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Distribution Grids in Europe

Facts and Figures 2020

December 2020

Eurelectric represents the interests of the electricity industry in Europe. Our work covers all major issues affecting our sector. Our members represent the electricity industry in over 30 European countries.

We cover the entire industry from electricity generation and markets to distribution networks and customer issues. We also have affiliates active on several other continents and business associates from a wide variety of sectors with a direct interest in the electricity industry.

We stand for

The vision of the European power sector is to enable and sustain:
- A vibrant competitive European economy, reliably powered by clean, carbon-neutral energy
- A smart, energy efficient and truly sustainable society for all citizens of Europe

We are committed to lead a cost-effective energy transition by:

investing in clean power generation and transition-enabling solutions, to reduce emissions and actively pursue efforts to become carbon-neutral well before mid-century, taking into account different starting points and commercial availability of key transition technologies;

transforming the energy system to make it more responsive, resilient and efficient. This includes increased use of renewable energy, digitalisation, demand side responseand reinforcement of grids so they can function as platforms and enablers for customers, cities and communities;

accelerating the energy transition in other economic sectors by offering competitive electricity as a transformation tool for transport, heating and industry;

embedding sustainability in all parts of our value chain and take measures to support the transformation of existing assets towards a zero carbon society;

innovating to discover the cutting-edge business models and develop the breakthrough technologies that are indispensable to allow our industry to lead this transition.

D&MF

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In the midst of the energy transition, Distribution System Operators (DSOs) are facing various challenges to ensure the cost efficient, reliable and secure development and operation of their networks:

- A constantly growing share of distributed renewable generation connected to the distribution grid
- The rising numbers of active customers engaged in demand-response and electric mobility.

DSOs have access to new tools to manage their grids more efficiently and to integrate increasing amounts of variable renewables in the system. Interactions between intelligent appliances, smart grids and home platforms–mediated by or on behalf of customers– will usher in a new era. Europe's distribution system will need to adapt its role to keep pace with the transformation of the energy world and with changing customer needs.

Undoubtedly, DSOs are central in the energy transition and they are moving towards a decentralised management of their grids. In other words, DSOs have to transform their business model from "pipes"- based to "platform"- based to meet the expectations of customers and to bring all market parties efficiently together.

For more details – Eurelectric vision – From "Pipes to Platforms"

1 Overview of the DSO landscape in Europe

Electricity distribution is a **natural monopoly** which is handled by Distribution System Operators (DSOs).

DSOs are:

- **Fully regulated companies** - Allowed revenue is deternined by national authorities.
- **Unbundled companies** - Activities that are potentially subject to competition (such as production and supply of energy) are separated from those where competition is not possible or allowed such as distribution of electricity.

The EU Regulation introduced unbundling requirements in the third Energy Package adopted in 2009[1] for vertically integrated undertakings.

With regards to the distribution activities. different levels of unbundling exist:

1. **Account unbundling** – Requirement to keep separate accounts for DSO activities.
2. **Functional unbundling** – Obligation for the persons responsible for the management of the DSOs do not participate in company structures of the vertically integrated undertaking responsible, directly or indirectly, for the day to day operation of production, transmision or supply activities.
3. **Legal unbundling** – Obligation to create a separate company for network activities. Other activities such as supply or production can be carried on within a single company.

Legal unbundling is required for electricity DSOs. **DSOs with less thant 100 000 customers are exempted from this requirement:** account and functional unbundliung are considered sufficient in this case.

[1] European Commission (2009): Art. 9 of the Electricity directive (2009/72/EC)

Core tasks of DSOs

DSOs are:

1. **System operators** – DSOs secure a reliable flow of electricity through their network to their customers. They constantly develop and maintain their networks to ensure that the networks operate efficiently and with high level of system security, reliability and efficiency in its areas with due regards for the environment and energy efficiency.
2. **Information providers -** For the needs of distribution system users for efficient access to, including use of the system.
3. **Neutral market facilitators** – DSOs are also required to provide non-discriminatory access to their networks for other system users, like power generators or service providers. They will increasingly move beyond their traditional role of "building and connecting" towards "connecting and managing". In many countries, DSOs also own and manage metering infrastructure, organise supplier switching or as an information hub by storing and providing metering data.

In the framework of the Clean Energy Package. the recast of the Electricity Directive (2019/944/EC) did not significantly change the legal framework for unbundling requirements but has provided additional specifications on the scope of activities that may be handled by DSOs.

Secure smart grid operation and system stability are the new core tasks as laid down in the Clean Energy Package:

- **Plan and connect EV charging infrastructure -** In principle, DSOs shall not own, develop, manage or operate **recharging points for electric vehicles.**[2] However. under certain conditions, national authorities may allow them to do it.
- **Integrate local storage facilities** – In principle, DSOs shall not own, develop manage or operate storage facilities. However, under certain conditions, national authorities may allow them to do it.
- **Unlock flexibilities -** DSOs may procure flexibility services, including congestion management in their areas, on a market-based approach.
- **Manage smart metering and data.**

For further information:

- Eurelectric report "The value of the Grid" (2019)
- In annex of the present document, you will find the list of relevant provisions for DSOs in the Electricity Regulation (EU) 2019/943 and in the Electricity Directive (EU) 2019/944.

[2] European Commission (2019): Art. 36 and 33 of the Electricity Directive (2019/944/EC)

[3] Ibid. Art. 32

Figure 1.1 Level of DSO concentration

	Country	Code	Number of DSOs	Number of legally unbundled DSOs
	Austria	AT	126	11
	Belgium	BE	16	12
	Bulgaria	BG	4	4
	Croatia	HR	1	1
	Cyprus	CY	1	1
	Czech Rep.	CZ	290	3
	Denmark	DK	40	10 [4]
	Estonia	EE	34	1
	Finland	FI	77	9
	France	FR	144	6
	Germany	DE	883	80
	Greece	GR	1	1
	Hungary	HU	6	6
	Ireland	IE	1	1
	Italy	IT	128	8
	Latvia	LV	11	1
	Lithuania	LT	6	1
	Luxembourg	LU	4	1
	Malta	MT	1	0 [5]
	The Netherlands	NL	6	6
	Norway	NO	119	7
	Poland	PL	184	5
	Portugal	PT	13 [6]	1
	Romania	RO	51	8
	Slovakia	SK	3	3
	Slovenia	SI	1	1 [7]
	Spain	ES	354	5
	Sweden	SE	170	6
	Switzerland	CH	630	0
	United Kingdom	UK	14	6
	Total		3319	195

Low concentration	Medium concentration	High concentration	Very high concentration
Mainly small, local DSOs. The three largest DSOs usually deliver less than 50% of distributed power	A mix of DSOs, with the three largest accounting for more than 60% of distributed power	One dominant DSO (more than 80% of distributed power) and several local DSOs	One DSO company

[4] The figure represents the number of DSOs that are not part of a company with power retailing activities. All DSOs are functionally unbundled.

[5] Malta benefits from the exemption from the requirements of Directive 2009/72/EC: the Maltese Electricity Market Regulations require unbundling at an internal accounting level only.

[6] In mainland Portugal 10 DSOs operate exclusively LV lines. Only 2 DSOs operate on the islands and do not have to be legally unbundled.

[7] The Slovenian DSO – SODO d.o.o. - is leasing the infrastructures and services from 5 Distribution companies.

This diversity is due to the historical organisation of distribution and differences in the role of local/national authorities. Most DSOs own the network and are granted an operation licence by local or national public authorities. In some countries, like France or Germany, DSOs are granted concession contracts to operate the network for a certain amount of time while the public authorities remain the owner in the long term. In these cases, DSOs are in charge of operation and maintenance as well as capital investment.

Figure 1.2 DSO Ownership[8]

Figure 1.3 Shareholding

[8] For each country the percentage of each type of ownership was calculated by aggregating the kWh distributed by each type of company. Where the DSOs are fully or partly publicly owned, the form of the mother company ownership was considered in the calculation.

2 Smart Meters

Smart meters are the main pillar of distribution networks digitalisation. Thanks to bidirectional communication between utilities and market participants, smart metering devices have become the interactive grid component enabling DSOs to effectively manage quality of service of the network, even at low-voltage levels. Thus, providing DSOs possibilities to develop new services and rearrange optimal network management, shifting the European energy supply industry from being infrastructure-driven to being more service-driven.

Smart metering infrastructure plays a crucial role in the transitioning electricity value chain. Traditionally, electric power systems have been unidirectional and centralised structures placing customers at the end of the supply chain. In recent decades and with the ongoing energy transition, the emergence of advanced digital technologies, the increasing number of distributed energy resources connected to the distribution grid, and new market players (i.e. aggregators and active consumers), unlocked new and efficient ways for DSOs to manage electricity distribution.

With the vertical unbundling of electricity supply, **metering activities** have been considered a **regulated monopoly** embedded in the distribution business.[9] Therefore, in many European countries, smart metering deployment arrangements have conferred DSOs the responsibility of installing, and consequently retaining ownership, of smart metering infrastructure. Nevertheless, competitive metering markets, where multiple competing operators supply meter availability and data management services, are also present in certain countries (e.g. Germany and UK).

Smart meter deployment in Europe

Smart meters have been set to replace conventional electricity meters throughout Europe. The European Commission encouraged the deployment of smart metering systems already in the Third Energy Package of 2009, and the Clean Energy Package of 2019 updated these provisions. Member States will have until the 31st of December 2020 to transpose the Electricity Directive (2019/944) into national law, which provides consumers **clear rights to request smart metering devices and dynamic pricing contracts** to be able to profit from the digitalisation of the energy system.[10]
The Electricity Directive (2009/72/EC) called for Member States to conduct a Cost-Benefit Analysis (CBA), and subject to **a positive outcome**, Member States were required to define implementation timetables over a period of up to ten years and reach a smart meter **penetration rate target of at least 80% by 2020.**[11]

6 market drivers in favor of smart meter's deployment cited in CBAs

1. Enabling dynamic tariffs for households and SMEs
2. Digitalisation of the distribution grid and optimisation of the network operations
3. Digitalisation of the retail market to foster innovation and new services by private actors
4. Integrating decentralised energy resources with flexible access, such as load shedding or infeed curtailment
5. Supporting actions tackling fuel poverty
6. Supporting energy efficiency

Aiming to increase a wide-scale deployment of smart meters in Europe, the Electricity Directive (2019/944/EC) mandates every Member State to update the CBA at least every four years, and **subject to a positive outcome**, 80% of final customers must be equipped with smart metering devices within seven years or by 2024.[12]

[9] Pursuant to Article 106(1) of the Treaty on the Functioning of the European Union

[10] European Commission (2019): Art. 21 of the Electricity Directive (2019/944/EC)

[11] European Commission (2009): Annex 1 of the Electricity Directive (2009/72/EC)

[12] European Commission (2019): Annex 2 of the Electricity Directive (2019/944/EC)

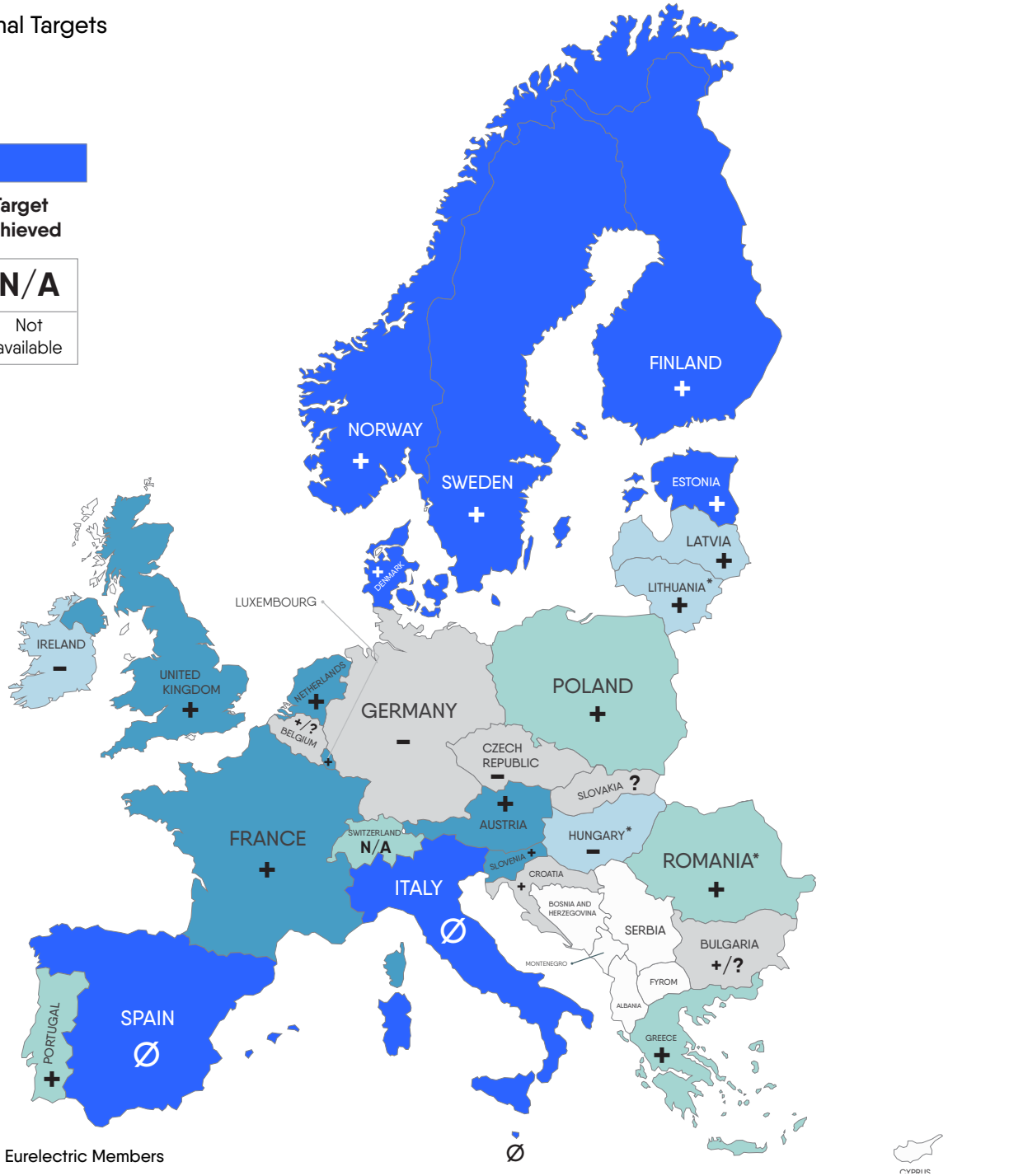
Figure 2.1 Outcomes of Cost-Benefit Analysis and National Targets

Smart meter penetration rate

After 2030	By 2028	By 2024	By 2022	Target achieved

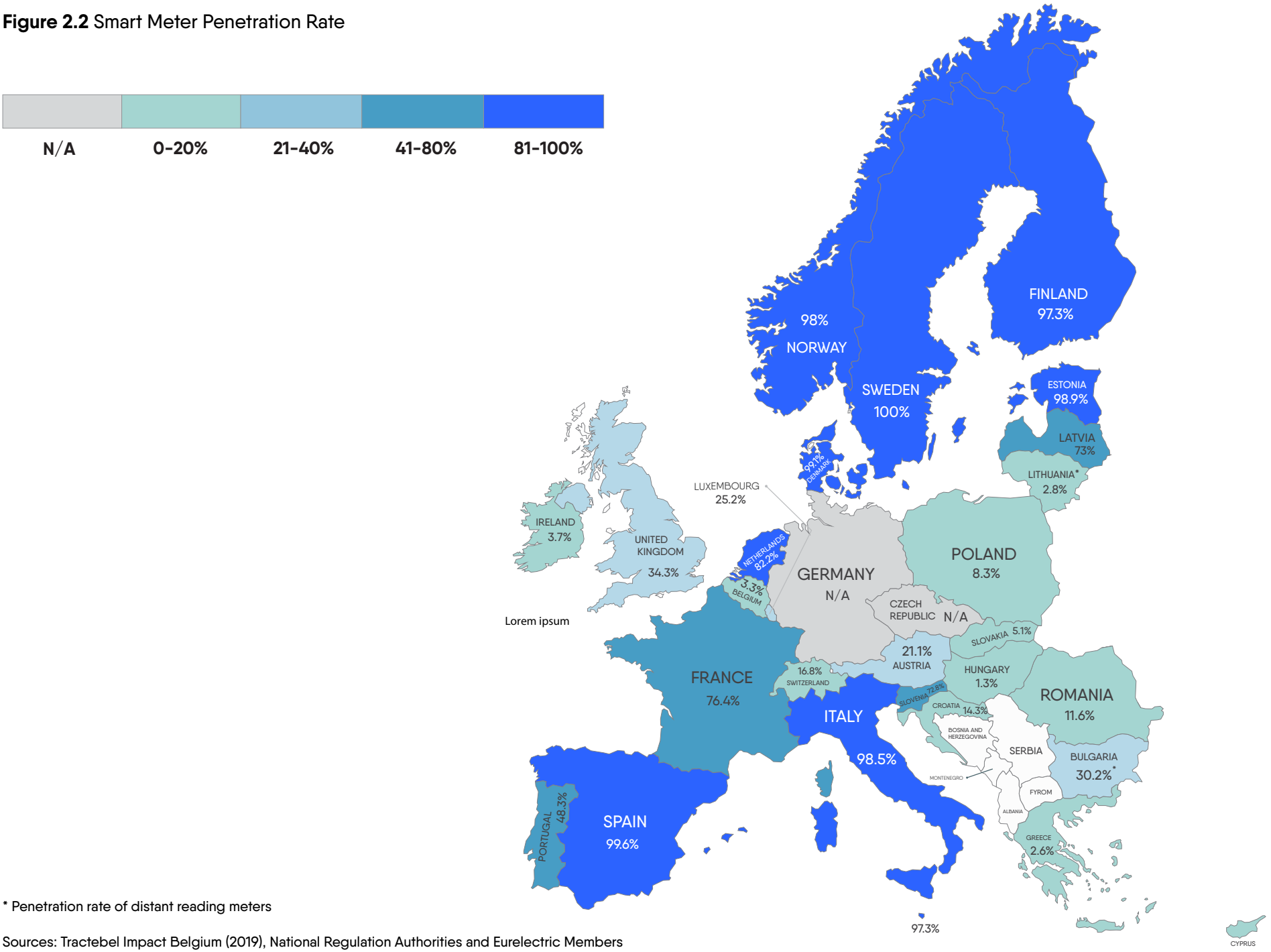
CBA Outcome	+	?	-	Ø	N/A
	Positive	Inconclusive	Negative	No CBA	Not available

* Planned partial roll-out



Sources: Tractebel Impact Belgium (2019), National Regulation Authorities and Eurelectric Members

Figure 2.2 Smart Meter Penetration Rate



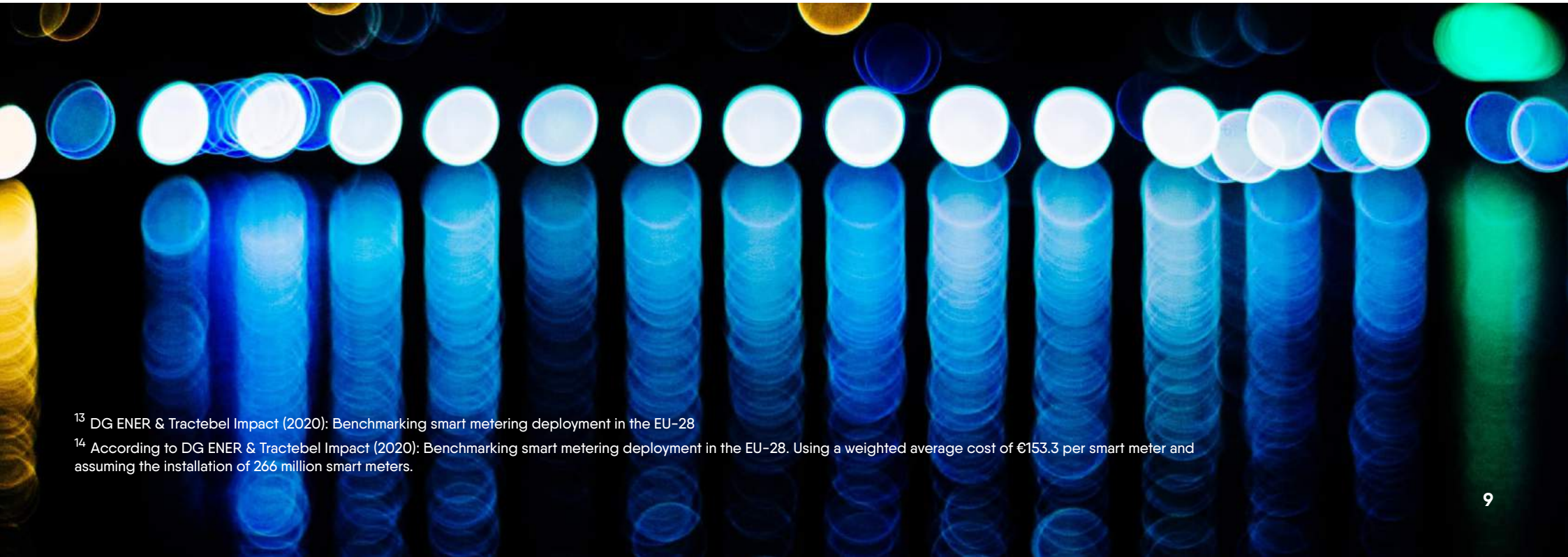
* Penetration rate of distant reading meters

Sources: Tractebel Impact Belgium (2019), National Regulation Authorities and Eurelectric Members

Main findings

- As of 2020, all but three Member States (i.e. Italy, Spain and Malta) have conducted at least one CBA for a large scale smart meter rollout.
- In many cases the benefits significantly outweighed the costs, as in the majority of CBAs operational savings, non-technical losses reductions and bill reductions were achieved. Almost all Member States have therefore adopted implementation strategies with specific legal provisions for the deployment of smart meters.
- Based on the reported rollout plans, by 2020, around 200 million smart meters should have been installed in the EU-28 (corresponding to a penetration ratio of ca. 78%).[13] Today in the EU-27, around 120 million smart meters have been installed, representing 48% of all metering points.
- Overall the EU-wide smart meter rollout keeps a steady progress forward, but within very different operational environments and speeds in each Member State. In fact, as some Member States (i.e. Italy, Sweden, Finland) are already planning and/or proceeding with the rollout of second-generation smart metering devices, other Member States have only begun conducting pilot tests.
- Coincidently countries with positive cost-benefit analyses and clear mandatory regulatory frameworks are on their way to reach their targets according to national plans. Whereas, countries without mandatory smart meter roll-out programs and clear legal frameworks, are facing considerable delays in their roll-out programs

€41 bn are needed to achieve a smart meter penetration rate of 92% by 2030[14]



[13] DG ENER & Tractebel Impact (2020): Benchmarking smart metering deployment in the EU-28

[14] According to DG ENER & Tractebel Impact (2020): Benchmarking smart metering deployment in the EU-28. Using a weighted average cost of €153.3 per smart meter and assuming the installation of 266 million smart meters.

3 Quality of Power Supply

DSOs are tasked with finding the most cost-effective and reliable way of delivering energy to customers, while ensuring continuous service quality. These technical performance requirements are laid out in national laws, European standards and grid codes.

The complexity of the system to move electric power from the point of production to the point of consumption combined with variations in weather, generation, demand and other factors provide many opportunities for the quality of supply to be compromised. To function in their intended manner (i.e. without significant performance losses) **distribution grids require good quality electrical power** with following characteristics:

- stable continuity of service
- low harmonic content
- low variation in voltage magnitude
- low transient voltages and currents

Quality of power supply is affected by a number of different dimensions: the most important being c**ontinuity of supply, voltage quality and network losses**.

Continuity of supply

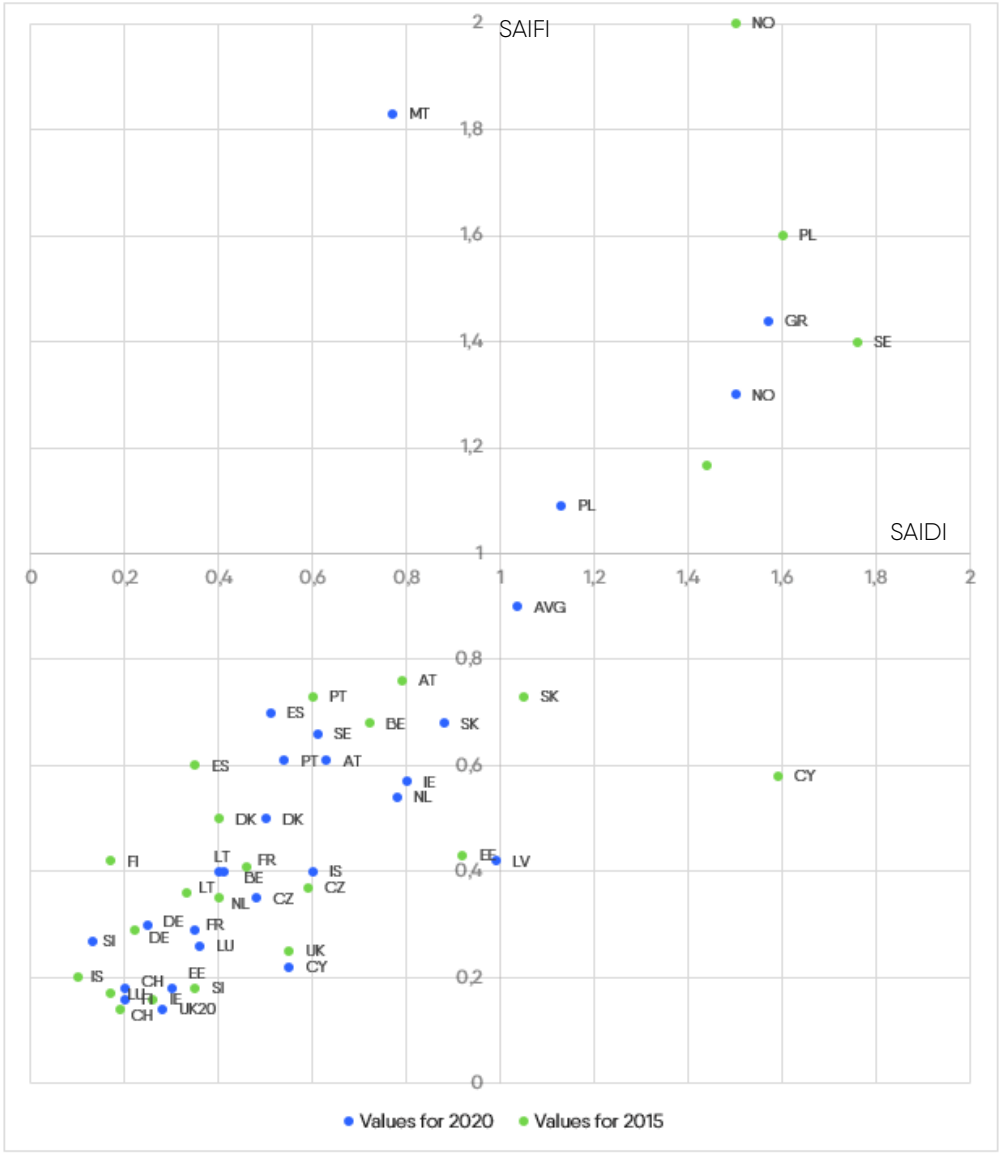
The continuity of supply refers to the availability of electricity to the grid user. The **duration and frequency of electricity supply interruptions**, as measured by **SAIDI** (System Average Interruption Duration Index) and **SAIFI** (System Average Interruption Frequency Index), are a good indication of the reliability of the grid.

Figure 3.1 depicts the average interruption duration (i.e. SAIDI) and frequency (i.e. SAIFI) on the on the x-axis and y-axis respectively. In the bottom-left quadrant values for both indices are below 1, meaning the continuity of supply is stronger than in the upper-right quadrant, where both SAIDIs and SAIFIs values are bigger than 1 (for further figures and outliers see the Annex).

Overall, the average power interruption duration and frequency of power distribution networks in EU-27 is low, averaging only **1.01 and 0.92 for SAIDI (2020) and SAIFI (2020)** respectively.[15] Furthermore, over the past years, the reliability of the power distribution network has continued to increase in all European countries due to the continuous efforts from DSOs to improve service quality: **both SAIDI and SAIFI decreased by 31% and 25% respectively since 2015.**

For more information on the historical development of reliability indices see p.7 of Eurelectric's report "The value of the Grid" (2019).

Figure 3.1 Reliability indices in 2015 and 2020



Source: World Bank (2020)

[15] According to the World Bank's methodology SAIDI indicates the average total duration of outages over the course of a year for each customer served, while SAIFI indicates the average number of service interruptions experienced by a customer in a year. Both indicators refer to power outages in the largest business city of each country and the minimum outage time considered for calculation is over 5 minutes (including planned and unplanned outages). For further information on the methodology, please consult Getting Electricity methodology from the World Bank.

Continuity of power supply indicators are also a key concern for national regulatory authorities, as these are often included in regulations for DSOs. Regulations aim to compensate customers for very long supply interruptions, to keep restoration times under control and to create incentives to reduce the total number and duration of interruptions.

Voltage quality

Thanks to voltage quality services, DSOs enable the safe operation of home appliances and industrial facilities. Voltage quality is ensured when deviations in voltage frequency and in voltage magnitude are kept within boundaries and when distortions of the voltage wave shape are minimised. Voltage quality is becoming an increasingly important issue due to the increasing susceptibility of end-user equipment, industrial installations and distributed generation to voltage disturbances. Thus preventing automatic shut-down of automated industrial machines and damage to sensitive assets such as computers and high-end electrical devices.

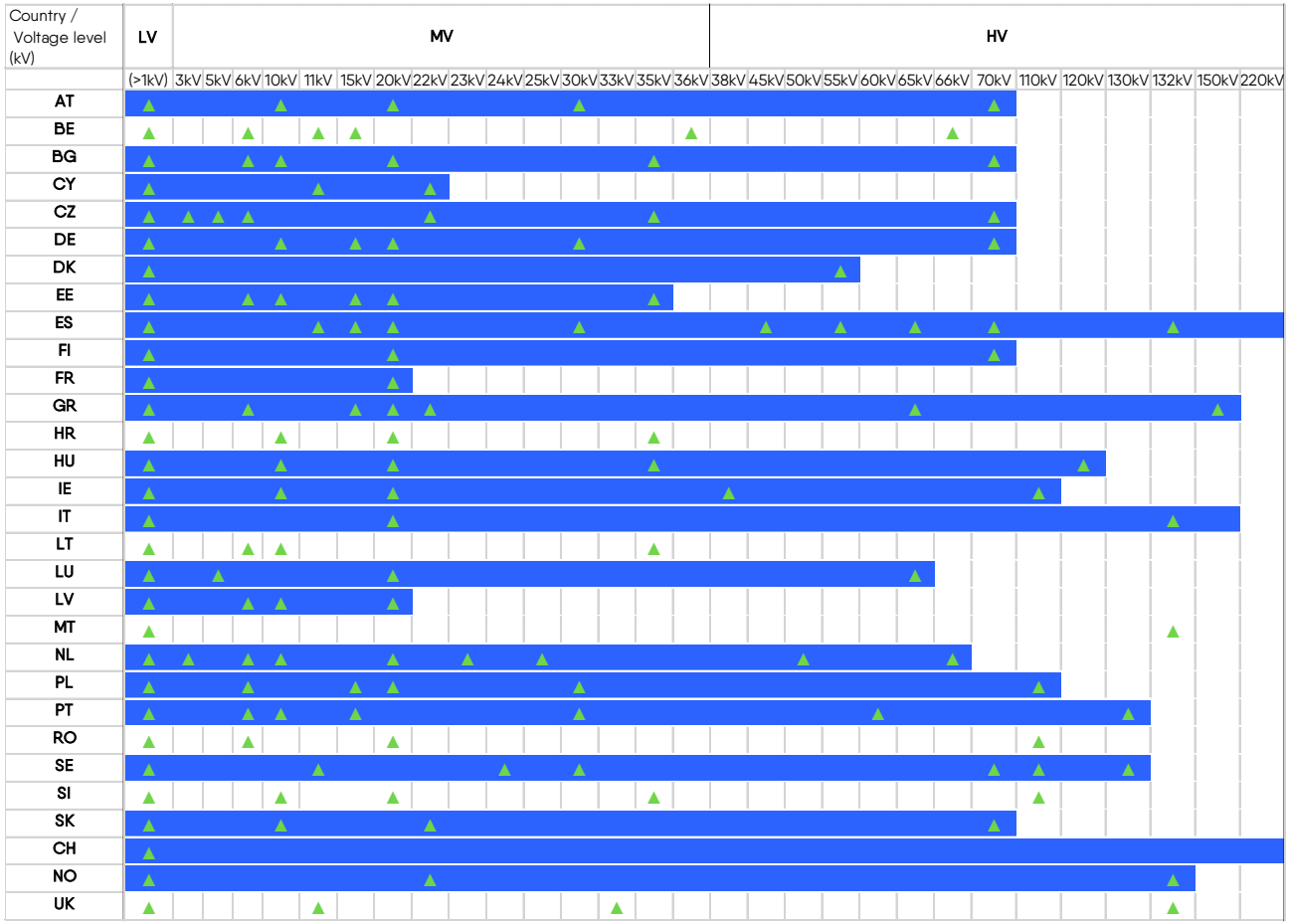
The European standard **EN 50160,** specifies voltage ranges to be respected in order to maintain an undisturbed operation of all connected devices. Despite voltage quality being a recent issue for regulators, most European DSOs routinely exceed these limits by a large margin.

In Europe, most **distribution network voltage levels range from <1kV to 36kV**. However, due to different national legislation and operational standards, a wide variety of voltage levels is used for power distribution.

Figure 3.2 reports in green the voltage levels commonly used within a country and in blue the voltage range in which DSOs can operate according to national legislation.

A large interconnected grid should naturally deliver a voltage wave quality that enables safe, secure and efficient use of the connected equipment. Regulatory arrangements and the relationship between DSOs and TSOs may need to evolve, as DSOs are facing new challenges in managing the impacts of increased generation connection at the distribution level and changing consumer demand, and TSOs are facing new challenges related to balancing supply and demand to maintain system frequency.

Figure 3.2 Voltage levels and ranges used for power distribution in Europe



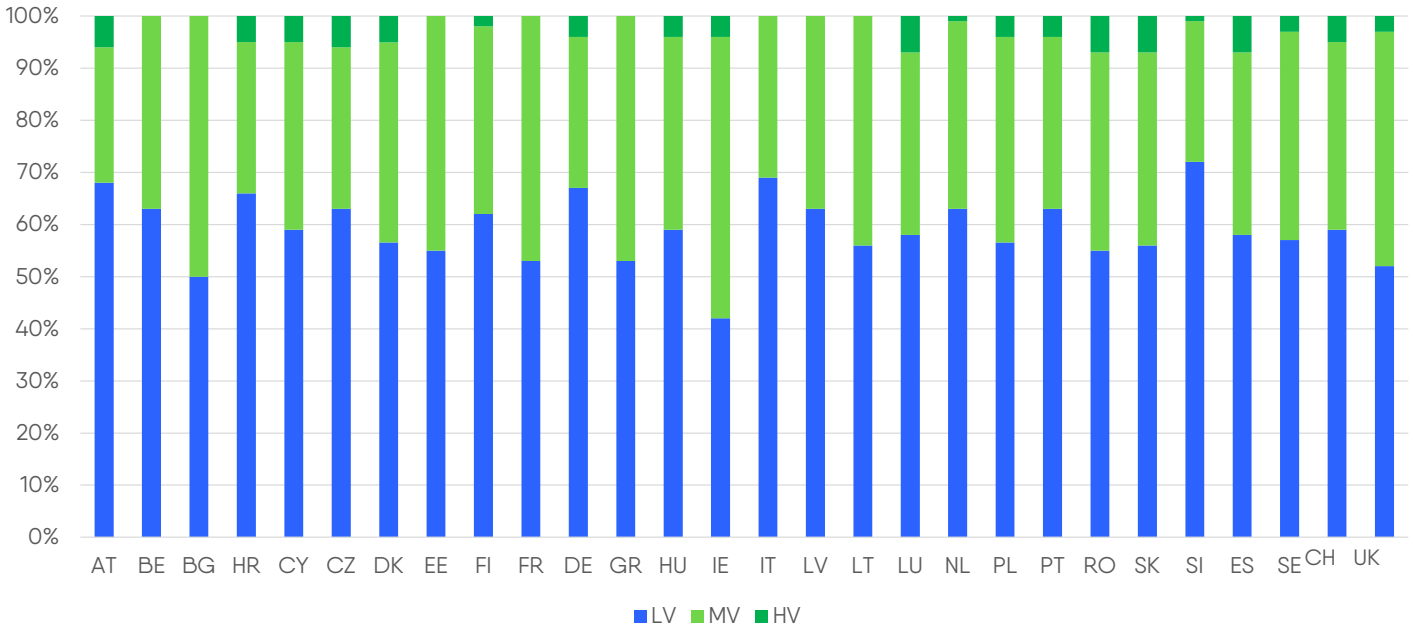
For more information on the role of DSOs on voltage quality, see Eurelectric (2018) Charges for Producers connected to the Distribution System

Sources: Eurelectric (2013) Power Distribution in Europe and Eurelectric (2018) Charges for Producers connected to the Distribution System

Network losses

Distribution networks are the connections that deliver electricity to its ultimate point of consumption: households and businesses. They are the link connecting high and extra high voltage power lines coming from power generation points to the end users. **In Europe, DSOs connect around 300 million customers by operating 10 millions km of power lines and supplying around 2800 TWh of electricity per year**.

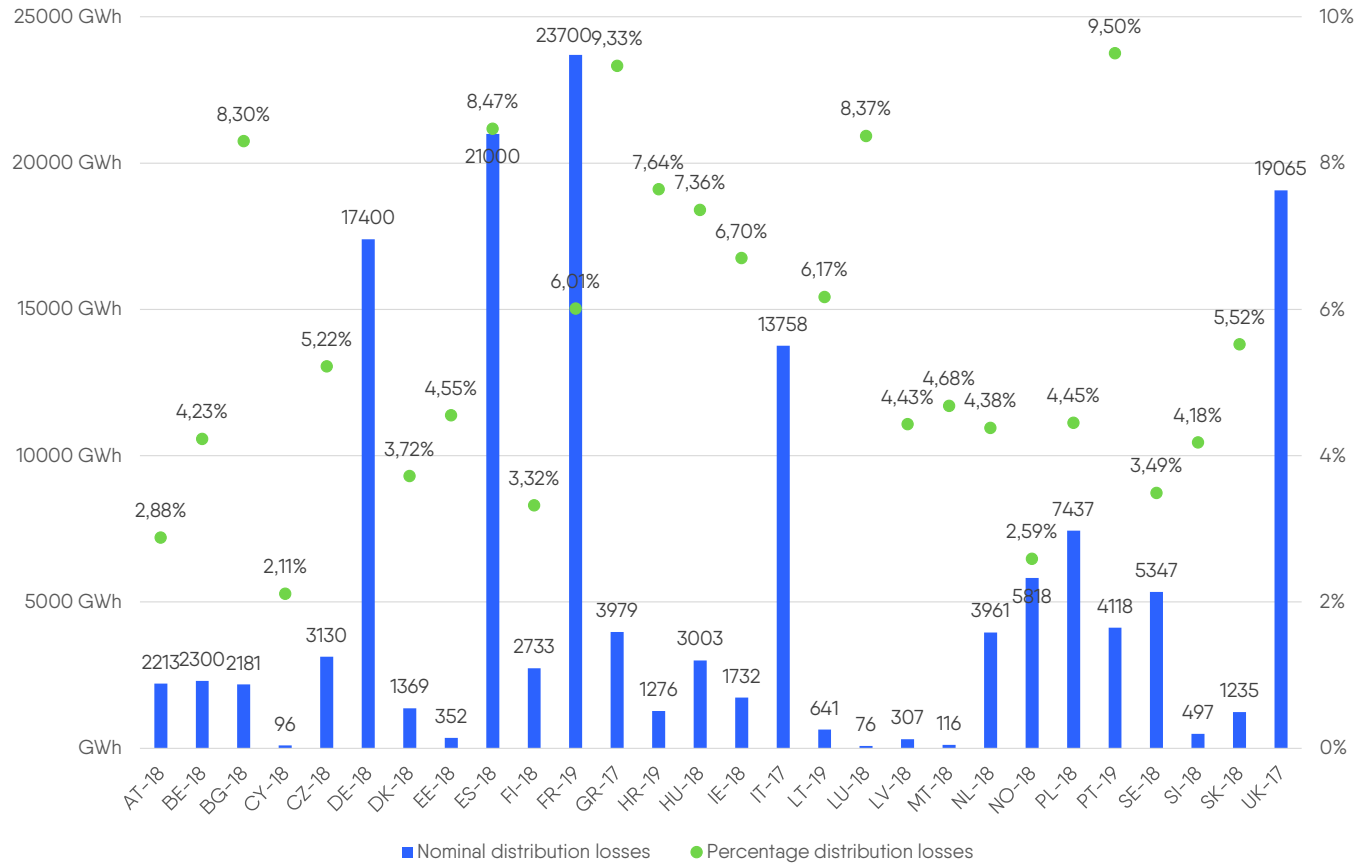
Figure 3.3 Share of distribution lines, per type



Although the definitions for high, medium and low voltage differ from country to country for historical reasons, according the European Committee for Electrotechnical Standardisation (CENELEC) LV ranges to below 1kV; MV between 1kv and 36kV and HV over 36kV. **Overall, 60% of the European power network is composed by low voltage lines, 37% by medium voltage lines and 3% by high voltage lines**. To deliver on the Green Deal's carbon neutrality objectives, it will be critical to optimise distribution grids and coupling them with flexibility sources, as this will help integrate an ever-increasing generation capacity of renewable energy.

Network losses are an inevitable consequence of transporting power across the distribution network. Nevertheless, their magnitude has increasingly been minimised through improvements in energy efficiency and grid reliability.

Figure 3.4 Distribution Losses



Source: National reports and 2nd Report on Power Losses (by CEER 2020); Eurelectric analysis

The Energy Efficiency Directive (2012/27/EU) states that Member States shall ensure that network operators are incentivised to improve efficiency in infrastructure design and operation[16]. In addition, the European Commission in COM (2014)520 highlighted the need to reduce network losses volume to achieve the 32.5% improvement in energy efficiency target by 2030.

DSOs are facing new challenges in managing the impacts of increased generation connection at distribution level and changing consumer demand. There is a need for DSOs to be increasingly innovative and explore smart and flexible solutions, including actively managing their networks. In a number of countries this transition is already underway.

[16] Article 15 of the Energy Efficiency Directive (2012/27/EU)

Main findings

- The Energy Union allowed European Institutions and NRAs to implement an effective set of regulatory instruments to limit inefficiencies, further strengthen the internal energy market and expand power infrastructure connecting European countries
- In the coming years DSOs core activities will remain geared around delivering system security, integrating renewables and ensuring service quality. However, as the evolution of the DSO operating model takes place, new competencies are being developed across different functional areas (e.g. network flexibility sources) as DSOs become pivotal enablers of the energy transition.
- The improvement of continuity of supply indicators demonstrate the positive impact of investment on distribution networks. Investment to date means that Europe's networks are regarded as some of the most reliable in the world. So far, DSOs have been able to deal with rising volumes of distributed generation due to the strength of the grid and the manageable number of new connections. Over time, further growth in large-scale distributed generation will challenge DSOs, affecting their ability to keep the network running smoothly and the grid infrastructure maintained and upgraded.
- DSOs will have to increase volumes of flexibility to ensure system stability. Combining efforts with TSOs will guarantee clean and reliable power to all European households and businesses. Harnessing flexibility in the power system will be a key enabler to meeting Europe's long-term decarbonisation goals.

For further information :

- Joint Eurelectric, CEDEC,E.DSO GEODE report "Flexibility in the energy transition a toolbox for electricity DSO"(2018)
- Joint Eurelectric, CEDEC, E.DSO GEODE – ENTSO-E report "An integrated approach to Active System Management" (2019)
- Eurelectric vision – From "Pipes to Platforms"
- Eurelectric report " The value of the Grid" (2019)

Good power quality saves money and energy: the consequences of insufficient power quality can inflict serious losses on businesses and economies

#Annex

Sources

Factsheet 1: Overview of the DSO's landscape in Europe

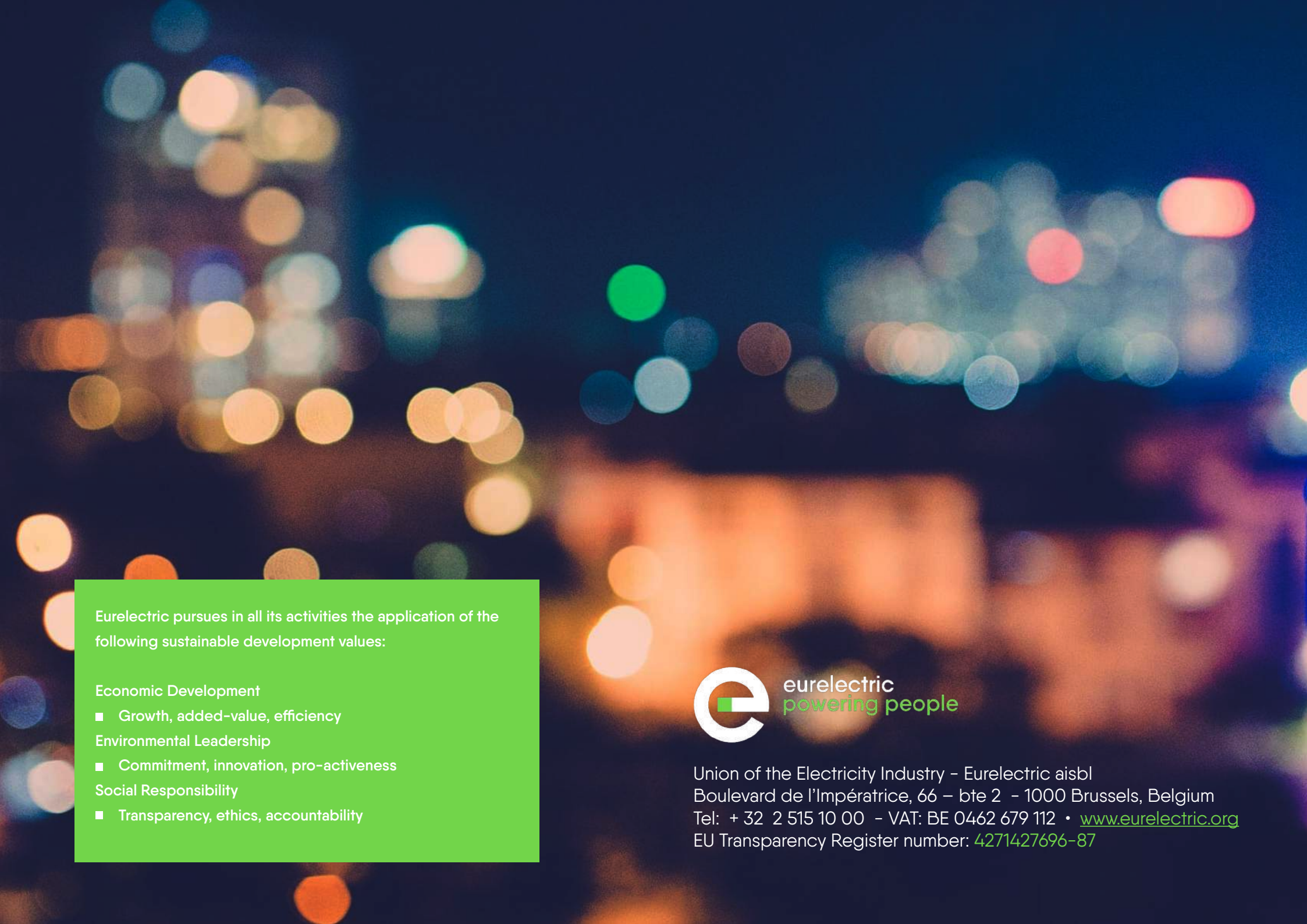
- CEER report "Implementation of TSO and DSO unbundling provisions" (2019)
- National reports from national authorities available on the CEER website (English version)
- Websites of national authorities
- ACER market monitoring report 2018 – Electricity and gas retail market volumes

Factsheet 2: Smart Meters

- Tractebel Impact Belgium (2019) 'Benchmarking Smart Metering deployment in the EU-28'
- National report from national authorities available on CEER website (English version)

Factsheet 3: Quality of Supply

- World Bank (2020) – DataBank: Doing Business (SAIDI & SAIFI)
- JRC (2018) - Distribution System Operators observatory
- CEER (2020) – 2nd Report on Power Losses



Eurelectric pursues in all its activities the application of the following sustainable development values:

Economic Development
- Growth, added-value, efficiency

Environmental Leadership
- Commitment, innovation, pro-activeness

Social Responsibility
- Transparency, ethics, accountability

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