Boccaccio 121

I-50133 Florence

Italy

Vlerick Business School, Vlerick Energy Centre

Bolwerklaan 21

B-1210 Brussels

Belgium

Email: leonardo.meeus@vlerick.com