Benchmarking smart metering deployment in the EU-28

Final Report

Tractebel Impact
December – 2019

EUROPEAN COMMISSION

Directorate-General for Energy
Directorate B — Internal Energy Market
Unit B.3 — Retail markets; coal & oil

Contact: Constantina Filiou

E-mail: Constantina.Filiou@ec.europa.eu

European Commission
B-1049 Brussels

Benchmarking smart metering deployment in the EU-28

Final Report

Authors: Frédéric Tounquet and Clément Alaton - Tractebel Impact

Directorate-General for Energy
2020

EUROPE DIRECT is a service to help you find answers to your questions about the European Union

Freephone number (*):
00 800 6 7 8 9 10 11

(*) The information given is free, as are most calls (though some operators, phone boxes or hotels may charge you)

LEGAL NOTICE

This document has been prepared for the European Commission however it reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

More information on the European Union is available on the Internet (http://www.europa.eu).

Luxembourg: Publications Office of the European Union, 2020

PDF	ISBN 978-92-76-17295-6	doi:10.2833/492070	MJ-02-20-176-EN-N

© European Union, 2020
Reproduction is authorised provided the source is acknowledged.

ACKNOWLEDGEMENT TO REVIEWERS

This report has been reviewed in draft form by EC officials and representatives of national authorities in all EU-28 Member States, national grid operators, service providers, stakeholders' associations such as ANEC, BEUC, CEER, E.DSO, GEODE, CEDEC, ENCS, ESMIG, Eurelectric, Eurogas, as well as energy mediators coming from EEMG and NEON. The purpose of the review was to provide candid and critical comments that assisted the authors in making the final report as sound as possible, and to ensure that the report meets the Commission's standards for objectivity, evidence and responsiveness to the study in charge.

We wish to thank all aforementioned parties, and the following individuals, for contributing to the review process:

Constantina Filiou (ENER), Manuel Sánchez Jiménez (ENER), Konstantinos Stamatis (ENER), Michaela Kollau (ENER), and Antonios Marinopoulos (JRC).

Although the reviewers listed above have provided many constructive comments and suggestions, they were not asked to endorse the conclusions and/or recommendations. Responsibility for the final content of this report rests entirely with the authors.

TABLE OF CONTENTS

TABLE OF FIGURES

TABLE OF TABLES

LIST OF ABBREVIATIONS

1G	1st generation
2G	2nd generation
ANEC	The European consumer voice in standardisation
CAPEX	Capital expenditure
CBA	Cost Benefit Analysis
CEN	European Committee for Standardisation
CENELEC	European Committee for Electrotechnical Standardisation
CO2	Carbon dioxide
DSO	Distribution System Operator
EC	European Commission
EG	Expert Group from the Smart Grids Task Force
ESO	European standards organisation
EU	European Union
EV	Electric vehicles
ICT	Information & communication technology
IOT	Internet of things
IT	Information technology
KPI	Key performance indicator
MS	Member State
N/A	Not available
NRA	National Regulation Authority
OPEX	Operational expenditure
PLC	Powerline communication
SM-CG	Smart Meter Coordination Group
SME	Small & medium enterprise
TOTEX	Total expenditure

1 EXECUTIVE SUMMARY

The European Union has already started the modernization and transformation towards a **climate neutral economy**. In this context, the Commission has proposed a strategic long-term vision for Europe to become the world's first major economy to go climate neutral by 2050[1].

To foster the transition of its economy from a centralized, rather rigid, fossil fuel-based energy system towards a flexible, decentralized, decarbonized energy system, the European Union has been adapting its policy and regulatory framework continuously. Accordingly, **the Clean Energy for all Europeans Package**[2] has been conceived as the central pillar of the Energy Union strategy for the way forward.

With digitalisation being a main enabler for the rise of a resilient and secure grid of the future, the recently updated European Union regulatory instruments stress more than ever the need for a large-scale roll-out of smart energy meters. Despite the current advanced stage of smart electricity and gas meter deployment in some Member States, others they are still at the very beginning of this process. Yet, the objectives of the European Union in terms of energy transition will not be reached if all European citizens do not find themselves on the same page. Thus, a **harmonization effort is required and guidance must be provided** to stakeholders in order to observe **consistent application of smart meters' provisions** across Member States. The European Commission is therefore calling for a **fit for purpose** deployment of smart metering systems across the Energy Union.

The adoption of the 2009/72/EC Electricity Directive and the 2009/73/EC Gas Directive has triggered the necessity to conduct a cost benefits analysis (CBA) on the deployment of smart metering systems in each Member States. In 2014, a first benchmarking report was presented by the European Commission, presenting the CBAs' outcome[3].

The aim of the present report is to update the information from that first benchmarking report, gauge progress with smart metering since then, and even go one step further and gather the returns of experience and lessons learned from previously initiated large-scale smart meters roll-out. This will help provide insights and guidelines for Member States currently planning their deployment strategy.

The report considers for the 28 EU Member States, the regulatory framework implemented at national level, the data management system architecture chosen, the functional and technical specification of smart meters as well as whether consumer benefits are incorporated into the roll-out strategy. Furthermore, the current roll-out state of play is described, and results of updated CBAs are analysed.

The data collection and validation methodology has been carried out by directly engaging with national authorities – NRAs and energy ministries – to collect relevant information in a systematic manner. A standard questionnaire has been sent to NRAs (or the entitled body for smart meters

[1] European Commission – Press release : http://europa.eu/rapid/press-release_IP-18-6543_en.htm

[2] European Commission website on the Clean Energy for all Europeans Package: https://ec.europa.eu/energy/en/topics/energy-strategy-and-energy-union/clean-energy-all-europeans

[3] European Commission, "Benchmarking smart metering deployment in the EU-27 with a focus on electricity," COM (2014) 356, and accompanying SWD(2014) 188 and SWD(2014) 189.

roll-out planning), to capture the state of play of smart metering deployment in each Member State. Based on the answers received to the questionnaire, country fiches have been elaborated and shared for early feedback. The next phase consisted of the validation of the findings coming from the consolidated analysis against the data gathered at Member States level. To this end, an informal consultation with relevant stakeholders permitted to gather views and insights on the recommendations that were preliminary drawn, following the consolidated analysis.

- **From planning to realisation…**

The Third Energy Package asked Member States to conduct a CBA for smart metering deployment, and to roll-out, for the case of electricity at least 80% by 2020, of the positively assessed cases. Yet, the purpose of this report is to assess how far the Member States have come in their national deployment plans with this obligation. The first aspect to consider is the development of implementation laws that will enable a roll-out strategy and detailed specifications to be put in place at national level.

The picture appears to be quite different when assessing the situation for gas and electricity smart meters. While three quarters of Member States have adopted specific legal provisions for the roll-out of electricity smart meters, only a quarter of them has done so for the roll-out of gas smart meters.

As of July 2018, all but two Member States have conducted at least one CBA for a large-scale rollout of electricity smart meters to at least 80% by 2020, with the results for most of these being positive. This can be seen in Figure 1. Regarding gas smart meters, the majority of Member States either did not conduct a CBA or did not specify whether the CBA conducted was for gas as well as electricity. But for those Member States that did perform a CBA for the roll-out of gas smart meters, the results were most of the time positive.

Taking a closer look at the CBA performed for electricity smart metering, more specifically the cost items considered by Member States (see Figure 2), the capital costs associated with smart meters themselves and the IT infrastructure was considered by approximately 90% of the Member States. Other cost items considered by Member States are the operation expenses linked to meter readings, IT maintenance, telecommunications and network management, being considered by 85% of the Member States when conducting their respective CBAs.

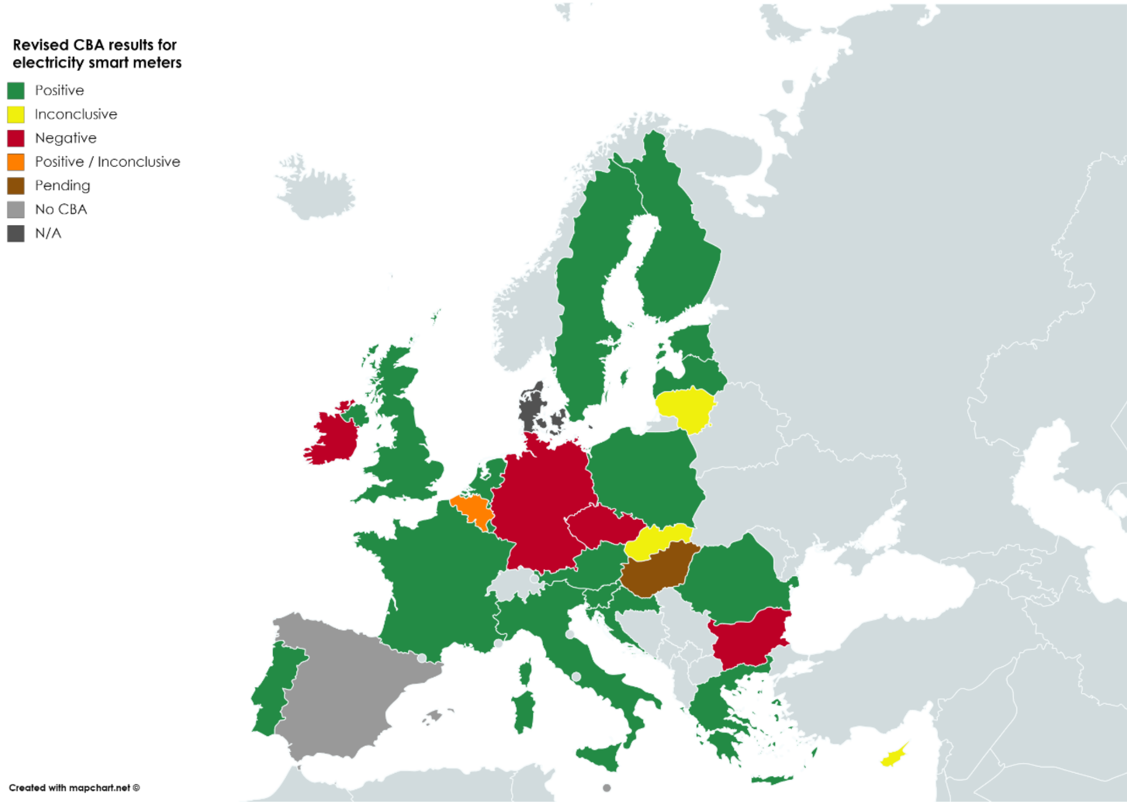


Figure 1: Revised CBA results electricity smart meters considering a large-scale rollout to at least 80% by 2020 (as of July 2018).

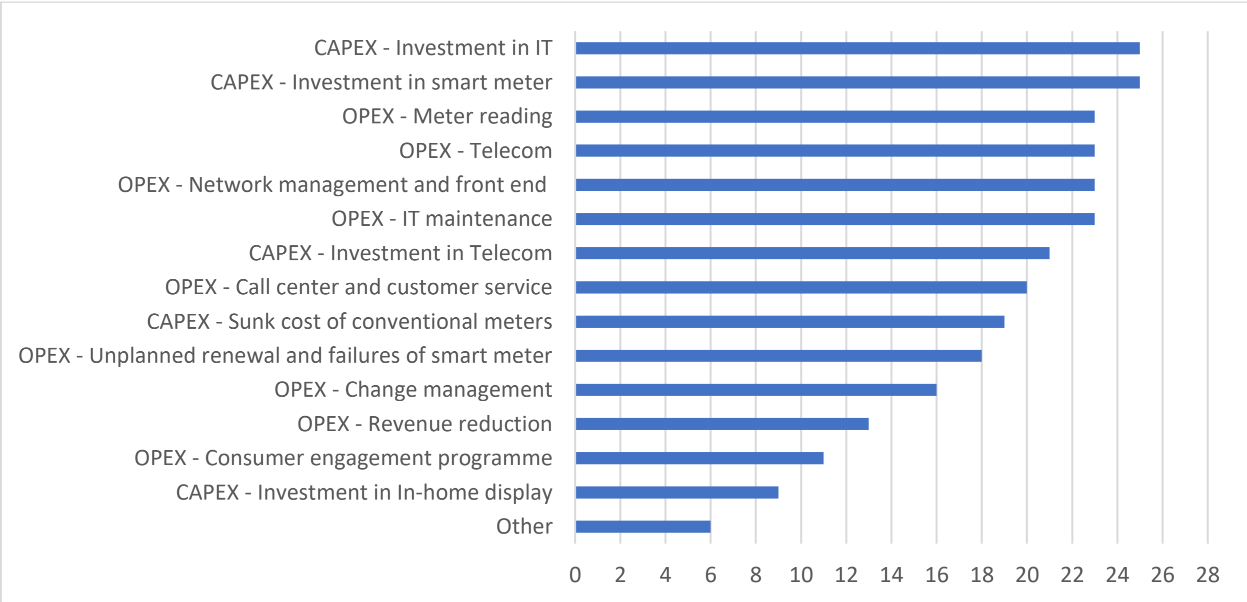


Figure 2: Ranking of the considered CAPEX and OPEX costs in the CBA for electricity smart metering deployment vs. number of Member States.

The most common benefits taken into account in the CBA for electricity smart metering are related to DSOs and are the operational savings that can be achieved through remote meter readings and the reduction of non-technical losses. 75% of Member States have also considered the consumer's bill reduction as a result of increased energy efficiency. Table 1 summarizes key electricity CBA parameters.

Smart metering deployment for electricity

	Range of value	Average based on data from positively assessed cases[4]
Lifetime	8 to 50 years	15 ± 4 years (57%)[5]
Evaluation period	8 to 50 years	23 ± 13 years (69%)
Costs per metering point	€38 to €546	€202 ± €108 (68%) Weighted average[6]: € 172
Benefits per metering point	€44 to €551	€271 ± €143 (62%) Weighted average[6]: €253
Energy savings as reported in pilots[7]	5.42% - 7.85%[8]	N/A

Table 1: Key electricity CBA parameters

As of 2018, **34%** of all electricity metering points were equipped with a smart meter (**ca. 99 million smart meters**). Taken separately, households electricity metering points and SMEs metering points were equipped at 35% and 28%, respectively. By 2020, based on the originally announced rollout plans as captured in the first benchmarking report of 2014 (COM (2014)356), a penetration rate of electricity smart meters of **72% was expected to be reached EU-wide.**

However, given the slow progress so far and the speed of deployment observed in 2017, we estimate[9] that only **24 million additional smart meters** will be installed by 2020, setting the total number of electricity smart meters to **123 million**, which would correspond to a **43% penetration rate**. With a weighted average cost per metering point of **€172[10]**, the deployment of these 123 million electricity smart meters would require an aggregated investment of over **€21 billion**.

Considering that Member States will proceed with the rollout according to their updated planning and new target periods, we expect that overall (in households and SMEs) **223 million smart meters**

[4] Averages computed based on data coming from positively assessed cases for a large-scale rollout of electricity smart meters. That includes data from Austria, Croatia, Denmark, Estonia, Finland, France, Greece, Ireland, Italy, Latvia, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, Slovenia, Sweden, and United Kingdom.

[5] This percentage relates to the number of measurements that fall within the range of the average value quoted ± the standard deviation given.

[6] The weighted average is calculated as follows: average value for the specific parameter, considering the positively assessed cases, divided by the total number of the respective metering points.

[7] Estimates provided by VaasaETT report on "The role of Data for Consumer Centric Energy Markets and Solutions" (https://esmig.eu/sites/default/files/report_-_the_role_of_data_for_consumer_centric_energy_markets_and_solutions_2019.pdf)

[8] The first figure relates to energy savings induced by non-real-time up to daily feedback on electricity consumption, while the second relates to energy savings induced by real-time feedback on electricity consumption.

[9] These estimations are based on the observed rate of deployment of electricity smart meters in 2017.

[10] The computation of this weighted average includes Austria, Croatia, Denmark, Estonia, Finland, France, Greece, Ireland, Italy, Latvia, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, Slovenia, Sweden, and United Kingdom.

will be installed by 2024 (corresponding to a **77% penetration rate**), which will represent an aggregated investment of **€38 billion based on the latest costing information (see Table 1)**. **By 2030, we expect that 266 million smart meters will be installed** (corresponding to a **92% penetration rate**), which will represent a total aggregated investment of **€46 billion**.

Smart metering deployment for electricity

	Number of electricity smart meters installed (in million)	Penetration rate at EU level (%)	Induced overall investment (€ billion)
2020 original target in households (ref. COM (2014)156)	~200 million	~72% in households	€45 billion based on original costing
Estimated 2020 State of play (households & SMEs)	123	43	21
Estimated 2024 State of play (households & SMEs)	223	77	38
Estimated 2030 State of play (households & SMEs)	266	92	46

Table 2: Key figures for different electricity smart meters deployment state of play scenarios

At the moment of writing of this report, more than half of the Member States have reached a 10% installation rate for electricity smart meters, meaning a first important step in their large-scale roll-out programmes. Seven have already reached 80% as Denmark, or even finished their large-scale electricity smart metering roll-out like Estonia (>98% in 2017), Finland (100% 2013), Italy (95% by 2011), Malta ([80-85]% by 2014), Spain (100% end of 2018) and Sweden (100% by 2009). Some of them are already proceeding with the second generation rollout, like Italy, or planning this (for instance, Finland, Sweden). Nevertheless, **only few from those remaining Member States that had committed to do so are still on track to reach the 80% deployment rate target by 2020**; some of them are now setting this target as late as 2030. One of the reasons for these deployment delays relates to consumer acceptance, an issue that is herein further investigated. As described in the relevant section 5.3.3 for Consumer outcomes, Member States have taken counter-measures to address these challenges and gain trust toward smart metering.

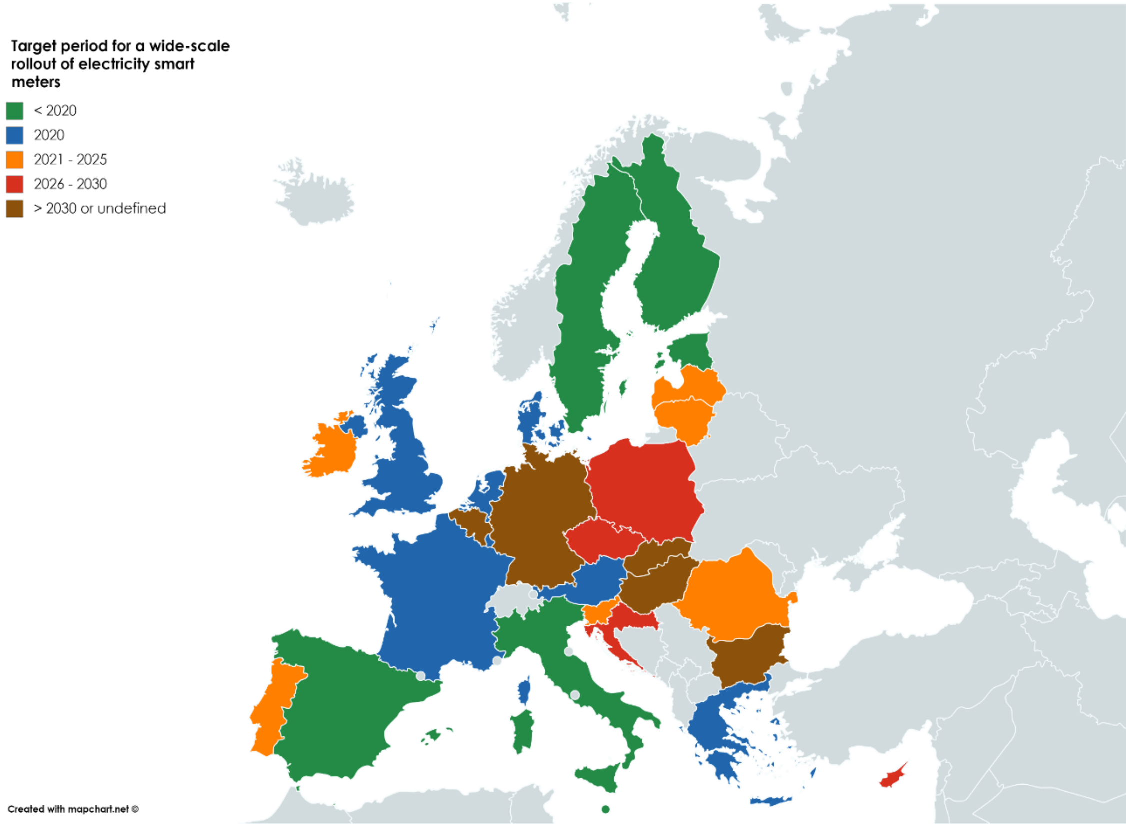


Figure 3: Overview of target period for a wide-scale rollout of electricity smart meters with at least 80 % of all consumers for each Member State.

To this day, 15 Member States conducted at least one CBA for gas smart metering deployment, and high variability of CBAs' outcome can be observed. Table 3 presents the key parameters of gas CBAs.

Smart metering deployment for gas

	Range of value	Average based on data from positively assessed cases [11]
Lifetime	8 to 20 years	16 + 3 years (63%)5
Evaluation period	9 to 50 years	23 + 12 years (75%)
Costs per metering points	€38 to €826	€181 + €90 (75%) Weighted average[6]: €171
Benefits per metering points	€44 to €493	€229 + €114 (64%) Weighted average[6]: €264
Energy savings as reported in pilots[12]	1.83% - 9.63%[13]	N/A

Table 3: Key gas CBA parameters

[11] Averages computed based on data coming from positively assessed cases for a large-scale rollout of gas smart meters.

[12] Estimates provided by VaasaETT report on "The role of Data for Consumer Centric Energy Markets and Solutions" (https://esmig.eu/sites/default/files/report_-_the_role_of_data_for_consumer_centric_energy_markets_and_solutions_2019.pdf)

[13] The first figure relates to energy savings induced by non-real-time feedback on gas consumption, while the second relates to energy savings induced by real-time feedback on gas consumption.

In January 2018 – according to the available data – 14% of all gas metering points were equipped with smart meters, which represents just over 16 million gas smart meters. Among the 6 Member States having so far adopted an implementation strategy for gas smart metering large-scale rollout - namely France, Ireland, Italy, Luxembourg, the Netherland and the United Kingdom - Luxembourg and the Netherlands seem to be the only ones on track to reach as they originally intended their 80 % roll-out target by 2020. Figure 4 depicts the target period for gas smart meters large-scale rollout for the concerned Member States.

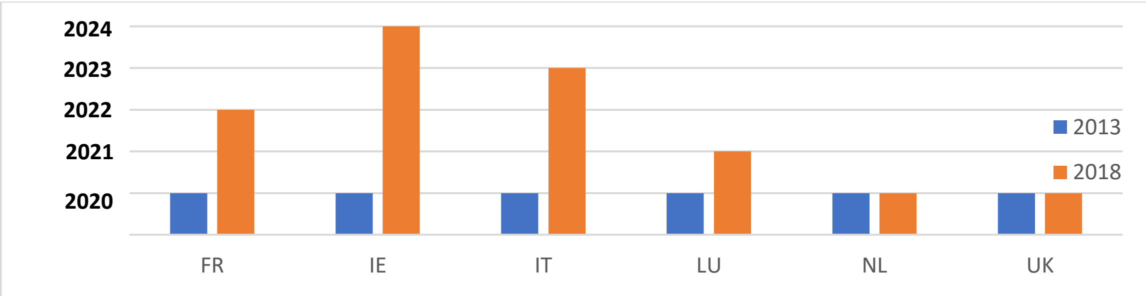


Figure 4: Overview of target period for a wide-scale rollout of gas smart meters for concerned Member State (data collection in 2018), compared to the initial targets set in the first benchmarking study[2] (data collection in 2013)

By 2024[14], based on the original announcements made by those Member States rolling out, the penetration rate could reach **51% with 60 million gas smart meters installed in 5 years**. With a weighted average cost per gas metering point[15] of **€171**, this would represent an aggregated investment of €10 billion.

Nevertheless, at the current slow pace of deployment, we estimate[16] that **in 2020, 31 million gas smart meters will be in place**, accounting for **27% of all gas metering points** and an aggregated investment of over **€5 billion. By 2024,** we expect that **51 million smart meters will be in place, representing a 44% penetration rate** EU-wide and a total investment of almost **€9 billion**. By 2024 only Italy, Luxembourg and the Netherland would have completed their large-scale rollout of gas smart meters.

Smart metering deployment for gas

	Number of gas smart meters installed (in million)	Penetration rate at EU level (%)	Induced overall investment (€ billion)
Original target for 2024	60	51	10
Estimated 2020 State of play	31	27	5
Estimated 2024 State of play	51	44	9

Table 4: Key figures for different gas smart meters deployment state of play scenarios

[14] 2024 is the latest targeted period within the group of Member States currently planning a large-scale rollout of gas smart meters.

[15] The calculation of this weighted average includes Austria, France, Ireland, Italy, Latvia, Lithuania Luxembourg, the Netherlands, Romania, Slovakia, Slovenia and the United Kingdom

[16] These estimations are based on the observed rate of deployment of gas smart meters in 2017.

- ### A secure and enhanced smart metering system

The energy sector is a particularly interconnected industry and whilst the digitalization is driving growth and innovation, it also increases the need to secure the smart grid. The European Commission therefore mandated CEN, CENELEC and ETSI to develop an open architecture for utility meters (mandate M/441) involving communication protocols enabling interoperability and cyber-resilience. As a follow-up to that successfully completed mandate that led to the development of standards including a common set of security requirements, a Protection Profile for smart meters was also developed that according to some stakeholders[17] could bring a positive contribution to the security certification of smart meters in Europe.

Currently, there are two main approaches for the management of smart metering data. Whilst some Member States seem to have opted for a centralised data hub, others prefer a more decentralized system where data activities are split amongst a greater number of players acting as metering responsible parties.

In our understanding, a central data hub is likely to deliver benefits of increased competition by lowering transaction costs for commercial parties whose business model heavily relies on access to metering data.

On the other hand, a decentralized data infrastructure provides benefits in terms of data protection and sovereignty of the customer, cascading effects and cybersecurity as well as lower barriers for integration with respect for other commodities.

The Commission Recommendation 2012/148/EU on the preparation for the rollout of smart metering systems identified 10 common minimum functionalities relevant for different market actors. We observed that 80% of Member States plan to have all ten functionalities available for their electricity consumers, and 50% of Member States aim to do that free of charge. Furthermore, all Member states that provided information about functionalities of their smart metering systems intend to enable smart metering systems (1) to provide direct reading to consumers and third parties of their choice, (2) to upgrade readings frequently enough to use energy saving schemes and (3) to support advanced tariff systems.

- ### Consumers benefits

Given that smart metering could bring numerous value propositions to consumers, **Member States should consider under which conditions consumers can actually reap benefits from it**. There is a clear trend within the EU-28 letting consumers compare their energy consumption based on historical data. Dynamic energy pricing and the integration of prosumers in the market are respectively the second and third most offered service to allow consumers benefit from smart meters.

But it must be understood that those value propositions can only benefit consumers if they carry motivations and abilities to do so. With regards to these considerations it should be noted that **consumer concerns about smart meters have been expressed in almost all Member States**; more

[17] Note: Regarding cybersecurity certification, the Smart Grids Task Force Expert Group 2, as stated in its latest report (June 2019), considers the need of having a harmonized holistic approach covering the electricity subsector. Moreover, it states that not all stakeholders, with the exception of the smart metering industry (as represented by ESMIG) and the consumer association ANEC, agree with the view that a certification for smart metering by Common Criteria could be an alternative to that approach.
Reference: https://ec.europa.eu/energy/sites/ener/files/sgtf_eg2_report_final_report_2019.pdf; SGTF EG2 - "Recommendations to the European Commission for the Implementation of Sector-Specific Rules for Cybersecurity Aspects of Cross-Border Electricity Flows, on Common Minimum Requirements, Planning, Monitoring, Reporting and Crisis Management", Final Report, June 2019.

specifically the accuracy of the smart meter, the electromagnetic radiation they produce and privacy related issues being the main concerns. Communication campaigns launched have a tendency to focus more on the installation and the advantages of smart meters but seem to have failed in some instances to fully address these concerns expressed by European citizens. NRAs (or smart metering deployment responsible parties) should proceed to the ex-post assessment of their communication campaigns' outcomes in order to track the key messages that have been successfully delivered to consumers. Probably more important, in a context of diversification of consumers (prosumers) behaviours, they should consider systematically tailoring their communication channels to a specifically targeted audience.

We conclude that smart metering system deployment should constitute for Member States an opportunity to empower consumers, to enable the grid digitalization and to foster the integration of European energy markets.

The level of progress of the legal and regulatory framework at national level shows a contrasted picture. This fragmentation precludes service providers from reaching economies of scale, which limits the upscaling of services offered to consumers.

The CBA, as performed by the large majority of Member States does not fully capture the full range of benefits enabled by smart metering. We recommend to national authorities to use the Cost Benefit Assessment to investigate how to best meet consumer needs and monitor the actual delivery of benefits, and not to justify political choices.

When designing their data management system, Member States must fully integrate considerations regarding the resilience of the system to cyber-attack, black-out recovery capability as well as the feasibility of a system replacement if better options can be considered.

A significant proportion of smart meters installed in Europe today still have a limited data storage capacity, which make it difficult to implement some value propositions enabled by smart meters (e.g. hourly dynamic pricing) while being fully compliant with the Measuring Instruments Directive[18] (MID) requirements. To help address this issue, the Commission could potentially consider, always with due respect to accuracy and transparency of measurements, a more inclusive interpretation, or even an update, of the MID requirements. This is to ensure that those pioneers who deployed the earlier smart metering set-ups in Europe are not punished having their customers deprived from access to novel energy services and products.

A better communication campaign and training of personnel to properly inform customers on smart meters is required to enhance their acceptance and their ability to reap benefits from it. The communications should also be broader (multi-channel), more customer-cluster specific and not time-consuming[19]. Moreover, deployment campaigns should not stay just in words but be followed by the actual provision in the field of new services and products that can deliver as advertised and accurately address consumers' expectations from smart meters. To gauge progress, Transition and Consumer KPIs should be developed and adopted by Member States. This would allow the effective tracking and monitoring of benefits' delivery to consumers, and the comparison of the measures taken by Member States to fulfil their respective obligations (see Article 19(4) of the recast Electricity Directive (EU) 2019/944).

[18] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32014L0032

[19] Among other positive examples, a dedicated website relevant to smart metering has been created in UK (weblink: https://www.smartenergygb.org/en) destined to address all consumers' concerns, from request for installation, safety and data privacy to smart metering benefits.

2 BACKGROUND

2.1 Context

The European Commission presented in its 2014 benchmarking report[20] the state of play of smart metering deployment in the European Union. This benchmarking report intended to provide an overview of the national cost benefit analyses (CBA) that Member States (MS) were invited to conduct following the adoption of the Electricity Directive 2009/72/EC[21] and Gas Directive 2009/73/EC[22].

The Electricity and Gas Directives promoted the wider user of smart metering systems as a key enabler to allow active participation of consumers in the internal electricity and gas markets, and to contribute to a secure, competitive and sustainable supply of energy for Europe.[23] According to these directives it is the Member States that decide whether they will proceed with smart metering and the deployment target, usually on the basis of an economic assessment of long-term costs and benefits to the market and the individual consumer. Where the roll-out of smart meters is assessed positive, at least 80 % of consumers are expected to be equipped with smart meters by 2020, in accordance with the aforementioned Directives.

The current document comes to update the information presented in that earlier benchmarking report regarding the implementation of smart metering in EU Member States. Moreover, it aims to help put into light lessons learned from the field and early returns of experience that might prove useful for others rolling out smart meters or planning to do so in the near future and are looking for guidance.

2.2 Objectives

The objectives of this report, entitled *"Benchmarking smart metering deployment in the EU-28"*, are to assess the current progress of smart metering deployment in the EU-28 against the objectives of the Third Energy Package adopted in 2009, consisting of the Electricity Directive 2009/72/EC and Gas Directive 2009/73/EC. The scope of this study includes both electricity and gas smart meters.

This report also considers the latest policy initiatives undertaken by the European Commission, especially the new provisions related to smart metering of the recast Electricity Directive (Directive (EU) 2019/944)[24] that has been recently adopted and which further paves the way for smart metering deployment. Those provisions include, amongst other topics of interest, smart metering system interoperability and support of new services to deliver benefits and ultimately satisfaction to consumers.

[20] European Commission, "Benchmarking smart metering deployment in the EU-27 with a focus on electricity," COM (2014) 356.

[21] Directive 2009/72/EC concerning common rules for the internal market in electricity and repealing Directive 2003/54/EC, OJ L211/55, 14.8.2009, p.55.

[22] Directive 2009/73/EC concerning common rules for the internal market in natural gas and repealing Directive 2003/55/EC, OJ L211, 14.8.2009, p.94.

[23] Third Energy Package objectives and Council Communication – 2007.

[24] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ:L:2019:158:TOC.

The analysis of the updated information collected during this exercise will provide an overall assessment of the smart metering landscape in Europe in a comprehensive and consistent manner as well as its future outlook.

2.3 This report

This report includes a detailed description of the work performed, the information collected, the results as well as the analyses performed for the different tasks, and principal conclusions and recommendations.

3 EUROPEAN LEGISLATIVE FRAMEWORK RELATED TO SMART METERING

The development of smart metering systems has been carried out gradually through the adoption of numerous legislative measures during the last decades (see Figure 1). Originally introduced in the frame of end-use energy savings, the deployment of smart metering systems was expected to contribute to the end consumers understanding of their actual energy consumption hence creating stronger incentives on the demand-side for energy efficiency. Pursuing the liberalization process of energy markets and the constitution of a single European market, the European Commission has also considered the smart metering systems as an effective tool to increase transparency and competition on retail markets for electricity, support self-generation and, in general, the integration of distributed energy resources, demand side flexibility and storage.

The booming of the digital economy and the proliferation of data, now considered as economic and strategic assets, led the European institutions to take further measures for the personal data protection of its citizens and table an overarching comprehensive legislative framework for this[25]. This framework applies also to the collection, processing and overall management of smart metering data when personal data is concerned. In the case of non-personal data, non-discriminatory and transparent access to it by eligible parties, and irrespectively of the data management model used, is ensured through specific provisions and rules set in the recast Electricity Directive.

3.1 Institutional background

Directive 2006/32/EC[26] on energy end-use efficiency and energy services prescribes the use of cost-effective technological innovations such as "electronic metering" in order to reach its energy saving target of 9% over the next nine years. Article 13 of this Directive, entitled "Metering and informative billing of energy consumption", provides that end consumers for electricity, natural gas, district heating and cooling and domestic water should be provided with competitively priced individual meters that reflect their actual consumption with information on actual time of use. Appropriate billing information should be provided to consumers in order to enable them to regulate their energy consumption. In particular, this information consists in the current actual price and actual consumption of energy, the comparison with the consumption for the same period in the previous year, and when possible, comparison with an average normalized user of energy in the same user category. This Directive constitutes the first step of making customers active by the use of metering.

Directive 2009/72/EC[27] and Directive 2009/73/EC[28], forming part of the so-called Third Energy Package, provide in Article 3.11 that Member States and regulatory authorities should recommend energy undertakings to optimise energy use via, amongst others, introducing intelligent metering systems or smart grids where appropriate. Annex I of the Directives provide instructions on the economic assessment of long-term costs and benefits to the market and the consumers, which had to be performed by 3 September 2012, and on the implementation of smart metering systems.

25 https://ec.europa.eu/info/law/law-topic/data-protection_en; Regulation (EU) 2016/679 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), OJ L119, 4.5.2016, p.1.

26 https://eur-lex.europa.eu/legal-content/FR/ALL/?uri=CELEX:32006L0032

27 https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=celex%3A32009L0072

28 https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A32009L0073

Annex I, in the case of electricity, specifically states that: "Where roll-out of smart meters is assessed positively, at least 80 % of consumers shall be equipped with intelligent metering systems by 2020"; but the Directive did not define the smart metering systems, neither set up a minimum of functionalities for smart meters.

In the context of the smart grids development, the Commission Recommendation 2012/148/EU[29] on the preparation for the roll-out of smart metering systems of 9 March 2012 defines a smart metering system as follows: "an electronic system that can measure energy consumption, adding more information than a conventional meter, and that can transmit and receive data using a form of electronic communication". The Recommendation provides guidance to Member States on the design of smart metering systems to ensure the protection of personal data and recommend Member States to include a data protection impact assessment in the design of smart grids and smart metering systems. This Recommendation also provides guidelines on the methodology for the economic assessment of the roll-out of smart metering, in accordance with Annex I of Directives 2009/72/EC and 2009/73/EC. Finally, this Recommendation lists a set of common minimum functional requirements for smart metering systems for electricity, stemming from standards and experiences from earlier deployments, in order to make them fit for purpose and help secure consumer benefits and increases in energy efficiency.

Directive 2012/27/EU[30] on energy efficiency which updates the energy saving target to 20% by 2020, in its introductory remarks, takes note of the limited effects of the provisions on metering and billing in Directives 2006/32/EC, 2009/72/EC and 2009/73/EC on energy savings, and states that: "it is important that the requirements of Union law in this area be made clearer". Article 9 is dedicated to metering and provides additional instructions on the deployment and on the minimum common features of smart metering systems as well as on data protection and privacy of final customers. These functional requirements for the case of electricity are later on consolidated within Article 20 of the recast Electricity Directive under the Clean Energy for all Europeans Package, and the Energy Efficiency Directive is accordingly amended[31].

Apart from the aforementioned provisions in energy-specific legislation, smart meters need to comply, being measuring instruments, also to Directive 2014/32/EU[32]. This Directive harmonises the national laws for making available on the market measuring instruments and came to repeal the earlier Directive 2004/22/EC[33] which aimed at establishing the requirements that measuring instruments must satisfy in order to be made available on the market. To ensure that a legal methodological control on these instruments would not lead to barriers to their free movement, the Measuring Instruments Directive (MID) provides that these essential requirements should be in conformity with harmonized standards. Regulation (EU) No 1025/2012[34] on European standardization designates the International Organisation for Standardisation (ISO), the International Electrotechnical Commission (IEC) and the International Telecommunication Union (ITU) as legitimate bodies to adopt international standards, and designates the European Committee for Standardisation (CEN), the European Committee for Electrotechnical Standardisation (CENELEC) and the European Telecommunications Standards Institute (ETSI) as legitimate bodies to adopt EU-wide standards. The MID applies to ten different type of measuring

[29] https://publications.europa.eu/en/publication-detail/-/publication/a5daa8c6-8f11-4e5e-9634-3f224af571a6/language-fr

[30] https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A32012L0027

[31] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ:L:2019:158:TOC;

[32] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32014L0032

[33] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32004L0022

[34] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32012R1025

instruments and notably gas meters and electrical energy meters. Requirements for measuring instruments are updated again in this Directive which provides the essential requirements common to all measuring instrument in its Annex I, while Annex IV and Annex V respectively concern gas meters and volume conversion devices, and active electrical energy meters.

To help Member States better prepare the smart metering deployment, the Commission tabled in 2012 guidelines under the Recommendation 2012/148/EU which included amongst other considerations for security and data protection. Those were followed up by the Commission Recommendation 2014/724/EU[35] which introduced measures for the promotion of the use of a Data Protection Impact Assessment Template (called the “DPIA Template”), developed at EU-level, with the aim “to help ensure the fundamental rights to protection of personal data and to privacy in the deployment of smart grid applications and systems and smart metering roll-out” (Article 1).

Recharging provisions for electric vehicles, as presented under the Directive 2014/94/EU[36] on the deployment of alternative fuels infrastructures, are also relevant to smart metering. Specifically in Article 7 the aforementioned Directive states: “The recharging of electric vehicles at recharging points accessible to the public shall, if technically feasible and economically reasonable, make use of intelligent metering systems as defined in point (28) of Article 2 of Directive 2012/27/EU and shall comply with the requirements laid down in Article 9(2) of that Directive”. This provision is directed by the opportunity given by smart metering systems which allow electric vehicles to be recharged during off-peak periods and which would also enable, in the long-run, these vehicles to feed power from the batteries back into the grid at times of high general electricity demand.

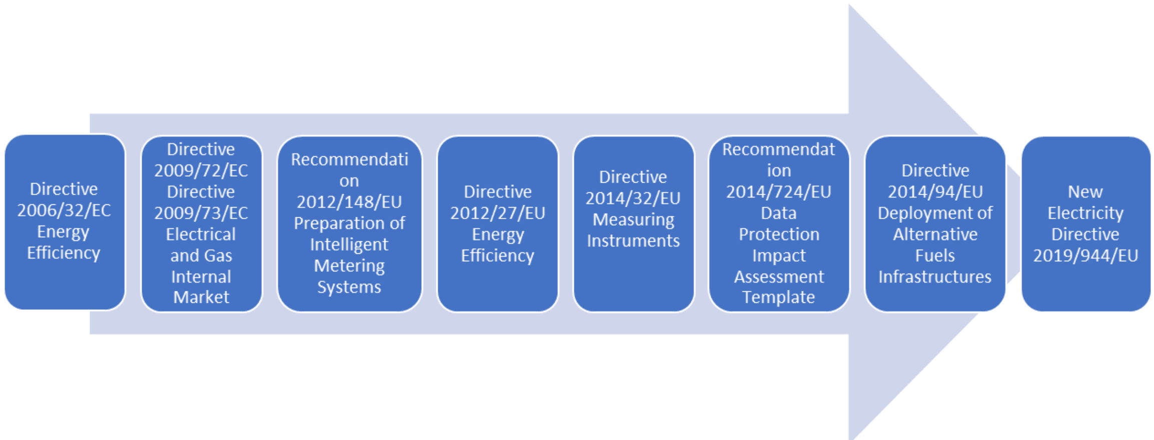


Figure 5: Evolution of European Legislation from the 2006/32/EC Energy Efficiency Directive, the Third Energy Package to the Clean Energy for all Europeans Package

3.2 Clean energy for all Europeans Package and recast of Internal Electricity Market Directive

The integration of the energy transition at the core of European Union political ambition has led the European Commission to present in November 2016 a package of measures called the Clean Energy for all Europeans Package (see Table 5). The 26 March 2019 the European Parliament, and later on the 22 May 2019 the Council, adopted one of these legislative texts called the Directive on common rules for the internal market for electricity[24] (the recast ‘Electricity Directive’ or Directive (EU) 2019/944) which updates the common rules for the generation, transmission, distribution,

[35] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv%3AOJ.L_.2014.300.01.0063.01.ENG

[36] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32014L0094

energy storage and supply of electricity. Specific provisions related to smart metering systems are included from Article 19 to Article 21, and Annex II.

Article 19 recalls the provision under which Member States shall recommend electricity market undertakings to implement smart metering systems, and specifically states that:

- The deployment of smart metering systems may be subject to a cost-benefit assessment, which shall be undertaken in accordance with the Commission Recommendation 2012/148/EU;
- Member States should publish the minimum functional and technical requirement for these systems which should be in accordance with those mandated in the Directive and in the spirit of the Commission Recommendation 2012/148/EU;
- Member States should ensure the interoperability of the smart metering systems and their ability to provide output for consumer energy management systems;
- Final customers should contribute to the associated cost of deployment of smart metering systems, in a transparent and non-discriminatory manner, while taking into account the long-term benefits to the whole value chain;
- When the deployment of smart metering systems is negatively assessed, Member States should revise this assessment at least every four year;
- Smart metering systems should be in accordance with applicable Union data protection rules.

Article 20 sets up specific requirements for the functionalities that smart metering systems should support in order to fit their purpose and deliver benefits for the consumers and the energy system as a whole. It furthermore provides that Member States should ensure that the deployed smart metering systems are in accordance with European standards, the spirit of the measures under the Commission Recommendation 2012/148/EU, and in line with other specific requirements coming from Article 9 of the Energy Efficiency Directive 2012/27/EU concerning:

- the type of data provided to customers;
- security of data and data communications;
- the availability of these data for the customers;
- the appropriate advice and information that should be given to final customers prior to or at the time of installation of smart meters.

Article 21 provides that customers be entitled to a smart meter in cases where the deployment has been negatively assessed nor systematically pursued. Then, customers should bear the associated costs of deployment, under fair, reasonable and cost-effective conditions.

Thereby, the new Electricity Directive updates and puts forward the following provisions that are of direct relevance to smart metering and its use as a tool for demand-side management and flexibility (see Figure 5: Smart meter provisions):

- Establishment of a level playing field for demand response with independent aggregator (Article 17)
- Consumers' entitlement to smart meter and how to exercise this (Article 21)
- Network tariffs: as a general principle of network charges, tariffs paid by customers should fairly reflect the cost they impose on the network operator. This should also be reflected on network charges related to smart metering deployment (full or segmented roll out) (Article 19)

- Consumer Outcomes: consumers directly benefitting from a smart meter to promote acceptance and satisfaction, but also to ensure that deployment does not fall short of expectations (of customers but also vis-à-vis the original cost-benefit analysis, e.g. estimated energy savings) (Article 19)
- Data protection and security: follow applicable Union rules; use and adoption of Data Protection Impact Assessment (Article 20, Annex II)
- Citizen engagement: wider use of data brings opportunities, but also poses new challenges for effective competition in retail markets (Article 20)
- Cost benefit assessment: periodic CBA updates at least every 4 years in case of negative CBA result (Article 19)

Figure 5: Smart meter provisions

Furthermore, Annex II "Smart Metering systems" of the recast Electricity Directive provides, with respect to the aforementioned CBA, that:

"Subject to that assessment, Member States or, where a Member State has so provided, the designated competent authority, shall prepare a timetable with a target of up to ten years for the deployment of smart metering systems.

Where the deployment of smart metering systems is assessed positively, at least 80 % of final customers shall be equipped with smart meters either within seven years of the date of the positive assessment or by 2024 for those Member States that have initiated the systematic deployment of smart metering systems before 4 July 2019".

	European commission *Proposal*	European Parliament *Adoption*	Council *Adoption*	Official Journal *Publication*
Energy Performance in Buildings	30/11/2016	17/04/2018	14/05/2018	19/06/2018 – Directive (EU) 2018/844
Renewable Energy	30/11/2016	13/11/2018	04/12/2018	21/12/2018 – Directive (EU) 2018/2001
Energy Efficiency	30/11/2016	13/11/2018	04/12/2018	21/12/2018 – Directive (EU) 2018/2002
Governance	30/11/2016	13/11/2018	04/12/2018	21/12/2018 – Regulation (EU) 2018/1999
Electricity Regulation	30/11/2016	26/03/2019	22/05/2019	14/06/2019 - Regulation (EU) 2019/943
Electricity Directive	30/11/2016	26/03/2019	22/05/2019	14/06/2019 - Directive (EU) 2019/944
Risk Preparedness	30/11/2016	26/03/2019	22/05/2019	14/06/2019 - Regulation (EU) 2019/941
ACER	30/11/2016	26/03/2019	22/05/2019	14/06/2019 - Regulation (EU) 2019/942

Table 5: State of play of the Clean Energy for all Europeans Package as of June 2019[37].

[37] https://ec.europa.eu/energy/en/topics/energy-strategy-and-energy-union/clean-energy-all-europeans

4 DATA COLLECTION AND VALIDATION METHODOLOGY

The objective is to provide a comprehensive and updated overview of the status of smart metering roll-out at the time of the writing of this report, both for electricity and gas. A key challenge is to achieve a consistent and complete view of smart metering deployment in the EU-28. The following figure represents the data collection and validation methodology used for this study.

Figure 6: Data collection & validation methodology.

4.1 Data collection at national level

A standard questionnaire was drafted and used to capture the state of play of smart meter deployment in each Member State. The targeted interlocutor for the questionnaire were the National Regulatory Authorities (NRAs). This was adapted for some Member States, where for instance the subject was under the perimeter of a national Ministry. The questionnaire was structured as to cover all following 8 parts:

1. Regulatory framework
2. Cost benefit analysis
3. Roll-out state of play
4. Functional specifications
5. Technical specifications
6. Access to data and data management
7. Consumer outcomes
8. Data privacy / security

For each Member State, a dedicated country fiche (see supporting documents) is compiled based on the answers received from the NRA and other publicly available data sources. The structure of the country fiche follows the structure used in the questionnaire. Additional insights have also been integrated in the fiches regarding deployment financing, and the use of best available techniques for privacy and information security, including information the data protection impact assessment.

Table 6 lists the source of the data collection based on the following legend:

1. Country fiche realised based on NRA (or responsible national authority) feedback and validated by project consortium (through an internal review process in which country fiches completed by a partner were reviewed by another partner).
2. Country fiche realised based on other sources (DSO if the NRA did not provide an answer) and validated by the consortium (similar to point 1).

Country	Code	Source	Country	Code	Source
Austria	(AT)	1	Italy	(IT)	1
Belgium [38]	(BE)	1	Latvia	(LV)	1
Bulgaria	(BG)	2	Lithuania	(LT)	1
Czech Republic	(CZ)	1	Luxembourg	(LU)	1
Croatia	(HR)	1	Malta	(MT)	1
Cyprus	(CY)	1	Netherlands	(NL)	1
Denmark	(DK)	2	Poland	(PL)	1
Estonia	(EE)	1	Portugal	(PT)	1
France	(FR)	1	Romania	(RO)	1
Finland	(FI)	1	Slovakia	(SK)	1
Greece	(EL)	2	Slovenia	(SI)	1
Germany	(DE)	1	Spain	(ES)	1
Hungary	(HU)	1	Sweden	(SE)	1
Ireland	(IE)	1	United Kingdom [39]	(UK)	1

Table 6: Status of data collection at national level

4.2 Data consolidation at European level

Based on the data collected from the 28 Member States, a consolidated analysis, covering both electricity and gas, has been carried out detailing the most relevant facts, and drawing out recommendations. At this stage we have also investigated the data comparability of collected information at national level. In this respect, most information has been gathered using pre-selected answers and options from closed lists of propositions. However, we faced significant challenges to compare data; some information might require additional treatment to allow a sensible benchmark, especially economic outputs coming from the national cost benefit assessment and more advanced topics like consumer outcomes and data management.

4.3 Stakeholders engagement activities

In order to deliver strong and undisputed recommendations, a workshop was organised in Brussels on the 20th February 2019 to test ideas and share the preliminary results with the target audience (NRAs) and other relevant stakeholders. The workshop also triggered an informal consultation that

[38] Given the individual and region-specific data in **Belgium**, it is rather difficult to determine a single, country-representative value for the parameters considered in the CBA. Data from the regions are available in the respective country fiche document.

[39] Throughout the report, the data on the **United Kingdom (UK)**, Great Britain (UK-GB) is discussed as representative of the UK. The region of Northern Ireland (NI) represents a very small proportion of the overall UK figures in terms of overall metering points, i.e. 1.5 % of the total UK number. Therefore, it is not reflective of the MS position as a whole. Furthermore, there are varying methodologies as well as differences in the energy markets between NI and UK-GB.

allowed stakeholders to express their views à posteriori on the material shared and on the opinions conveyed during this interactive event.

5 BENCHMARKING

The aim of this study is to assess the current progress of smart metering deployment in the EU-28 against the objectives of the Third Energy Package adopted in 2009, taking also into consideration the latest policy initiatives undertaken by the European Commission, especially the new provisions related to smart metering under the recast Electricity Directive that has been recently adopted by the co-legislators[24] and which further paves the way for smart metering deployment.

Those provisions include, amongst other topics of interest, smart metering system interoperability and support of new services to deliver benefits and ultimately satisfaction to consumers.

The analysis of the data collected and herein presented provides an overall assessment of the smart metering landscape in the EU-28, in a comprehensive and consistent manner, as well as its outlook. Based upon this analysis, and consolidating our fact-finding exercise, an attempt is made to frame clear and strong recommendations for the way forward, at both national and European level, towards a successful smart metering deployment in Europe.

5.1 Electricity smart meters

5.1.1 Regulatory framework

This section provides an overview of the regulatory framework for smart metering deployment in all EU-28 Member States. Table 7 gives a comprehensive and updated review of the main legal and regulatory provisions related to electricity smart metering, that have come into force in each Member State. It is noted that, Member States have to transpose the aforementioned EU Directives into national law, and it is only if the CBA shows a positive case for a (wide-scale or partial) roll out of smart meters that they detail rules on smart metering, and those rules would then need to be adopted (see related information included in the tables below).

Whilst some Member States have done so when transposing the Third Energy Package, others have not adopted a national specific law for smart metering yet, even though they have also started to roll-out their smart meters following in most cases a positive CBA.

Country	Relevant legislation for electricity smart metering
Austria	The primary law is 'ElWOG 2010'. Delegated laws that further implement smart metering deployment are 'IME-VO' for the implementation plan, "IMA-VO" for the functional scope, and 'DAVID-VO' for the requirements concerning data availability and presentation to the customer.

Country	Relevant legislation for electricity smart metering
Belgium	The primary law that enables smart metering for electricity in the Brussels Capital Region is the ‘Ordonnance du 19 juillet 2001 relative à l'organisation du marché de l'électricité en Région de Bruxelles-Capitale’. The primary law that enables smart metering for electricity in Wallonia is the ‘Décret du 19 juillet 2018 modifiant les décrets du 12 avril 2001 relatif à l’organisation du marché régional de l’électricité et du 19 janvier 2017 relatif à la méthodologie tarifaire applicable aux gestionnaires de réseau de distribution de gaz et d’électricité en vue du déploiement des compteurs intelligents et de la flexibilité’. In Flanders, the primary law that enables smart metering for electricity and gas is the ‘Decreet van 8 mei 2009 houdende algemene bepalingen betreffende het energiebeleid’.
Bulgaria	No specific laws have been adopted to frame the deployment of smart metering.
Croatia	The Croatian primary law that enables both smart electricity and gas metering is the ‘Energy Act’.
Cyprus	The primary law that enables CERA to ensure the implementation of smart metering for electricity is the ‘Regulation of the Electricity Market Act2003’. It was introduced and amended as follows: 239(I)/2004, 143(I)/2005, 173(I)/2006, 92(I)/2008, 211(I)/2012, 206(I)/2015 18(I)/2017 and 145(I)/2018.
Czech Republic	‘Act No. 458/2000, Coll. on Business Conditions and Public Administration in the Energy Sectors and on Amendment Other Laws (Energy Act)’.
Denmark	The primary law that enables smart metering for electricity is the ‘Danish Electricity Supply Act’ which were revised 2019. Other relevant regulations are: • ‘Forskrifter, som implementerer EU direktiv 32009L0072’ • ‘Forskrifter, som implementerer EU direktiv 32012L0027’ • ‘Alle cirkulærer, vejledninger m.v. til denne bekendtgørelse’ • ‘Afgørelser truffet i henhold til denne retsforskrift’ • ‘Beretninger fra ombudsmanden, der anvender denne retsforskrift’
Estonia	The primary law that enables smart metering for electricity is the ‘Grid code (Võrgueeskiri) under Electricity Market Act’, which was revised in July 2010.
Finland	The primary law that enables smart metering for electricity is ‘Decree of the State Council (66/2009)’.
France	The primary law that enables smart metering for electricity is the ‘Law n° 2005-781’ of 13th of July 2005 providing energy policy guidelines, that has been incorporated into the ‘Energy Code (art. L.341-4)’.
Germany	The primary law that enables smart metering for both electricity and gas is ‘Gesetz zur Digitailiserung der Energiwende’ introducing the ‘Messstellenbetriebsgesetz’ (Metering Point Operation Act).
Greece	The primary law that enables smart metering for electricity is ‘Law 3855/2010’. This law is still to be revised. The purpose of this law is to enable to replace 80% of the conventional meters with smart meters until 2020.
Hungary	The primary laws that enable smart metering for electricity is the ‘Electricity Act LXXXVI’ of 2007. The ‘Government Decree No. 26/2016’ is currently the delegated law that further implements smart metering deployment for both smart electricity and gas meters.
Ireland	The primary law introduced by the Department of Communications, ‘Climate Action and Environment in 2014 that enables smart metering for electricity and gas meters is the ‘Statutory Instrument 426’, transposed into Irish law by way of secondary legislation based on the obligations under the Third Directive.
Italy	The primary law enabling smart metering for electricity in Italy is the ‘Legislative Decree 102/2014’, approved on 4th July 2014, which transposes the EU Directive on Energy Efficiency (EED 2012/27/EU).
Latvia	There is no specific law framing the smart metering deployment for electricity.

Country	Relevant legislation for electricity smart metering
Lithuania	The general principles of implementation of the Lithuanian energy sector vision are approved in the National Strategy for Energy Independence. The latest version of the strategy was approved by the Parliament of the Republic of Lithuania in June 21st, 2018 'Resolution No. XIII-1288' (hereinafter referred to as NENS). The approved NENS envisages that the development of the Lithuanian energy sector must be based on smart technologies and digitalization of energy (Article 19.8). They are set out in the General Regulations for the Installation of Electrical Equipment, approved by the Minister for Energy in January 13th, 2017 ('Order No 1-9'). These requirements are based on the implementation of the 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 (i.e. Article 9 (2) (a), (b), (c) and (d), and Article 10 (2) and (3) (a) and (e)).
Luxembourg	The primary law that enables smart metering for electricity is 'Loi modifiée du 1er août 2007 relative à l'organisation du marché de l'électricité (Art 29)'. This law was last revised in 2015. This revision introduced the mandate to roll out Smart Meters. Next revision was submitted to parliament on 19/03/2018, this time no changes were made to the Smart Meter paragraphs.
Malta	The primary laws that enable smart metering for electricity are the Subsidiary 'Legislation 545.13 on Electricity Market Regulations (S.L. 545.13)' and the 'Subsidiary Legislation 545.01 on Electricity Supply Regulations (S.L. 545.01)'.
The Netherlands	The primary laws that enables smart metering for electricity and gas are: • 'Wet implementatie EG-richtlijnen energie-efficiëntie' • 'Wijziging van de Elektriciteitswet 1998' • 'Gaswet ter verbetering van de werking van de elektriciteits- en gasmarkt (31374)' These laws are currently under revision. A delegated law that further implements smart metering deployment for electricity is the 'Besluit op afstand uitleesbare meetinrichtingen ten behoeve van de grootschalige uitrol van de slimme meter'.
Poland	The Primary law that enables smart metering for electricity is under legislative process. The draft provisions were presented for public consultation in October 2018
Portugal	The primary laws that enable smart metering for electricity and gas are 'Decreto-Lei n° 215-A/2012' (October 8) and 'Decreto-Lei n° 231/2012' (October 26), which have been both revised. The delegated law that further implements smart metering deployment for electricity is 'Portaria n° 231/2013' (July 22).
Romania	The primary law that enabled smart metering for electricity is the 'Law on Electricity and Natural Gas No. 123/2012', put in place in 2012 and revised in 2018 with 'Law no. 167/2018'.
Slovakia	The Slovak primary law that enables smart metering is 'Act on Energy No. 251/2012'. The 'Decree No. 358/2013' of the Ministry of Economy of the Slovak Republic is currently the delegated law laying down the procedure and conditions for the introduction and operation of smart metering systems in the electricity sector.
Slovenia	The 'Energy Act' is currently the primary law that enables electricity and gas smart metering in Slovenia, as it includes Articles 49 addressing "Intelligent metering systems" for the electricity sector. In 2015, as set out by the Energy Act (see Paragraph 2.1.1), the "Decree on Measures and Procedures for the Establishment and Connectivity of Advanced Measuring Systems for Electricity" ("Uredba o ukrepih in postopkih za uvedbo in povezljivost naprednih merilnih sistemov električne energije (Uradni list RS, št. 79/15)") was adopted.
Spain	The primary law that enables smart metering for electricity is the 'Royal Decree 1110/2007', of August 24th. The order 'ITC/3860/2007' (1st additional provision) reviews the electricity tariffs and further sets the implementation of smart metering deployment for electricity. While order 'IET/290/2012' also reviews the latter to include various modifications.
Sweden	The primary law that enables smart metering for electricity is the 'Electricity Act 2012' which has been revised. A further revision is expected at the end of 2018.
United Kingdom	The primary law that enables smart metering for electricity is the 'Energy Act 2008', as amended by the Energy Act 2011 and the Smart Meters Act 2018.

Table 7: National legislation for the deployment of electricity smart meters

Figure 7 provides an overview on the status of smart meter related legislation for electricity.

It can be observed that approximately three quarters of Member States have implementation strategies in place with specific legal provisions for the deployment of smart meters. For instance, in Germany, deployment and operation of the smart metering system is a legal obligation of the Metering Point Operator (MPO). This specific legal status has been created by 'Messstellenbetriebsgesetz' (the " Act on the Operation of Metering Systems and Data Communication in Smart Energy Grids") that fully liberalised metering point operation and metering services.

Therefore, Member States show a variable progress in the redefinition or refinement of their legal framework devoted to prevent and accommodate smart metering challenges. It is noted that our intention was to assess here if Member States had taken steps further, namely defining a deployment strategy (high level objectives and key changes to the market model to be implemented) and eventually the implementation laws that will accompany the day-to-day deployment of smart metering, such as priority targets, channels for communication and dispute resolution, tariffs,…etc.

An interesting development we have witnessed in several Member States is the progress achieved by grid operators with deployment and installation of smart metering systems, while the complete legal package is yet to be adopted by National Authorities. For instance, in Flanders the definitive political decision to roll out was taken only in April 2019, even though significant progress has been realized by local grid operators prior to this decision, in terms of smart meter penetration rate as well as the preparatory steps to enable a consistent value chain as a prerequisite to deliver benefits to consumers. Moreover, in Croatia, and Slovenia there is significant activity on smart grids deployment by local operators despite the absence of a specific legal framework.

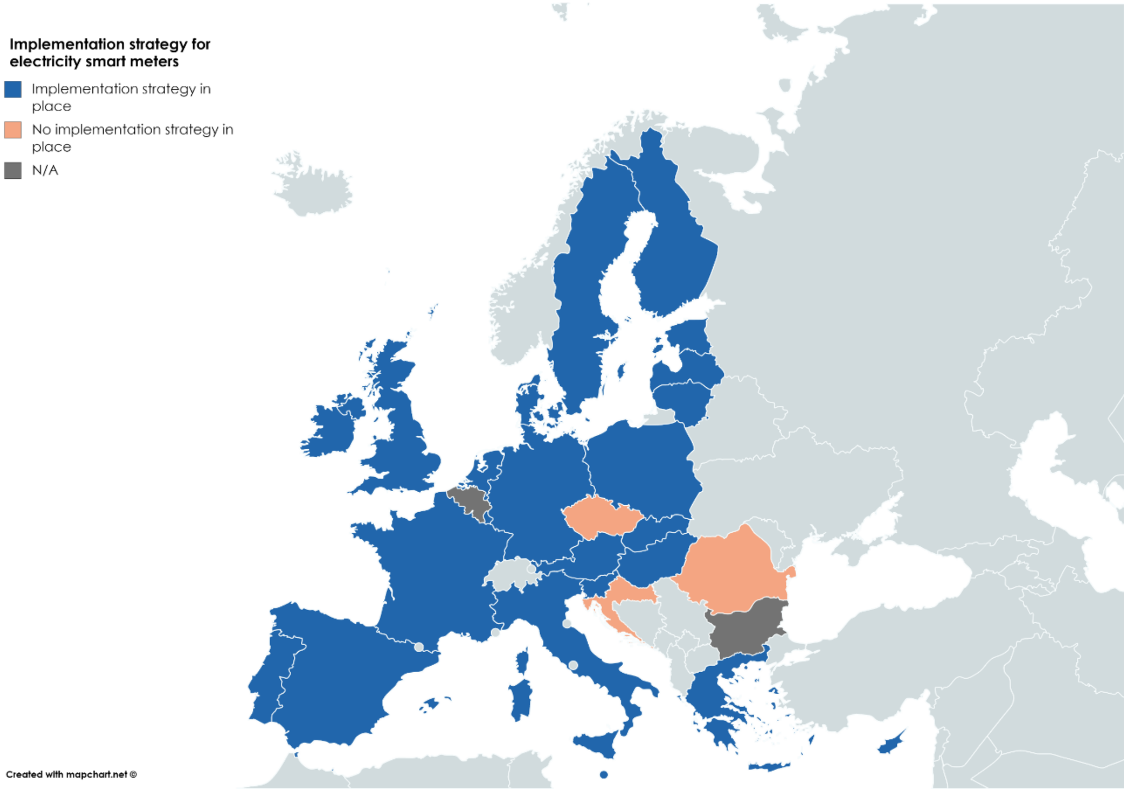


Figure 7: Overview of MS which have a national implementation strategy in place with specific legal provisions for the deployment of electricity smart meters.[40]

5.1.2 Cost benefit analysis

This section provides an overview of the timing and the result of the latest national cost benefit assessment (hereafter CBAs) performed for the deployment of smart meters by each Member State. For many of the Member States the initial CBA was carried out on the back of pilot projects, in order to integrate the experiences from those projects. Whereas the revised CBAs focus more on the actual scale and timing of the rollout.

First, the status and outcome of the latest national CBAs for electricity smart meters are described in subsection 5.1.2.1. In a second step (subsection 5.1.2.2), the CBA analysis is detailed with a focus on the cost, benefits and market roles considered in the CBA analysis for each Member State.

5.1.2.1 STATUS OF MOST RECENT CBA

For electricity smart meters, most Member States have performed at least one CBA, except for Spain. As it can be observed in Table 8, for many Member States the results of the CBA have remained unchanged compared to the initial benchmarking exercise carried out in 2013 (COM(2014) 356). In some cases, the CBA results for a large-scale rollout have changed, going from negative or non-conclusive to positive in the case of electricity smart meters; like in Latvia and Portugal.

On the other hand, in Ireland the result of the CBA has gone from positive (in 2013) to broadly neutral or negative (in 2018). The new Electricity Directive[24] under the “Clean Energy for all Europeans Package” indicates that Member States having obtained a negative CBA result must

[40] Whilst no implementation strategy for the wide-scale rollout of smart meters has been designed in Belgium, Flanders and Wallonia both have defined a strategy for segmented rollout.

regularly revise their CBA, at least every 4 years, or more frequently, in response to significant changes in their assumptions and to technological and markets developments. Once the result of the CBA is positive, at least 80 % of final customers for electricity shall be equipped with smart metering systems within 7 years from the date of the positive assessment.

Figure 8 provides a graphical overview of the most recent CBA results (as of July 2018) for the deployment of electricity smart meters.

	Initial CBA result [41] (as of July 2013)	**Revised CBA result[42] (as of July 2018)**	**Latest CBA conducted (as of July 2018)**
Austria	Positive	No new CBA	2010
Belgium[43]	Negative/Inconclusive	Positive/inconclusive	2017
Bulgaria	N/A	Negative	2013
Croatia	N/A	Positive	2017
Cyprus	N/A	Inconclusive	2014
Czech Republic	Negative	Negative	2016
Denmark	Positive	N/A	N/A
Estonia	Positive	No new CBA	2011
Finland	Positive	No new CBA	2008
France	Positive	Positive	2013
Germany	Negative[44]	Negative	2013
Greece	Positive	No new CBA	2012
Hungary	Inconclusive	Pending	2018
Ireland	Positive	Negative[45]	2017
Italy	N/A	Positive	2014
Latvia	Negative	Positive	2017
Lithuania	Negative	Inconclusive	2018
Luxembourg	Positive	Positive	2016
Malta	NO CBA	No new CBA	NO CBA
Netherlands	Positive	No new CBA	2010

[41] The conditions of the initial CBA results (as of July 2013) were a large-scale roll-out covering at least 80 % of the consumers by 2020.

[42] The conditions of the revised CBA results (if applicable) were a large-scale roll-out covering at least 80 % of the consumers by 2020.

[43] In Flanders, the CBA has been revised in 2018 and provided a positive outcome (https://www.vreg.be/nl/nieuws/actualisatie-van-de-kosten-batenanalyse-digitale-meters)

[44] Positive CBA for a segmented rollout only, for Germany, Slovakia, and originally also for Latvia,

[45] The last revision of the CBA in Ireland provided a slightly negative outcome, which has thus been considered as ‘broadly neutral’ by the Commission for Regulation of Utilities (CRU).

	Initial CBA result [41] (as of July 2013)	Revised CBA result[42] (as of July 2018)	Latest CBA conducted (as of July 2018)
Poland	Positive	Positive	2014
Portugal	Inconclusive	Positive	2015
Romania	Positive	No new CBA	2012
Slovakia	Negative	Inconclusive	2013
Slovenia	N/A	Positive	2014
Spain	NO CBA	NO CBA	NO CBA
Sweden	Positive	N/A	2015
United Kingdom	Positive	Positive	2016

Table 8: Status of last CBA for electricity smart meters conducted as of the previous and current study, including the outcome of the CBA(s) already conducted

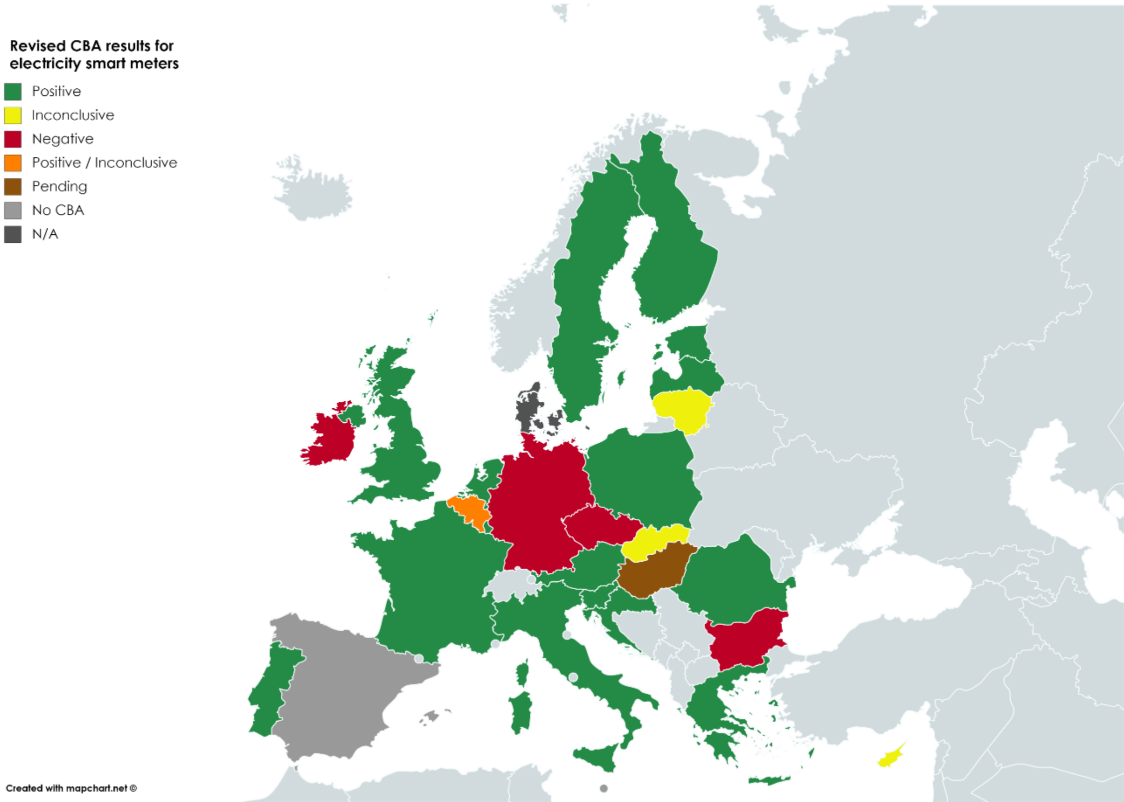


Figure 8: Revised CBA results electricity smart meters, considering a large-scale rollout to at least 80% by 2020 (as of July 2018).

5.1.2.2 CBA ANALYSIS

As provided by Article 19 and Annex II of the recast 'Electricity Directive' (2019/944/EU), the deployment of smart metering systems may be subject to a cost-benefit analysis, conducted in accordance with Recommendation 2012/148/EU. When the CBA results in a positive outcome, "at least 80 % of final customers shall be equipped with smart meters either within seven years of the date of the positive assessment or by 2024 for those Member States that have initiated the systematic deployment of smart metering systems before 4 July 2019". When the deployment is negatively assessed, Member States shall revise their CBA at least every four years.

Key cost and benefit items were defined in the Recommendation 2012/148/EU, inviting Member States to use the same structure for their CBA. This subsection presents all costs, benefits and market actors considered in the CBA for each Member State. As indicated in Figure 9, the functionalities foreseen will create benefits for the different actors (e.g. consumers, grid operators, etc.), while the assets involve capital (CAPEX) and operational expenditures (OPEX). These costs and benefits serve as input for the Cost Benefit Analysis.

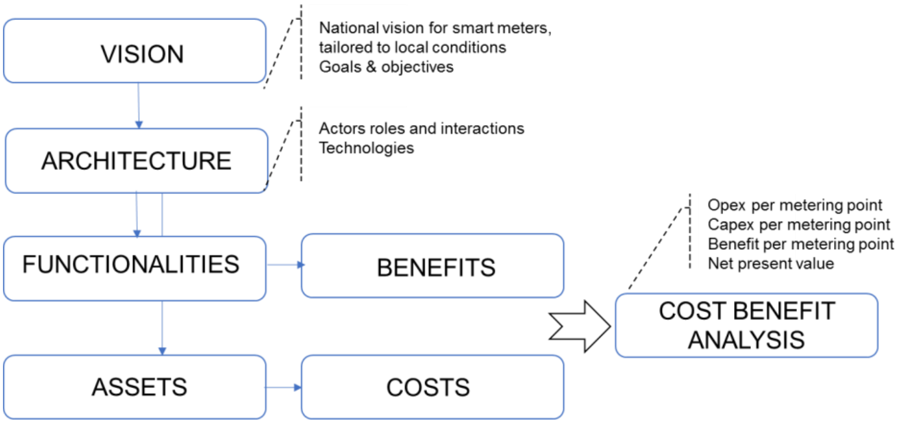


Figure 9: Basic steps for a cost benefit analysis.

Costs considered in the electricity CBA

Table 9 provides an overview of the cost items considered by each Member State in their latest CBA, both for electricity and gas smart metering deployment. The most common cost items considered by the Member States while conducting their CBA can be observed in Figure 10. The capital investment linked to the smart meters themselves and the IT infrastructure are the cost items most selected by Member States. These are followed closely by operational expenses linked to meter readings, IT maintenance, telecommunications and network management.

	CAPEX - Investment in smart meter	CAPEX - Investment in IT	CAPEX - Investment in Telecom	CAPEX - Investment in In-home display	CAPEX - Sunk cost of conventional meters	OPEX - IT maintenance	OPEX - Network management and front end	OPEX - Telecom	OPEX - Change management	OPEX - Unplanned renewal and failures of smart meter	OPEX - Revenue reduction	OPEX - Meter reading	OPEX - Call center and customer service	OPEX - Consumer engagement programme	Other
AT	✓	✓	✓		✓	✓	✓	✓			✓	✓	✓	✓	
BE (BR)	✓	✓	✓			✓	✓	✓	✓	✓			✓		✓
BE (FL)	✓	✓				✓		✓	✓	✓	✓	✓	✓		
BE (WA)	✓	✓	✓			✓	✓	✓	✓	✓		✓	✓		
BG	✓	✓	✓		✓	✓	✓	✓		✓		✓			
HR	✓	✓	✓			✓	✓	✓	✓			✓		✓	
CY	✓	✓	✓									✓	✓		
CZ	✓	✓	✓		✓	✓	✓	✓	✓	✓					
DK	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
EE	✓	✓			✓	✓	✓	✓	✓			✓	✓		
FI	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
FR	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
DE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
EL	✓	✓	✓	✓	✓	✓	✓	✓		✓		✓	✓		
HU	✓	✓	✓		✓	✓	✓	✓			✓	✓	✓	✓	
IE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
IT	✓	✓	✓	✓	✓		✓					✓			✓
LV	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓		
LT	✓	✓	✓		✓	✓	✓	✓	✓	✓		✓	✓	✓	
LU	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
MT	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
NL	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓		✓
PL	✓	✓	✓		✓	✓	✓	✓		✓		✓	✓		✓
PT	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	
RO	✓	✓				✓	✓	✓		✓		✓	✓		
SK	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
SI	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
ES	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
SE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
UK	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	

Table 9: Considered CAPEX and OPEX costs in the CBA for each Member State (legend: green = included, blank = not included; grey = data not available).

Despite the Electricity Directive 2009/72/EC and Gas Directive 2009/73/EC promoting the wider use of smart metering systems as a key enabler to allow the active participation of consumers in the internal electricity and gas markets and to contribute to a secure, competitive and sustainable supply of energy for Europe, only few (6 out of 28) Member States are considering both investment expenditures in in-home-displays and operational expenditures for active customer engagement while carrying out their assessment. While the installation of in-home displays is not a mandatory measure of smart metering implementation per se, the provision of validated historical consumption data as well as near real-time consumption data to consumers, in a securely and easily accessible way, remains a key requirement of EU regulation related to smart metering. Thus, Member States that do not consider deploying in-home displays must ensure that the alternative solutions they foresee (e.g. internet platforms) fulfil those requirements and adequately provide consumers with consumption data enabling energy efficiency programmes, demand response schemes and other services.

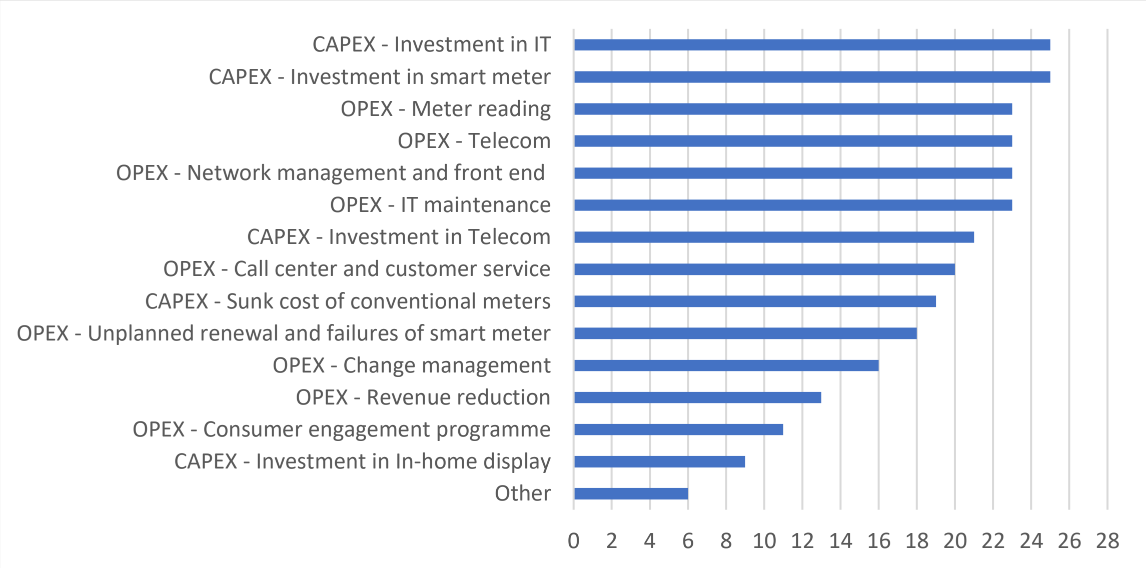


Figure 10: Ranking of the considered CAPEX and OPEX costs in the electricity CBAs vs. number of Member States.

Benefits considered in the electricity CBA

Table 10 provides an overview of the various benefit items considered by each Member State when performing the CBA. Table 11 shows the ranking of the considered CAPEX and OPEX costs in the electricity CBAs vs. the number of Member States

Consumers will have **direct benefits** from bill reductions, as a result of:

- Increased energy efficiency as smart meters will allow them to get an insight into their energy consumption. These insights may result in a reduction of energy consumption and bill savings.
- A reduced bill due to dynamic pricing, i.e. a price defined by the day ahead and intraday markets and shared with the consumer. A dynamic pricing profile will allow the consumers to shift their energy consumption in time (e.g. white goods) and get rewarded for that, e.g. reduce their annual energy bill.

Moreover, consumers will **benefit indirectly from potential cost savings that other market actors** can benefit from as a result of several other technical and non-technical benefits.

- Smart meters will allow automated meter reading resulting in operational savings (vs. manual reading by for instance the DSO). The automated reading will also allow reduce other non-technical losses. For instance, meter readings will be less sensitive to administrative errors, or energy offtake will be less sensitive to fraud, and technical losses or fraud can be much faster identified than with regular meter reading (e.g. thanks to frequent, near real-time measurements).
- Consumers and other actors may offer flexibility services, enabling different actors (e.g., grid operators, supply chain and generators) to optimise the operation and maintenance of their assets. This translates into reduced technical losses, potential deferral of additional assets/capacity, etc, and can lead to cost savings for market actors which may ultimately result in a reduced energy bill for consumers.
- Additionally, the reduction of services' cost for the DSO (or other smart meter operators) achieved by the remote management of the metering system, should bring tangible economic benefits to consumers. Nevertheless, this will be realised if the NRAs ensure that operation and management costs reductions enabled by smart metering systems are effectively passed-on to consumers charges.

Figure 11 presents the ranking of the consolidated results of the considered benefits across the EU-28. The most common benefit considered by Member States is linked to the operational savings that can be achieved through remote meter readings. The reduction of non-technical losses (e.g. administrative or fraud), and the consumer's bill reduction as a result of increased energy efficiency are the next two main benefits considered.

As smart metering roll-out is currently in nearly all Member States DSO-led, in practice, the main benefits from this exercise so far are accrued by the DSO and are related to the meter reading and operation savings and non-technical losses. Despite that, issues such as distribution capacity deferral, O&M of assets, outage management and reduction of technical losses are less considered and recognised as benefits while conducting the CBAs.

Benefits that focus on the potential services that could be offered to consumers through smart meters (e.g. optimisation of auto-consumption through access to solar PV installations) as well as flexibility services have been considered by a very small number of Member States.

	Bill reduction due to energy efficiency	Bill reduction due to dynamic pricing	Provision of explicit flexibility services	Increased competition in retail market	Easier access to photovoltaic production	Meter reading & operation savings	Operation & maintenance of assets	Distribution capacity deferral	Transmission capacity deferral	Generation capacity deferral	Technical losses reduction	Non-technical (administrative, including fraud) losses	Outage management (based on societal value of lost load)	Outage management (based on reduced customer indemnification)	CO_2	Air pollution (particulate matters, NOx, SO2)	Other
AT	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓				✓		
BE (BR)	✓	✓				✓		✓			✓	✓			✓		✓
BE (FL)	✓		✓	✓		✓		✓				✓	✓		✓		
BE (WA)			✓			✓					✓	✓					✓
BG		✓				✓						✓					
HR	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓	
CY	✓					✓						✓	✓		✓		
CZ						✓	✓					✓					
DK	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
EE						✓	✓					✓					
FI	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
FR	✓					✓	✓	✓			✓						
DE	✓	✓				✓	✓	✓	✓	✓	✓	✓		✓	✓		
EL	✓	✓		✓	✓	✓	✓				✓	✓			✓	✓	
HU	✓	✓	✓		✓	✓	✓					✓	✓	✓	✓	✓	✓
IE	✓	✓				✓				✓		✓					
IT	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
LV	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
LT	✓			✓		✓	✓					✓	✓		✓	✓	
LU	✓					✓	✓				✓	✓					
MT	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
NL	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
PL	✓	✓		✓		✓	✓	✓	✓	✓	✓	✓					
PT	✓			✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
RO	✓	✓				✓	✓	✓			✓	✓					
SK	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
SI	✓	✓				✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
ES	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
SE	✓				✓	✓	✓				✓		✓				✓
UK	✓			✓		✓									✓		

Table 10: Considered benefits in the CBA for each Member State (legend: green = considered, blank = not considered; grey = data not available).

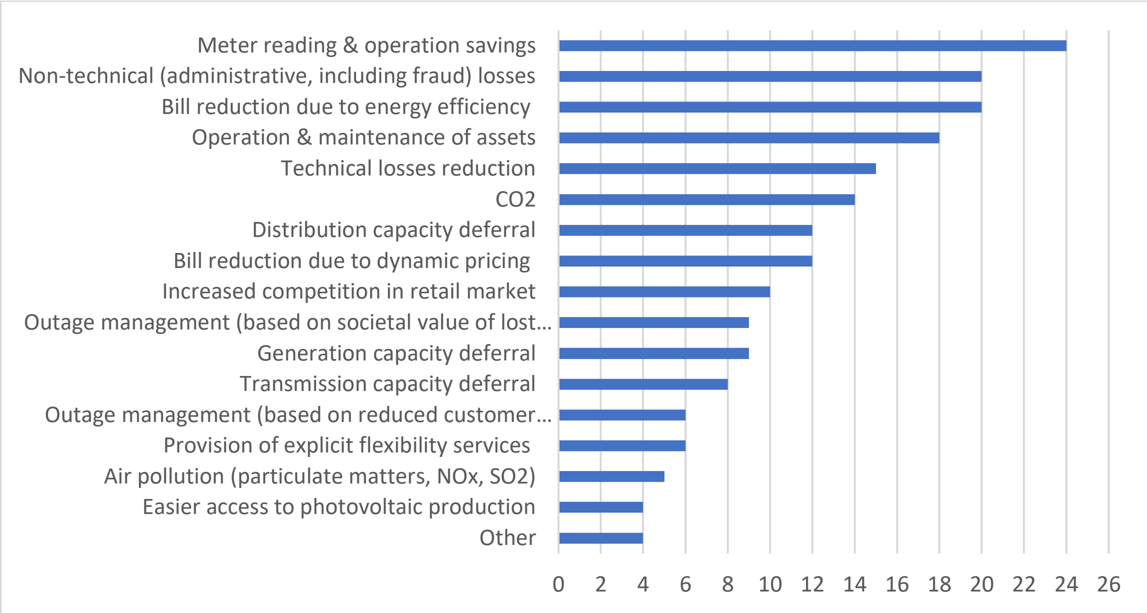


Figure 11: Ranking of the considered benefits in the electricity CBA vs. number of member States

Beside these benefits items, other smart metering benefits are not taken into account because of the complexity of their estimation. For instance, the higher efficiency of smart metering systems might benefit market actors in increasing the speed of commercial transactions. Moreover, customers' request can be satisfied in a much faster and efficient way than with regular meters. These two cases are examples of a large variety of currently unmeasurable, non-quantifiable, benefits that smart metering systems might bring.

Market actors considered in the electricity CBA

The various market actors considered by each Member State when carrying out the CBA can be observed in Table 12; a consolidated ranking in terms of frequency of occurrence in Member States CBAs, is presented in Figure 12.

With no real surprise, the most common actor is the distribution system operator (DSO), who in many countries is responsible for metering installation, meter reading, and distribution grid operations. Apart from UK where the smart meter ownership and installation is supplier-led, in all Member States the smart metering deployment is DSO-led. Many technical benefits are directly related to the DSO, such as meter reading and operations savings, technical operational and maintenance benefits, etc.

Table 11 demonstrates which market actor (i) owns the smart meter and which market actor (ii) is responsible for the installation of the smart meter in each Member State.

	Meter ownership	Meter installation
AT	DSO	DSO
BE (BR)	DSO	DSO
BE (FL)	DSO	DSO
BE (WA)	DSO	DSO
BG	DSO	DSO

	Meter ownership	Meter installation
HR	DSO	DSO
CY	Distribution system owner	Distribution system owner
CZ	DSO	DSO
DK	DSO	DSO
EE	DSO	DSO
FI	DSO	DSO
FR	DSO[46]	DSO[46]
DE	DSO or 3rd party meter operator[47]	DSO or 3rd party meter operator
EL	DSO	DSO
HU	DSO	DSO
IE	DSO	DSO
IT	DSO	DSO
LV	DSO	DSO
LT	DSO	DSO
LU	DSO	DSO
MT	DSO	DSO
NL	DSO	DSO
PL	DSO	DSO
PT	DSO	DSO
RO	DSO	DSO
SK	DSO	DSO
SI	DSO (through concession granted by government)	DSO (through concession granted by government)
ES	DSO	DSO
SE	DSO	DSO
UK	Energy supplier	Energy supplier

Table 11: Meter ownership & installation in Member States for both electricity and gas smart metering

[46] In France meters ownership is retained by local municipalities while the DSO operates them under a multi-annual concession.

[47] In Germany smart meters' ownership and installation is by default DSO-led, unless the DSO refuses to perform the mandatory roll out. Following a tendering procedure, another metering operator will then perform the mandatory roll out. Customers can also choose 3rd party meter operators for smart meters.

Other important market actors are the energy supplier who collects metering data, e.g. to send the energy bill to the consumer, and the consumers.

Actors such as the transmission system operator (TSO), balance responsible parties (BRP), producers, state/society (e.g. less tax incomes due to energy efficiency) and NRAs are also considered to some extent, as they are mainly actors which will benefit from smart metering data, but are less involved in the smart metering roll-out (from a cost-perspective).Service providers like telecom companies and aggregators are the least considered actors in the assessment.

	DSO	Supplier	NRA	Consumer	State/Society	TSO	BRP	Producer	Independent aggregator	Telecom service provider	Other actor
AT	green	green		green		green					
BE (BR)	green	green	green	green	green						
BE (FL)	green	green		green	green	green	green	green			
BE (WA)	green	green	green	green							
BG	green										
HR	green	green		green	green	green					
CY	green	green		green							green
CZ	grey	grey	grey	grey	grey	grey	grey	grey	grey	grey	grey
DK	grey	grey	grey	grey	grey	grey	grey	grey	grey	grey	grey
EE	green										
FI	grey	grey	grey	grey	grey	grey	grey	grey	grey	grey	grey
FR	green			green	green			green			
DE	green	green		green	green	green	green	green	green		
EL	green	green	green	green	green			green			
HU	green	green		green					green	green	
IE	green	green		green	green						
IT	green	green	green	green	green	green	green			green	
LV	green										
LT	green	green	green	green	green						
LU	green	green		green			green	green			
MT	grey	grey	grey	grey	grey	grey	grey	grey	grey	grey	grey
NL	green	green		green	green	green		green			green
PL	green	green		green	green	green	green	green	green		
PT	green	green		green	green	green		green			
RO	green			green							
SK	green	green		green							
SI	green	green	green	green	green	green		green		green	
ES	grey	grey	grey	grey	grey	grey	grey	grey	grey	grey	grey
SE	green	green	green	green	green						green
UK		green		green	green						

Table 12: Considered market actors in the CBA for each Member State (legend: green = considered, blank = not considered; grey = data not available).

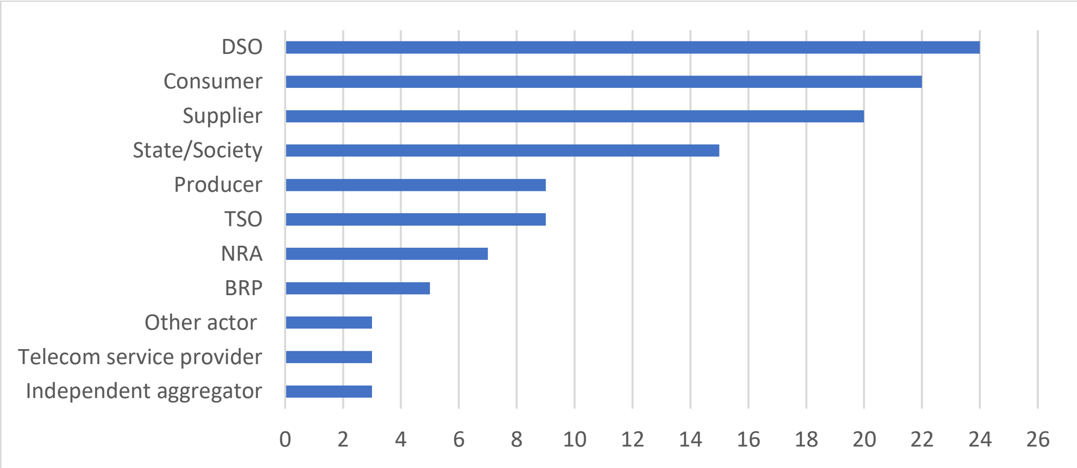


Figure 12: Ranking of the considered market actors in the CBA vs. number of Member States

Energy savings and peak load reduction

Other particularly relevant input factors when conducting the CBA are the estimated energy savings and peak load reduction induced by the real-time consumption feedback provided by smart meters. Unfortunately, this information was most of the time not reported during the data collection phase. However, a VaasaETT report on "The role of Data for Consumer Centric Energy Markets and Solutions"[48], provides detailed information on these two factors, based on current experiences and pilot programmes. According to this report, the average energy savings induced by smart metering are close to 5.4 % of the total consumption while the peak consumption reduction (in case of no home-automation system) is on average 8.9%.

A general comment that emerges from the analysis of the different CBAs conducted by the Member States, is the observed inconsistency of the considered costs, benefits and market actors, that precludes a strict comparison. Whilst country-specific characteristics might explain part of these discrepancies, in some cases choices related to input factors considered do not seem to be based on solid and clear ground. A more rigorous and homogeneous application of Recommendation 2012/148/EU would allow Member States to compare their respective analyses and to draw lessons from neighbours' experiences so as to boost the robustness and accuracy of their CBAs.

5.1.2.3 NORMALISED COST AND BENEFIT PER METERING POINT FOR ELECTRICITY

The normalised estimations of cost and benefit per metering point, for each Member State, can be seen in Table 13. It is important to note that two methods were proposed for the computation of these values in the data collection exercise. These were:

1. Direct computation of key indicators (cost and benefit per installed meter) by the NRA (or other entity in charge)
2. The providing of yearly estimates on OPEX, CAPEX, benefits, number of meters in order to estimate the cost and benefit over the given period

All responding Member States in the current investigation have chosen the first method. As highlighted in the following table, the collected data shows inconsistencies between initial and updated CBAs outcomes. During the earlier benchmarking exercise of 2013/2014 (see

[48] https://esmig.eu/sites/default/files/report_-_the_role_of_data_for_consumer_centric_energy_markets_and_solutions_2019.pdf

COM(2014)356), national regulatory authorities had at their disposal, and made available, recent cost/benefit data coming from their CBAs that were meant to be conducted, in accordance with the Electricity Directive 2009/72/EU, by September 2012 – an option that most Member States decided to take. In this updated benchmarking, we gathered the latest information where available, with the following outcome:

- 2 Member States did not perform a CBA (Malta and Spain) and 2 others were unable to provide the suggested information to compute comparable indicators, namely Bulgaria and Hungary, neither in 2014 nor in 2018.
- 8 Member States did not update their initial CBA: Austria, Denmark, Estonia, Finland, Greece, Netherland, Romania and Sweden.
- 4 Member States have performed their first national CBA that occurred after the publication of the first benchmarking report (2014). These are Croatia, Italy and Slovenia that show a positive result, whereas the CBA outcome in Cyprus was inconclusive (the sensitivity analysis showed a high degree of deviation of benefits).
- There were some cases where the updated CBA showed different results than the initial one: in Latvia, Lithuania and Portugal, the new CBA produced a positive result; while the contrary happened in Ireland where although displaying a negative result, the updated CBA was considered as "broadly neutral". In spite of that, Ireland is still pursuing smart metering deployment. In Slovakia, the updated CBA has been considered inconclusive.
- An updated CBA for smart metering deployment has confirmed the initial result in a number of countries - that was negative for the Czech Republic, Belgium and Germany, and positive for the remaining 4 Member States (France, Luxembourg, Poland and the United Kingdom).

	TOTEX (€/meter) 2018	**TOTEX (€/meter) 2013**	**Benefit (€/meter) 2018**	**Benefit (€/meter) 2013**
Austria	€	316.00 €	€	383.00 €
Belgium[49]				
Bulgaria				
Croatia	272.40 €		353.10 €	
Cyprus	275.80 €		969.00 €	
Czech Republic	350.33 €	766.00 €	100.82 €	499.00 €
Denmark		225.00 €		233.00 €
Estonia	147.10 €	155.00 €	269.00 €	269.00 €
Finland	209.70 €	210.00 €		-
France	135.00 €	135.00 €		-
Germany	546.00 €	546.00 €	493.00 €	493.00 €
Greece		309.00 €		436.00 €

[49] As the CBA is performed separately for each region, it is not possible to provide a single figure for costs and benefits of smart metering system deployment in Belgium. The last revision of the CBA in Flanders provided a net present value of €440 million, considering the segmented rollout of both electricity and gas smart meters. More information on this can be found in the accompanying country fiches.

	TOTEX (€/meter) 2018	TOTEX (€/meter) 2013	Benefit (€/meter) 2018	Benefit (€/meter) 2013
Hungary				
Ireland		473.00 €		551.00 €
Italy[50]	94.00 €		176.00 €	
Latvia	38.18 €	302.00 €	43.64 €	18.00 €
Lithuania	169.60 €	123.00 €	185.90 €	82.00 €
Luxembourg	139.00 €	142.00 €	158.00 €	162.00 €
Malta	77.00 €	77.00 €		-
Netherlands		220.00 €		270.00 €
Poland	78.00 €	167.00 €	87.00 €	177.00 €
Portugal	333.30 €	99.00 €	466.70 €	202.00 €
Romania		99.00 €		77.00 €
Slovakia		114.00 €		118.00 €
Slovenia	145.50 €		170.50 €	
Spain				-
Sweden		288.00 €		323.00 €
United Kingdom	232.00 €	161.00 €	352.00 €	377.00 €

Table 13: Normalised costs and benefits per metering point, for the case of electricity, for each Member State (Legend: blank = data not available).

[50] One should be careful comparing the 2013 and 2018 costs per metering point for Italy. Whilst the first is an estimate of capital cost and operational expenses, the latter is an estimate of capital cost only.

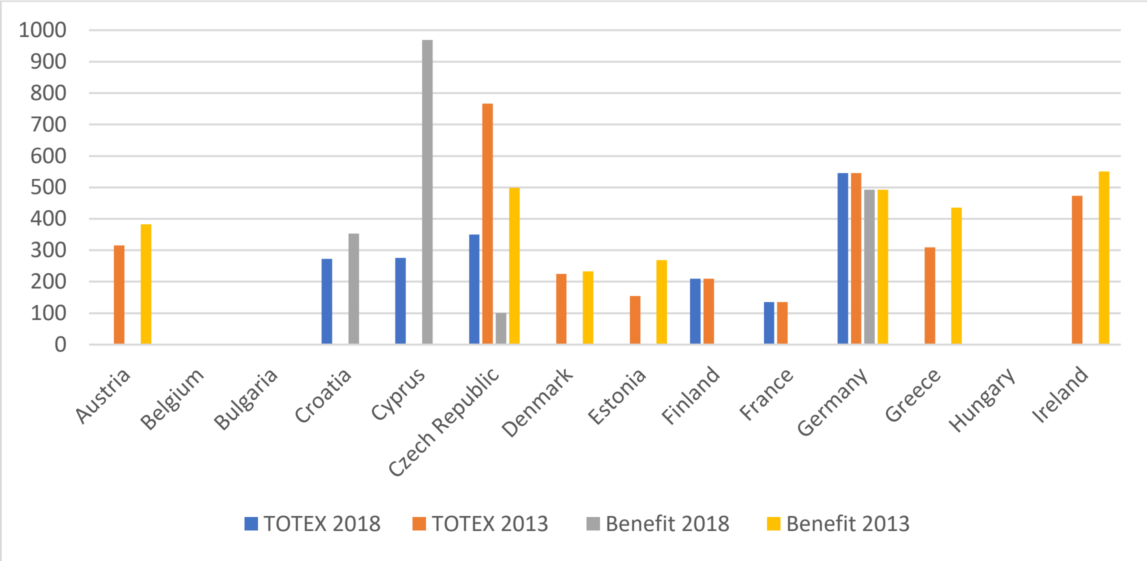


Figure 13: Comparison on normalised costs and benefits per metering point for each Member States between the previous (2014) and current benchmarking report (2018).

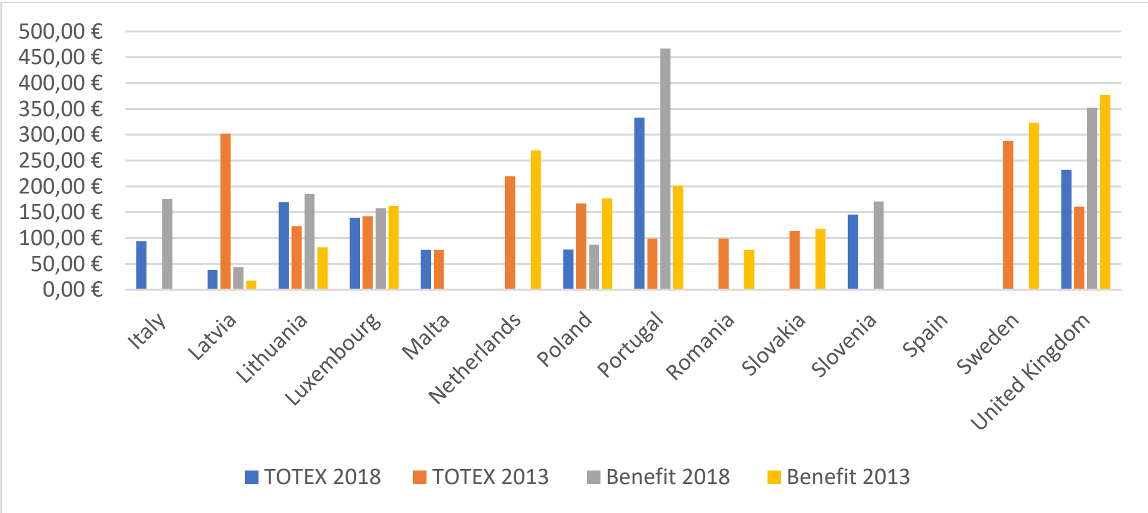


Figure 14: Comparison on normalised costs and benefits per metering point for each Member States between the previous (2014) and current benchmarking report (2018)

Figure 13 and Figure 14 bring out the high variability in some of the results compared to the earlier data (comparing the 2013 and 2018 CBA results). For instance, three countries (namely the Czech Republic, Luxembourg and Poland) exhibit lower costs and benefits in the 2018 CBA compared to the previous one, two other (Lithuania and Portugal) show higher costs and benefits this time around, whilst irregular variation levels can be observed for Latvia and the United Kingdom.

What can be seen from Table 9 - Table 12 is that there is high variation between the market actors, and cost and benefit items considered by each Member State, and as a result, there will be a high variation between the normalised cost and benefit per metering point. This is also reflected in Figure 15.

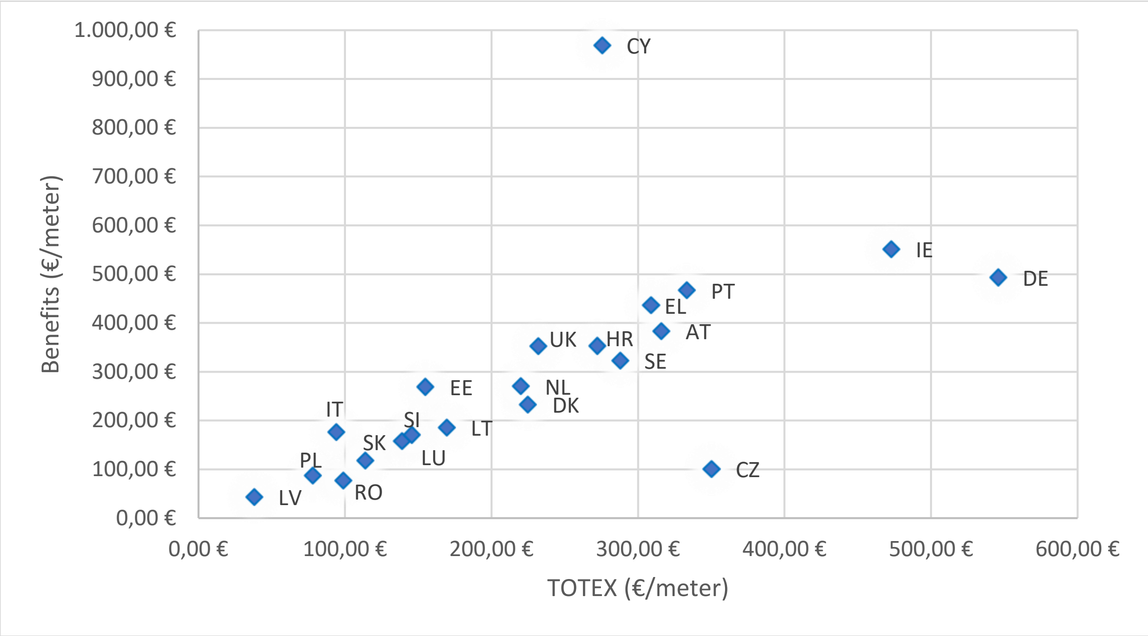


Figure 15: Normalised costs vs. benefits per metering point (most recent figures for each MS), for the case of electricity.

Those statistics indicate, on average, that both costs and benefits have decreased since the first benchmark. Moreover, new cost estimates show less variation amongst member states than in the previous exercise. However, benefits' estimates still vary greatly between member states, with the latest statistics showing a higher variation than previously.

€/metering point	TOTEX 2018	TOTEX 2013	Benefit 2018	Benefit 2013
Average	200.99 €	246.35 €	281.59 €	274.71 €
Standard deviation	126.95 €	169.90 €	243.03 €	157.34 €

Table 14: Average and standard deviation for cost and benefit per metering point, in the case of electricity smart meters and considering data from all EU-28 countries

In order to refine this analysis, we have separated Member States into 4 groups[51], depending on their actual penetration level and their deployment targets. Group 1 includes countries that have more than 75% of smart meters, group 2 targets countries that took a commitment to deploy 80% in 2020 but did not exceed 75% of deployment at the moment of writing this report. The third group gathers countries that committed to the large-scale rollout of smart meters and with less than 10% of smart meters in place, while the last group focuses on countries that did not commit to the 80% target by 2020.

The results are detailed in the following table and in Figure 16.

[51] **Group 1** includes Denmark, Estonia, Finland, Italy, Malta, Spain and Sweden. **Group 2** includes Austria, France, Latvia, Luxembourg, The Netherlands and the United Kingdom. **Group 3** includes Greece, Ireland, Poland, Romania and Slovakia. **Group 4** includes Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Germany, Hungary, Lithuania, Portugal and Slovenia.

		TOTEX 2018	TOTEX 2013	Benefits 2018	Benefits 2013
Group1	Average	126.90 €	191.00 €	176.00 €	275.00 €
	Standard deviation	58.96 €	71.02 €	0.00 €	36.99 €
Group 2	Average	136.05 €	212.67 €	184.55 €	242.00 €
	Standard deviation	68.55 €	73.49 €	127.28 €	138.18 €
Group 3	Average	78.00 €[52]	232.40 €	87.00 €[52]	271.80 €
	Standard deviation		141.31 €		187.35 €
Group 4	Average	298.99 €	383.50 €	391.29 €	319.00 €
	Standard deviation	123.27 €	283.51 €	274.26 €	182.03 €

Table 15: Statistical outcomes of cost and benefit per metering point for different groups of Member States depending on their level of smart metering deployment

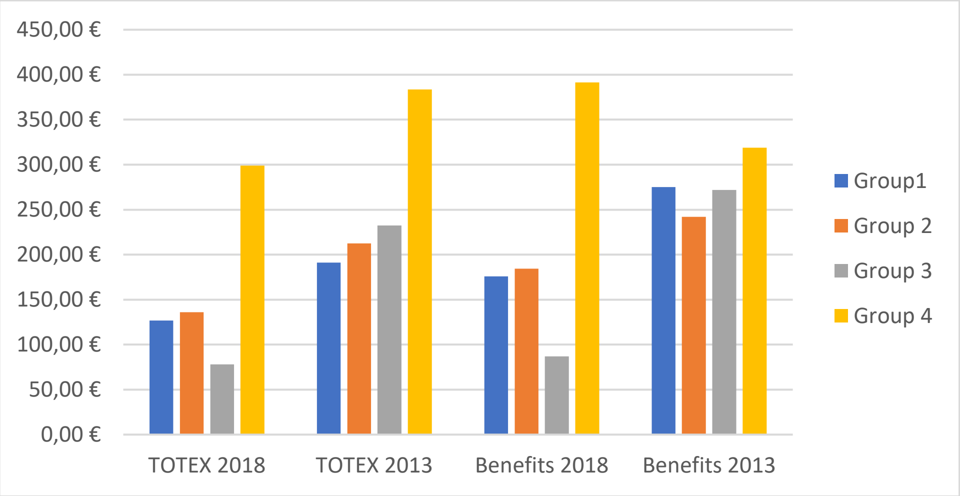


Figure 16: Comparison of average total costs and benefits per group of countries between the previous (2014) and current benchmarking report (2018)

The first group (Denmark, Estonia, Finland, Italy, Malta, Spain and Sweden) shows a significant variation of the benefits in their assessment between the 2013 and the 2018 data, which is partly explained by the fact that most of these Member States conducted only one CBA, some before 2013 and some after 2013. Nonetheless, these Member States dispose of a better knowledge of economic outcomes and expenses of smart metering systems potentially due to access to relevant field data. Thus, the costs and benefits of smart metering system deployment provided by this group of Member States are likely to be considered as the most reliable assessment.

The second group (Austria, France, Latvia, Luxembourg, The Netherlands and the United Kingdom) shows a common pattern, namely that cost and benefits have both declined. The decrease in variation depicts an increased maturity and knowledge of benefits and costs, using pilot projects and early waves of deployment as a source of feedback for the economic assessment.

[52] This figure only represents the case of Poland as data were not available for other MS from this group.

The third group, composed of Greece, Ireland, Poland, Romania and Slovakia, has witnessed a simultaneous decrease in costs and increase in benefits, which might foster the deployment of smart metering systems.

The last group (Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Germany, Hungary, Lithuania, Portugal and Slovenia), exhibits the same pattern as the second group. Compared to their previous CBAs, costs and benefits have significantly decreased, yet in similar proportion. While suffering an important delay in smart meters deployment, the refinement of their respective CBAs might have prepared these Member States to proceed to a fit-for-purpose smart metering system rollout (e.g. in 2018, the Cyprus Energy Regulation Authority decided, and accordingly instructed the DSO, to proceed with the appropriate actions to initiate the procedures for large-scale rollout of electricity smart meters, starting from January 2019). It should also be mentioned that, among this group, Slovenia has the highest penetration rate of smart meters (ca. 58%). This might though demonstrate some sort of ambiguity towards smart metering, given that the deployment is proceeding without any formal commitment in place for the target to reach.

5.1.3 Deployment state of play

A detailed analysis has been performed on the progress and the current deployment rate of the smart metering deployment across the EU-28, for each Member State.

5.1.3.1 MARKET DRIVERS FOR SMART METER ROLL-OUT

6 primary market drivers were identified for the deployment of smart meters:

- Enabling dynamic tariffs for households and SMEs;
- Digitalization of the distribution grid and optimization of the network operations;
- Digitalization of the retail market to foster innovation and new services by private actors;
- Integrating decentralized energy resources with flexible access, such as load shedding or infeed curtailment;
- Supporting actions for tackling fuel poverty;
- Supporting energy efficiency.

The primary drivers for the deployment of smart meters in each Member State can be observed in Table 16. Figure 17 consolidates this information to visualize the ranking of these market drivers across the EU-28.

The key driver to roll-out smart meters is the ‘digitalization of the distribution grid to allow optimization of the network operations’, providing direct value for grid and generation operators to optimize the operation and usage of their existing assets. This may defer additional grid capacity (investments), leading to indirect benefits for the consumer. For instance, the German legislator has conceived smart metering systems as a digital infrastructure for the energy transition.

Digitalisation of the retail market and enabling dynamic pricing for households and SMEs are the second and third ranked key drivers for the deployment of smart meters, providing value for multiple actors (e.g. flexibility for grid operators and reduced energy bills for customers).

On the other hand, tackling issues like fuel poverty or supporting energy efficiency are rarely seen as main drivers for the deployment of smart meters by most Member States, except for some countries where the risk of fuel poverty recently stood at worrying level (e.g. Romania).

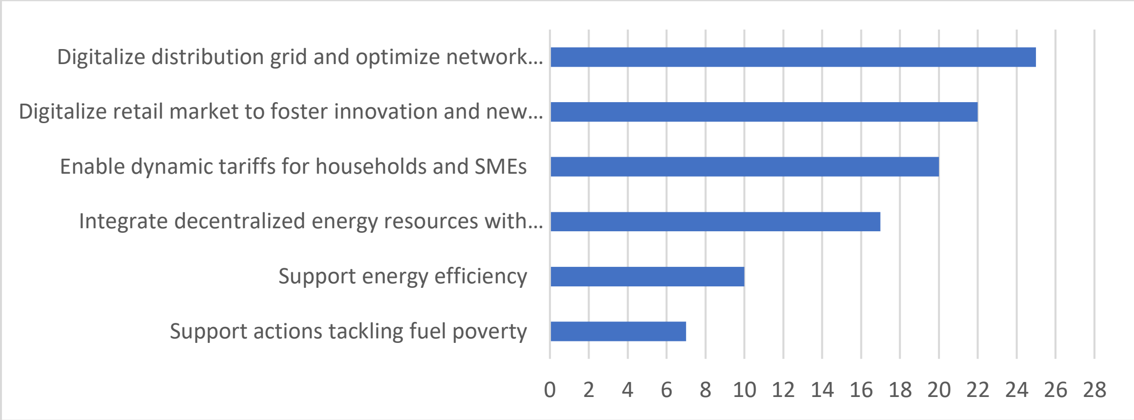
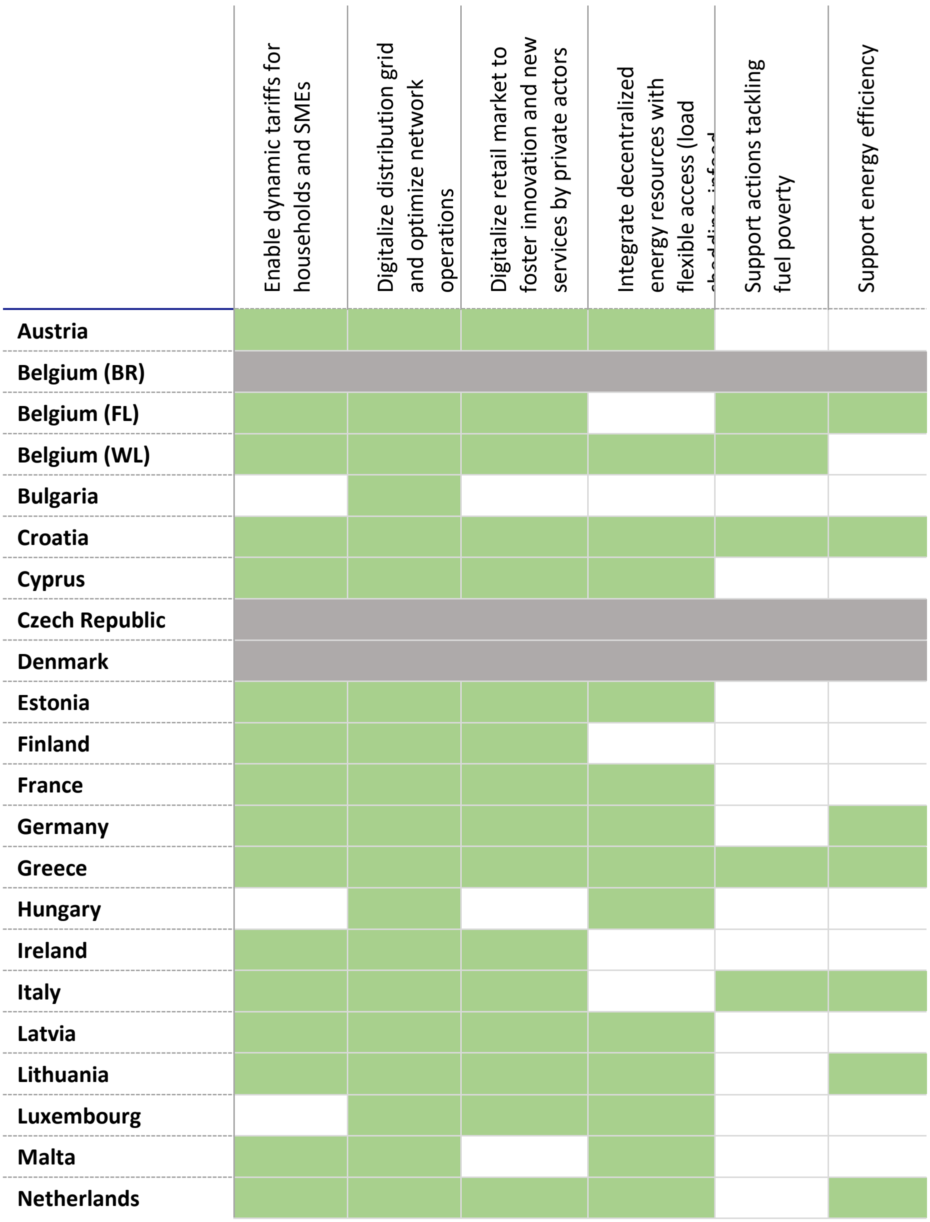


Figure 17: Primary market drivers for smart meter rollout in the case of electricity vs. number of member States



	Enable dynamic tariffs for households and SMEs	Digitalize distribution grid and optimize network operations	Digitalize retail market to foster innovation and new services by private actors	Integrate decentralized energy resources with flexible access (load	Support actions tackling fuel poverty	Support energy efficiency
Poland		green	green	green		green
Portugal	grey	grey	grey	grey	grey	grey
Romania	green	green	green		green	
Slovakia	green	green		green		
Slovenia	green	green	green	green		green
Spain		green	green			green
Sweden	green	green	green			
United Kingdom			green		green	

Table 16: Market drivers for smart meter rollout in the case of electricity (legend: green = considered, blank = not considered; grey = data not available).

5.1.3.2 ELECTRICITY SMART METERING LARGE-SCALE ROLLOUT IN MEMBER STATES

The targets for reaching wide scale rollout (i.e. to at least 80 % of consumers) for electricity smart meters for each Member State can be observed in Figure 18. Only a few countries – namely Sweden, Finland, Italy, Estonia, Malta, Spain and Denmark – have already a wide-scale roll-out for electricity in place today. Most countries will reach such a wide-scale roll-out (to at least 80 % of the consumers) in the period 2020-2025. About one third of the Member States will roll-out smart meters by 2030 or later, as their latest CBA is still negative. According to the recast Electricity Directive[24], these Member States will have to perform a CBA at least every 4 years. Once the result of the CBA is positive, at least 80 % of the corresponding final customers shall be equipped with smart metering systems within 7 years from the date of the positive assessment.

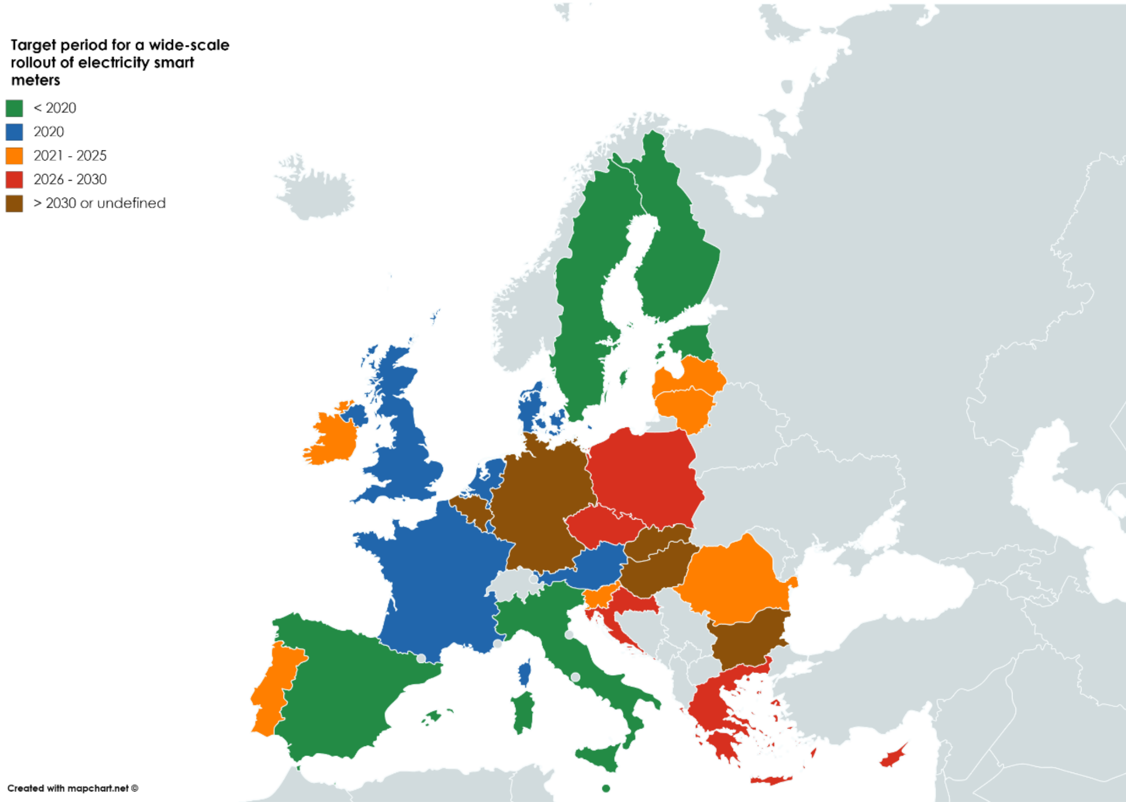


Figure 18: Overview of target period for the completion of a wide-scale rollout of electricity smart meters with at least 80 % of all consumers for each Member State, based on Member States' planning.

Figure 19 shows the estimated target date for completion of a wide scale rollout of smart meters (at least 80% of consumers) as of 2018, and its comparison with the original estimations from 2013. It can be seen that compared to the initial targets, fewer Member States are in line to reach the deployment rate of at least 80 % by 2020. Furthermore, some Member States that had no targets or targets beyond 2030, are putting steps in place to achieve mass rollout of smart meters by 2030, following a positive CBA.

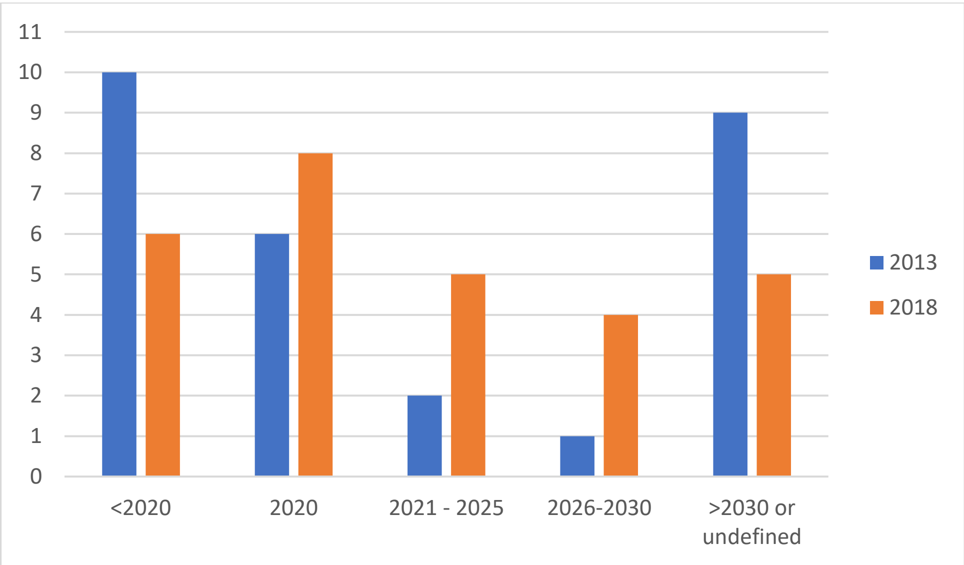


Figure 19: Overview (aggregated) of target period for a wide-scale rollout of electricity smart meters with at least 80 % of all consumers (study 2018), compared to the initial targets set in the previous study (data as of 2013).

Figure 20 shows the evolution of the target period for a large-scale rollout for each Member State. As an example, Slovenia that had a target for wide scale rollout of beyond 2030 (or defined), is now putting measures in place to ensure a wide scale rollout of 80 % by 2020 and 100 % by 2025.

Another example is Poland which has initially planned to reach a wide scale rollout by 2020 following the CBA carried out in 2012. However, the initial primary law that enables smart metering, did not made it mandatory. A draft legislation, which is under public consultation at the moment of writing this report, will mandate DSOs to install electricity smart meters in at least 80 % of the consumers' premises. According to latest estimates, Poland is now on track to reach a wide scale rollout by 2026.

By the time this report is being elaborated, it can be foreseen that some target periods for large-scale electricity smart metering rollouts may be missed. For instance, Greece planning to complete its large-scale rollout by 2020 should install ca. 7,000,000 smart meters within 6 month, which is already a challenge to complete their procurement process; and United Kingdom which set his large-scale rollout target to 2020 exhibited in January 2018 an electricity smart meter penetration rate of only 19.9%.

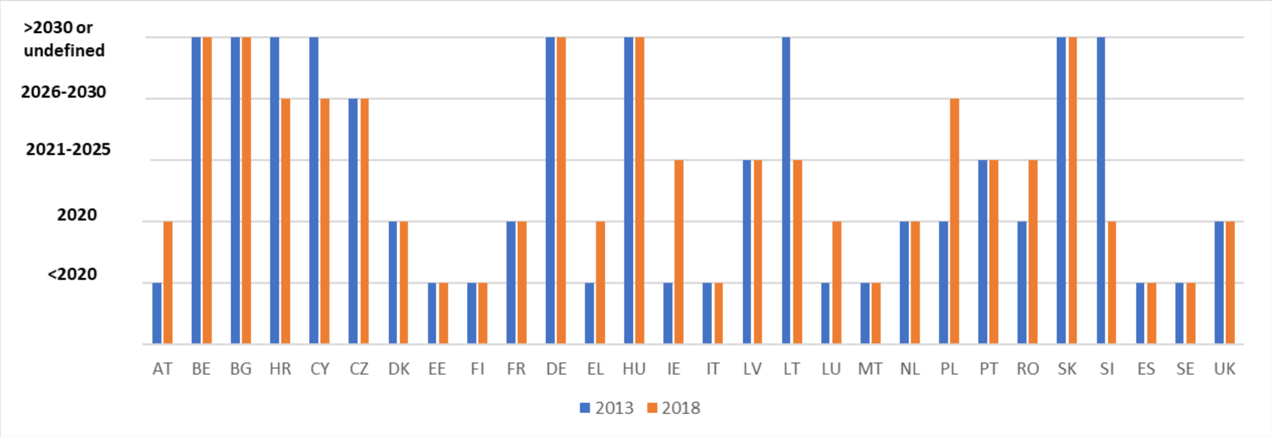


Figure 20: Overview of target period for a wide-scale rollout of electricity smart meters with at least 80 % of all consumers for each Member State (study 2018), compared to the initial targets set in the previous benchmarking study[20] (data as of 2013)

To conclude, Figure 21 presents the official deployment strategy per Member State to reach their 80% target on the roll-out of electricity smart meters. Other countries that are already rolling out smart meters include Slovakia, with a target of about 10 % roll-out by 2020, Germany, Flanders and Wallonia with a selective roll-out, and Portugal whose electricity smart meters have reached a 20.5% penetration rate. HEDNO, the Hellenic DSO, initiated a pilot project to replace 200,000 meters by electric smart meters, and a tender process has been launched for the selection of a meter's provider. The project is not yet under way because of legal disputes around the tender process. However, based on its draft National Energy and Climate Plan (NECP), the objective for completion of electricity rollout should happen by 2030.

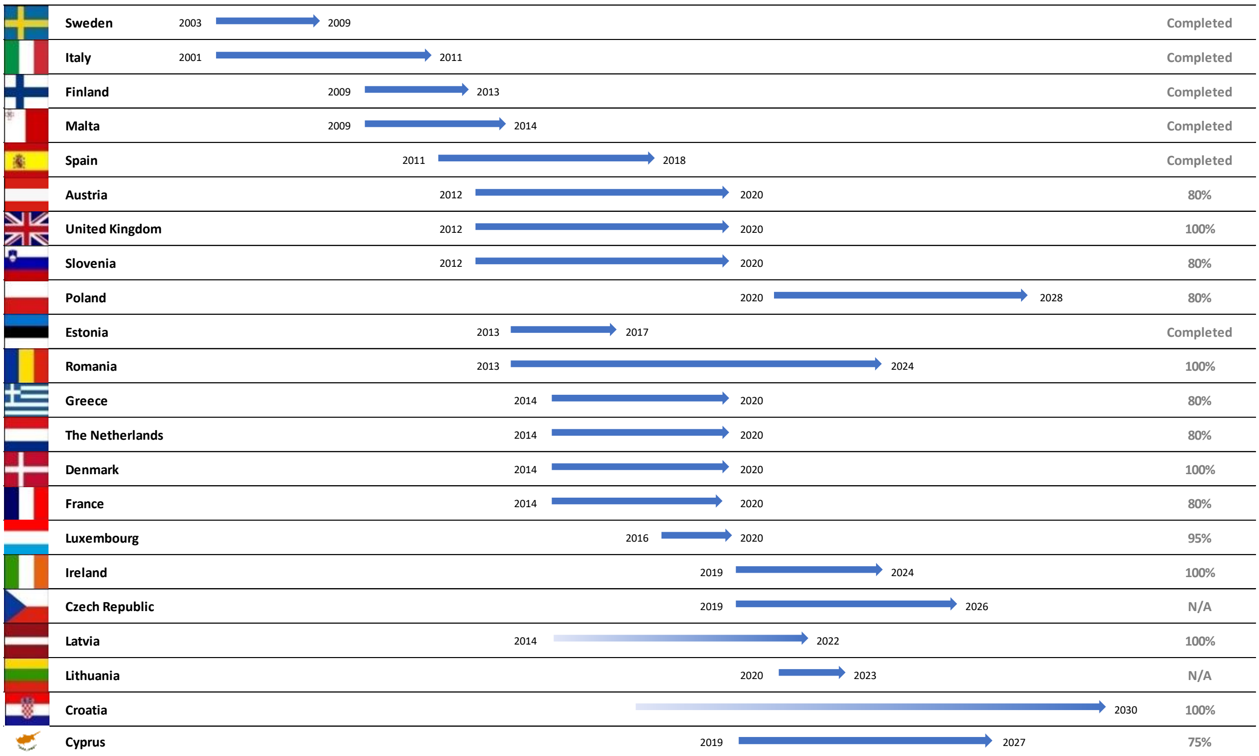


Figure 21: Official deployment strategy per Member State[53] on the large-scale roll-out (80 % or higher coverage) of smart electricity meters.

In order to have a second source of information and check the consistency of the collected data, key manufacturer data has been used, as shown in Figure 22.

[53] For Latvia and Croatia, the starting year of the large-scale roll-out has not been communicated.

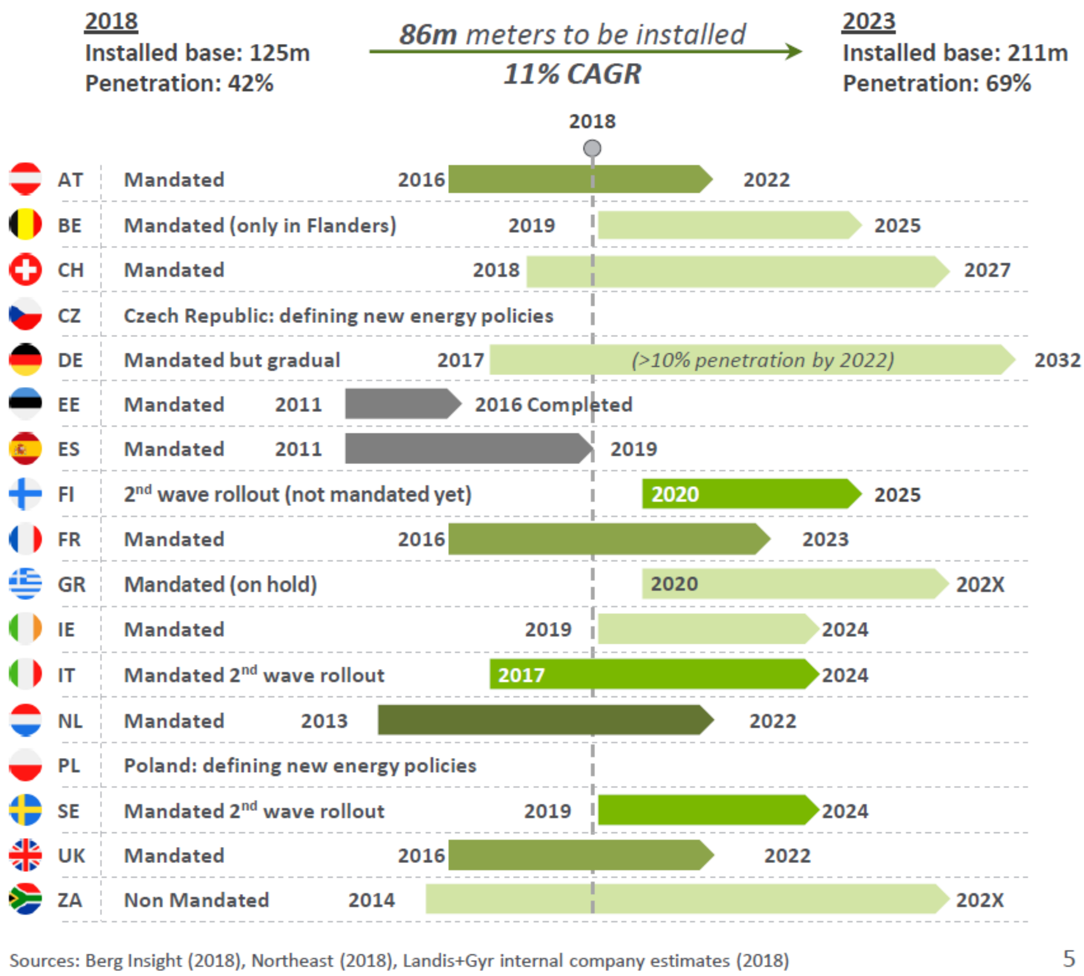


Figure 22: Electricity smart meters deployment strategy foreseen by the smart meter manufacturer Landis+Gyr[54]

Those data show a high degree of consistency even though for some countries, the deployment timelines seem to be longer. In our understanding, these statistics represent market expectations; we have a more conservative view, which reflects the commitment made by NRAs.

5.1.3.3 CURRENT STATUS ON SMART METER DEPLOYMENT RATE

This subsection provides insight into the state of play of electricity smart meter deployment rate in all Member States as of January 2018.

Table 17 presents the total number of metering points[55] and the total number of smart meters installed (cumulative, and in 2017), from which the overall penetration rate of smart meters per Member State can be defined. The number of smart meters installed in 2017 has also been provided as an indication of the rhythm in which each Member State is deploying smart meters.[56]

[54] https://www.landisgyr.com/webfoo/wp-content/uploads/2019/01/4.-CMD-EMEA.pdf

[55] The total number of metering points includes household and SME metering points.

[56] However, no instalment rate curve is available.

In January 2018, 34% of all electricity metering points in the EU-28 were equipped with a smart meter (ca. 99,080,000 smart meters). Taken separately, households' electricity metering points and SMEs' metering points were equipped at 35% and 28% respectively.

It should be noted that some Member States did not provide differentiated data on metering points for households and metering points for SMEs, nor on the smart metering installation progress per segment. For those Member States, we used Eurostat data[57] to determine the number of SMEs for each country and estimate the number of metering points for SMEs. We followed a simple yet realistic hypothesis under which each SME accounts for one metering point. We were then able to differentiate between households and SMEs metering points. To estimate the number of smart meters installed for households metering points and the number of smart meters installed for SMEs, we applied the ratio of SMEs metering points over the total number of metering points in the country to the total number of smart meters installed. The underlying hypothesis is that Member States did not favour a specific segment while rolling out their smart meters. We then just had to subtract the total number of smart meters installed by the number of smart meters installed for SMEs to obtain the number of smart meters installed for households.

In order to provide even more accurate, yet less inclusive statistics, we computed the penetration rates for households' smart meters and SMEs smart meters separately, including only Member States which provided differentiated data for smart meters installed[58]. In this scenario, the penetration rate for households' smart meters is equal to 24% and the penetration rate for SMEs smart meters is equal to 13%.

By 2020, based on the originally announced rollout plans as captured in the first benchmarking report of 2014 (COM (2014)356), a penetration rate of electricity smart meters of **72%** was expected to be reached EU-wide**.**

However, given the speed of deployment observed in 2017, we estimate[59] that only **24 million additional smart meters** will be installed by 2020, setting the total number of electricity smart meters to **123 million**, which would correspond to a **43% penetration rate**. With a weighted average cost per electricity smart meter of **€172**[60], the deployment of these 123 million smart meters would have required an aggregated investment of **€21 billion**.

Considering that Member States will proceed with the rollout according to their new planning and target periods (see Figure 20) we expect that overall **223 million smart meters will be installed in 2024** (corresponding to a **77% penetration rate**), which will represent an aggregated investment of **€38 billion**. **By 2030, we expect that 266 million smart meters will be installed** (corresponding to a **92% penetration rate**), which will represent a total aggregated investment of **€46 billion**.

Figure 23 represents the information about smart metering deployment) for each Member State and shows two sets of information:

1. The overall penetration of electricity smart meters in each Member State which is represented by the overall bar (a combination of blue and orange).

[57] https://ec.europa.eu/growth/smes/business-friendly-environment/performance-review_el

[58] These MS are Austria, Denmark, Italy, Luxembourg, Portugal, Slovakia and Sweden.

[59] These estimations are based on the observed rate of deployment of electricity smart meters in 2017.

[60] The computation of this weighted average Austria, Croatia, Denmark, Estonia, Finland, France, Greece, Italy, Latvia, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, Slovenia, Sweden and the United Kingdom.

2. The percentage of electricity smart meters that was installed in 2017, which is represented by the orange bar.

As indicated in Section 5.1.2, many Member States obtained a positive CBA result for electricity smart meters. Six countries have already finished their large-scale electricity smart meter rollout, namely Estonia (2017), Finland (2013), Italy (2011), Malta (2014), Spain (93% end of 2017) and Sweden (2009). Moreover, Denmark reached by the end of 2017 a smart metering penetration rate of nearly 80% (based on data from CEER), meaning that it is on track to reach its 100 % roll-out target by 2020. Equally, Luxembourg by maintaining a deployment rate of above 20% since 2016 should approximate 95% penetration rate by 2020. So, in total eight Member States will have reached or well surpassed the 80% penetration rate by end of 2019.

Different Member States reached in 2017 an installation rate for electricity smart meters of more than 10% of the total number of metering points within the country, meaning a first important step in their large-scale roll-out. France can reach the 80 % roll-out target by 2021 and only needs to slightly increase its installation rate (compared to 2017) to reach its 90 % target in 2021 (+ 1 % point per year). Latvia has a current electricity smart meters penetration rate of 36 % and is on track to reach its 100 % roll-out by 2022. The Netherlands is as well on track to reach the 80 % rollout by 2020, but it will need to increase its installation rate if this Member State wants to reach its 100 % roll-out target by 2020. To conclude, Portugal will – at its current installation rate – be able to reach an 80 % roll-out by 2022-2023.

	Actual number of existing metering points (as of 2018)[61]	Total Smart Meters installed (as of 2018)	Total Smart Meters installed in 2017	Total smart meter penetration rate (as of 2018)	Total smart meters installed in 2017
Austria	6,148,094	728,477	214,671	11.8%	3.5%
Belgium	5,975,000				
Bulgaria	4,700,000				
Croatia	2,424,060	55,000	23,000	2.3%	0.9%
Cyprus	546,500	0	0	0%	-
Czech Republic	5,712,550				
Denmark	3,361,816	2,324,439	2,324,439	69.1%	-
Estonia	707,900	700,000	5,752	98.9%	0.8%
Finland	3,557,500	3,551,500	0	99.8%	-
France	40,743,844	9,045,000	6,257,000	22.2%	15.4%
Germany[62]	50,700,000[63]	0	0	0%	-
Greece	7,485,000	195,000	50,000	2.6%	0.7%
Hungary	7,500,000	75,000	0	1.0 %	-

[61] The 'Actual number of existing metering points' in Belgium and Ireland are based on the previous Benchmarking report[20].

[62] The figures for Germany on "Smart Meters" refer to smart metering systems equipped with Smart Meter Gateways for which mandatory deployment is expected to start in 2019. The deployment of electronic metering devices, capable of being connected to a Smart Meter Gateway (moderne Messeinrichtung) on the other hand, has already been initiated.

[63] Of which about 15% are part of the partial roll-out in Germany, i.e. obligatory to be equipped with Smart Meter Gateways.

	Actual number of existing metering points (as of 2018)[61]	Total Smart Meters installed (as of 2018)	Total Smart Meters installed in 2017	Total smart meter penetration rate (as of 2018)	Total smart meters installed in 2017
Ireland	2,200,000				
Italy	36,789,000	36,237,165	n.a.	98.5%	-
Latvia	981,633	356,358	112,430	36.3%	11.5%
Lithuania	1,722,925	40,687	3,915	2.4%	-
Luxembourg	300,499	75,847	67,477	25.2%	25.2%
Malta	317,747	309,287	15,634	97.3%	4.9%
Netherlands	8,600,000	4,000,000	1,114,000	46.5%	13%
Poland	17,719,000	1,469,661	62,800	8.3%	0.4%
Portugal	6,000,000	1,500,000	600,000	25.0%	10%
Romania	9,237,788	442,206	159,618	4.8%	1.7%
Slovakia	2,513,743	127,325	50,458	5.1%	2.0%
Slovenia	935,333	544,332	65,028	58.2%	7.0%
Spain	28,000,000	26,067,500	5,000,000	93.1%	17.9%
Sweden	5,300,000	5,300,000	0	100.0%	-
United Kingdom	29,807,531	5,935,202	2,759,082	19.9%	9.3%
Total	289,987,463	99,079,986	18,885,304	34.2 %	6.5%

Table 17:Number of electricity metering points by 2020, and total number of smart meters installed today by Member State (legend: grey = data not available).

While 3 Member States (Austria, Greece and United Kingdom) are not on track to reach their large-scale rollout by 2020, many Member States are in the initial phase of their mass rollout. Cyprus for instance, following a decision by its national regulatory authority (Reg. Decision 02/2018 (ΚΠΔ 259/2018)), has initiated just in 2019 the procedures for preparing a large-scale rollout with the ultimate goal of installing 400,000 smart meters for electricity. Germany and Slovakia have currently a selective rollout planned. However, Germany set obligations to install electronic meters, capable of being connected to Smart Meter Gateways, in order to prepare the market for a large-scale roll-out and enable smart meter functions to all consumers as soon as they are cost-effective. In Belgium, the regions of Flanders and Wallonia also proceed with a segmented rollout. Flanders will undertake the mandatory installation of smart meters in the cases of new constructions and renovations, meter renewals as well as for prosumers, while other market segments' customers will be entitled to have a smart meter installed on demand. In Wallonia the segmented rollout (target of 80% of the concerned segments by 2029) focuses on customers with an annual consumption above 6,000 kWh, prosumers with an installed capacity of at least 5 kW, and for charging points open to the public. Another example is Ireland which is setting up a deployment plan that will be carried out in three phases. Phase One (2019-2020) will be based on voluntary take-up of smart meters and also on asset replacement requirement. The Phase Two (2021-2022) and Phase Three (2023-2024) will be based on a national rollout.

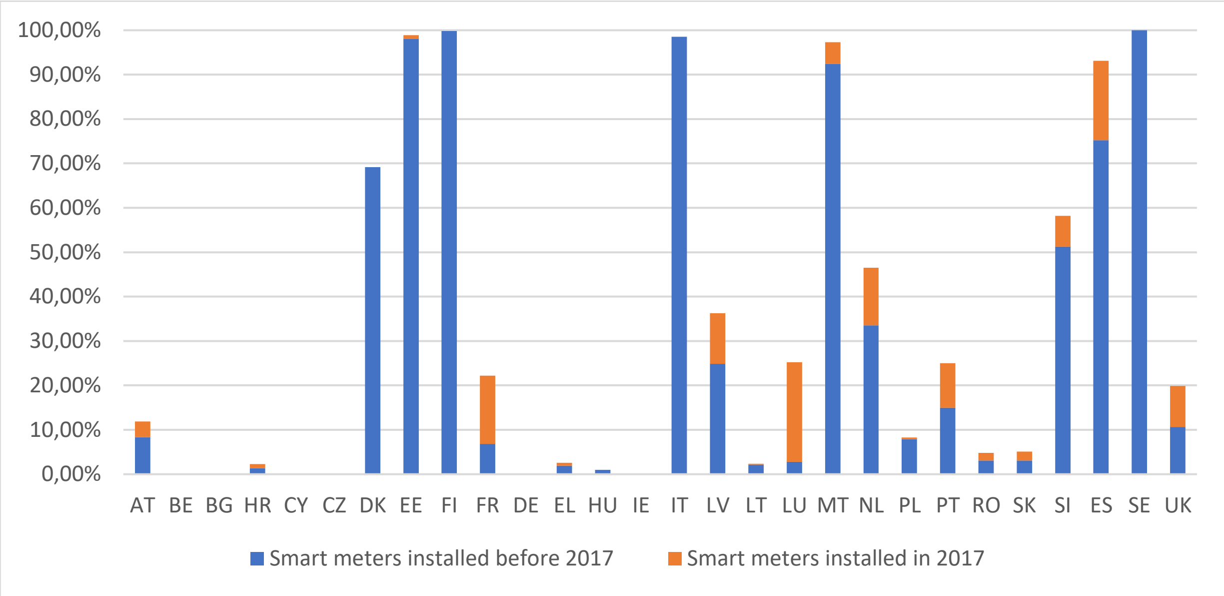


Figure 23: Overall electricity smart meter penetration by Member State

Figure 24 allows to compare the 2018 actual penetration rate, the 2020 expected one as of 2013 and the new expected 2020 penetration rate as of 2018. While we observe discrepancies (in value) in the evolution of the originally foreseen penetration rate, a general trend can be drawn among the Member States that have not met yet a significantly large portion of metering points equipped with smart meters: most of these countries have softened their expectations.

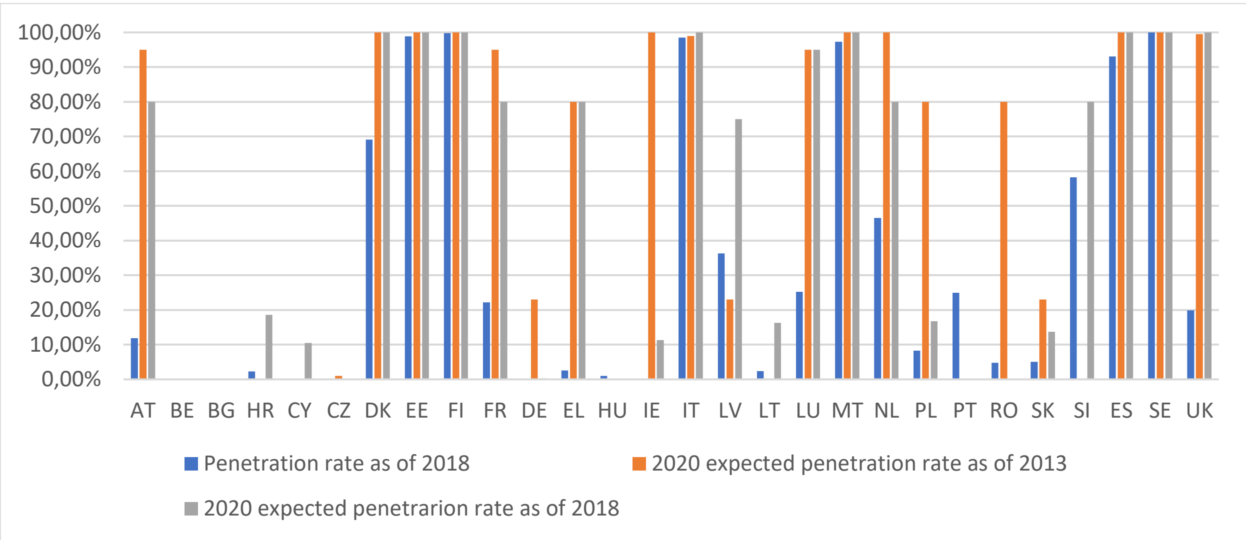


Figure 24: Comparison of actual and announced electricity smart meters penetration rate

Considering the significant gap between current penetration rate and the announced penetration rate in 2020 for many countries, we estimated the penetration rate by 2020, based on the current pace deployment of smart meters. Figure 25 allows to compare the current penetration rate and the expected 2020 penetration rate based on our estimates.

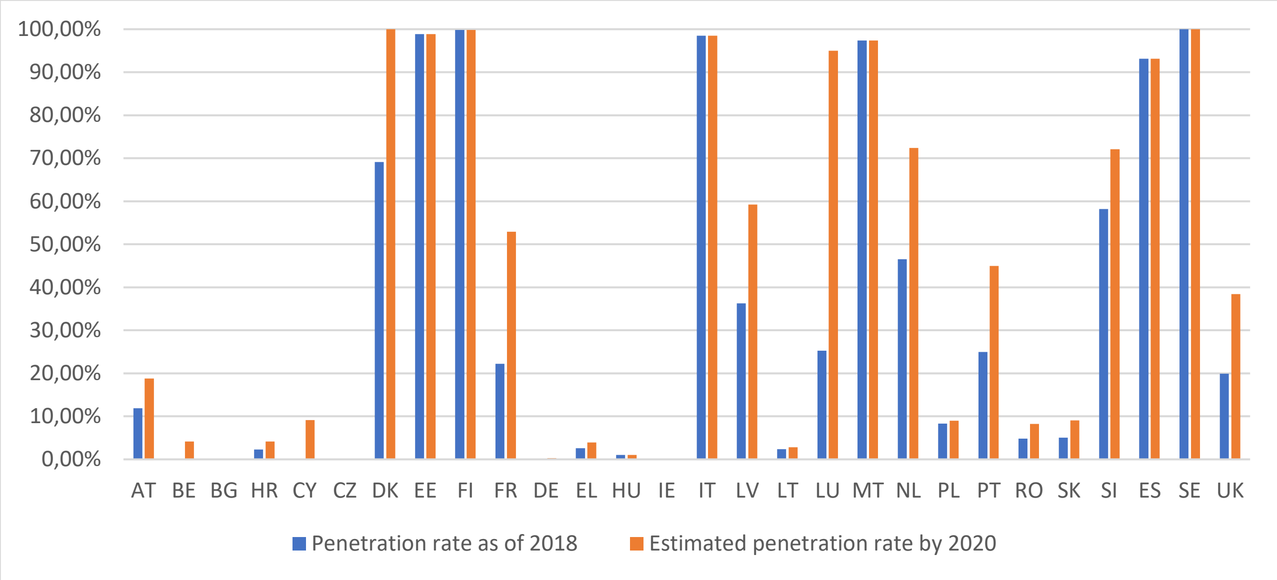


Figure 25: Comparison of penetration rate as of 2018 and estimated penetration rate by 2020

A breakdown of installed electricity smart meters can be observed in Table 18. The table comprises the total electricity smart meters in households and SMEs, the electricity smart meters installed in 2017 for households and SMEs, as well as the overall number of electricity metering points for these two segments.

	Actual number of existing metering points (as of 2018)[61]			Total smart meters Installed (as of 2018)			Total smart meters installed in 2017		
	SME	Household	Total	SME	Household	Total	SME	Household	Total
AT			6,148,094			728,477			214,671
BE			5,975,000						
BG			4,700,000						
HR	236,412	2,187,648	2,424,060	40,000	15,000	55,000	15,000	8,000	23,000
CY	109,000	437,500	546,500						
CZ			5,712,550						
DK			3,361,816			2,324,439			2,324,439
EE		707,900	707,900		700,000	700,000		5,752	5,752
FI	82,500	3,475,000	3,557,500	82,500	3,469,000	3,551,500			
FR	4,379,550	36,364,294	40,743,844	1,000,000	8,045,000	9,045,000	700,000	5,557,000	6,257,000
DE	3,100,000	47,600,000	50,700,000						
EL	1,670,000	5,815,000	7,485,000	160,000	35,000	195,000	25,000	25,000	50,000
HU	1,000,000	6,500,000	7,500,000	25,000	50,000	75,000			
IE			2,200,000						

	Actual number of existing metering points (as of 2018)[61]			Total smart meters Installed (as of 2018)			Total smart meters installed in 2017		
IT			36,789,000			36,237,165			
LV		981,633	981,633		356,358	356,358		112,430	112,430
LT	148,756	1,574,169	1,722,925	36,369	4,318	40,687	2,866	1,049	3,915
LU			300,499			75,847			67,477
MT	48,722	269,025	317,747	44,653	264,634	309,287	3,862	11,772	15,634
NL	900,000	7,700,000	8,600,000	400,000	3,600,000	4,000,000	114,000	1,000,000	1,114,000
PL	1,500,000	16,219,000	17,719,000	109,661	1,360,000	1,469,661	2,800	60,000	62,800
PT			6,000,000			1,500,000			600,000
RO	747,119	8,490,669	9,237,788	26,713	415,493	442,206	9,672	149,946	159,618
SK			2,513,743			127,325			50,458
SI	93,793	841,540	935,333	54,433	489,899	544,332	6,503	58,525	65,028
ES		28,000,000	28,000,000	67,500	26,000,000	26,067,500		5,000,000	5,000,000
SE			5,300,000			5,300,000			
UK	2,499,218	27,308,313	29,807,531	802,766	5,132,436	5,935,202	84,302	2,674,780	2,759,082

Table 18: Overview of total electricity metering points, total electricity smart meters installed, and number of electricity smart meters installed in 2017 by Member State. (Legend: Blank = data not available).

5.1.4 Functional specifications

The Commission Recommendation 2012/148/EU defines 10 common minimum functionalities for smart metering systems, mainly applicable for electricity, which are relevant for different market actors (see Figure 26), namely:

a) Provide readings directly to consumer and/or any 3rd party
b) Upgrade readings frequently enough to use energy saving schemes
c) Allow remote reading by the operator
d) Provide 2-way communication for maintenance and control
e) Allow frequent enough readings for network planning
f) Support advanced tariff systems
g) Remote ON/OFF control of the supply AND/OR flow or power limitation
h) Provide secure data communications
i) Fraud prevention and detection
j) Provide import/export and reactive metering

These recommendations have been drawn in close consultation with National Regulatory Authorities, especially from Member States with significant experience with their rollout and are aligned with those developed by the standardisation mandate M441[64]. The most important functionalities related to engagement of consumers are functionalities a, b, and f, and are also

[64] "Functional reference architecture for communications in smart metering systems" (CEN-CLC-ETSI TR 50572:2011).

included in the list of smart metering functionalities mandated in the recast Electricity Directive (EU) 2019/944.

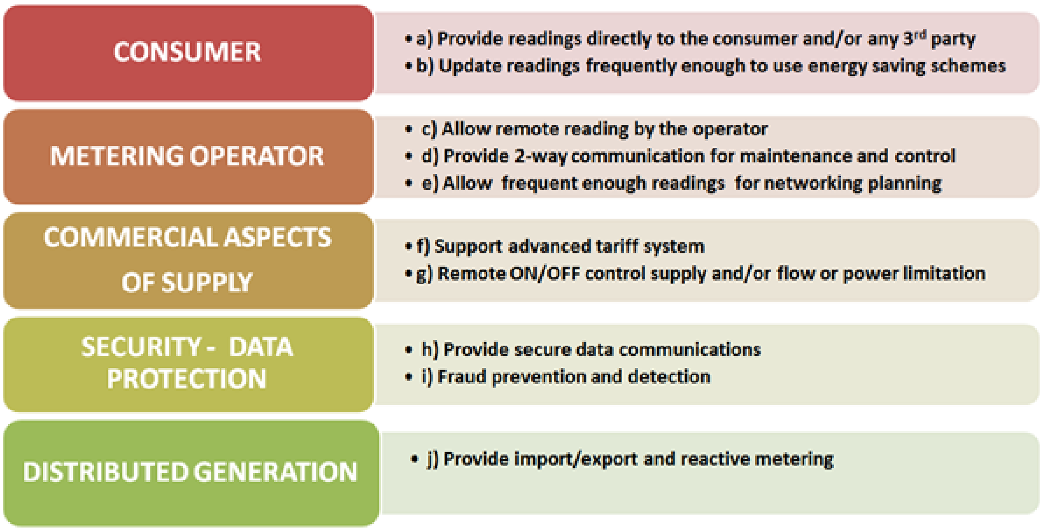


Figure 26: Overview of 10 smart metering functionalities, including the relevance for the different actors. Ref: European Commission, ENER- Smart Grids Team, 2014.

Based on the data collected during this study, the majority of the Member States foresee to have all ten smart metering functionalities available to their electricity consumers, except for Germany, Lithuania, The Netherlands, Slovenia and Sweden. Many of these functionalities will be activated by default and will be free of charge for the consumer (see Table 19), whereas others might not be seen as relevant in all cases (i.e. provide import/export metering). Croatia, Ireland and Luxembourg are among those Member States where all the ten functionalities recommended by the European Commission will be made available, activated by default and free of charge (regarding electricity smart meters).

	Provide readings directly to consumer and/or any 3rd party	Update readings frequently enough to use energy saving schemes	Allow remote reading by the operator	Provide 2-way communication for maintenance and control	Allow frequent enough readings for network planning	Support advanced tariff systems	Remote ON/OFF control of the supply AND/OR flow or power limitation	Provide secure data communications	Fraud prevention and detection	Provide import/export and reactive metering
	a	b	c	d	e	f	g	h	i	j
Austria	X	X	X	X			X	X	X	X
Belgium (BR)										
Belgium (FL)	X	X	X	X	X	X	X	X	X	X
Belgium (WL)	X	X	X	X	X	X	X	X	X	X

	Provide readings directly to consumer and/or any 3rd party	Update readings frequently enough to use energy saving schemes	Allow remote reading by the operator	Provide 2-way communication for maintenance and control	Allow frequent enough readings for network planning	Support advanced tariff systems	Remote ON/OFF control of the supply AND/OR flow or power limitation	Provide secure data communications	Fraud prevention and detection	Provide import/export and reactive metering
Bulgaria										
Croatia	X	X	X	X	X	X	X	X	X	X
Cyprus										
Czech Republic										
Denmark										
Denmark	X[65]	X				X				
Estonia	X	X	X	X	X	X	X	X	X	X
Finland	X	X	X	X	X	X	X	X	X	X
France	X	X	X	X	X	X	X	X	X	
Germany	X	X	X	X	X	X		X	X	X
Greece			X	X	X	X	X	X	X	X
Hungary										
Ireland	X	X	X	X	X	X	X	X	X	X
Italy	X	X	X	X	X	X	X	X	X	X
Latvia	X		X	X	X	X[66]	X	X	X	X
Lithuania	X	X	X	X	X	X		X	X	
Luxembourg	X	X	X	X	X	X	X	X	X	X
Malta	X								X	X
Netherlands		X		X		x[67]		X		X
Poland			X	X	X	X	X	X	X	X
Portugal	X	X	X	X	X	X	X	X	X	X
Romania		X	X	X	X		X	X	X	
Slovakia	X	X	X	X	X	X	X	X	X	X
Slovenia			X	X			X		X	
Spain	X	X	X	X	X	X	X	X	X	X
Sweden			X	X	X	X	X	X		X
United Kingdom	X	X	X	X	X	X	X	X	X	X

Table 19: Overview of all smart metering functionalities for electricity by Member State (legend: blank = nor foreseen nor available, green = free of charge, orange = not free of charge, 'X' = activated by default, grey = data not available)

[65] Only for smart meters installed after 2011.

[66] Limited to four tariff zones.

[67] In the Netherlands, advanced tariff systems mainly focus on high and low tariff.

	(a) Provide readings directly to consumer and/or any 3rd party	(b) Update readings frequently enough to use energy saving schemes	Frequency at which consumption data is updated and provided to customers
Austria	YES	YES	15’
Belgium (BR)	N/A		
Belgium (FL)	YES	YES	15’ (near real-time on request)
Belgium (WL)	YES	YES	15’ (near real-time on request)
Bulgaria	N/A		
Croatia	YES	YES	Hourly
Cyprus	N/A		
Czech Republic	N/A		
Denmark	YES[68]	YES	15’ (Hourly for smart meters installed before 2012)
Estonia	YES	YES	Hourly
Finland	YES	YES	Near real-time
France	YES	YES	30’
Germany	YES	YES	15’ (near real-time on request)
Greece	YES	YES	1”
Hungary	N/A		
Ireland	YES	YES	Near real-time on request
Italy	YES	YES	Near real-time (through continuous update)
Latvia	YES	YES[69]	Daily
Lithuania	YES	YES	15’
Luxembourg	YES	YES	10”
Malta	YES	YES	15’
Netherlands	YES	YES	Near real-time
Poland	YES	YES	Near real-time
Portugal	YES	YES	60”
Romania	YES	YES	Daily
Slovakia	YES	YES	Daily or 15’ (depending on the DSO)
Slovenia	YES	YES	15’
Spain	YES	YES	Hourly
Sweden	YES	YES	Near real-time
United Kingdom	YES	YES	10”

Table 20: Frequency of data update intervals (implemented or foreseen) for electricity smart meters

When it comes to the frequency at which data is updated and provided to consumers, it is recommended that this is done close to real time or at least every 15 minutes or, considering a more inclusive interpretation of functionality ‘b,’ at intervals matching the national market balance settlement period, to support advanced (dynamic) tariffs for demand response programmes or even account settling.

[68] Only for smart meters installed after 2011.

[69] Only on consumer request

5.2 Gas smart meters

5.2.1 Regulatory framework

This section provides an overview of the regulatory framework for gas smart metering deployment in all EU-28 Member States. Table 21 gives a comprehensive and updated review of the main legal and regulatory provisions related to gas smart metering that have come into force in each Member State. It is noted that, Member States have to transpose the aforementioned EU Directives (see the earlier section on the European legislative framework related to smart metering) into national law, and it is only if the CBA shows a positive case for a (wide-scale or partial/segmented) rollout of smart meters that they detail rules on smart metering. Those rules would then need to be adopted (see related information included below).

Whilst some Member States have done so when transposing the Third Energy Package, others have not adopted national specific law for smart metering yet, even though they have also started to roll-out their smart meters following a positive CBA.

Country	Relevant legislation for gas smart metering
Austria	The primary law is 'GWG2011'. The status of this law is also nearly unchanged since implementation. A delegated law that further implement smart metering deployment is 'IGMA-VO 2012' which contains functional requirements for Gas Meters.
Belgium	The primary law that enables smart metering for gas in the Brussels Capital Region is the 'l'ordonnance du 1er avril 2004 relative à l'organisation du marché du gaz en Région de Bruxelles-Capitale' At this stage there are no laws that enable smart metering for gas in Wallonia. In Flanders, The primary law that enables smart metering for electricity and gas is the 'Decreet van 8 mei 2009 houdende algemene bepalingen betreffende het energiebeleid '.
Bulgaria	No specific laws have been adopted to frame the deployment of smart metering.
Croatia	The Croatian primary law that enables both smart electricity and gas metering is the 'Energy Act'.
Cyprus	The 'Regulation of the Gas Market Act2004' enables the CERA to ensure the implementation of smart meters and has been amended as follow 103(I)/2006, 199(I)/2007, 219(I)/2012, 148(I)/2018.
Czech Republic	'Act No. 458/2000, Coll. on Business Conditions and Public Administration in the Energy Sectors and on Amendment Other Laws (Energy Act).'
Denmark	No specific laws have been adopted to frame the deployment of smart metering.
Estonia	The primary law that enables smart metering for gas is the 'Natural Gas Act', which was revised and valid as of June 2017.
Finland	*Information regarding national law relevant for gas smart metering has not been provided by the NRA*
France	A framework similar to that of the electricity market has been adopted.
Germany	The primary law that enables smart metering for both electricity and gas is 'Gesetz zur Digitaliserung der Energiwende'.
Greece	*Information regarding national law relevant for gas smart metering has not been provided by the NRA*
Hungary	The primary laws that enable smart metering for gas is the 'Natural Gas Act XL of 2008'. The 'Government Decree No. 26/2016' is currently the delegated law that further implements smart metering deployment for both smart electricity and gas meters.

Country	Relevant legislation for gas smart metering
Ireland	The primary law introduced by the Department of Communications, Climate Action and Environment in 2014 that enables smart metering for electricity and gas meters is the 'Statutory Instrument 426', transposed into Irish law by way of secondary legislation based on the obligations under the Third Directive.
Italy	Although a first legislative mandate was laid down in 'Law 99/2009', the primary law enabling smart metering for gas in Italy is the 'Legislative Decree 102/2014' (same as for electricity).
Latvia	There is no specific law framing the deployment of smart metering for natural gas.
Lithuania	No specific laws have been adopted to frame the deployment of smart metering.
Luxembourg	The primary law that enables smart metering for gas is 'Loi modifiée du 1er août 2007 relative à l'organisation du marché du gaz naturel'. The last revision of this law was in 2015.
Malta	There is no gas market in Malta.
The Netherlands	The primary laws that enables smart metering for electricity and gas are: • 'Wet implementatie EG-richtlijnen energie-efficiëntie' • 'Wijziging van de Elektriciteitswet 1998' • 'Gaswet ter verbetering van de werking van de elektriciteits- en gasmarkt (31374)' These laws are currently under revision.
Poland	There is no specific law framing the deployment of smart metering for natural gas.
Portugal	The primary laws that enable smart metering for electricity and gas are 'Decreto-Lei n° 215-A/2012' (October 8) and 'Decreto-Lei n° 231/2012' (October 26), which have been both revised. Concerning gas smart metering, at present, there is no delegated law to further implement its deployment.
Romania	There is currently no specific law framing the deployment of smart metering for natural gas.
Slovakia	No Decree is in place for the implementation of gas smart meters.
Slovenia	The 'Energy Act' is currently the primary law that enables electricity and gas smart metering in Slovenia, as it includes Articles 174 addressing "Intelligent metering systems" for the gas sector.
Spain	Following the negative outcome of the CBA for gas smart meters deployment, no specific law framing the deployment of smart metering for gas has been implemented. Nonetheless, Orden ETU/1283/2017 on natural gas activities, requested the Comisión Nacional de los Mercados y la Competencia to prepare a new CBA on gas smart meter rollout by 2019.
Sweden	*Information regarding national law relevant for gas smart metering has not been provided by the NRA*
United Kingdom	The same framework to that of the electricity market applies.

Table 21: National legislation for the deployment of gas smart meters

Figure 27 provides an overview on the status of smart metering deployment strategy with reference to the related legislation for gas.

Approximately a quarter of Member States have implementation strategies in place with specific legal provisions for the deployment of gas smart meters. It can be observed that most of these Member States have replicated the legal framework they have adopted for electricity smart meters for the implementation of gas smart meters or have adopted implementation laws dedicated to both electricity and gas smart meters.

Generally, Member States are still at an early stage of the definition or refinement of their legal framework devoted to address and accommodate smart metering gas-specific challenges, when compared to electricity. However, one should carefully notice that the average ratio of gas meters over electricity meters within the EU is ca. 29%, and some Member States do not host any gas market (e.g. Malta). This can be a beginning of an explanation for the delay in the adoption of a legal framework for gas smart metering deployment.

It is noted that our perspective was to assess here if Member States had taken steps further, namely defining a deployment strategy (high level objectives and key changes to the market model to be implemented) and eventually the implementation laws that will accompany the day-to-day deployment of smart metering, such as priority targets, channels for communication and dispute resolution, tariffs, etc.

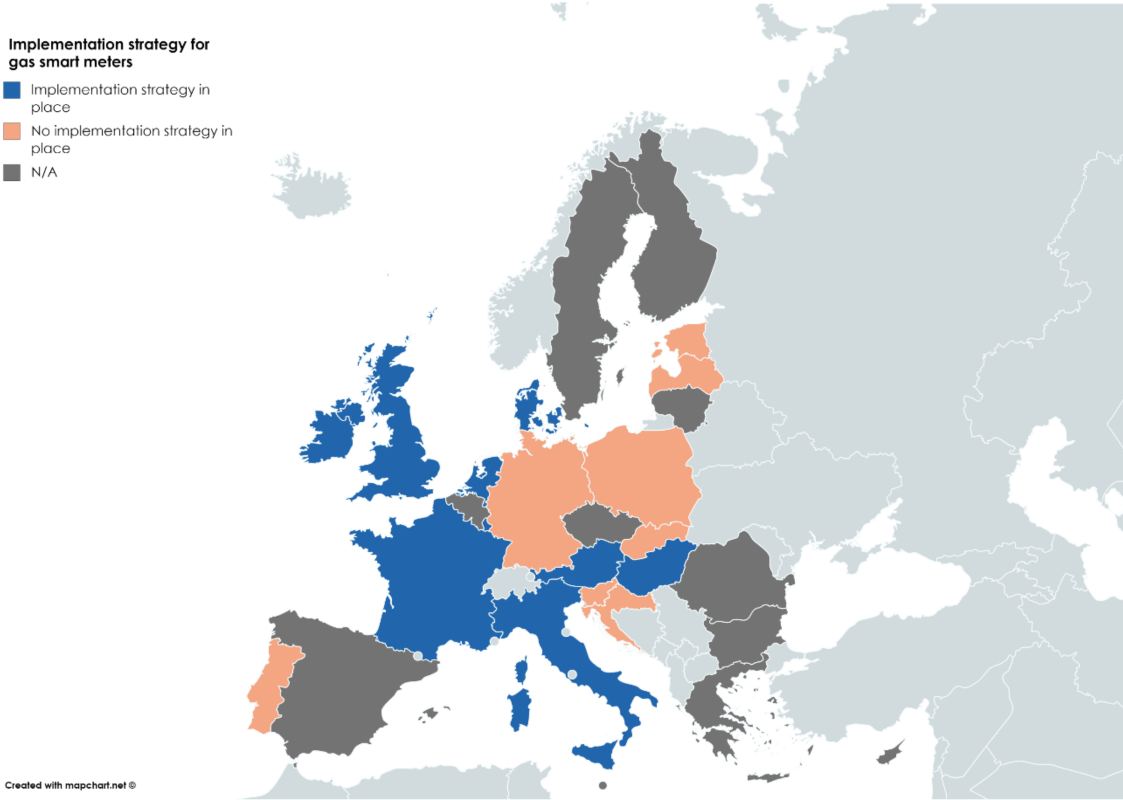


Figure 27: Overview of MS which have an implementation strategy in place with specific legal provisions for the deployment of gas smart meters. N/A stands for data not made available in the course of the project by the relevant national authorities[70]

5.2.2 Cost benefit analysis

This section provides an overview of the timing and the result of the latest national cost benefit assessment (hereafter CBAs) performed for the deployment of gas smart meters by each Member State. For many of the Member States the initial CBA was carried out on the back of pilot projects, in order to integrate the experiences from those projects, whereas the revised CBAs focus more on the actual scale and timing of the rollout.

[70] Flanders is planning a segmented rollout of gas smart meters simultaneously with the segmented rollout of electricity smart meters.

First, the status and outcome of the latest national CBAs for gas smart meters are described in subsection 5.1.2.1. In a second step (subsection 5.1.2.2), the CBA analysis is detailed with a focus on the cost, benefits and market roles considered in the CBA analysis for each Member State.

5.2.2.1 STATUS OF MOST RECENT CBA

Table 22 gives an overview of the results of Member States' CBAs regarding smart metering deployment for gas, as well as information on the timing and outcome of their latest update. Compared to electricity, less Member States have already conducted a CBA for gas smart metering. Where CBAs have been conducted, nearly 40 % of these have a negative outcome.

For a number of Member States, no new information has been provided by the NRA (or associated body) on the timing and result of the CBA conducted for gas smart meters. In some cases, it has not been specified if the information provided extends beyond electricity, and whether it is applicable also to gas. These Member States have been marked with a (*) in the table below.

	Initial CBA result[71] (as of July 2013)	**Revised CBA result[72] (as of July 2018)**	**Latest CBA conducted (as of July 2018)**
Austria	Positive	No new gas CBA	2010
Belgium	Negative	Negative / Positive / Inconclusive[73]	2017
Bulgaria*	No gas CBA	No gas CBA	N/A
Croatia	No gas CBA	No gas CBA	N/A
Cyprus	No natural gas network		
Czech Republic*	Negative	No new gas CBA	N/A
Denmark*	N/A	No new gas CBA	N/A
Estonia	No gas CBA	No gas CBA	N/A
Finland	Negative	No new gas CBA	2008
France	Positive	Positive	2013
Germany	Negative	No new gas CBA	2013
Greece*	N/A	No gas CBA	N/A
Hungary*	N/A	No gas CBA	N/A
Ireland	Positive	Negative[74]	2017
Italy	Positive	No new gas CBA	2008
Latvia	Negative	Positive	2017
Lithuania	N/A	Inconclusive	2018
Luxembourg	Positive	Positive	2016
Malta	No natural gas network		

[71] The conditions of the initial CBA results (as of July 2013) were a large-scale roll-out covering at least 80 % of the consumers by 2020 (even though there is no such target in the gas legislation).

[72] The conditions of the revised CBA results (if applicable) were a large-scale roll-out covering at least 80 % of the consumers by 2020 (even though there is no such target in the gas legislation).

[73] In Belgium the following can be observed: the latest CBA performed in the Brussels Capital region was in 2011 and the result was negative. In Wallonia, the latest CBA for the gas sector was performed in 2017 and consisted of a qualitative analysis, focused on the deployment by one DSO only and for prepaid functions. The result of this analysis was inconclusive. In Flanders, the latest CBA was performed in 2018 and the result of the assessment was positive.

[74] See footnote 45

	Initial CBA result[71] (as of July 2013)	Revised CBA result[72] (as of July 2018)	Latest CBA conducted (as of July 2018)
Netherlands	Positive	No new gas CBA	2010
Poland*	No gas CBA	No gas CBA	N/A
Portugal*	No gas CBA	No gas CBA	N/A
Romania*	Positive	No new gas CBA	N/A
Slovakia	Positive	No new gas CBA	2012
Slovenia	No gas CBA	Positive	2014
Spain	Negative	No new gas CBA	2011
Sweden*	N/A	No new gas CBA	N/A
United Kingdom	Positive	Positive	2016

Table 22: Status of last CBA for gas smart meters conducted as of the previous and current study, including the outcome of the CBA(s) already conducted (Legend: (*) = No new information was provided or it was not mentioned if CBA results extended beyond electric)

As of 2018, four groups of Member States can be identified regarding CBA for gas smart meters deployment:

- A first group of nine Member States did not conduct any gas smart metering CBA. These Member States are Bulgaria, Croatia, Estonia, Greece, Hungary, Poland, Portugal. Cyprus and Malta do not host any natural gas network and therefore did not perform a gas CBA.
- Thirteen Member States conducted one CBA: Austria, Czech Republic, Denmark, Finland, Germany, Italy, Lithuania, the Netherlands, Romania Slovakia, Slovenia, Spain and Sweden.
- Six Member States conducted two gas CBAs, namely Belgium, France, Ireland, Latvia, Luxembourg and the United Kingdom.

Figure 28 provides a graphical overview of the most recent CBA results (as of July 2018) for the deployment of gas smart meters. It can be observed that for the majority of the Member States the information has not been provided.

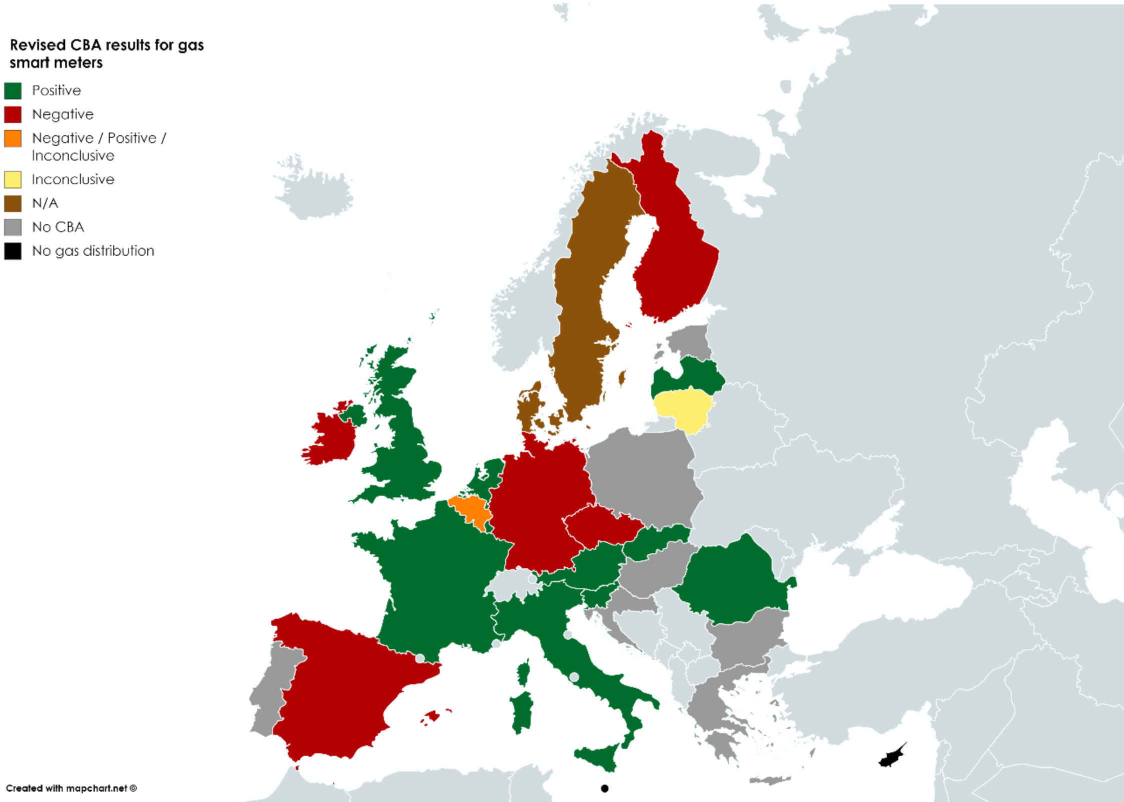


Figure 28: Revised CBA results, considering a large-scale rollout of gas smart meters (as of July 2018).

5.2.2.2 CBA ANALYSIS

Key cost and benefit items were defined in the Recommendation 2012/148/EU, inviting Member States to use the same structure for their CBA. This section presents all costs, benefits and market actors considered in the gas CBA for each Member State. As indicated in Figure 9, the functionalities foreseen will create benefits for the different actors (e.g. consumers, grid operators, etc.), while the assets involve capital (CAPEX) and operational expenditures (OPEX). These costs and benefits serve as input for the Cost Benefit Analysis.

Costs considered in the gas CBA

Table 23 provides an overview of the cost items considered by the 19 Member State that have conducted at least one CBA for gas smart metering deployment. The most common cost items considered by Member States in their CBA can be observed in Figure 29. The capital investment linked to the smart meters themselves and the IT infrastructure and the operational expenses associated with meter readings, IT maintenance, telecom and network management are the cost items most considered by Member States.

Both the Electricity Directive 2009/72/EC and Gas Directive 2009/73/EC are promoting the wider use of smart metering systems as a key enabler for the active participation of consumers in the internal market and contributor to a secure, competitive and sustainable supply of energy for Europe. However, only few Member States (Germany, Slovenia and United Kingdom) are considering, while carrying out their respective cost-benefit assessments, investment expenditures in tools that can facilitate this customer engagement (e.g. in-home-displays) and operational expenditures for active customer participation in the energy market.

	CAPEX - Investment in smart meter	CAPEX - Investment in IT	CAPEX - Investment in Telecom	CAPEX - Investment in In-home display	CAPEX - Sunk cost of conventional meters	OPEX - IT maintenance	OPEX - Network management and front end	OPEX - Telecom	OPEX - Change management	OPEX - Unplanned renewal and failures of smart meter	OPEX - Revenue reduction	OPEX - Meter reading	OPEX - Call center and customer service	OPEX - Consumer engagement programme	Other
AT	✓	✓	✓		✓	✓	✓	✓			✓	✓	✓	✓	
BE (BR)	✓	✓	✓			✓	✓	✓	✓	✓			✓		✓
BE (FL)	✓	✓				✓		✓	✓	✓	✓	✓	✓		
BE (WA)	✓	✓	✓			✓	✓	✓	✓	✓		✓	✓		
CZ	✓	✓	✓		✓	✓	✓	✓	✓	✓					
DK	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
FI	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
FR	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
DE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
IE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
IT	✓	✓	✓	✓	✓		✓					✓			✓
LV	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓		
LT	✓	✓	✓		✓	✓	✓	✓	✓	✓		✓	✓	✓	
LU	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
NL	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓		✓
RO	✓	✓				✓	✓	✓		✓		✓	✓		
SK	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
SI	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
ES	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓			
SE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
UK	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	

Table 23: Considered CAPEX and OPEX costs in the gas CBA for Member States that conducted at least one gas CBA (legend: light grey = included, blank = not included; dark grey = data not available).

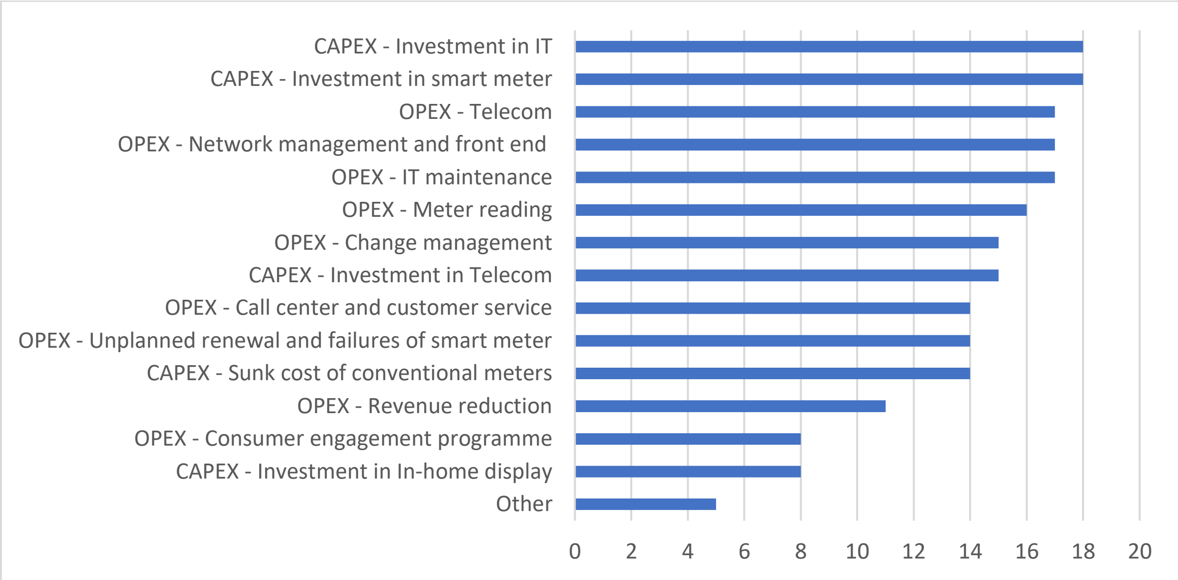


Figure 29: Ranking of the considered CAPEX and OPEX costs in the gas CBAs vs. number of Member States that conducted at least one gas CBA.

Benefits considered in the gas CBA

Table 24 provides an overview of the various benefit items considered by each Member State when performing the CBA and Figure 30 shows the frequency of the type of costs considered in CBAs.

Consumers will have **direct benefits** from bill reductions, as a result of:

- Increased energy efficiency as smart meters will allow them to get insight into their energy consumption.
- A lower bill due a reduction of energy consumption.

Moreover, consumers are expected to **benefit also indirectly from potential cost savings that other market actors** can have at technical and non-technical level.

Smart meters will allow automated meter reading resulting in operational savings (vs. manual reading by for instance the DSO). The automated reading will also allow reduce other non-technical losses. For instance, meter readings will be less sensitive to administrative errors, energy offtake is less sensitive to fraud, technical losses or fraud can be much faster identified with regular meter reading (e.g., near real-time).

Figure 30 presents the ranking of the consolidated results of the considered benefits across the EU-28. The most common benefit considered by Member States is linked to the operational savings that can be achieved through remote meter readings and the consumer’s bill reduction as a result of increased energy efficiency. Tackling of non-technical losses (e.g. administrative or fraud) is the next main benefit considered.

Despite the smart metering roll-out being in nearly all Member States DSO-led, the main DSO-related benefits that were frequently encountered in Member States’ CBAs are limited to the meter reading and operation savings, while other benefits such as outage management and enhanced competition (induced by increased prices transparency) are less considered.

	Bill reduction due to energy efficiency	Increased competition in retail market	Meter reading & operation savings	Operation & maintenance of assets	Technical losses reduction	Non-technical (administrative, including fraud) losses	Outage management (based on reduced customer indemnification)	CO_2	Air pollution (particulate matters, NOx, SO2)	Other
AT	x	x	x	x	x			x		
BE (BR)	x		x		x	x		x		x
BE (FL)	x	x	x			x		x		
BE (WA)			x		x	x				x
CZ			x	x		x				
DK	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
FI	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
FR	x		x	x	x					
DE	x		x	x	x	x	x	x		
IE	x		x			x				
IT	x	x	x	x	x	x	x	x	x	
LV	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
LT	x	x	x	x		x		x	x	
LU	x		x	x	x	x				
NL	x	x	x	x	x	x	x	x		
RO	x		x	x	x	x				
SK	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
SI	x		x	x	x	x	x	x		
ES	x	x	x	x	x	x	x	x		
SE	x		x	x	x					x
UK	x	x	x					x		

Table 24: Considered benefits in the gas CBA for Member States that conducted at least one gas CBA (legend: light grey = considered, blank = not considered; dark grey = data not available

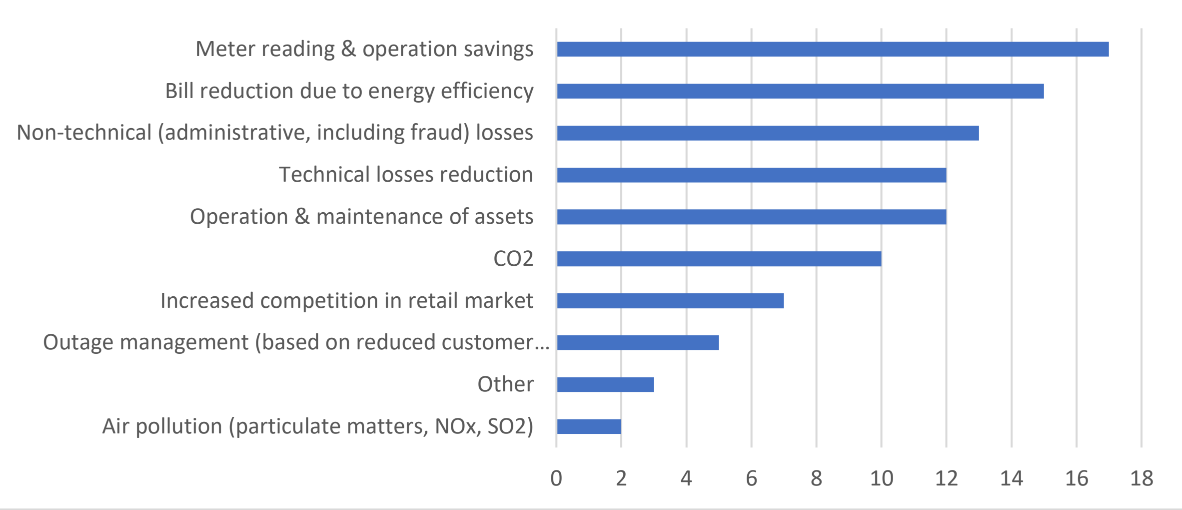


Figure 30: Ranking of the considered benefits in gas CBA vs. number of Member States that conducted at least one gas CBA

Market actors considered in the gas CBA

The various market actors considered by each Member State when carrying out the CBA can be observed in Table 25; a consolidated ranking is presented in Figure 31.

As expected, the mostly encountered common actor in these CBAs is the distribution system operator (DSO), who in many countries is responsible for metering installation, meter reading, and grid operations. Apart from UK where the rollout of smart meters is supplier-led, in all Member States it is DSO-led. Many technical aspects of the deployment are directly related to the DSO, such as meter reading & operations savings, technical operational & maintenance benefits, etc. The consumers are also a main market actor considered in most of the CBAs, as they will directly benefit from energy bill reduction.

Table 11 demonstrates which market actor (i) owns the smart meter and which market actor (ii) is responsible for the installation of the smart meter in each Member State.

Another important market actor is the energy supplier who collects metering data, e.g. to send the energy bill to the consumer.

	DSO	Supplier	NRA	Consumer	State/Society	BRP	Telecom service provider	Other actor
AT	✓	✓		✓				
BE (BR)	✓	✓	✓	✓	✓			
BE (FL)	✓	✓		✓	✓	✓		
BE (WA)	✓	✓	✓	✓				
CZ								
DK	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
FI	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
FR	✓			✓	✓			
DE	✓	✓		✓	✓	✓		
IE	✓	✓		✓	✓			
IT	✓	✓	✓	✓	✓	✓	✓	
LV	✓							
LT	✓	✓	✓	✓	✓			
LU	✓	✓		✓		✓		
NL	✓	✓		✓	✓			✓
RO	✓			✓				
SK	✓	✓		✓				
SI	✓	✓	✓	✓	✓		✓	
ES	✓			✓				
SE	✓	✓	✓	✓	✓			✓
UK		✓		✓	✓			

Table 25: Considered market actors in the CBA for Member States that conducted at least one gas CBA (legend: green = considered, blank = not considered; grey = data not available).

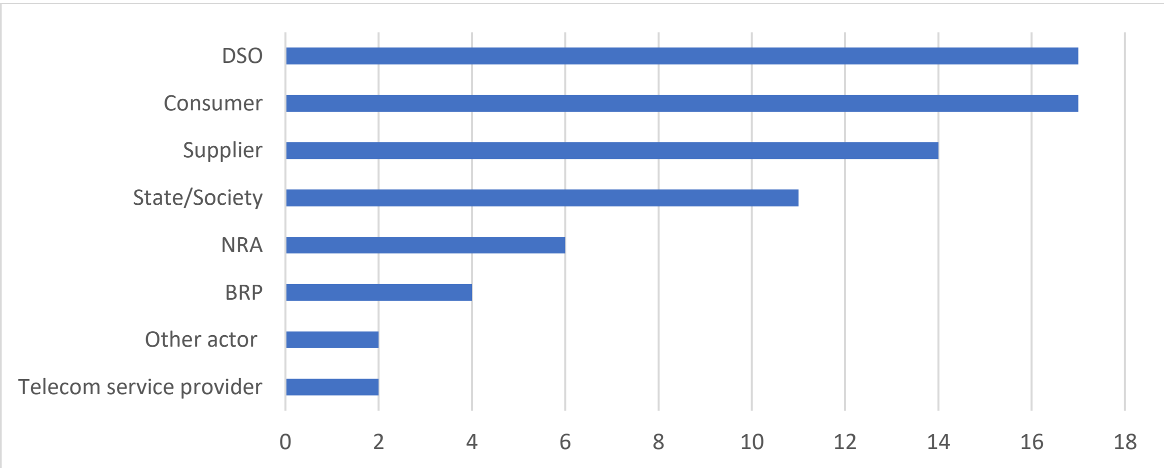


Figure 31: Ranking of the considered market actors in the gas CBA vs. number of Member States that conducted at least one gas CBA

5.2.2.3 NORMALISED COST AND BENEFIT PER METERING POINT FOR GAS

The normalised cost and benefit per metering point for each Member State can be seen in Table 26. This table only includes Member States that already conducted at least one CBA for gas smart meters deployment. The figures quoted in this table represent the most recent data available.

It is important to note that two methods were proposed for the computation of normalised cost and benefit per metering point in the data collection exercise. These were:

1. Direct computation of key indicators (cost and benefit per installed meter) by the NRA (or other entity in charge)
2. The providing of yearly estimates on OPEX, CAPEX, benefits, number of meters in order estimate the cost and benefit over the given period

All the information collected in 2018 was done so using method 1. It must be highlighted that the variation and level of consistency of the information provided makes it difficult to provide an accurate benchmark.

For the Member States marked with an (*) in the following table, a joint CBA for electricity and gas has been conducted, hence no separate calculation of costs and benefits per metering points for electricity and for gas was available.

	TOTEX 2018 (€/meter)	TOTEX 2013 (€/meter)	Benefit 2018 (€/meter)	Benefit 2013 (€/meter)
Austria	no CBA	316.00 €	no CBA	383.00 €
Belgium*	N/A	N/A	N/A	N/A
Bulgaria	no CBA	no CBA	no CBA	no CBA
Croatia	no CBA	no CBA	no CBA	no CBA
Cyprus	no CBA	no CBA	no CBA	no CBA
Czech Republic	no CBA	825.78 €	no CBA	328.92 €
Denmark	no CBA	268.29 €	no CBA	N/A
Estonia	no CBA	no CBA	no CBA	no CBA
Finland	no CBA	N/A	no CBA	N/A
France*	135.00	100.00 €	N/A	N/A
Germany*	no CBA	546.00 €	no CBA	493.00 €
Greece	no CBA	no CBA	no CBA	no CBA
Hungary	no CBA	no CBA	no CBA	no CBA
Ireland*	380.00 €	233.33 €	448.00 €	N/A

	TOTEX 2018 (€/meter)	TOTEX 2013 (€/meter)	Benefit 2018 (€/meter)	Benefit 2013 (€/meter)
Italy	no CBA	97.00 €	no CBA	176.00 €
Latvia*	38.18 €	2,113.64 €	43.64 €	N/A
Lithuania*	169.60 €	no CBA	185.90 €	no CBA
Luxembourg*	139.00 €	150.00 €	158.00 €	181.25 €
Malta	no CBA	no CBA	no CBA	no CBA
Netherlands*	no CBA	220.00 €	no CBA	270.00 €
Poland	no CBA	no CBA	no CBA	no CBA
Portugal	no CBA	no CBA	no CBA	no CBA
Romania	no CBA	145.36 €	no CBA	150.71 €
Slovakia	no CBA	160.25 €	no CBA	183.85 €
Slovenia*	145.50 €	no CBA	25.50 €	no CBA
Spain	no CBA	120.00 €	no CBA	105.00 €
Sweden	no CBA	N/A	no CBA	N/A
United Kingdom*	232.00 €	161.00 €	352.00 €	377.00 €

Table 26: Normalised costs and benefits per metering point, for each Member States that conducted at least one gas CBA (Legend:"-"= data not available).[75]

The unavaibility of data does not allow us to provide a detailed benchmark of costs and benefits per gas metering point. Nevertheless, the quoted figures (shown in the previous table) depict significant variation in the results. Indeed, the average costs per gas metering point for the Member States included in the table (taking into account the most recent figures for each country) equal €246 with a standard deviation of €192, while the average benefits also equal €246 with a standard deviation of €129.

What can be seen from Table 23 - Table 25 is that there is high variation between the market actors, cost and benefit items considered by each Member State and as a result, there is a high variation between the normalised cost and benefit per metering point. This can be seen in Figure 32.

[75] While some Member States did not update their gas CBA since 2013, differences between the costs and benefits quoted in this table and the ones quoted in the previous benchmarking report come from the current availability of more comprehensive data.

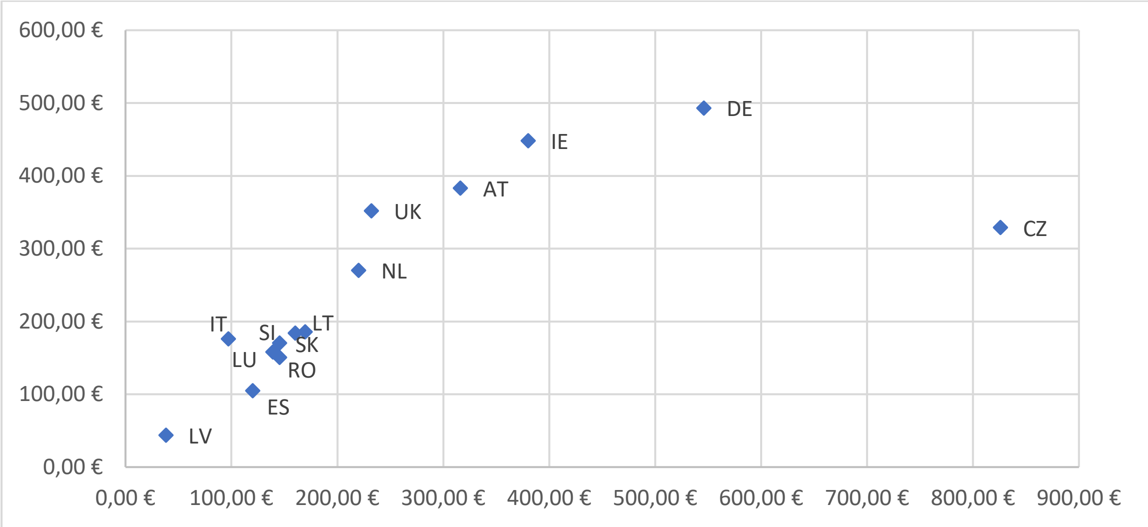


Figure 32: Normalised costs vs. benefits per metering point (most recent figures), for the case of gas.

5.2.3 Deployment state of play

A detailed analysis has been performed on the progress and the current deployment rate of the smart metering deployment across the EU-28, for each Member State.

5.2.3.1 MARKET DRIVERS FOR GAS SMART METER ROLL-OUT

Four primary market drivers were identified for the deployment of smart meters:

- Digitalization of the distribution grid and optimization of the network operations;
- Digitalization of retail market to foster innovation and new services by private actors;
- Supporting actions for tackling fuel poverty;
- Supporting energy efficiency.

The primary drivers for the deployment of gas smart meters can be observed in Table 27 for each Member State that conducted at least one gas CBA. Figure 33 consolidates this information to visualize the ranking of these market drivers across these countries.

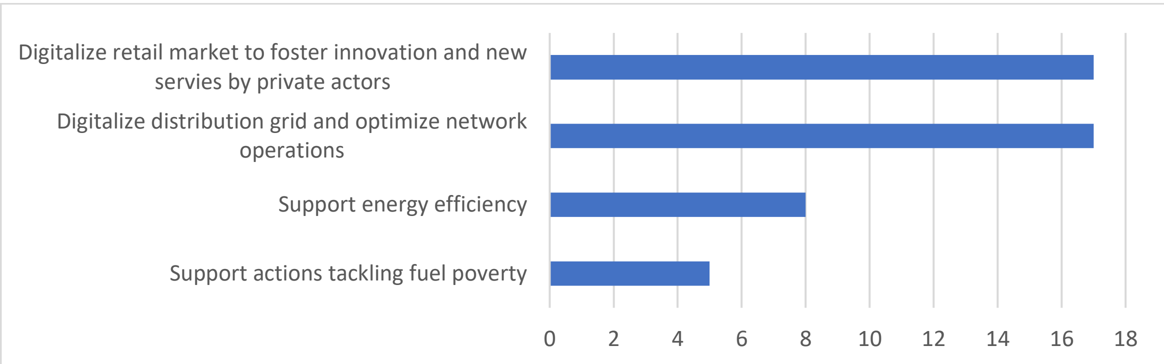


Figure 33: Primary market drivers for gas smart meter rollout vs. number of Member States that conducted at least one gas CBA.

	Digitalize distribution grid and optimize network operations	Digitalize retail market to foster innovation and new services by private actors	Support actions tackling fuel poverty	Support energy efficiency
Austria	green	green		
Belgium (BR)	grey			
Belgium (FL)	green	green	green	green
Belgium (WL)	green	green	green	
Czech Republic				
Denmark	grey			
Finland	green	green		
France	green	green		
Germany	green	green		green
Ireland	green	green		
Italy	green	green	green	green
Latvia	green	green		
Lithuania	green	green		green
Luxembourg	green	green		green
Netherlands	green	green		green
Romania	green	green	green	
Slovakia	green			
Slovenia	green	green		green
Spain	green	green		green
Sweden	green	green		
United Kingdom		green	green	

Table 27: Market drivers for gas smart meter rollout for Member States that conducted at least one gas CBA (legend: green = considered, blank = not considered; grey = data not available).

The key drivers to roll-out gas smart meters are the 'digitalisation of the distribution grid to allow optimisation of the network operations' (providing direct value for grid and generation operators to optimise the operation and usage of their existing assets which may defer additional grid capacity investments), and the digitalisation of the retail market.

Supporting energy efficiency is not a main driver for the deployment of gas smart meters.

It should also be noted that even though biogas injection in the distribution grid has become a reality in some Member States, it is not considered as a significant driver for gas smart metering rollout.

5.2.3.2 GAS SMART METER LARGE-SCALE ROLLOUT IN MEMBER SATES

Whilst Directive 2009/73/EC requires that Member States proceed, usually subject to a CBA, with the deployment of smart metering for gas, and consecutively draw up an implementation strategy, these provisions are less restrictive than the ones of the mirror Directive for electricity since no deployment target for gas smart meters is set.

Consequently, as of 2018, only six Member States have decided to proceed with a large-scale rollout of gas smart meters. These Member States – namely France, Ireland, Italy, Luxembourg, the Netherland and UK - account for 56% of all gas metering points within the Union. It should be mentioned that as of July 2019, and following the positive outcome of its revised CBA, Flanders (Belgium) is proceeding to a segmented rollout of gas smart meters. Additionally, even though there is no explicit implementation strategy for the rollout of gas smart meters in Germany, it is mandatory to equip gas metering points with meters capable of being connected to a Smart Meter Gateway, in order to prepare the market for a large-scale rollout, once the revised CBA presents a positive outcome.

Figure 34 shows the estimated target date for completion of a wide scale rollout of gas smart meters as of 2018, and its comparison with the original estimations from 2013. It can be seen that the large majority of Member States has not yet defined a target period.

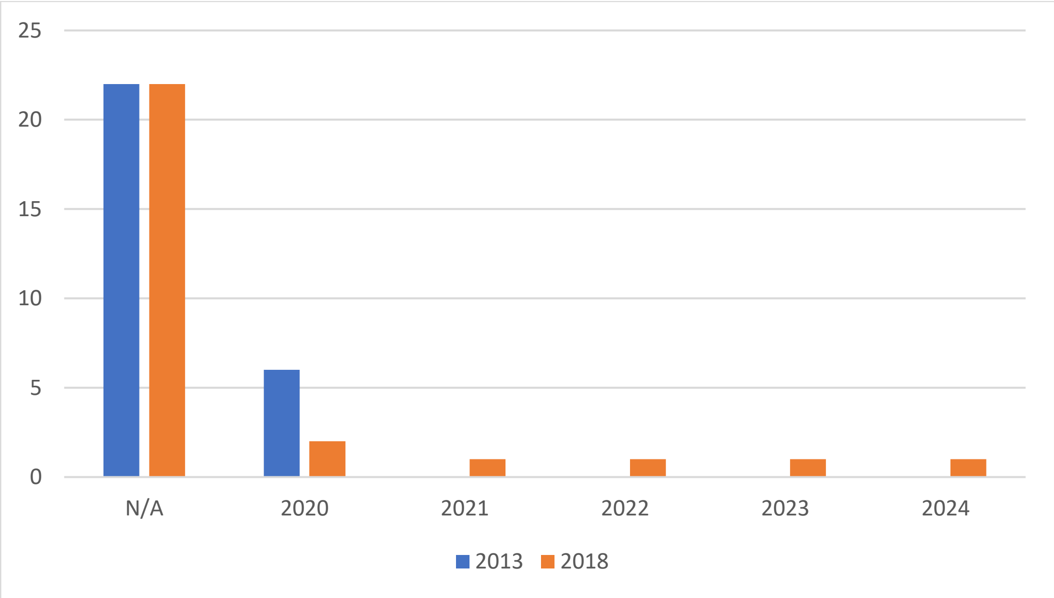


Figure 34: Overview (aggregated) of target period for gas smart meters (study 2018), compared to the initial targets set in the previous study (2013).

Figure 35 shows a detailed view on the target period for a large-scale rollout of gas smart meters for the Member States having set up an implementation strategy.

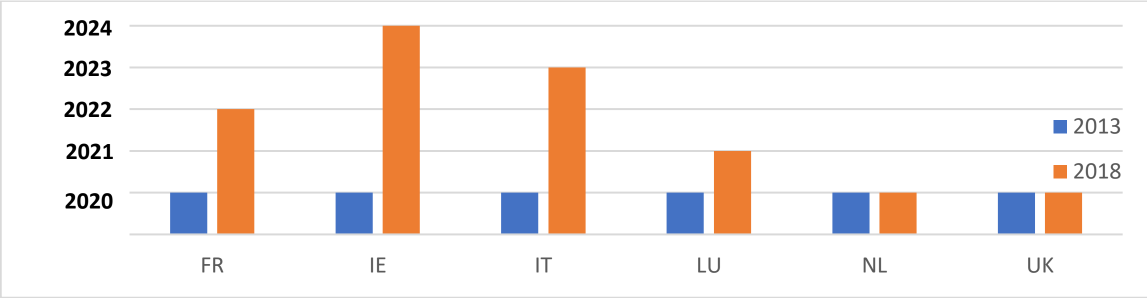


Figure 35: Overview of target period for a wide-scale rollout of gas smart meters for concerned Member State (study 2018), compared to the initial targets set in the previous benchmarking study2 (2013)[76]

One should notice that these 6 Member States are still at an early stage of their large-scale deployment, except for the Netherlands. Within this group of countries, the penetration rate in January 2018 varied from close to 0% for Ireland to 46.6% for the Netherland, with an average (weighted by the number of metering points to be equipped with a smart meter) of 25%.

To conclude, Figure 36 presents the official deployment strategy per Member State to reach their respective target on the large-scale roll-out of gas smart meters.

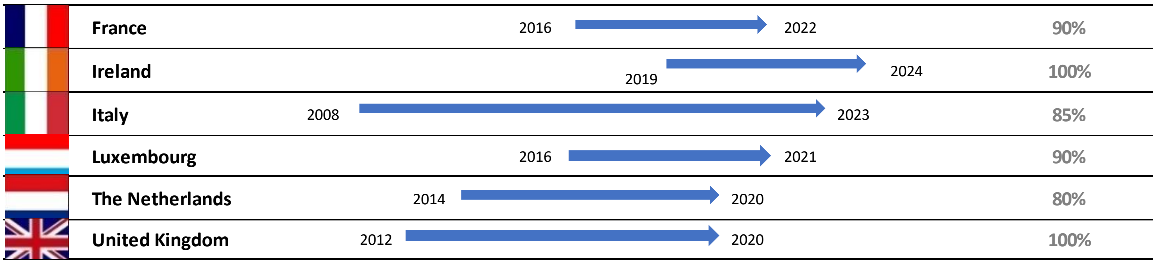


Figure 36: Deployment strategy per Member State on the large-scale rollout of gas smart meters

Among those countries that took the decision to proceed with a large-scale rollout of gas smart meters, four (France, Ireland, Italy and Luxembourg) out of six revised their target period for the completion of the process. Among the two others, which kept 2020 as target period for the completion of the rollout, only the Netherlands might be able to reach its 80% penetration rate by 2020.

5.2.3.3 CURRENT STATUS ON SMART METER DEPLOYMENT RATE

This subsection provides insights into the state of play of gas smart meter deployment rate in all Member States as of 31/12/2017.

Table 28 presents the total number of existing gas metering points and the total number of gas smart meters installed, from which the overall penetration rate of smart meters per Member State can be calculated (as indicated in the final column). Similar as for electricity smart meters, Figure 37 shows:

[76] As not proceeding to a wide-scale rollout, Flanders has not been include in the above figures. The segmented rollout should last from July 2019 to the year 2025.

1. The overall penetration of gas smart meters in each Member State which is represented by the overall bar (a combination of blue and orange).
2. The percentage of gas smart meters that was installed in 2017, which is represented by the orange bar.

Based on the data collected from National Authorities it can be observed that the deployment of gas smart meters is much less advanced than that for electricity smart meters. Nearly all existing gas smart meters are installed in France, Italy, The Netherlands and United Kingdom. From Figure 37 it can also be observed that almost half of existing gas smart meters – around 46 % of all existing gas smart meters as of 2018 – were installed throughout 2017.

Among Member States planning to rollout their gas metering system by 2020 (namely the Netherlands and the United Kingdom), only the Netherlands is on track to reach its original roll-out target. Meanwhile, Luxembourg is on track to reach its 90% target of smart meters for gas by the end of 2020.

In January 2018 – according to the available data – 14% of all gas metering points were equipped with smart meters, which represents just over 16 million gas smart meters.

By 2024[77], based on the announcements made by the NRAs of Member States rolling out smart gas smart meters, the penetration rate of gas smart meters should approximate **51% with 60 million of gas smart meters installed in 5 years**. With a weighted average cost per gas metering point[78] of **171€**, this would represent an aggregated investment of over €10 billion.

Nevertheless, considering the current pace of deployment of gas smart meters, our previsions are less optimistic. We estimate[79] that **in 2020, 31 million of smart meters will be in place**, accounting for **27% of all gas metering points**, which will represent an aggregated investment of over **€5 billion. By 2024, we estimate that 51 million of smart meters will be in place, accounting for a 44% penetration rate EU-wide**. The deployment of these 51 million gas smart meters would trigger a total investment of almost **€9 billion.** By 2024 only Italy, Luxembourg and the Netherland would have completed their large-scale rollout of gas smart meters.

[77] 2024 is the latest targeted period within the group of Member States currently planning a large-scale rollout of gas smart meters.

[78] The calculation of this weighted average includes Austria, France, Ireland, Italy, Latvia, Lithuania Luxembourg, the Netherlands, Romania, Slovakia, Slovenia and the United Kingdom.

[79] These estimations are based on the observed rate of deployment of gas smart meters in 2017.

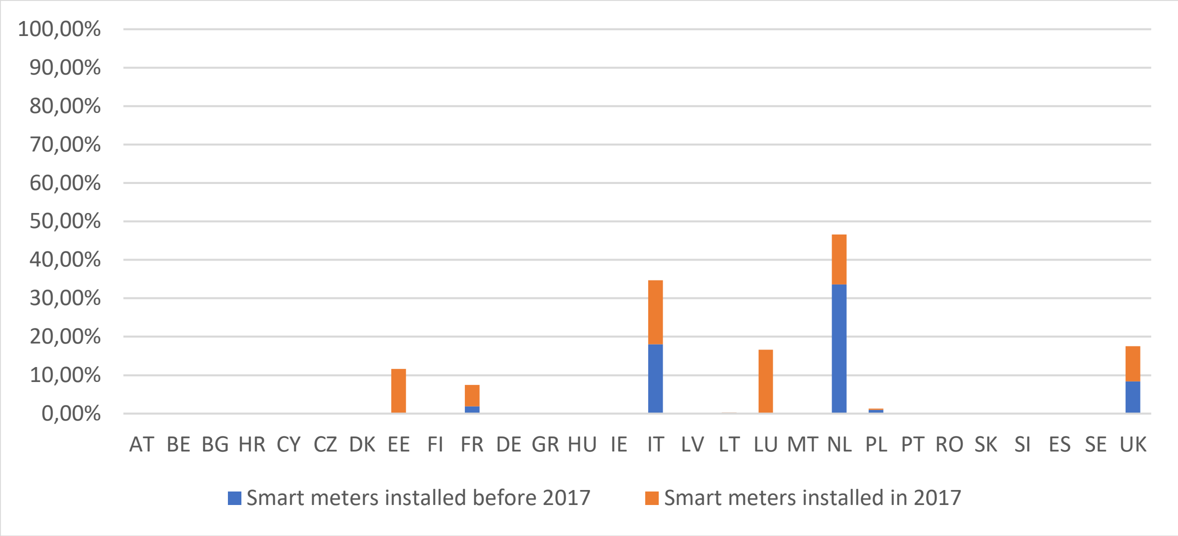


Figure 37: Overall gas smart meter penetration by Member State.

	Actual number of existing metering points (as of 2018)	Total Smart Meters installed (as of 2018)	Total Smart Meters installed in 2017	Total smart meter penetration rate (as of 2018)	Total smart meters installed in 2017
Austria	1,473,684			0.00%	0.00%
Belgium	> 3,510,404			0.00%	0.00%
Bulgaria	180,000			0.00%	0.00%
Croatia	647,000			0.00%	0.00%
Cyprus	0				
Czech Republic	2,870,000			0.00%	0.00%
Denmark	410,000			0.00%	0.00%
Estonia	43,000	5,000	5,000	11.63%	11.63%
Finland	37,000			0.00%	0.00%
France	10,960,000	818,000	609,900	7.46%	5.56%
Germany	14,000,000			0.00%	0.00%
Greece	287,938			0.00%	0.00%
Hungary	7,000,000	11,584	6,492	0.17%	0.09%
Ireland	600,000			0.00%	0.00%
Italy	22,200,000	7,700,000	3,700,000	34.68%	16.67%
Latvia	2,200			0.00%	0.00%
Lithuania	582,058	1,258	46	0.22%	0.01%
Luxembourg	88,527	14,723	14,723	16.63%	16.63%
Malta	0				
Netherlands	7,300,000	3,400,000	947,000	46.58%	12.97%
Poland	7,349,885	94,266	21,443	1.28%	0.29%
Portugal	1,251,000			0.00%	0.00%
Romania	2,800,000			0.00%	0.00%
Slovakia	805,000			0.00%	0.00%
Slovenia	133,630	165	0	0.12%	0.00%
Spain	7,500,000			0.00%	0.00%
Sweden	37,000			0.00%	0.00%
United Kingdom	23,417,428	4,101,072	2,134,983	17.51%	9.12%
Total	115,004,011	16,146,068	7,439,587	14.04%	6.47%

Table 28: Number of gas metering points by 2020, and total number of smart meters installed today by Member State (Legend: Blank = data not available).

A breakdown of installed gas smart meters can be observed in Table 29. The table comprises of the total gas smart meters in households and SMEs, the gas smart meters in households and SMEs installed in 2017, as well as the overall gas metering points for these two segments.

	Actual number of existing metering points (as of 2018)			Total smart meters Installed (as of 2018)			Total smart meters installed in 2017		
	SME	Household	Total	SME	Household	Total	SME	Household	Total
AT			1,473,684						
BE			2,970,208						
BG			180,000						
HR			647,000						
CY			0						
CZ			2,870,000						
DK			410,000						
EE		43,000	43,000		5,000	5,000		5,000	5,000
FI			37,000						
FR	400,000	10,560,000	10,960,000	132,500	685,500	818,000	24,400	585,500	609,900
DE			14,000,000						
EL			287,938						
HU	3,500,000	3,500,000	7,000,000	5,885	5,699	11,584	2,166	4,326	6,492
IE			600,000						
IT			22,200,000			7,700,000			3,700,000
LV			2,200						
LT	10,565	571,493	582,058	1,212	46	1,258		46	46
LU			88,527			14,723			14,723
MT			0						
NL	700,000	6,600,000	7,300,000	300,000	3,100,000	3,400,000	97,000	850,000	947,000
PL	65,993	7,283,892	7,349,885	60,422	33,844	94,266	14,422	7,021	21,443
PT			1,251,000						
RO			2,800,000						
SK			805,000						
SI	13,952	119,678	133,630	165		165			
ES			7,500,000						
SE			37,000						
UK	823,099	22,594,329	23,417,428	257,814	3,843,258	4,101,072	63,769	2,071,214	2,134,983

Table 29: Overview of total gas metering points, total gas smart meters installed, and number of gas smart meters installed in 2017 by Member State.

5.2.4 Functional specifications

As mentioned in section 5.1 related to electricity smart meters, the Commission Recommendation 2012/148/EU defines 10 common minimum functionalities for electricity smart metering systems, among which 9 are also relevant to gas smart metering. These functionalities are:

- **a)** Provide readings directly to consumer and/or any 3rd party
- **b)** Upgrade readings frequently enough to use energy saving schemes
- **c)** Allow remote reading by the operator
- **d)** Provide 2-way communication for maintenance and control
- **e)** Allow frequent enough readings for network planning
- **f)** Support advanced tariff systems
- **g)** Remote ON/OFF control of the supply AND/OR flow or power limitation
- **h)** Provide secure data communications
- **i)** Fraud prevention and detection

These recommendations were drawn in close consultation with National Regulatory Authorities, especially from Member States with significant experience with their rollout and are aligned with those developed by the standardisation mandate M441[80]. The most important functionalities related to engagement of consumers are functionalities a, b, and f.

In this subsection, we considered the Member States that are currently proceeding to the rollout of gas smart meters. Based on the data collected here, and as showed in Table 30 the majority of these 6 Member States undertaking a large-scale rollout foresees having all nine smart metering functionalities, apart from the remotely ON control feature of functionality 'g', available to their electricity consumers. Many of the functionalities will be activated by default and will be free of charge for the consumer. For instance, France and Ireland are Member States rolling out gas smart meters where all the nine functionalities recommended by the European Commission will be made available, activated by default and free of charge.

	Provide readings directly to consumer and/or any 3rd party	Update readings frequently enough to use energy saving schemes	Allow remote reading by the operator	Provide 2-way communication for maintenance and control	Allow frequent enough readings for network planning	Support advanced tariff systems	Remote ON/OFF control of the supply AND/OR flow or power limitation	Provide secure data communications	Fraud prevention and detection
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**
Belgium (Flanders)	X	X	X	X	X	X	X	X	X
France	X	X	X	X	X	X	X	X	X
Ireland	X	X	X	X	X	X	X	X	X
Italy	X		X	X				X	X
Luxembourg	X	X	X	X	X	X		X	X

80 "Functional reference architecture for communications in smart metering systems" (CEN-CLC-ETSI TR 50572:2011).

Netherlands		X		X	X			X	
United Kingdom	X	X	X	X	X	X	X	X	X

Table 30: Overview of all smart metering functionalities for gas by Member State (legend: blank = nor foreseen nor available, green = free of charge, orange = not free of charge, 'X' = activated by default, grey = data not available).

When it comes to the frequency at which data is updated and provided to consumers, it is recommended that this done frequently enough to enable participation in energy management programs or support advanced tariffs and account settling.

	(a) Provide readings directly to consumer and/or any 3rd party	(b) Update readings frequently enough to use energy saving schemes	Frequency at which consumption data is updated
Belgium (Flanders)	YES	YES	15' (near real-time on request)
France	YES	YES	N/A
Ireland	YES	YES	Daily
Italy	YES	YES	Variable[81]
Luxembourg	YES	YES	Hourly
Netherlands	YES	YES	5'
United Kingdom	YES	YES	30'

Table 31: Frequency of data update intervals (implemented or foreseen) for gas smart meters

5.3 Cross-cutting considerations for both electricity and gas

5.3.1 Technical specifications

This section, applicable to both electricity and gas smart meters, will go beyond the mere update of the data information on smart metering system specifications and the status of interoperability of the smart metering architecture on local interfaces and interoperability of those interfaces.

Figure 38 represents the smart meter environment, based on the reference architecture for smart metering communications developed by the Smart Metering Coordination Group, in the framework of the M/490 smart grids mandate and the M/441 smart meters mandate (CEN/CLC/ETSI/TR 50572, 2011).

The smart meter is usually composed of 2 elements (that can be physically separated or integrated):

- the meter itself (with metrology functions and other functionalities), and
- a gateway for communication, also called the local network access point (LNAP).

To enable communication between the network components, interfaces are required.

[81] In Italy, as no legal obligation has been set, the frequency of consumption data update for gas smart meters depends on the choice of the DSO and on the customer consumption volume.

- The **H1 interface** connects the smart meter system to an external display, via one-way communication. The external display is not uniquely designed. For instance, information may be provided only visually, or be available for downloading. The so-called « P1 » implemented in the Netherlands, Luxemburg or Austria is one example of an H1 interface.
- The **H2 interface** connects the smart meter system with the Home Area Network (HAN). The HAN interconnects smart home devices for energy management purposes. The H2 provides a two-way communication, i.e. the HAN can send information on individual devices back to the smart meter system.
- The NNAP may also have an **H3 interface** to the HAN. It seems, however, that H3 is currently not implemented or planned in Europe.
- Data from the smart meter is shared externally with the meter data management system (a central communication system). This system communicates with meters either directly through the Wide Area Network (WAN) and enabled by the **G-type interfaces** (**G1** or **G2** depending on the physical network architecture being used), or via a data concentrator where information from several meters in a neighbourhood is concentrated (Neighbourhood Network Access Points, NNAP).
- The **C interface** is used to connect the LNAP and/or the metering end devices to the NNAP, typically using narrowband PLC, local wired or wireless networks.
- The **M interface** is used to connect the metering end devices to the LNAP. The profile used by this interface depends on the type of metering device being used (electricity meter / non-electricity meter).

Note that the **Meter Data Management System** is represented in a very simplified way: in practice, the way consumption data is collected, validated and stored is organized differently. Some countries have opted for centralized systems where an independent third party is responsible, other countries have opted for a decentralized system (where DSOs or suppliers are responsible), or a combination. It provides validated historical and usually non-validated near-real time consumption data that is used by different data users for several purposes: DSOs and suppliers for traditional activities (for switching and billing purposes for instance), suppliers and third parties for emerging energy and flexibility services.

To this end, consumption data might be combined with wholesale market data, or transmission and distribution grid data to deliver services to DSOs/TSOs. Finally, suppliers and third parties may also have direct access to the smart meter (not shown in Figure 38)

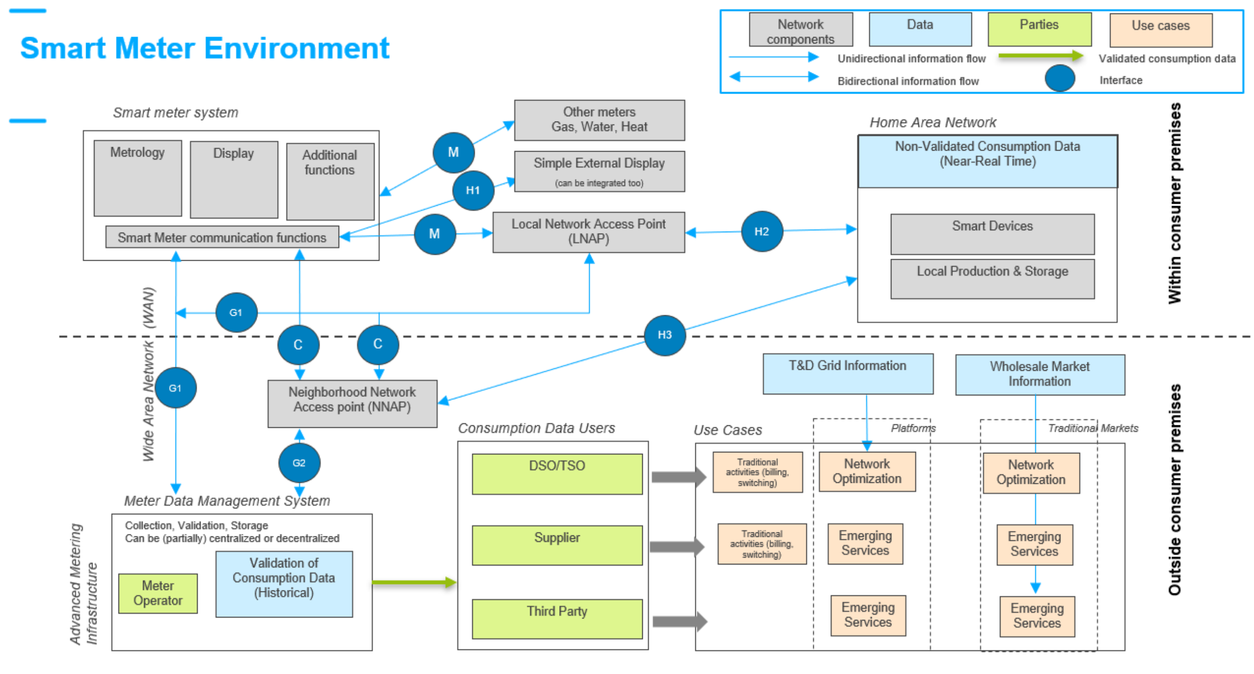


Figure 38: Smart metering communications' and related data management architecture[82]

Table 32 gives an overview of the preferred communication technologies for the different interfaces H1-H3, G1-G2 and C, based on Member States' feedback. More than two thirds of the Member States have already defined the preferred communication technologies (Power line communication or other wireless technologies) for the different interfaces. Depending on the Member State, one specific technology is preferred for each interface, or a set of technologies is given. Only two countries (Hungary and Italy) have today defined different preferred technologies for electricity and gas smart meters.

Member State	Choice of communication technology for H1, H2, H3, C, G1, G2, M
Austria	The interfaces are open to the decision of the DSO. Due to the fact that few DSOs have started their rollout yet, the information is not complete. H1: IDIS CII, IR according to IEC 62056-23, MEP (Multipurpose Expansion Port), Plug AV (IEEE 802.2), ZigBee, Wireless, MBUS; protocols according OSGP specifications H2: OMS (Specification Volume 2, primary communication issue 3.0.1 mit wired Mbus nach EN 13757-1 bis EN 13757-3, MEP (Multipurpose Expansion Port), Plug AV (IEEE 802.2), ZigBee, Wireless ; H3: MEP (Multipurpose Expansion Port), Plug AV (IEEE 802.2), ZigBee, Wireless
Belgium (Brussels)	Not available
Belgium (Flanders)	H1: DSMR P1 V5.0 G1: GSM (NB-IoT) H2: OMS (for gas smart meters) Additionally, to the P1 port, an S1 port sampling energy data (voltage, current) will be implemented
Belgium (Wallonia)	Not available
Bulgaria	C: GPRS / PLC

[82] The functions represented in these boxes can be implemented in separate hardware components, or physically combined in the same hardware.

Member State	Choice of communication technology for H1, H2, H3, C, G1, G2, M
Croatia	Not available
Cyprus	Not available
Czech Republic	Not available
Denmark[83]	Interfaces H1 and H2 defined, supporting functionality (a) and (b), for meters installed after 2011. No specific standard has been chosen for interface H1, but open standards will be required H1: DLMS/COSEM data model will probably be used H2: open standards wired (RS-485) or wireless (wM-Bus), and DLMS
Estonia	C: PLC G1: GSM G2: GSM
Finland	H1: EN 62053-31, EN 13757-2, EN 62056-7-5 G1: PLC, GPRS, RF
France	*STEP 1 (2,5 million meters)* H1: TIC Wire Interface H3: PLC G1: PLC *STEP 2 (32 million meters)* G3: PLC H1: WPAN H2: WPAN G1: GSM and Long-Range Radio
Germany	G1: Ethernet, Mobile (2G,4G), BPLC, open for further standards M: RS485, wMBUS, open for further standards H1: Ethernet H2: Ethernet H3: communication must be separated from the Home Area Network according to BSI TR 03109. Smart Meter Gateway Access through the public internet is permitted in Germany.
Greece	The standards that has been adopted to support the chosen communication technology are GSM, GPRS, 3G, 4G, PLC. The following gives an overview of the implementation of the different interfaces with regards to the implementation and the technology used. Interface Implementation Technology H1: Activated upon customer explicit request H2: Activated upon customer explicit request H3: No C: No Powerline Cable G1: Implemented by default GSM G2: No GSM
Hungary	C: Power Line Carrier (electricity smart meter) & Wireless technology (gas smart meter) G1: GSM G2: GSM

[83] Information provided by European Smart Grids Task Force Expert Group 1 report on "Interoperability, Standards and Functionalities applied in the large scale roll out of smart metering" https://ec.europa.eu/energy/sites/ener/files/documents/EG1_Final%20Report_SM%20Interop%20Standards%20Function.pdf

Member State	Choice of communication technology for H1, H2, H3, C, G1, G2, M
Ireland	Today, it cannot be confirmed which technologies will be adopted and which standards will be applicable. This decision depends on the DSO's procurement process which is currently ongoing. The DSO, ESBN, will make overall decisions on the design, functionality and customer interaction procedures. It is expected that the procurement process will be finalized by the end of 2018. In 2019 the chosen technology will be known, once ESBN completes its procurement activities. In terms of communication standards adopted, it seems that an open standard solution will be chosen for the only implemented interface, H2.
Italy	<u>1G Electricity smart meters</u> H1: PLC (activated upon customer explicit request) H2: PLC (activated upon customer explicit request) H3: not implemented C: PLC (implemented by default) G1: GSM (implemented by default only for MV/HV) G2: GSM (implemented by default); <u>2G Electricity smart meters</u>: more advanced solutions such as the Universal Mobile Telecommunications System (UMTS) and its LTE (Long-Term Evolution) will be implemented on G2 interface. In addition to the PLC channel, a second communication radio channel (RF 169 MHz) from the 2G meters to the 2G data concentrator will be implemented on C interface. This channel will be used as a back-up of the primary PLC channel and for the reception of real-time voltage interruption coming from 2G meters. While 1G smart electricity meters have only one communication channel, new 2G meters can rely on two separate communication channels: one with the central distribution system (Chain 1) and the other towards any consumer energy management systems, i.e. the In-home or smart and portable devices (Chain 2). The combination of the following technologies achieve performance levels consistent with those indicated for 2G meters in Resolution 87/2016/R/eel: - Chain 1: A-band Power Line Carrier (A-PLC) combined with RF 169 MHz (back-up); - Chain 2: C-band Power line Carrier (C-PLC); a possible second channel for Chain 2 is under investigation (see consultation paper n. 245/2018); a decision is expected by mid-2019. The two communication channels on power-line (Band A and Band C according to Cenelec technical standards) respectively used in Chain 1 and 2 are independent each other, thus avoiding interferences between them. <u>For Gas smart meters</u>: H1: Logical Port (>G6) H2: under consideration H3: not implemented C: 169 MHz G1: GSM G2: GSM The architecture of smart metering gas systems can be either point-to-point (generally with communication on public telecommunication network) or point-multipoint, with concentrator. In these cases, the communication on radio frequency at 169 MHz is adopted (C interface). The interoperability and interchangeability technical standards have been set by CIG (Comitato Italiano Gas) and can be updated according to technical innovation.
Latvia	C: Power Line Carrier G1: GSM G2: GSM
Lithuania	H1: Wire H2: Wire C: PLC

Member State	Choice of communication technology for H1, H2, H3, C, G1, G2, M
	G1: GSM G2: GSM
Luxembourg	G1: GPRS 2G/ LTE 4G between meter and central system. DLMS COSEM security suite 1. G2: GSM 2G/3G/LTE 4G or ethernet H1: based on Dutch standard DSMR 4.2.1. (based on IEC 62056-212). A companion profile for P1 (H1) is available for all DSO's. H2: LNAP implemented in e-meter C: PLC 3G to concentrator. DLMS COSEM security suite 1. H3: optional for DSO Smart grid system feeding M: OMS 4.0.2 between e-meter and Mbus devices
Malta	In Malta the PLC technology is implemented by default for all consumers connected to the low voltage network, while the GSM technology is implemented by default for consumers connected to the medium voltage network. In addition to the PLC channel, a second communication radio channel (RF 169 MHz) from the 2nd Generation meters to the 2nd Generation data concentrator is being implemented on the C interface. This channel is used as a back-up of the primary PLC channel and for the acquisition of real-time supply interruptions. With this, Enel (and now Enemalta) are aiming to establish a communication channel with the metering units that up till now were not being reached via PLC. The 2nd Generation of meters now being installed have also a 2nd separate communication channel towards any consumer energy management system (i.e. in-house display systems, smart phones and other devices). The combinations of such technologies achieve performance levels consistent with those indicated for the 2nd Generation of Meters in resolution 87/2016/R/eel: - A-band PLC combined with RF169 MHz (as a backup). - C-band PLC, with an available second channel. The two communication channels on PLC (bands A and C as per the CELENEC technical standard) used in the two chains are independent on each other, thus avoiding any possible cross-talking or interference between the two.
Netherlands	In the Netherlands, a national companion specification has been defined and is supported by several manufacturers (DSMR). In that context, the P1 port is covering the functional specification of interfaces H1 H2 and H3. The Dutch Smart Meter Architecture defines ports (P1 to P4) as a mean on which communication takes place between two instances. • P1 is used for connecting the smart meter to third party hard-/software. • P2 is used to connect to a gas- or water meter. • P3 connects (most commonly via GPRS) with the DSO. • P4 is on the DSO's site and allows suppliers and/or third parties to connect to and to gather data from a customer. Serial protocol (115 kbaud) is the chosen technology for the interfaces. G1 relies on GSM and PLC. DSOs have defined the standards for H2 and were free to choose G1.
Poland	H2: USB / Wireless M-bus C: PLC G1 & G2: GSM
Portugal	H1 implemented by default H2 activated upon customer explicit request, relying on Wi-Fi Technology C, G1, G2 implemented by default and they rely on PLC
Romania	C: PLC G1: GSM/GPRS G2: GSM/GPRS
Slovakia	H1, H3: not implemented H2: RS485 DLMS (activated upon customer explicit request)

Member State	Choice of communication technology for H1, H2, H3, C, G1, G2, M
	C: RS485 IEC62056-21 (implemented by only one Slovak DSO and not by the other two DSOs) G1: GSM (implemented by default) G2: GSM (implemented by only one Slovak DSO and not by the other two DSOs)
Slovenia	H1: Wired/Wireless M-Bus (activated upon customer explicit request) H2: WPAN, Wi-Fi (activated upon customer explicit request) H3: not implemented C: PLC (implemented by default) G1: GSM (implemented by default) G2: Ethernet (Fiber Optic), GSM, WiMAX (implemented by default)
Spain	The technology for H1, C, G1 and G2 interfaces has not been fixed. The technology that can be used is open (GSM, GPRS, PLC, RTC, etc.) and may vary between areas. Based on the feasibility and optimal costs the technology may use existing infrastructure or be adjusted to the area's specific situation (e.g.: communication problems in remote areas) Additionally, there are two existing communication protocols with different characteristics: PRIME and METERS&MORE, both based on power line communication (PLC).
Sweden	Not available
United Kingdom	H1: Zigbee H2: Zigbee G1: GSM and Long-Range Radio

Table 32: Technical specifications on the choice of communication technology for standardised interfaces H1, H2, H3, C, G1, G2 in and within the smart metering infrastructure.

5.3.2 Information security & Data management

5.3.2.1 CONTEXT

Thanks to information and communication technologies, the grid of the future (i.e. smart grid) becomes smarter so as to improve the reliability, security, and efficiency of the energy system through information exchange, distributed generation, storage sources, and the active participation of the end consumer. Internet of Things (IoT) communication networks are already in use and enable modern energy services provided by grid operators and energy service companies. Therefore, digitalization is driving growth and innovation in the electricity and gas industry.

Traditionally, risk management dealt with issues such as component failure via robust mitigation and recovery plans. The electricity system has always been a complex and heavily interconnected system. The digitalization has increased this level of interconnectivity and introduced a new cyber risk dimension. With this increasingly connected environment comes the risk of **vulnerabilities**, which could affect the **reliability** of the energy system and the **trust** of consumers. **Therefore, securing the smart grid and the related communications systems between all actors using cyber resilience strategies is essential for a successful energy transition**.[84]

As shown in Figure 39, the electricity ecosystem consists of many interdependent relationships between numerous stakeholders, relying on providing business-critical components and services. The mapping of the stakeholder consists of the core value chain with generation, transmission and distribution operators and the customer, extending to the business and extended ecosystem. All

[84] World Economic Forum, "Cyber Resilience in the Electricity Ecosystem: Principles and Guidance for Boards," January 2019.

stakeholders are interconnected through physical, network and strategic relations. The complexity of the network layer continues to grow as the electricity system further digitalizes and therefore forms the challenge to secure the cyber resilience.

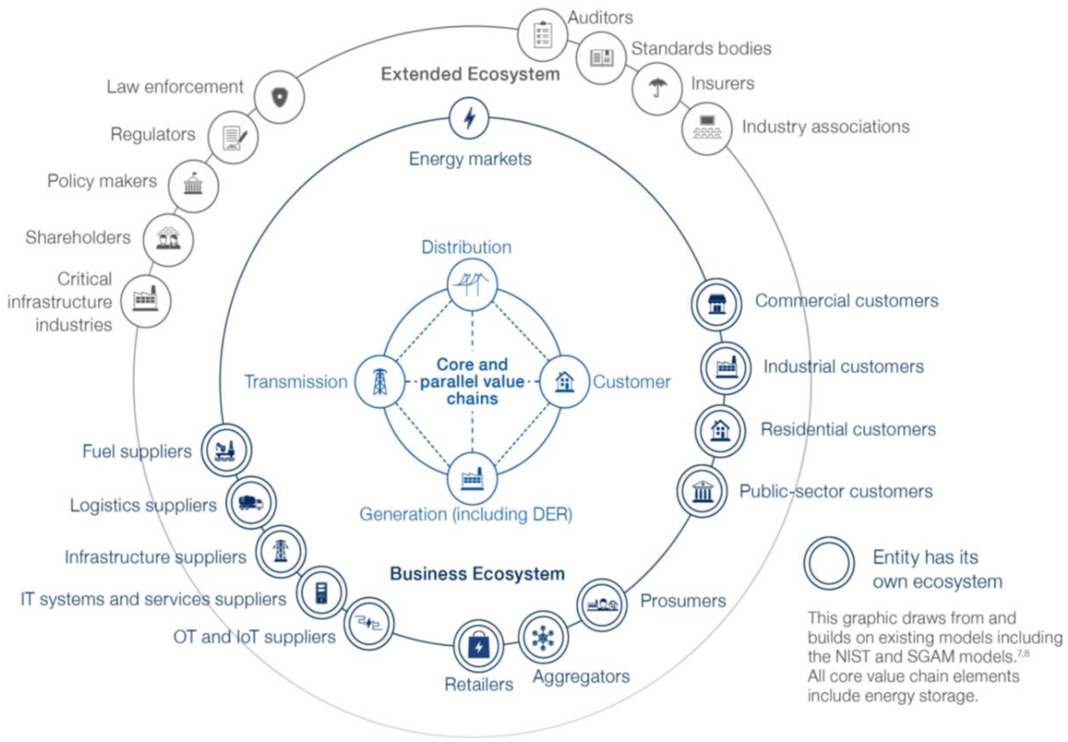


Figure 39: Smart grid ecosystem[84]

The previous figure, published by the World Economic Forum (WEF) in the context of its report “Cyber resilience in the Electricity Ecosystem: Principles and guidance for the board”, illustrates the main topics at the heart of the Forum approach for cyber resilience in the power industry.

First, it needs to be recognized that the electricity system is a highly interdependent and complex ecosystem. Delivering energy in a secure and resilient way implies the close collaboration of all stakeholders active in the value chain. Digitalization further extends the cyber-attack surface for malicious actors to exploit.

It is also pointed out that cyber resilience can no longer be perceived as an IT-only issue and no longer be managed in isolation. It needs to be integrated with business risks and owned by all parts of the organization and ecosystem.

Finally, WEF experts pointed out the unavoidable gap between regulatory safeguards and technology evolution. Even tough significant efforts have been devoted in the world to deliver future-proof, digital-savvy regulation for protecting the power system against cyber-attacks, it is not reasonable to expect those regulations to keep pace with the newest cyber risks, meaning that compliance will not necessarily ensure being effectively secure. It is therefore necessary to develop and promote a resilience mindset and take a strategic and holistic approach to manage cyber risks.

In addition to the general principles, boards in the electricity industry are invited to adopt seven-specific principles to advance systemic cyber resilience[85], as illustrated by the following figure.

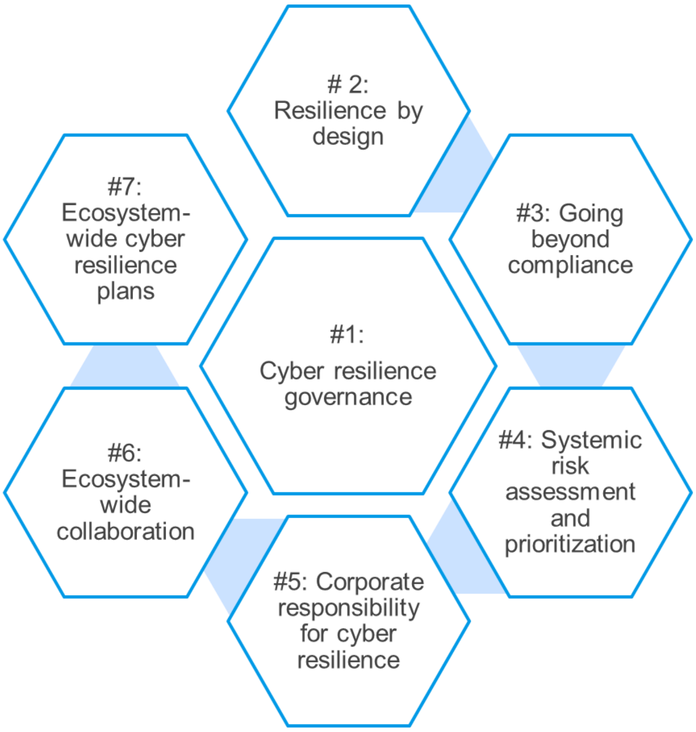


Figure 40: Electricity specific recommendations for cyber resilient power systems

5.3.2.2 DEVELOPMENT OF AN OPEN ARCHITECTURE FOR SMART METERING

To address those challenges, the European Commission initiated specific actions in 2009 and mandated CEN, CENELEC and ETSI (**Mandate M/441**) to develop an open architecture for utility meters involving communication protocols enabling interoperability (i.e. smart metering). In response to Mandate M/441, the European Standardization Organizations (ESOs), CEN, CENELEC and ETSI decided to combine their expertise and resources by establishing the Smart Meters Coordination Group (SM-CG). This group is a joint advisory body that provides a focal point concerning smart metering standardization issues.

The work under the M/441 mandate has been successfully completed, while the Smart Meters Coordination Group continues, as it is the norm in standardization, to follow up developments and provides input for the maintenance of new and existing standards related to advanced metering[86].

In a first phase of Mandate M/441, the different functional entities and interfaces that the communications standards should address were identified, with the intention to support the development of software and hardware architecture and related standards.

The second phase of Mandate M/441 (starting in 2013) focused on the development of European standards containing harmonized solutions for additional functionalities within interoperable frameworks. First, a set of use cases and technical requirements for smart meters on European level were developed. Security requirements were then split off and extended with more input from

[85] WEF, Cyber resilience in the Electricity Ecosystem: Principles and guidance for the board, January 2019, from the Center for Cybersecurity and Electricity Industry Community, http://www3.weforum.org/docs/WEF_Cyber_Resilience_in_the_Electricity_Ecosystem.pdf

[86] https://www.cencenelec.eu/standards/Sectorsold/SustainableEnergy/SmartMeters/Pages/default.aspx

several EU Member States. Based on this extended set of requirements and in line with the provisions of the "Cybersecurity Act" – adopted by the EU in 2019, the coordination group supported by ESMIG developed a Protection Profile for Smart Meters.

According to some stakeholders,[17] this Protection Profile could be a positive contribution towards the security certification of smart meters in Europe and the enabling of the mutual recognition of certificates by multiple EU Member States. To this respect, it could help (i) avoid further fragmentation of the certification approaches across Europe, (ii) reduce the certification cost, and (iii) increase the security level of smart grids.

Parallel to these mandates, the EC had launched the dedicated experts' platform of the Smart Grid Task Force[87], to offer its advice on related policy and regulatory issues in order to help accelerate the deployment of the smart energy grid solutions and therefore also of smart metering, mainly concentrating on :

- **EG1**: Smart grid standards and interoperability
- **EG2**: Regulatory recommendations for privacy, data protection and cyber-security in the smart grid environment
- **EG3**: Regulatory recommendations for smart grid deployment
- **EG4**: Smart grid infrastructure deployment
- **EG5**: Implementation of smart grid industrial policy

The Smart Grids Task Force latest assignment was to help prepare, through the work of its ad-hoc expert working groups, the background for secondary legislation under the Clean Energy for all Europeans Package, on access to data and interoperability, demand side flexibility and on energy-specific issues for cybersecurity.

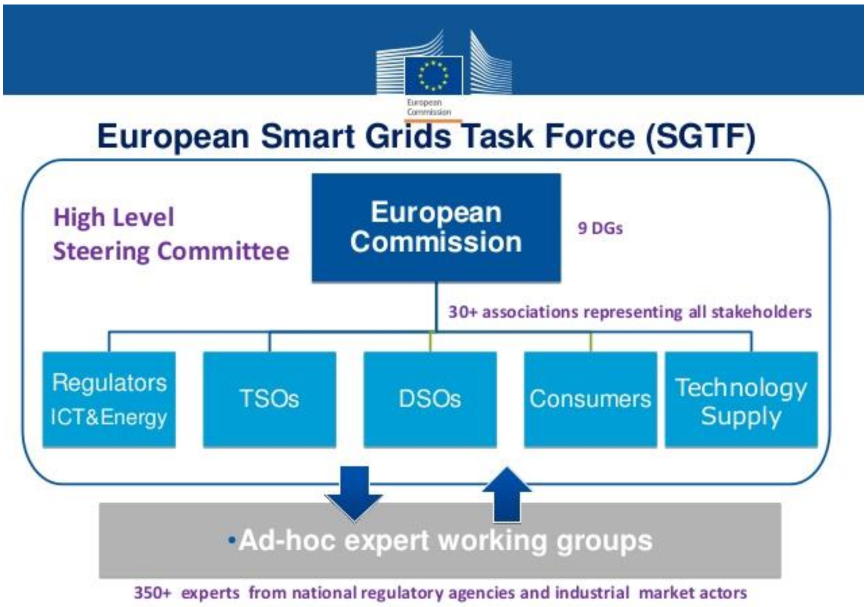


Figure 41: Structure of the European Smart Grids Task Force (SGTF). Ref: European Commission, ENER- Smart Grids Team, 2010.

[87] Smart Grids Task Force: https://ec.europa.eu/energy/en/topics/markets-and-consumers/smart-grids-and-meters/smart-grids-task-force

In parallel to those initiatives that are specific to the energy sector, the European Commission has also progressively adopted a comprehensive legislative framework to cope with the broader challenge of digitalisation.

The framework builds on the EU Cybersecurity strategy (JOIN (2013)01 final) and the Directive on Security of Network and Information Systems (the NIS Directive) (EU) 2016/1148 and has been reinforced by the Cybersecurity Package (JOIN (2017) 450 final) from September 2017, which also includes the Cybersecurity Act.

An energy sector specific guidance has been issued in April 2019 by the European Commission (Recommendation C(2019)2400 final and staff working document SWD(2019)1240 final) to implement horizontal cybersecurity rules. This guidance aims to increase awareness and preparedness in the energy sector, tackling cybersecurity challenges while taking into account the specificities of the energy sector:

- Real-time requirements - some energy systems need to react so fast that standard security measures such as authentication of a command or verification of a digital signature can simply not be introduced due to the delay these measures impose.
- Cascading effects - electricity grids and gas pipelines are strongly interconnected across Europe and well beyond the EU. An outage in one country might trigger blackouts or shortages of supply in other areas and countries.
- Combined legacy systems with new technologies - many elements of the energy system were designed and built well before cybersecurity considerations came into play. This legacy now needs to interact with the most recent state-of-the-art equipment for automation and control, such as smart meters or connected appliances, and devices from the Internet of Things without being exposed to cyber-threats.

5.3.2.3 DATA MANAGEMENT – TYPES & PROCESSES IN THE ELECTRICITY MARKET MODEL

Smart metering data that is required to ensure the running of different processes, among which retail/wholesale functionalities, energy services, grid functionalities, etc., is not just about metered data of physical flows. It also includes other types of data, such as market data and grid data that are needed for the optimal integration of data and processes (see Figure 42). With increasing data volumes and data sources, data integrity, availability and confidentiality are becoming more and more complex to ensure.

Data management can be performed through different technical solutions, such as decentralized or centralized data hubs; currently, most Member States have already deployed or intend to deploy a data hub. Some countries have opted for centralized systems where an independent third party is responsible for managing the data and the respective flows (e.g. United Kingdom, Estonia), whereas others have opted for a decentralized system (where DSOs or suppliers are responsible), or a hybrid combination of the above systems.

Whatever the solution chosen, the key requirement of efficient, non-discriminatory and secure data access and exchange remains, as also instructed in the recast Electricity Directive[24]. According to Article 20 and Article 23 of the recast Electricity Directive, the following criteria are to be assessed regarding data management:

- Availability of metering data and settlement at the same time resolution as the national imbalance settlement period.

- Access to (and exchange of) data for the customer and eligible third parties[88]. For this purpose, data is understood to include metering and consumption data as well as data required for customer switching, demand response and other services.
- Interoperability requirements and non-discriminatory and transparent procedures for access and exchange of data (e.g. converged standardized processes built upon existing national practices, potentially data formats and communication protocols).

Moreover, **easy and secure access** for the consumer to their **non-validated near real time** data, as well as to their validated data (that is used for billing) irrespectively of frequency of readings, is required. This must also be in accordance with the Measuring Instruments Directive (MID)[89] and WELMEC guide[90] requiring the ability to directly read from the meter all the data used for billing, which may be challenging in terms of easy visualization, storage capacity and the amount of data in function of the time resolution (e.g. consumption data, dynamic prices, etc.).

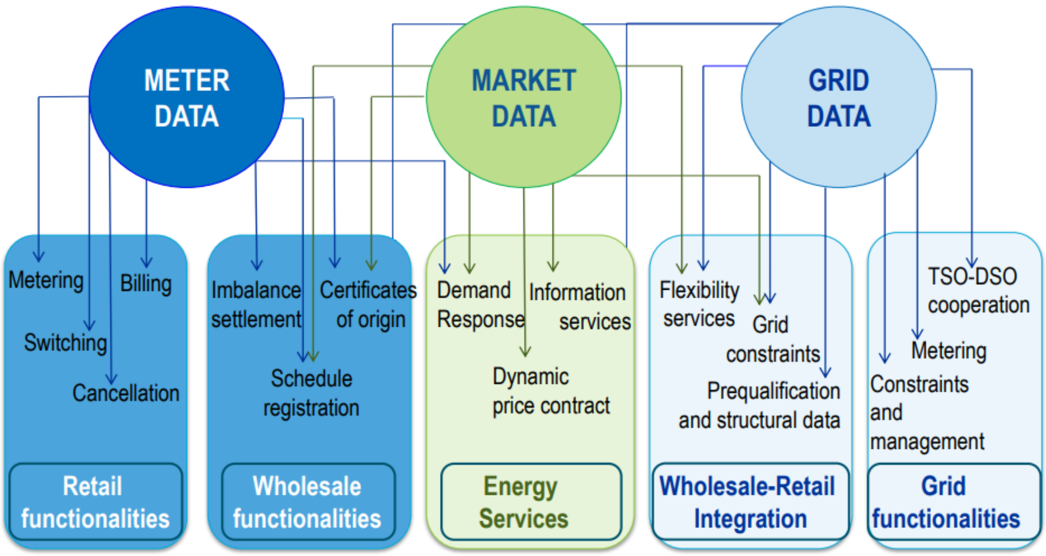


Figure 42: Overview on data types & processes for an electricity market model.[91]

5.3.3 Consumer outcomes

A major aim of the European legislation when it comes to smart metering, is to empower final customers and to assist their active participation in the energy market. To this end, Article 19 of the recast Electricity Directive provides that Member States should regularly monitor the deployment of smart metering in order “to track the delivery of benefits to consumers”. Hence consumers’ outcomes should be systematically considered when framing the deployment of smart metering, and accordingly monitored to ascertain the success of the deployment from this point of view.

[88] An eligible third party for instance needs the explicit consent of the consumer to access their data.

[89] Directive 2014/32/EU of the European Parliament and of the Council of 26 February 2014 on the harmonisation of the laws of the Member States relating to the making available on the market of measuring instruments (recast).

[90] WELMEC, “Guideline on time depending consumption measurements for billing purposes (interval metering)”, May 2010, issue 1. (https://www.welmec.org/documents/guides/112/?L=0&type=94)

[91] M. Sánchez-Jiménez (European Commission 2018), “Overall DSOs’ tasks and functions under the CEP framework”, GEODE Spring Seminar, Brussels, 29/05/2018.

To be able to assess consumer benefits from smart metering deployment and use in the European Union, the following approach, which was proposed in a recent investigation,[92] is the starting point in this study (see Figure 43):

- **Supply side**, i.e. the **potential value propositions** related to smart meters, delivering benefits to consumers
- Demand side, i.e. the characterization of the interests, needs and concerns of consumers, and their segmentation according to socio-demographic characteristics
- **Matching 'supply/demand'**, i.e. looking **under which conditions consumers can actually reap benefits** from the value propositions enabled by smart meters. These conditions include:
  - the characteristics of the 'context' of a given Member State (e.g., information campaign in place, regulatory framework, development of energy market.)
  - the socio-demographic characteristics of consumers

This framework developed in the previous investigation[92] was applied there only to few Member States, while in this study we capitalize on this methodology to help assess the potential consumer outcomes from the smart metering deployment in all Member States.

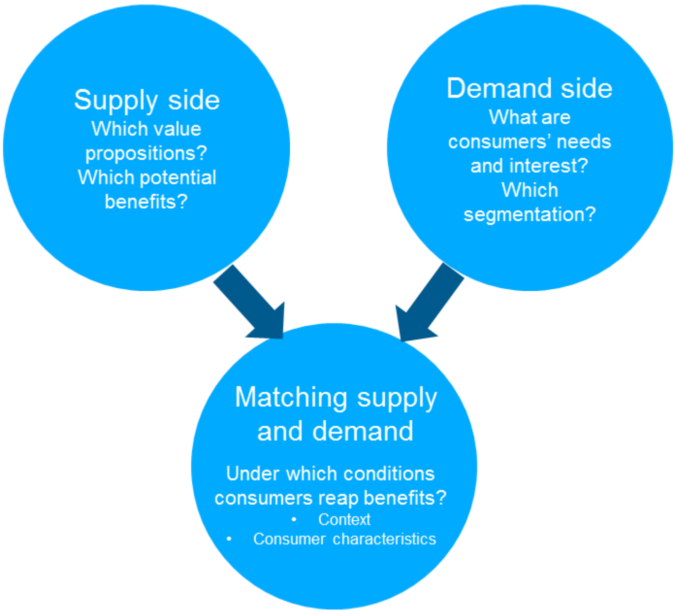


Figure 43: Synthetic view of the analysis

5.3.3.1 POTENTIAL VALUE PROPOSITIONS AND BENEFITS FOR THE CONSUMER ENABLED BY SMART METERS

The potential value propositions enabled by smart meters are divided in two groups: **standard and advanced/future value propositions**. Smart meters can bring direct benefits to consumers, both in terms of monetary (e.g., bill reduction) and non-monetary value (e.g., reducing environmental

[92] F. Tounquet, L. De Vos, M. Goes, and T. van Melle, "Consumer Satisfaction KPIs for the rollout of Smart Metering in the EU Member States (ASSET study)", 2018. Online available: https://asset-ec.eu/home/advanced-system-studies/cluster-4/consumer-satisfaction-kpis-for-the-roll-out-of-smart-metering-in-member-states/

footprint). However, it is important to note that these direct benefits are possible benefits and it will depend on the consumer's motivations and abilities if he or she will benefit.

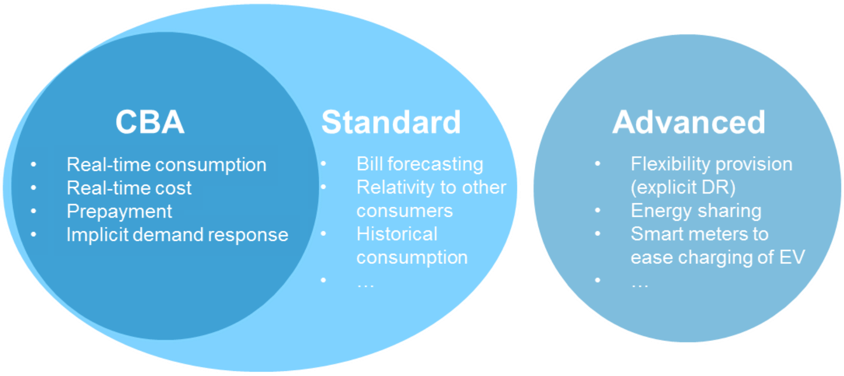


Figure 44: Standard and Advanced set of Value propositions enabled by Smart Meters and relationship with the main value propositions included in the CBAs carried out by Member States

5.3.3.1.1 Standard value propositions

In the following we describe the set of most common value propositions enabled by smart meters (herein defined as "standard') and the associated benefits for end-consumers (Figure 45). Each value proposition brings one or several benefits to the consumers. Basically, all standard value propositions allow consumers to better understand and control their energy consumption.

It is worth mentioning, that not all these "standard" value propositions have been considered in the CBAs carried out by Member States. The CBAs have mainly focused on real time consumption display, real-time cost display, prepayment and implicit demand response.

The following standard value propositions are considered:

- **Comparison with peer consumers** refers to the possibility to leverage smart meters' data to allow consumers to compare their energy consumption with comparable peers.
- **Bill forecasting** refers to the possibility to use historic smart meter consumption data and on-going consumption level to forecast the amount of the bill at the end of the month. This can help consumers to better understand their bill and also energy consumption patterns.
- **Real-time consumption** relates to the possibility to make accessible to consumers energy consumption data in real-time. This can help reducing the energy consumption and the associated bill and could increase consumers' awareness over their energy consumption and possible actions to have it under control.
- **Real-time cost** displayed on a digital application or IHD can help the consumer reduce the electricity bill and also better understand the bill.
- **Unusual usage alert**: This service alerts the consumer when an unusual high consumption occurs during a longer time period. This can help reduce the energy consumption and can also increase safety.
- **Historical consumption** overview can be helpful for comparing consumption during specific periods, which can help consumers understand and reduce their energy consumption.

- **Real-time carbon impact**: This value proposition consists in making the energy consumption CO_2 footprint, expressed in tCO_2 eq., available to the consumer, which helps understand the impact of their energy consumption on the environment.
- **Pre-payment** capability to display the credit balance to consumers who take a pay-as-you-go tariff.
- **Different tariffs (implicit demand response)**: Consumers with a smart meter and a time-of-use tariff can benefit from it as smart meters provide them with better information and enable them to react accordingly and to reduce their energy bill.

		Achieved benefits					
		Bill reduction	Energy consumption reduction	Lower CO2 emissions	Accurate billing	Understand and control energy consumption	Safety
Standard value propositions	Comparison with peer consumers	✓	✓				
	Bill forecasting					✓	
	Real-time consumption	✓	✓			✓	
	Real-time cost	✓			✓	✓	
	Unusual usage alerts		✓				✓
	Historical consumption		✓			✓	
	Real-time carbon impact			✓			
	Pre-payment					✓	
	Implicit demand response (ToU)	✓					

Figure 45: "Standard" value propositions enabled by smart meters and associated benefits (source: ASSET study[92])

5.3.3.1.2 Advanced value propositions

The implementation of an **advanced value proposition** (Figure 46) requires further developments in technologies (e.g., data analytics) and market/regulatory contexts (e.g., set-up of flexibility market; penetration of EVs, etc.). The following table provides the advanced value propositions:

- **Flexibility provision (through implicit demand response with dynamic pricing)**: Consumers with a smart meter and a tariff with variable dynamic tariff (spot based, peak pricing, etc.) can benefit since smart meters will provide them with better information and enable them to react accordingly.
- **Flexibility provision (through explicit demand response):** This value proposition has the ability to provide and valorise flexibility to the power markets, either through existing suppliers or by signing a new service agreement with a new and independent aggregator.
- **Fuel poverty detection:** Data analytics can be used to detect fuel poverty (deprivation) for households who have not yet applied for help or do not have access to social protection. This can increase safety for vulnerable consumers.
- **Energy sharing:** The implementation of smart meters has an enabling role for the local energy communities' value propositions, like virtual metering and collective self-consumption.[93]

[93] Virtual metering is a bill crediting system for community solar. The solar production is not used onsite but is installed at a distance, where there is a better yield or/and more area available. The solar energy is then shared amongst its subscribers. The subscribers receive credits on the electricity bill.

- **Smart meter to integrate prosumers in the market:** The smart meter can be used either as a prerequisite to install decentralised generation or as a way to introduce new tariffs, for instance to promote self-consumption, reduce network usage or provide economic signals that are consistent with energy markets. These economic signals can be price signals of the energy market, that can push for more self-consumption or the opposite, selling the produced PV energy on the market.
- **Smart meter to facilitate smart charging of electric vehicles at home:** depending on the local regulation a smart meter can reduce the system impact of EV charging by enabling smart charging schemes that take market and grid constraints into account, possibly lowering the cost of charging.
- **Smart meters to facilitate smart charging of batteries:** The smart meter could also be used to in the same way as the smart charging of electric vehicles, but for batteries. This can optimise the battery charging based on grid constraints, tariff prices or roof PV production.

<table>
<tr><th></th><th></th><th colspan="6">Achieved benefits</th></tr>
<tr><th></th><th></th><th>Bill reduction</th><th>Energy consumption reduction</th><th>Lower CO2 emissions</th><th>Accurate billing</th><th>Understand and control energy consumption</th><th>Safety</th></tr>
<tr><td rowspan="6">Advanced value propositions</td><td>Implicit DR (Spot pricing)</td><td>✓</td><td></td><td></td><td rowspan="6">✓</td><td>✓</td><td></td></tr>
<tr><td>Flexibility provision (explicit DR)</td><td>✓</td><td></td><td></td><td>✓</td><td></td></tr>
<tr><td>Fuel poverty detection</td><td>✓</td><td></td><td></td><td></td><td>✓</td></tr>
<tr><td>Energy sharing</td><td>✓</td><td>✓</td><td></td><td></td><td></td></tr>
<tr><td>Smart meter to integrate prosumers in the market</td><td>✓</td><td></td><td>✓</td><td></td><td></td></tr>
<tr><td>Smart meter to ease charging of EV at home</td><td>✓</td><td></td><td></td><td></td><td></td></tr>
</table>

Figure 46: The consumer benefits related to the smart meter and its enabling “advanced value propositions” (source: ASSET study[92])

Table 33 and Figure 47 highlight the currently available services and value propositions enabled by smart meters and made available for the consumers in each Member State. These services and value propositions could materialize into direct benefits for the consumers, that Member States are considering nowadays or for the near future. As meter deployment progresses, it is likely that more services will become available.

There is a clear convergence within EU-28 to let consumers **compare their energy consumption (weekly, monthly, yearly, etc.) based on historical consumption data**. Integrating and visualising **dynamic energy tariffs** (e.g., hourly varying electricity price in function of technical/market boundary conditions) is the 2nd most offered service and allows consumers to better plan the operation of certain (smart) appliances (e.g. washing machines, dryers or dishwashers) to minimize their total energy cost. The 3rd most popular service is the **integration of prosumers in the market**.

Collective self-consumption is the transfer of any production surplus, meaning that besides individual self-consumption, the surplus can be used in by members of the same legal entity, which includes various participants, energy producers and end users.

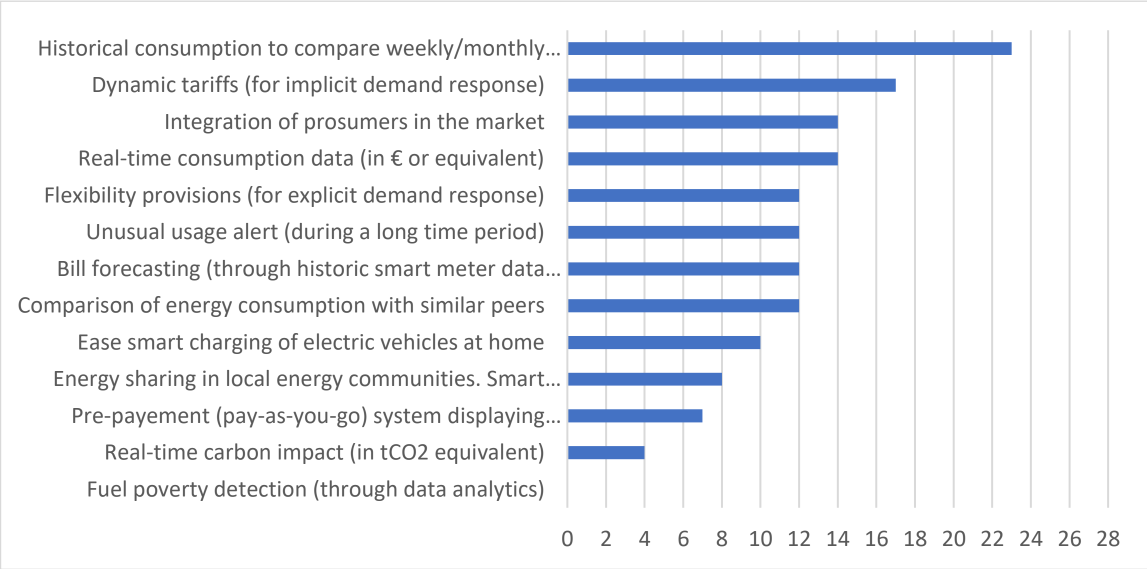


Figure 47: Ranking of services & value propositions available for the consumers in EU-28 vs. number of Member States.

	Comparison of energy consumption with similar peers	Bill forecasting	Real-time consumption data	Real-time carbon impact	Unusual usage alert	Fuel poverty detection	Historical consumption to compare weekly/monthly consumption	Dynamic tariffs (implicit demand	Flexibility provisions (explicit demand	Pre-payment (pay-as-you-go) system displaying credit balance	Energy sharing in local energy	Integration of prosumers in the market	Ease of smart charging of electric vehicles
AT	green						green	green	green	green	green	green	green
BE (BR)	grey	grey	grey	grey	grey	grey	grey	grey	grey	grey	grey	grey	grey
BE (Fl)	grey	grey	grey	grey	grey	grey	grey	grey	grey	grey	grey	grey	grey
BE (Wa)	grey	grey	grey	grey	grey	grey	grey	grey	grey	grey	grey	grey	grey
BG		green	green				green			green			
HR		green	green				green	green					green
CY	grey	grey	grey	grey	grey	grey	grey	grey	grey	grey	grey	grey	grey
CZ	grey	grey	grey	grey	grey	grey	grey	grey	grey	grey	grey	grey	grey
DK	grey	grey	grey	grey	grey	grey	grey	grey	grey	grey	grey	grey	grey
EE	green	green			green		green	green	green		green		
FI	green		green				green	green	green			green	
FR	green		green		green		green	green	green		green	green	green
DE	green	green	green	green	green		green	green	green	green	green	green	green
EL							green					green	
HU		green	green	green	green		green						
IE	green	green	green	green			green	green		green		green	
IT			green		green		green	green	green	green		green	green
LV							green	green				green	
LT		green					green						
LU	green		green		green		green	green	green	green	green	green	green
MT		green			green		green						green
NL	green	green	green		green		green	green					
PL		green					green		green	green			
PT	green		green		green		green	green	green		green	green	green
RO		green	green				green	green				green	
SK							green						
SI			green		green		green	green	green			green	
ES	green	green			green		green	green			green	green	green
SE	green		green		green		green	green	green				
UK	green	green	green	green	green		green	green	green	green	green	green	green

Table 33: Services & value propositions available for the consumers in each Member State (legend: green = considered or available, blank = not considered; grey = data not available).

5.3.3.2 CONSUMER CONCERNS, MOTIVATIONS AND ABILITIES TO BENEFIT

According to the ASSET findings[92], consumers' ability to reap benefits from smart meter deployment is determined by:

- **Motivations and abilities to effectively benefit from smart meter**. Consumer motivations can be mapped on three dimensions: **economic, behavioural and innovation** (see Figure 48).

Figure 48: Interests and needs of the consumer

- **Perceived risks, fears and concerns** related to the deployment of smart meters (Figure 49) which may prevent certain smart meter benefits to be materialized. To have a successful deployment, Member States need to carefully consider and properly address related consumer concerns at the earliest stage of deployment as a prerequisite for further engagement.

  The **accuracy of the smart meter**, the **electromagnetic radiation** and **privacy** are the main consumer concerns within the EU-28 (see Table 34 and Figure 50). Thus, and even though smart meters are subject to strict national and EU product safety legislation, and the aforementioned topics are already covered by technical standards, that provide guarantees for the consumers, Member States have taken measures to address these concerns (see Figure 51).

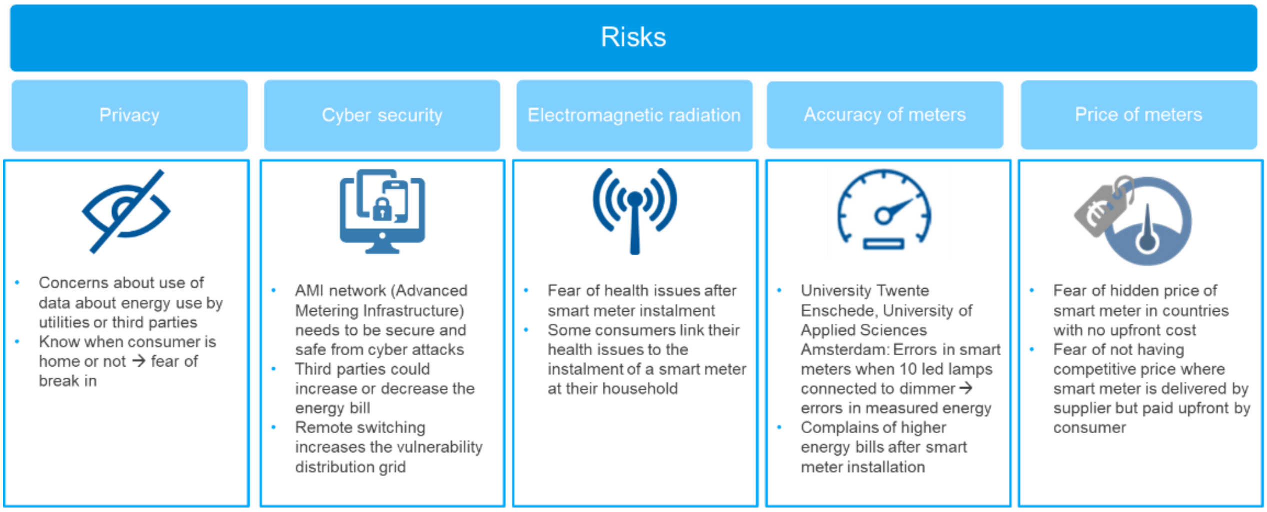


Figure 49: Perceived concerns of the consume (source: ASSET study[92])

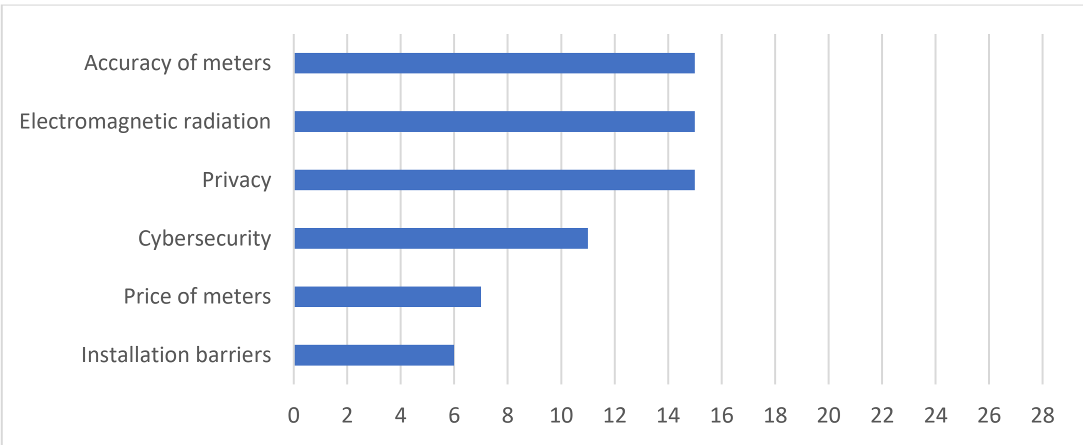


Figure 50: Ranking of perceived concerns of the consumer in EU-28 vs. number of Member States.

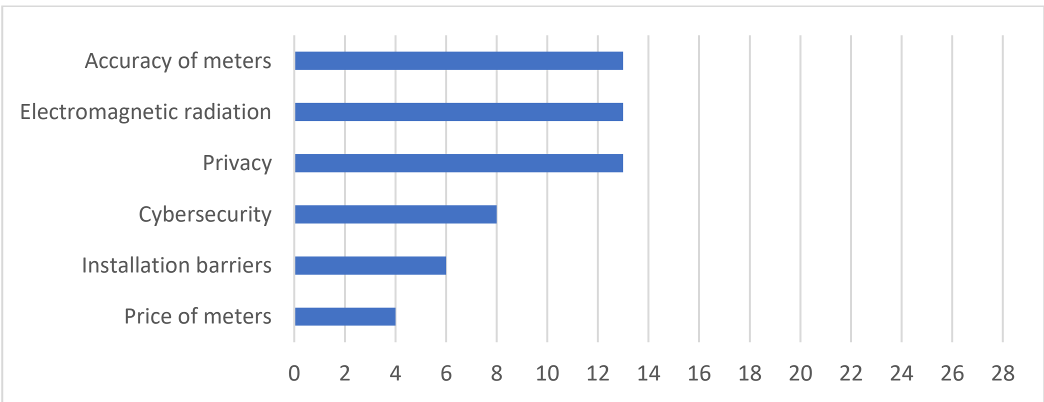


Figure 51: Ranking of focus on measures to counteract on the perceived concerns by consumers in the EU-28 vs. number of Member States.

	Privacy	Cybersecurity	Electromagnetic radiation	Accuracy of meters	Price of meters	Installation barriers
Austria	green	green	green	green	green	green
Belgium (Brussels)	grey	grey	grey	grey	grey	grey
Belgium (Flanders)	green		green			green
Belgium (Wallonia)	green	green	green	green	green	green
Bulgaria				green		green
Croatia				green		
Cyprus	grey	grey	grey	grey	grey	grey
Czech Republic	grey	grey	grey	grey	grey	grey
Denmark	grey	grey	grey	grey	grey	grey
Estonia	green		green	green		
Finland						
France	green	green	green	green	green	green
Germany	grey	grey	grey	grey	grey	grey
Greece			green			
Hungary	grey	grey	grey	grey	grey	grey
Ireland	green	green	green	green	green	green
Italy	green		green	green	green	green
Latvia						
Lithuania				green		
Luxembourg	green	green	green	green		
Malta	grey	grey	grey	grey	grey	grey
Netherlands	green	green		green		
Poland	green	green	green		green	
Portugal	green	green	green	green		
Romania			green	green		
Slovakia	grey	grey	grey	grey	grey	grey
Slovenia	green	green	green	green		
Spain	green	green	green	green		green
Sweden	green	green	green			
United Kingdom	green	green	green	green	green	green

Table 34: Perceived concerns of the consumer in each Member State (legend: green = considered, blank = not considered; grey = data not available).

The context factors influencing the consumers' ability to benefit from smart meters mainly depend on:

- the set-up of a **suitable communication campaign about the installations and advantages of a smart meter** to raise awareness about the potential value of smart meters for consumers. In the EU-28, communication campaigns are mainly conducted through a website, advertisement and dedicated letters to the consumer (see Figure 52). Exemplary communication campaigns are shown in Figure 53. Furthermore, it is important to point out that one of the main factor influencing the consumers' ability to benefit from smart meters is the availability of clearly identifiable benefits. In that sense, communication campaigns should also be tailored to ensure that this information is effectively transmitted to consumers (e.g. savings potential on energy bill). Meanwhile, smart meters should not be oversold (e.g. by making unrealistic promises and creating unreasonable expectations), which might increase consumers scepticism and dissatisfaction.
- the existence of a **suitable regulatory framework** that can address consumers' concerns regarding smart meters at the earliest stage of deployment as a prerequisite for further engagement. Exemplary measures to tackle consumers' concerns are shown in Figure 54. Additionally, consumers should be provided with a contact point who can help them understand the functioning and uses of their smart meter.
- the **market conditions** enabling market actors to develop value propositions. Indeed, we will not observe wide consumers engagement if the provision of new services does not follow the pace of smart meters' deployment.

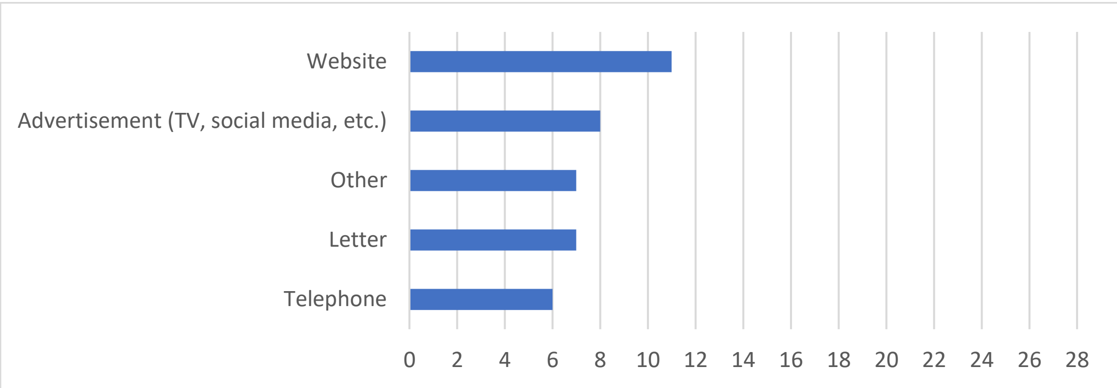


Figure 52: Most used communication campaigns used within the EU-28 vs. number of Member States.

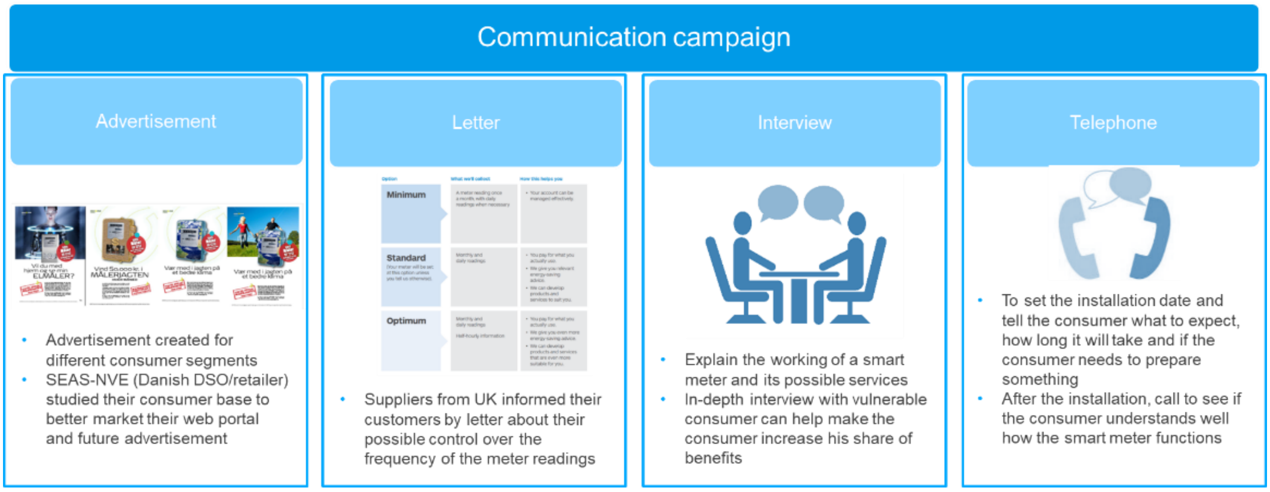


Figure 53: Communication campaign example (source: ASSET study[92])

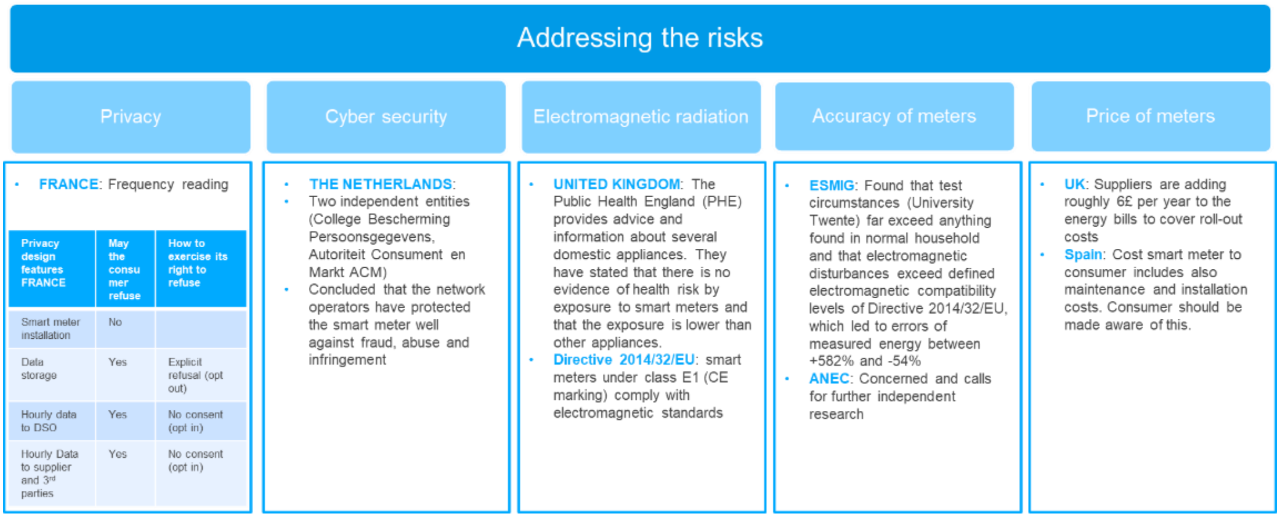


Figure 54: Addressing the risks perceived by the consumer (source: ASSET study[92])

Regarding research on consumers' benefits, we are noting that in Lithuania for instance, extensive research and evaluations have been carried out to that respect. In 2016 and 2017, interviews were conducted before and after the start of a smart meter pilot. The majority of the respondents considered the advantage of basic intelligent accounting, and about half of them indicated the advantages of being able to pay bills automatically and tracking online electricity consumption.

5.3.3.3 TRANSITION AND CONSUMER KPIS FOR MEASURING SUCCESS OF SMART METERING DEPLOYMENT FROM A CONSUMER PERSPECTIVE

A set of Key Performance Indicators - KPIs (non-exhaustive) has been defined in the ASSET study[92] in an attempt to provide guidance to Member States for **systematically** and **transparently monitoring progress** and impact from a **consumer perspective** as to ultimately assess the success of **smart metering deployment in the EU**. These KPIs (see Table 35) are based upon the four dimensions suggested by the European Consumer Organisation ANEC[94], further refined into

[94] ANEC position paper (June 2015) "Monitoring the success of smart metering deployment from a consumer perspective"; http://www.anec.eu/attachments/ANEC-PT-2015-AHSMG-017.pdf

Transition KPIs – depending on the national context – and Consumer KPIs – depending on how consumers have been embracing the new smart energy system put at their disposal.

These four different dimensions/levels can be compared with the pyramid of Maslow[95], which depicts the hierarchy of human needs and their motivation.

- First, the **consumer** needs to be made **aware** of the smart meter deployment, its value propositions and benefits. In that sense, consumer KPIs in addition of acknowledging the existence of communication campaign, should take into account the quality of said campaign.
- Second, the **customer satisfaction** regarding the smart meter rollout becomes of importance, where the consumer may have concerns regarding his privacy, health or any other issue. To have a successful deployment, Member States need to carefully consider and properly address related consumer concerns at the earliest stage of deployment as a prerequisite for further engagement.
- Next, the **active engagement** of the consumer becomes important. The consumer will feel empowered. Of course, for this to occur, the regulation and market need to be well developed.
- Finally, the consumer should be able to **benefit from the smart meter** thanks to the available value propositions.

The monitoring of consumer KPIs should enable Member States to further identify areas of concern for consumers and act as an early warning of emerging issues with deployments so that prompt and appropriate action can be taken to address them.

In this chapter we investigated what consumer outcomes smart metering is likely to deliver. Obviously, a key success factor identified is the ability to present direct benefits to consumers. We also highlighted that a few pre-requisites have to be met to reach this point: consumers have to be informed about smart metering, they have to accept the installation of the smart meter itself and to choose a relevant value proposition for them.

	Domain	1. Transition KPI	2. Consumer KPI
1	**Consumer awareness**	• Communication campaign level	• Awareness of installation • Awareness of available value propositions
2	**Consumer satisfaction**	• Response to consumer concerns • % bills based on actual meter readings	• Ratio of complaints • Deactivation ratio
3	**Active engagement**	• Maximum allowable switching time • Availability of detailed load curve	• Switching rate • Number of consumers changing to different tariff
4	**Benefit realisation**	• Available value propositions	• Energy consumption reduction • Peak demand reduction

Table 35: Transition and Consumer KPIs to systematically and transparently monitor progress and impact from a consumer perspective as to ultimately assess the success of smart metering deployment in the EU (source: ASSET study[92])

[95] Maslow's hierarchy of needs is a theory in psychology proposed by Abraham Maslow in 1943 in his paper 'A Theory of Human Motivation'

Since the last benchmarking report, the good news is that a lot of innovation occurred within retail markets (gas and electricity). A diversity of value proposition is now offered by market actors, so the next challenge is to facilitate customer choice. We recommend NRAs and national authorities to put in place legal safeguards and didactic tools to help consumers make the appropriate retail choice (e.g. price comparison tool set up by a neutral party). Nevertheless, it is fair to expect that those value propositions will mature over time depending on the actual successes and failures triggered by market competition.

In the context of this report, our aim when discussing consumer satisfaction with smart metering is to transfer lessons learnt and avoid design failures that were already identified as such in the past. Since most of the value propositions depend on the legal framework set up at national level, the relevant markets for the diffusion of innovation are the national ones. Our purpose here is to share the return of experience among national stakeholders and to contribute to the diffusion of innovation within the Energy Union. Our proposition is therefore to use the KPIs: (1) as a practical tool to help fulfil requirements under the EU Directives and keep track of the benefits and (2) to transfer lessons learnt and success factors as experienced by early smart metering adopters as further guidance for others proceeding with the rollout.

We invite all national authorities to take inspiration from this investigation and our reflection on how best to monitor and work towards consumer satisfaction with smart metering. We would also suggest ACER and CEER to take a leading role in the definition of a common methodology to compute KPIs and ultimately to contribute to a collective regulatory intelligence. Finally, we suggest including those preliminary KPIs in the reporting of their National Energy and Climate Plans.

6 DEEP DIVES

Three smart meter case studies[96] across Europe are described below to illustrate some examples of smart metering advancements so far:

- The roll out of the 2nd generation of smart meters[97] in **Italy**;
- The digital transformation in **Estonia**;
- Advanced consumer services in **The Netherlands**.

6.1 Roll out of the 2nd generation of smart electricity meters in Italy

Italy is a frontrunner of smart metering deployment in the EU, as it was the first European country to introduce a large-scale deployment of remotely-read, advanced electricity meters for low-voltage end-users, and is the world's first country in terms of number of installed smart meters in operation (over 35 million).

As not fully compliant with the subsequent functional requirements by the EC (mainly because it was not able to communicate with (non-interoperable) in-home devices and provide consumption data with 15 minutes granularity), the first generation (1G) of smart meters would not have allowed the development of additional and advanced services (Table 36 and Figure 55). Therefore, Italy has introduced the second generation (2G) of smart meters that are able to deliver near-real time information to consumers and third parties of their choice via a separate communication channel, and therefore making it possible to offer advanced and customer-centric services, at the same cost of 1G smart meters. The 2G smart meter will introduce extra benefits for the consumer and other market parties (Figure 55).

	1G smart meter	**2G smart meter**
Remote readings	✔ Monitoring of energy and peak consumption ✔ Monitoring of the correct functioning of the meter ✔ Increase of the number of clients with hourly readings	✔ Increased efficiency of remote reading ✔ Higher granularity ✔ Readings and hourly based values available within 24h to the retailer via SII
Remote management	✔ Remote commercial operations ✔ Remote activation and deactivation of the meter ✗ Reconfiguration of the setup of the meter at large scale	✔ Increased efficiency of remote management ✔ Additional functionalities available ✔ 2 Channels available ✔ Reconfiguration of meters' setup at large scale

Table 36: Functional comparison of 1G and 2G meters on remote reading and management (source: ARERA, 2018)

[96] The country selection was the responsibility of the consortium partners and achieves a balance between the level of access to information about the national deployment plan and the representativeness of contrasted implementation strategies. It has come to our knowledge that the three selected countries have adopted a centralized data management model, nevertheless it is not our intention to favour one model compared to another.

[97] Malta is also as of mid-2019 rolling out the 2nd generation of smart meters.

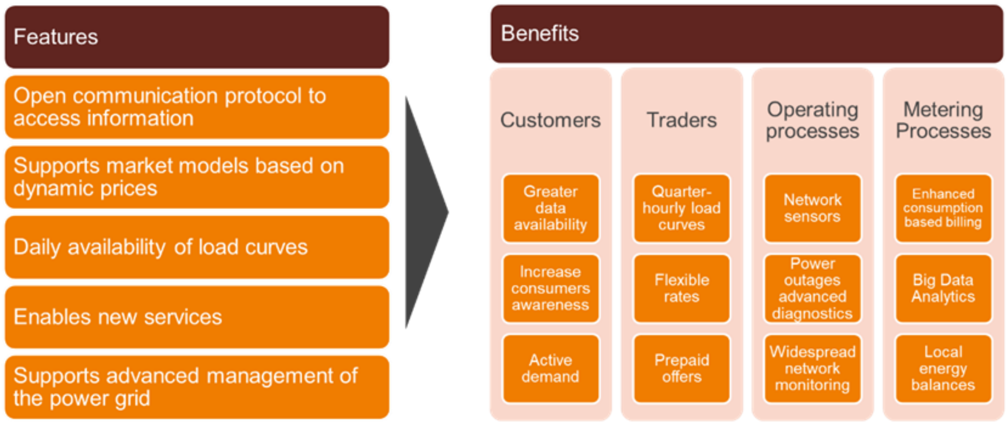


Figure 55: Overview of main features and benefits of the 2G smart meter (source: ARERA, 2018)

6.1.1 Regulatory framework

The deployment of the 1G smart electricity meters started as early as 2001 as a voluntary initiative by ENEL Distribuzione (today: e-distribuzione). In 2006, recognizing the benefits of implementing smart metering, the National Regulatory Authority (ARERA) set a mandatory installation of 1G smart meters to all low-voltage metering points with its Deliberation 292/06, so that a mandatory smart metering rollout was extended to all Italian DSOs. This allowed Italy to meet and surpass the electricity Directive 2009/72/EC target (i.e. 80 % of all households equipped with smart meters by 2020) by reaching a 95 % penetration rate in 2011.

The primary law enabling smart metering for electricity in Italy is the Legislative Decree 102/2014[3], approved in July 2014, which transposes the EU Directive on Energy Efficiency (EED 2012/27/EU). The Decree assigned to the Authority the duty of defining the functional and performance specifications of the **2G smart meters**. In 2016, ARERA issued two resolutions and one consultation on 2G smart electricity metering rollout:

- Resolution 87/2016/R/eel[4] includes the definition of the functional specifications and performance levels expected for 2G smart meters.
- Resolution 646/2016/R/eel[5], includes the tariff regulation setting the criteria for the recognition of capital costs for smart metering systems complying with the functional requirements and performance levels defined by Resolution 87/2016/R/eel.
- Consultation 468/2016/R/eel identifies improvements in existing services and processes, as well as potential new services enabled by the diffusion of 2G smart meters. Furthermore, this document illustrates the expected benefits for the electricity system arising from 2G smart metering technology.

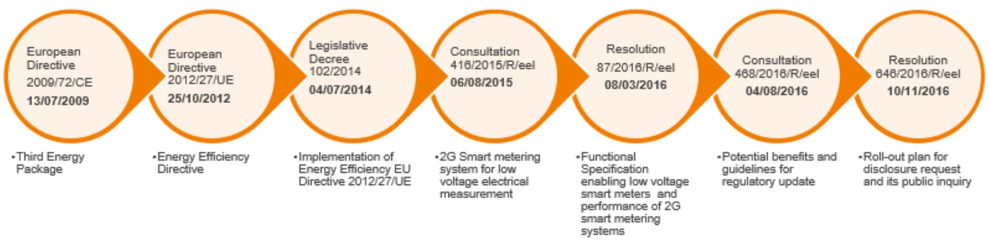


Figure 56: Regulation framework on smart meter roll out in Italy (source: ARERA, 2018)

With Resolution 222/2017/R/eel[6], ARERA approved the 2G smart metering rollout plan for e-distribuzione, starting in 2017. E-distribuzione's deployment plan develops over a period of 15 years (2017-2031) and sets out the nationwide substitution of its 31.8 million 1G meters with 2G meters, reaching an 80 % penetration rate by 2022. As of July 2019, e-distribuzione has already installed and committed 10 million 2G meters across the country (see Figure 57).

Finally, following the good performance observed by these smart meters and the results of a dedicated consultation, ARERA, in its Resolution 409/2019/R/eel[98], affirmed amongst others that the communication between 2G smart meters and user devices ("Chain 2") is satisfactory and delivering well against expectations. As a result, it concluded that there is no need for additional requirements under a so-called "2.1 version" for the second generation smart meters.

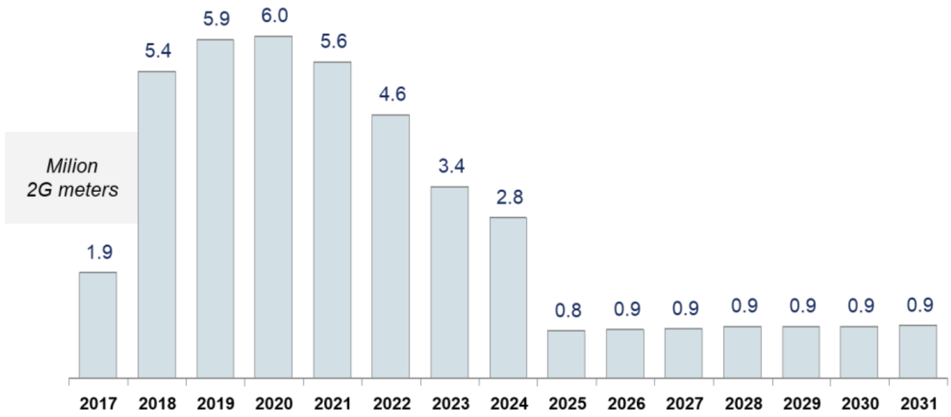


Figure 57: Planned annual installation volumes of 2G smart meters in Italy (total: 41 million meters) (source: ARERA, 2018).

6.1.2 Features and benefits of the 2G smart meter

Most of the 10 key functionalities recommended by the EC (2012/148/EU) are available and activated by default on the 1G smart electricity meters. More advanced technological solutions are now adopted for the 2G smart meters that are currently being deployed, in order to respond to the need for functional and performance evolution induced by the ever-growing computational requirements and higher volumes of data to be transmitted. Figure 58 depicts the system architecture of the 2G smart meters.

While 1G smart electricity meters have only one communication channel, new 2G meters can rely on two separate communication channels:

1. Communication with the head-end system (HES) (**Chain 1**: *"from the meter to the customer through the supplier"*)
2. Communication with any customer energy management systems, e.g., the In-home display (**Chain 2**: *"from the meter directly to the customer (or designated third parties)"*).

The first chain will provide data that are validated by the DSO within 24 hours that the supplier can use for billing, while the second chain will provide non-validated data in real time. The supplier (or

[98] https://www.arera.it/it/docs/19/409-19.htm

third parties designated by the customer) can use such non-validated data for energy efficiency goals, and for the development of new commercial offers integrated with other services.

The combination of the following communication technologies (freely adopted by each DSO) allows to achieve performance levels consistent with the functional requirements established for 2G meters in Resolution 87/2016/R/eel and avoiding data interferences between both chains:

- Chain 1: A-band Power Line Carrier (A-PLC) combined with RF 169 MHz;
- Chain 2: C-band Power line Carrier (C-PLC). Chain 2 requires the installation of an in-home device that may be acquired from a third party or from one's energy supplier. A standard communication protocol was established to guarantee interoperability of said in-home devices with the smart metering system.

Suppliers have the right to access energy consumption data for billing and other regulated purposes without specific. Only the consumer, who is the owner of data, can provide third parties the access to their consumption data.

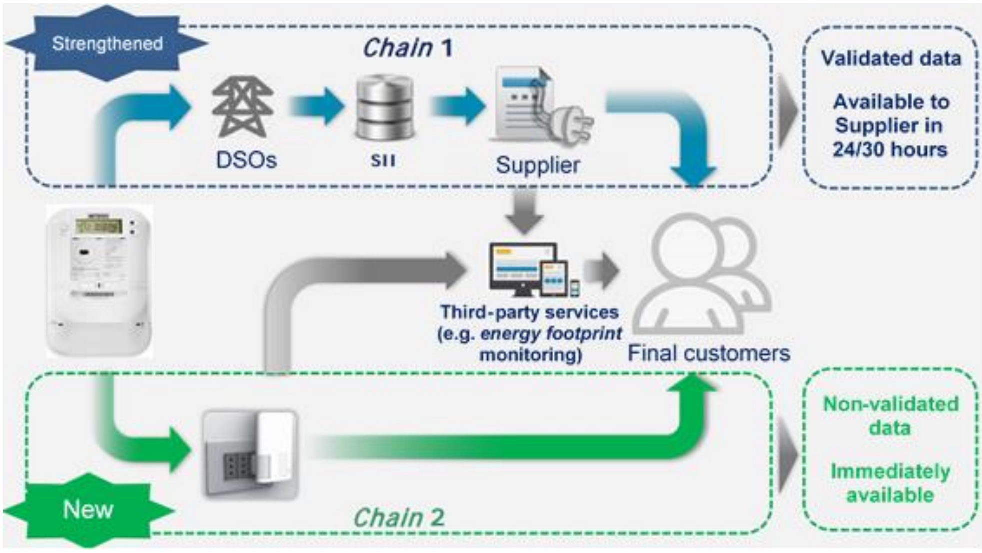


Figure 58: System architecture of the 2G Smart meter (source: ARERA; 2018)

6.2 Digital transformation in Estonia

Smart metering was deployed in Estonia by 2017 to all customers (~700,000), and a central data hub is already in use. According to the national Electricity Market Act and Natural Gas Act all smart meters were to be installed by 1st of January 2017, and 1st of January 2020 for electricity and gas, respectively. The deployment is mandatory for all consumers (for gas if consumption is higher than 750 m^3/year).

6.2.1 Estonia, one of the world's most advanced digital nations

When it comes to the level of maturity of government services ("eGovernment"), Estonia is considered as leading in the field (see Figure 59).[99] This **high level of IT maturity** in the country has

[99] European Commission, "eGovernment Benchmark 2018: Securing eGovernment for all", Insight report, 2018 (ISBN 978-92-79-96381-0).

been one of the key success parameters in the smart metering and central data hub design and deployment.

Estonia is a frontrunner in both digitisation and penetration of its public services (e.g., e-Governance, e-Tax, I-Voting, Digital ID, etc.) and also scores high technologically, due to its, amongst others:

- Highly developed telecommunications and IT infrastructure;
- Digital networks providing wireless internet (400 Mbps with 4G connections);
- Fiber optic backbone network throughout the country;
- Two competing 10 Gbps optical networks (being built & among the first in Europe);
- Providing 10 Gbps to at least 40 % of the households in Estonia within the next few years.

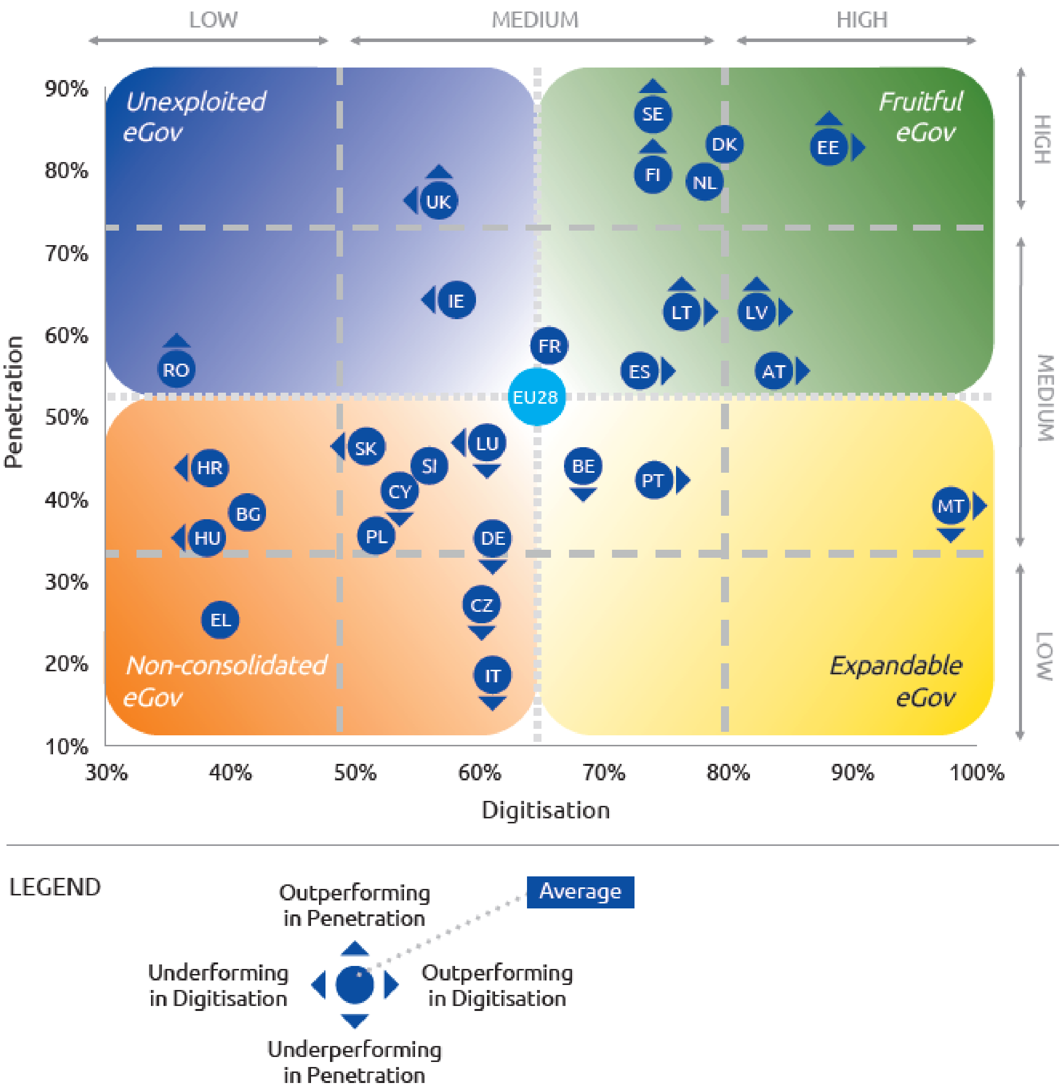


Figure 59: Performance on digitisation and penetration of EU-28 countries (Source: EC eGovernment Benchmark 2018[99])

In Figure 59, "Penetration" captures the extent to which use of the online channel is widespread among users of government services and stems from Eurostat data. Digitisation is a proxy for the

Digitisation level of the back- and front-office of Public Administration and its source is the eGovernment benchmark indicators." [100]

[100] European Commission, "eGovernment Benchmark 2018: Securing eGovernment for all", Insight report, 2018 (ISBN 978-92-79-96381-0).

6.2.2 Central data hub

A central data hub (see Figure 60), administered by Elering as an independent transmission system operator, is in operation in Estonia:

- To manage the central exchange of electricity metering data between market participants;
- to support the process of changing electricity suppliers in the market;
- to archive the metering data of electricity consumption

The Estonian Data Hub system is a software/hardware solution managed by the TSO. User access to the Estonian Data Hub is granted to grid operators, open suppliers and line operators operating in Estonia. Market participants are encoded, as well as measuring points measuring electricity flows between participants. Encoding defines the market participants' rights, as well as the supply chains.

Through the data hub web portal, all parties have access to their own consumption volume measurement data (remotely readable in one-hour increments). The data hub system ensures principles of equal treatment. The network operator must ensure measurement, collection, control and accuracy of measurement data.

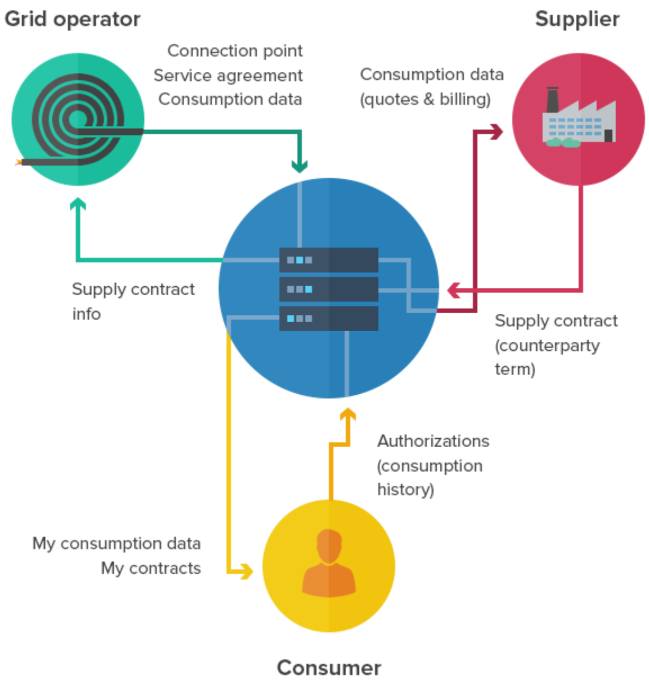


Figure 60: Estonian data hub – an example of a centralised data management system (source: Ennomotive)

6.3 Advanced consumer services in The Netherlands

By the end of 2017, smart metering systems have been rolled out (on the basis of the original timeline 2015 – 2020) to over 50 % of all users. Only 11 % of the users have declined the smart meter, while 2 % asked to deactivate the communication. Around 18 % of the consumers with a smart meter also have an energy consumption manager, such as a smart thermostat, which offers direct feedback to allow energy consumption reductions. Smart meters are one part in the smart grid strategy (see Figure 61), among digital operation, intelligent substations (low and medium voltage), flexible grid structures and telecom.

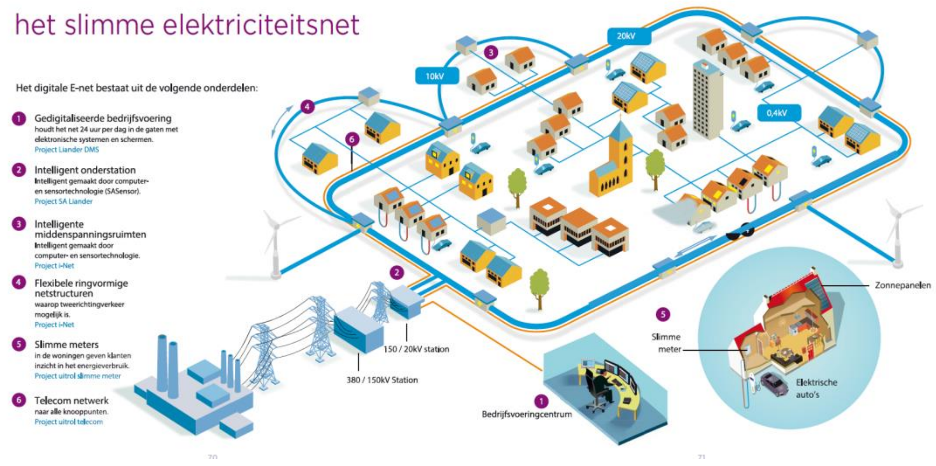


Figure 61: For grid operators, smart meters are one part of the smart grid strategy (source: Liander, DSO)

In The Netherlands, the DSOs are responsible for the roll out (see Figure 62 for DSO Enexis) and communication with the smart meter (see Figure 63). It will be offered to consumers with a smart meter installed, to receive a bi-monthly energy bill.

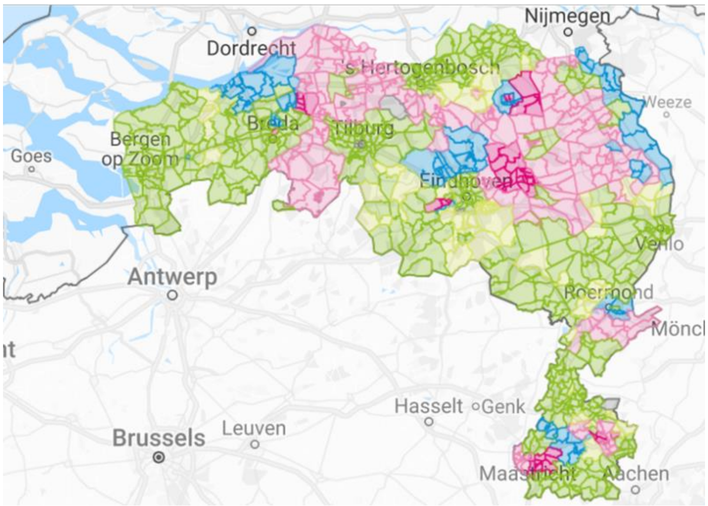


Figure 62: Smart meters installed and planned in the south of The Netherlands (DSO: Enexis) *Legend: green (installed); yellow (roll out started); blue/purple (roll out planned); grey (roll out not planned)*

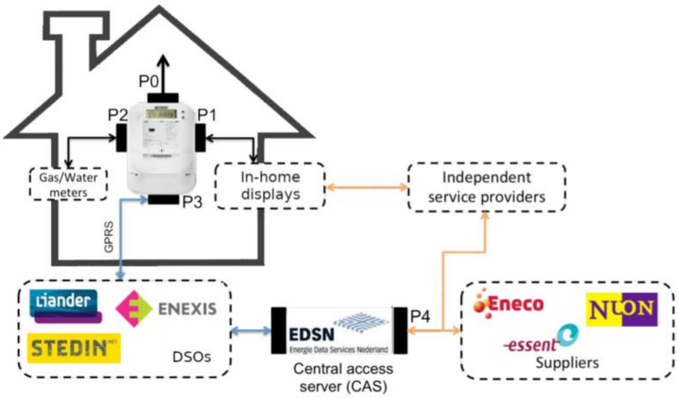


Figure 63: Smart meter communication interface (source: P. Van Aubel, Nijmegen University)

6.3.1 Case study – Dynamic energy pricing

During the last decade, several pilot projects have been executed in the scope of smart grids as preparation for the scale up of smart metering roll out. One pilot project "Your Energy Moment" (*Jouw Energy Moment*) was conducted between 2012 – 2015 to gain experience with technical, economic and social options to create flexibility and increase sustainability in the energy consumption of consumers[101,102] and help answer questions like:

- How can consumers become actively involved in a smart grid system? How will they change their behaviour?
- Which technical and social options can unburden the energy grid?
- How can supply and demand be better aligned, in order to use available renewable energy efficiently?

The participants of the pilot project are equipped with a smart meter, a photovoltaic system, smart appliances (e.g., washing machine and dryers), and a "Home Energy Management System" (HEMS). The HEMS can be used to consult interactive information of their energy use, local energy production and energy prices. Based on this information, users can insert their preferences to plan the operation of their smart appliances and other "dumb" appliances. The dynamic price information – based on the available grid capacity, local electricity production and APX (day-ahead) prices – is communicated to the consumer 24 h through a central ICT system (CEMS) (see Figure 64 and Figure 65).

101 Eindrapportage (report) Jouw Energiemoment Zwolle, November 2014.

102 A second phase of the project has been executed to assess new scalable business models for flexible tariffs to avoid peak loads on the energy system. In 1/3 of the houses, a battery and heat pump were installed which was automatically turned on and off.

Enexis, 2018, https://www.enexisgroep.nl/nieuws/jouw-energie-moment-20-jem-20-trekt-conclusies-over-flexibele-tarieven/

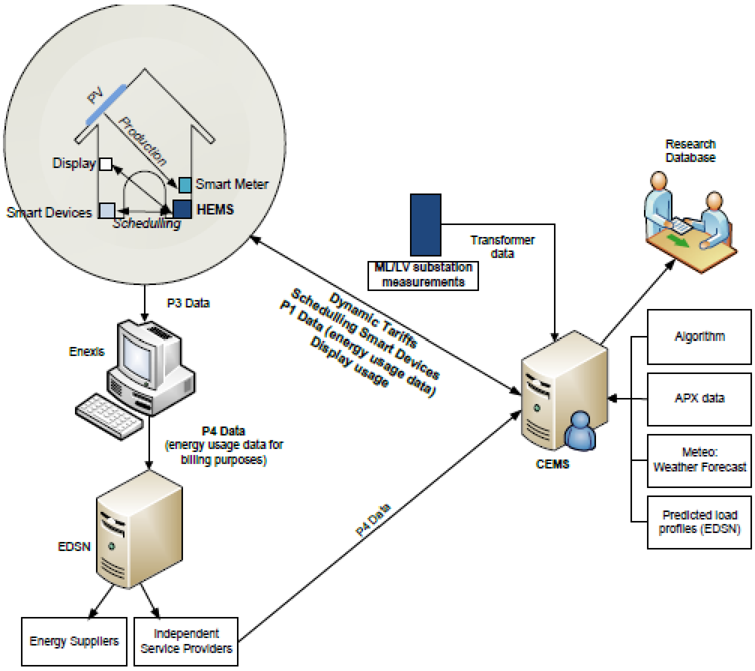


Figure 64: Processing and communication between smart meter and central ICT system (CEMS)[43]

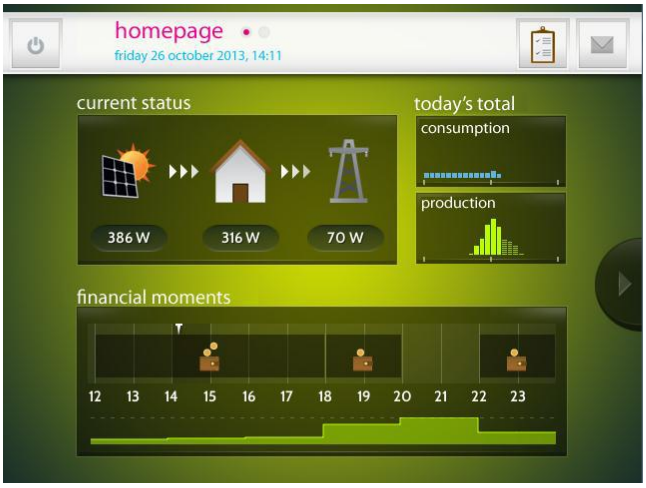


Figure 65: Example of a dynamic price profile[43]

The outcome of the first pilot project is that dynamic energy tariffs are a reason for energy consumers to change their consumption behaviour and move their consumption to periods with low energy prices. Among the appliances, the dishwasher, washing and drying machine are for consumers the most popular appliances to shift their energy demand.

7 RECOMMENDATIONS FOR NATIONAL AUTHORITIES

7.1 Purpose

In this chapter, we present a set of recommendations to national stakeholders, especially lawmakers and regulatory agencies but also for industry and consumer representatives active at European level. Our initial views were confronted with those of the relevant stakeholders, to finally converge to the final recommendations. These recommendations were elaborated by analysing the extensive data received and consolidated, as previously detailed in this benchmarking report.

As explained in the introduction of this report, our goal is to assess smart metering deployment in the light of the European legal framework. And it comes with a vision – as reflected in the Clean Energy for all Europeans - and a target to reach – that is the 2030 climate goals - and an ambition to realise – secure, clean and affordable energy for all Europeans. Our recommendations have the ambition to serve that vision. However, it is neither our purpose to promote per se smart meters themselves, nor to assess any form of legal compliance of national authorities with respect to the European regulatory framework.

We first leave aside for a while our strict European mandate and take a look at smart metering as an industrial opportunity, a trade gateway for growth and external sales of goods and services. Then we go through each of the specific areas that have structured our analysis, from the legal framework to consumer outcomes.

7.2 Recommendations

7.2.1 Global context

7.2.1.1 HIGH POTENTIAL FOR SMART METERING TECHNOLOGIES AND APPLICATIONS

The smart metering technologies and applications enable a whole new range of business models for all actors across the power and gas value chain. Given the scale of the energy system, the potential market for these technologies and applications is very large.

All stakeholders recognise the disruptive impact of smart metering technologies and related applications on the energy system, which is expected to look substantially different from today.

The energy system will be more decarbonised, digitalized and decentralised. Energy flows will be increasingly bidirectional, thereby making the notion of producers following consumers less relevant. This will create a need for a higher level of engagement of the end users, compared to the situation today.

7.2.1.2 SMART METERING ACTIVIES OUTSIDE EUROPE

Many innovative and mass-scale smart metering projects and commercial implementations are taking place outside Europe. The Middle East, Asia-Pacific, and North America are three key non-EU regions where a high level of activity is observed.

From a world trade perspective, several European companies are active in these non-EU countries, especially for aspects that are not highly region-specific, such as ICT-aspects. Non-EU companies are also very active in these regions, and they have the advantage of operating in their domestic market.

Thus, the prospect of smart metering deployment should be considered globally, with competition pressures from industrial actors that can rely on a strong domestic market. Within such an environment, a substantial level of activity in the EU might effectively support the EU industry, by creating a substantial domestic market for smart metering-related goods and services.

This all points out to smart metering "made in Europe" as an opportunity Europe should not miss. How could we possibly sustain our leadership role in climate action if we are to rely on an old-dated, non-digital metering layer in the Energy Union? In what follows we take a deeper look and reflect on this question.

7.2.2 Legal framework

Even though all Member States have successfully transposed the smart metering related provisions from the current EU legislation, the level of progress of the specific national legal and regulatory frameworks on this very subject shows a contrasted picture. Starting from the strict transposition, national authorities have progressively and diversely adopted general provisions related to the design of smart metering systems: allocation of roles and responsibilities to the different actors, principles for funding and cost recovery, eventually definition of a more advanced set of functionalities. These next steps are usually focused on the actual implementation and transition towards the new metering paradigm. Some key topics to consider are specific rules for the deployment modalities, such as refusing the installation or allowing for the lesser use of metering data (opt out and default provisions for data access), as well as for the implementation phase, such as the definition of dedicated tariffs schemes for grid users equipped with smart meters.

From a service provider perspective, the regulatory framework for smart metering applications is fragmented across the member states, e.g. the regulation concerning access to consumer data. Due to this fragmentation, some economies of scale cannot be achieved, which limits/slows down the upscaling opportunities for European companies that can offer smart metering technologies/applications.

At the same time, this upscaling is possible and is already taking place in some non-EU regions, boosting the business opportunities and development of their domestic players. Examples here are the initiatives taken by cross-state ISOs in the USA to allow for residential demand response to participate in the electricity markets. This allows for the industrialisation of North-American demand response aggregators.

7.2.3 Cost benefit assessment

In this broader context of competitive digitalization, national authorities should also take into account the missed opportunities of having a lagging smart metering deployment.

While the Third Energy Package put "smart meter" in the spotlight as a driver for innovation and competition in the retail energy markets, the time has come to refer to "smart metering" as a system whose ultimate goal is to address consumers – or citizens – needs. And those needs are real, as experienced in various ways by national stakeholders.

From energy communities and collective self-consumption to dynamic electricity prices and flexibility aggregation, smart metering should not become the missing link in the new digital value chain.

In this respect, we fear that the cost benefit assessment, as generally defined in the EU legal framework and in some cases not comprehensively performed by Member States, does not fully capture the range of benefits enabled by smart metering. Due to the lack of consistency between members states' CBAs, no reliable quantitative analysis could be performed during our investigation for this study. However, major trends were identified, where the cost benefit assessment meets different needs. As detailed in the following table, we found out that, depending on the actual level of progress of smart metering deployment, national authorities will use the cost benefit assessment for very different motivations.

	Motivation for performing CBA	**Actual level of progress of smart metering deployment**
Early adopters	Upgrade of first generation	>95%
Promoters	Keep track of benefits delivered	[25% to 95%]
Newcomers	Support communication during deployment campaign	[5% to 25% [
Waverers	Justify segmented vs massive roll out and avoid binding target	[0% to 5% [

Table 37: A simplistic typology of Member States use of the Cost Benefit Assessment

Those "early adopters" that are now investigating a wider range of services and benefits thanks to a more versatile and functional smart metering system at their disposal, are able to support the move to innovative, inclusive and citizens-centred energy policies and support schemes. In these countries, where deployment in fact was debated years ago, the CBA has not been used as a tool for monitoring progress and benchmarking performance against original aims. This constitutes a missed opportunity for others that could learn from their more experienced pears.

Smart metering "promoters" are using the CBA in the most interesting manner, namely to keep track of benefits. However, as was mentioned by several stakeholders during the course of this project, those countries using the CBA as a monitoring tool and making efforts for greater consumer engagement are also the ones that took the most optimistic assumptions for computing smart metering benefits. In our opinion, using the CBA for reacting to a growing discrepancy between initial assumptions and actual realization of benefits is perfectly sound, since it demonstrates accountability and transparency that are prerequisites for consumers to trust smart metering.

For Member States that have less experience of large-scale deployment of smart metering systems, CBAs are used in a much more conservative and less transparent way. The economic assessment is not designed to be debated in public – due to its inner complexity and somewhat conflicting objectives in certain cases. Our perception is that national authorities, generally the regulatory authority in charge of setting and controlling the grid tariffs that will be used in most countries to finance the deployment, have been trying to build a solid business case based on value pockets located within the DSO regulated perimeter of activities. While this approach is robust and reliable, since it is based on partially controllable expenses, it is also conservative in that sense that it fails to capture the potential for smart metering benefits for market participants, consumers and the broader economy.

The new electricity Directive turns the Cost Benefit Assessment into a periodic process, with the binding target of 80% (originally set in 2020 by the Third Energy Package) becoming a moving – 7 years (from a positive cost-benefit assessment) – target. We have identified lessons learned, return of experience from large scale deployment and best practices that could lead a more favourable economic assessment of smart metering deployment for those member states that are still assessing the economic relevance of a digital energy system. However, those authorities are accountable for the costs they approve. It is therefore their duty to define a consistent vision for their domestic energy system that supports the energy transition, is compliant with the Clean Energy for all Europeans Package provisions, and makes use of the many degrees of freedom that national authorities have at their disposal to sustain a clean, affordable and secure energy for their citizens.

Our recommendation to those national authorities is to use the Cost Benefit Assessment to investigate how to best meet consumer needs and monitor the actual delivery of benefits, not to justify political choices.

7.2.4 State of play

Whilst the recast of the Electricity Directive has updated and mandated the required functionalities of smart meters, a significant number of countries have already rolled out their metering systems. According to article 20 of the Directive, countries whose smart metering systems do not meet the new requirements have up to 12 years (up to 05/07/2031) to update their systems. Thus, we can be concerned that a critical proportion of EU citizens residing in those countries could be stuck for that long with outdated, limited-functionality smart meters. Indeed, the development of new businesses and services will be significantly slowed down there if not completely impeded, thus precluding end-users from fully benefitting from the grid digitalisation. Hence, a nationally scaled updating process of the software and hardware that compose these smart metering systems will be required and should be cost-effectively and timely undertaken to minimise the impact in those countries.

In the meantime, one should consider that the countries which have already rolled out their metering system are among the ones with the higher degree of acceptance of smart meters and are also the ones who had best integrated the potential benefits of smart metering system in their network development framework. Hence, whilst the updating of the smart metering systems will require additional investment, which might slower the process, the risk that those countries do not launch such an update before 12 years is unlikely to realise.

Today, one of the obstacles to the digitalisation of the European grid and the metering infrastructure, which is where the grid meets the end consumer, is probably the limitation in the functionalities imposed by Member States. Although EU manufacturers claim to be able to deliver all functionalities, those are limited inconsistently across Member States. This choice, whatever the reason, and beyond the missed benefits for consumers, could have far reaching consequences to the European energy market.

First, those differences significantly impede the interoperability of smart metering systems among Member States which might create, or at least not help remove, barriers to entry in national markets. In such a configuration, where smart metering systems must be differently adapted to serve each national market, we are missing out on potential economies of scale, the development of more competitive new products, and are falling short of reaching an internal market. Then, the fact that European manufacturers are limited by national constraints with regards to smart meter functionalities might also slower the pace of improvement of smart metering systems, particularly in terms of extra features they can safely support and cost-efficiency, as well as the development of related services. Considering the arising competitive pressure for the smart meter provision, at global level, particularly from the US and China, Member States and European institutions should be particularly cautious at ensuring that European manufacturers will not be suffering from a significant competitive disadvantage in the forthcoming years when the smart metering deployment will be peaking in Europe.

7.2.5 Functional and technical specifications

Smart metering business models rely heavily on the communication functionality. On the other hand, there are some barriers that are specifically related to this communication part.

Interoperability, gaps in standards and protocols – For upscaling smart energy grid solutions, it is necessary to connect all types of appliances, such as cars or smart assets, with all other types of smart infrastructure, such as (public) re-chargers. For example, in the case of smart charging this might include roaming between different national and international networks. On a local level, a standardised type of connection facilitates interconnectivity and interoperation, and it is relevant for IT/OT integration. Interoperability is the cost-effective approach to facilitate the seamless integration of all smart energy grid components and to help enhance competition in the respective markets. It is thus important that interoperable arrangements are in place and to the extent possible that standards and protocols are commonly agreed upon, so as to help make these smart solutions possible across the entire EU.

Economic lifetime mismatch between energy and ICT/Telecom – The economic lifetime of ICT infrastructure and commercial telecommunications is very short compared to the long lifespan of energy infrastructure. Telecom and ICT undergo rapid innovation and development pressured by the public want for better, faster performance and increased functionality. In order to keep tariffs low, the energy infrastructure has an economic lifespan that ranges from decades to over half a century. While this already proves a challenge to smart grid business cases and investments, there is a risk of technology or supplier lock-in, when large parts of the consumer ICT and telecom market and technology have moved away from the legacy technology.

Telecom frequencies are regularly reallocated – Related to the previously described risk, most commercial telecom frequencies are periodically reallocated by means of a government auction. For energy infrastructure such an auction may provide a risk of losing connectivity, while not having earned back the smart grid investments. Some market actors advocate the allocation of a dedicated band for utility communication, that is exempted from the auctions and provides long-term investment stability. To guarantee resilience, DSOs’ experts’ opinion is that it would be more efficient and secure to have a specific spectrum (which already has a precedent in CENELEC EN50065-1 for power line carrier communication), and some countries are already allocating specific spectra (Poland and Germany). In addition to that, there is also a risk of switching off 2G and 3G because there is a move to 4G on the same frequency. This very much links to the previous point of fast evolving telecom and ICT.

Leverage the synergies with the ICT Industry – Electricity and communication grids can be unified. The ICT industry is capable of building a more flexible, less capital-intensive layer on top of the physical grid infrastructure, for instance by using power lines. These are much more cost effective than conventional telecommunication solutions as they use the grid infrastructure itself to transfer communication signals on top of electricity flows.

7.2.6 Data management

7.2.6.1 GENERAL CONSIDERATIONS

The new Electricity Directive made access to data and exchange of data the cornerstone of smart metering data management. Different technical solutions are used by Member States, from centralized data hub to decentralized system. During the present investigation we gathered evidences of efficient data management systems, considering cost efficiency and data security, both in de-centralized and centralized environments. Assessing the suitability and the best option for data management systems architectures is not an easy task and, in any case, is not in the scope of this study.

When designing their data management system, Member States must fully integrate considerations regarding the resilience of the system to cyber-attack, black-out recovery capability as well as the feasibility of a system replacement if better options can be considered. Member States should also integrate requirements stemming from the GDPR such as data minimisation, proportionality to purpose and risk mitigation. Last but not least, Member States should ensure an effective mitigation of the market power de facto acquired by the data management responsible party.

Still, access to and exchange of data, where data is understood as metering and consumption data as well as data required for customer switching, demand response and other services, is the key for consumers and eligible 3rd parties to enjoy those retail/wholesale functionalities and new energy services that are of interest and benefit to them.

Thus, smart meters must be able to support the delivery of the full range of near real time data as well as validated data of actual consumption/generation (even at frequent intervals), while complying also with the provisions of the Measuring Instruments Directive (MID) and the WELMEC guide. These require that customers are able to directly read data used for billing from their smart meters data. Whilst new smart meters seem to be able to provide all these data, it appears that not all already installed smart meters in EU are able to do this for the required data frequency (e.g. due to storage or display limitations, etc.).

This calls for promptly implementable solutions without waiting for smart meters upgrades. One possible option to investigate could be to use another channel than the smart meter itself to provide feedback to consumers and inform them appropriately with timely information, such as Internet-based solutions. One could consider then this arrangement as part of the whole smart metering system, and therefore subject in its entirety to the MID provisions. This could have though significant cost implications that need to be carefully considered and weighed against any other possible solution or a retrofit.

In any case, parties responsible for smart meters deployment and/or data management should focus on digitalisation of their systems. In that context, new services such as price signal for switching or for flexibility provisions, have to be taken into account. With regard to near real-time and small interval data provision and the significant amount of data that has to be collected, data managing parties should not fixate on smart meter only but should also consider cost effective channels that can complement each other to provide a reliable and timely information to consumers. In conclusion, we do not favour one-solution-fits-all approach for handling the data management challenges. Metrology experts need to design flexible solutions that are cost effective and inclusive. Pioneers should not be punished for being early adopters; instead practical accommodations need to be implemented that do not jeopardize consumer's trust and continue to support their timely access to their metering data to check their consumption and accuracy of their energy bills.

Considering the accelerating pace of technological evolutions, the MID provisions should be accordingly adapted and become more inclusive of new realities where data are always moving faster and the digitalisation is way more anchored in citizens' life that it was years ago when the MID related provisions were last revised.

In the following paragraphs, we focus on two specific but promising advanced services that have the potential to directly benefit consumers and therefore to promote smart metering acceptance by its users. These are representing a services-based market and grid drivers, respectively. In both cases, smart metering is a prerequisite in order to differentiate the individual consumption profile that can be translated into direct monetary benefits. Without smart metering, any effort to incentivize consumers to adopt a more favourable behaviour will not induce direct benefits but will rather be spread over the system users.

7.2.6.2 VARIABLE RETAIL ELECTRICITY PRICES

Various business models build on a lower energy bill for the electricity user by allowing them to use the variable retail electricity prices. For instance, in advanced services like smart charging, vehicle to grid and energy management systems, flexibility is used to purchase electricity at a more competitive price by taking advantage of its wholesale price volatility.

Flexible tariffs are not always allowed or feasible for small end users – To protect residential customers from price risk, some Member States have taken specific provisions that might prevent consumers from fully benefitting from their active participation in the electricity market. In those countries that have chosen to implement a form of price regulation, it is not always allowed to charge flexible tariffs**.** In the Member States where the adoption of flexible tariffs is possible for residential customers, the provisions of understandable, transparent and comparable information related to the pricing mechanism in such contracts is essential for consumers to make informed choices. Moreover, NRAs should ensure the protection of vulnerable consumers with regards to uninterrupted tariff changes.

As also described in the report *Regulatory Recommendations for the Deployment of Flexibility*[103], the ability of consumers to offer their demand side flexibility to be used in the capacity, forward, day ahead, intraday and balancing markets, is limited. Industrial consumers and generators with their own bi-lateral power purchasing agreements can participate. Smaller industrial, commercial or domestic consumer access to flexibility services varies in Member States but tend to be limited. The result is that not all of the demand side flexibility which could be provided by motivated and willing consumers is accessed. This barrier makes it impossible to pass on the benefit of demand shifting to the consumers.

To enable companies to use prosumers and electric vehicles to access the flexibility market will require careful design of the flexibility market. A first step is to accept flexibility as a resource in the full range of energy markets.

Smart meters are not installed – To confirm that demand shift has taken place, hourly or even quarter-hourly metering matching the national balance settlement period, must be in place at the end consumer. These costs might be prohibitive for the entrepreneur to carry, while the benefits of the smart meters are broader than for the specific business models. Different consumer products exist that bypass the need for a smart meter, e.g. by offering a similar functionality as an integrated or modular part of an energy management system.

[103] Regulatory recommendations for the deployment of flexibility, EG3 Smart Grids Task Force, European Commission, 2015.

Allocation does not take place based on smart meter data – For the supplier to be rewarded for the demand shift, it must be possible to allocate it to that specific supplier. At the moment, even while smart meters are installed, the allocation of hourly electricity flows are still based on predefined synthetic load profiles. This means that individual profiles are aggregated and can no longer be allocated to the BRP.

7.2.6.3 CONGESTION MANAGEMENT USE

Direct participation in the electricity market is one possible value stream for active consumers, but it would also be possible to get value from flexibility put at DSOs disposal to alleviate congestion by reducing peak demand. The main difference with the previous case is the way demand side management is incentivised. For these “grid-focused” business models the following additional barriers can be identified:

There is no remuneration for providing local flexibility products – For the business model to work there must be a revenue stream that originates from DSOs. DSOs in turn can finance this stream from lower investments. For a number of reasons these revenues do not exist.

Aggregation for ancillary services – To be eligible for providing ancillary services, TSOs often fix sources of a minimum size. This has historically grown as providers have always been medium to large generators. They also demand regular test running of specific installations. These requirements are impossible to meet with a portfolio of EVs or smart prosumers.

DSOs are not allowed to apply congestion management – In many countries’ DSOs are obliged to always allow customers to use their full capacity, and make sure the grid can facilitate this. Congestion management is considered a limitation on the freedom of the end user to access the grid at any time. Similarly, in many countries DSOs are not allowed to diversify tariffs based on capacity requirements.

DSOs are not allowed to include costs related to congestion management in their tariffs – DSO tariffs are regulated. In many cases the tariff structure does not allow including costs not related to physical infrastructure. This means costs related to local flexibility and congestion management cannot be recuperated and constitute a loss from the perspective of the DSO.

Net metering is a disincentive for prosumers to maximise true self consumption – In many countries net metering is in place. This means that prosumers have no incentive to use the electricity they produce simultaneous to their production. In practical terms, from the point of view of the end-user benefiting from net metering, the grid acts like a storage system service, without remuneration, thus leading to unfair extra costs for those end-users that do not benefit from net metering. Abolishing net metering would give an incentive for prosumers to shift their demand to moments of production. This would provide an additional revenue for business models that are based on increasing flexibility behind the meter. Self-consumption can be synergetic with the needs of the DSOs – it can be combined, without additional costs, with congestion management.

Supplier blocking aggregators from approaching their customers – Suppliers do not like third party aggregators to change the demand behaviour of their consumers. This might cause imbalance in their portfolio. For this reason, they are reluctant to allow aggregators to approach their customers and supply them with the information that is required to perform their operations.

The recently adopted recast Electricity Directive (EU) 2019/944 and Regulation (EU) 2019/943 come to address these very issues raised here. To this respect, it is worth mentioning as an example the following consumer rights that the new Electricity Directive is mandating, namely (i) the right to a smart meter, and to a dynamic price contract (based on prices in the spot or day-ahead market) from at least one supplier and every supplier with more than 200,000 customers, and right to be provided information about the opportunities and risks involved; (ii) the right to an aggregation contract independent of electricity supply; or (iii) the right to produce, consume, store and sell electricity, individually or through an aggregator. Furthermore, the recast Electricity Directive introduces specific provisions to abolish net metering schemes by 2023, incentivise DSOs to purchase flexibility services for local congestion management and being remunerate for that, etc.

These two aforementioned examples – that of the variable retail electricity prices and the other one on the congestion management use – demonstrate that smart metering is a prerequisite to be able to provide benefits and value to the end users. They also show that the whole value chain has to adjust to the new digital reality: from predefined (also called synthetic) to real load profiles, from yearly net metering to incentives for real time self-consumption, the same question comes again: what is the best balance between protecting the consumers and providing them with appropriate incentives and economic signals?

7.2.7 Consumer satisfaction

In spite of all the efforts exerted by Member States and NRAs to make the smart metering deployment a success, only an insufficient share of possible benefits will be realised out of this exercise if European consumers are not enabled to exploit the full potential of their smart meters. To make it happen, a process which informs customers about the smart meters' deployment, their value propositions and benefits, accurately addresses their concerns and provides them with incentives to become active participants of energy markets, has to be implemented. Member States have launched over time communication campaigns about the smart meters roll-out, with more or less success. Opt-out and refusal rates, assuming that the legal framework foresees that, and the information is monitored, provide useful insights into the level of acceptance of smart metering. This kind of information is key to help tailor and enhance consumer engagement initiatives.

One of the main concerns expressed by consumers, when it comes to smart meters being installed in their premises, relates to electromagnetic radiation and the broader impact of smart meters on health, and to data privacy. Regarding the former, smart meters – like any electronic device – have to follow strict European safety and quality standards and are subject to laboratory tests to demonstrate their compliance. But information related to those tests (process and results) have not always been appropriately communicated by grid operators, which constitutes a missing opportunity to reassure consumers about health and safety of smart meters and to increase their acceptance. With regards to consumers concerns relating to data privacy, a focus on GDPR provisions should be put forward when communicating about collection and management of smart meters data. It is worth recalling here that the extensive communication campaign Union-wide of the GDPR has effectively comforted Europeans about the protection of their data. - Accordingly, energy regulators, in cooperation with the support of national Ombudsmen and consumer associations, should ensure that energy market actors fully comply with GDPR requirements and include data protection policies in the offers they provide.

Furthermore, an EU-wide set of rules, as foreseen by the Cybersecurity Act[104], for the quality assurance of security, notably in the energy industry, would lead to better measurability of security systems and more trust in the future.

Smart meters bring a wide range of value propositions for customers, creating stronger incentives for demand-side, enabling flexibility provision, energy sharing, etc. In order to maximize the

[104] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019R0881&from=EN

potential value for consumers, the market parties' endeavour to extend the range of services enabled by smart metering systems should be facilitated, or at least promoted by public authorities.

Equally, metering data responsible parties should make consumption data timely available to consumers with due regard to data security requirements, and through an interface that is as user-friendly as possible, so as to help consumers make educated choices and prompt for the most appropriate and rewarding services for their case.

Summarizing, there is a need for better communication campaigns and training of personnel to properly inform customers on smart meters and their potential. The communications should also be broader (multi-channel), tailored-made for the final customers and not time-consuming. Moreover, communication campaigns should be followed by the provision of new services and offers that accurately address consumers' expectations and that allow them to reap benefits from smart meters.

Finally, the broader adoption of Transition and Consumer KPIs (see section 5.3.3.3) by Member States would allow (1) for an effective tracking and monitoring of benefits' delivery to consumers and (2) for the comparison of the measures taken by the different Member States to comply with the new requirements (under Article 19) of the recast Electricity Directive. These are mandatory measures to lay the foundation for consumer's trust and acceptance of smart metering systems and give them the confidence and the right means to actively engage in energy markets.

8 CONCLUSION

The European Commission presented in its 2014 benchmarking report the state of play of smart metering deployment in the European Union. It provided an overview of the national cost benefit analyses (CBA) that Member States were invited to conduct following the adoption of the Electricity Directive 2009/72/EC and Gas Directive 2009/73/EC.

The present document constitutes an updated benchmarking report for smart metering deployment in the EU-28. It has built upon the initial benchmarking report, but it further investigated areas of interest that have been demonstrated as key by Member States that have already experienced challenges to make smart metering actually deliver the business case, including also direct benefits to consumers.

This report also considered the latest policy initiatives undertaken by the European Commission, especially the new provisions of the recast Electricity Directive (EU) 2019/944 that further paves the way for smart metering, as well as system interoperability and support of new services with the aim to deliver benefits and ultimately satisfaction to consumers.

Next to the reminder of the specific background of our report, the European regulatory and legal framework related to smart metering has been presented in detail.

Following that, the report presents how data was collected and validated to feed the analysis, in order to draw conclusions and then proceed with relevant recommendations. Data was effectively collected and validated in each of the EU-28 Member States; that allowed to have access to the most consistent and complete view on smart metering in the EU-28 that was reasonably possible to achieve.

National regulatory authorities and energy ministries across the EU-28 have been regularly consulted and closely involved in the course of producing this benchmarking report. Comments and expectations expressed during the initial 2014 benchmarking report have fed our approach for stakeholders' engagement from the very start of the project.

We committed to engage with national authorities and did actually involve them in our benchmarking journey. From the initial questionnaire and additional Q&A that followed, we engaged in bilateral activities to come with a refined overview of the country at hand, using a country fiche put at NRA scrutiny, to later invite those national authorities and other relevant stakeholders to a dedicated interactive workshop in Brussels on the 20th of February 2019.

During this event, we tested our recommendations with the stakeholders and gathered feedback and comments on the consolidated data that we shared. Finally, this report was put at the disposal of the national authorities to further react and provide any last reactions before finalizing this report.

Our discussions with stakeholders and findings show that since the 2014 initial report, a mind shift has progressively occurred. It is not anymore about the economic assessment of a new (regulated) asset, it is now about defining a consistent value chain to deliver benefit and usage to end consumers and citizens.

The analysis of our findings coming from a comprehensive data collection and consolidation exercise throughout the EU-28, translated national insights into European-wide recommendations to further strengthen the deployment of smart metering at the benefits of European consumers.

Each of the specific area/domain of knowledge we gathered has been analysed, summarized and finally assessed.

Our key message is that smart metering represents an opportunity Europe should not miss. Smart metering should not become the missing link in the new digital value chain. We also call National Authorities to embrace the opportunity offered by the Cost Benefit Assessment as institutionalized in the European regulatory framework and implement an efficient and consistent monitoring tool for smart metering deployment. Early adopters of smart metering systems have gathered a precious return of experience, and the smartest have learned from their mistakes. We believe it is now time for the rest of the Energy Union to be even wiser and learn from the earlier mishaps and success stories of others.

MJ-02-20-176-EN-N

ISBN 978-92-76-17295-6
doi: 10.2833/492070

Publications Office
of the European Union