Connecting the dots: Distribution grid investment to power the energy transition

Final Deliverable

January 2021

Preamble

- The **2015 Paris Agreement marked a historic milestone to drive the transition to a climate-neutral world**. An **extensive international agreement was reached** during the Conference (COP21), and the commitments adopted by different countries portrayed a **significant progress compared to previous efforts.** The **European Union was aligned to the ambition required to reach a binding agreement,** with strong provisions for transparency and accountability, and a strong will to raise the ambition over time.

- The **EU has led the way to deploy ambitious decarbonisation policies and targets**, as it is considered in its 2030 Climate and Energy Framework (at least 40% cuts in greenhouse gas emissions - from 1990 levels -, at least 32% share for renewable energy, and at least 32.5% improvement in energy efficiency). Moreover, as part of the **European Green Deal, the European Commission proposed in September 2020 to raise the 2030 greenhouse gas emission reduction target to at least 55% compared to 1990**.

- **Power grids are critical to enable the Energy Transition**, as they are **key for energy demand electrification and renewable integration in the power system**. Electrification reduces GHG emissions due to the fact that it **enables a switch from emitting fuels to carbon neutral electricity** (e.g. generated from renewable sources), as well as higher efficiency for most relevant applications. Moreover, electric production of energy carriers, such as green hydrogen, and power-to-X, will also reduce emission in end uses where direct use of electricity may not be appropriate. Moreover, **power distribution grids generate synergies between the Energy Transition and the recovery of the COVID19 crisis**, mobilising high value-added investments and a great indirect effect, such as that related to renewable or electric vehicle deployment, while DSOs contribute to enable new services for end-consumer and to reinforce its active role in the power system.

- This **Eurelectric study jointly undertaken with EDSO is intended to assess DSO investments required for the Energy Transition in Europe**, and subsequently, to develop policy and regulatory recommendations. Monitor Deloitte has **assisted Eurelectric and EDSO in this endeavour** in order to: (1) Understand the **importance of power distribution grids in the coming years to comply with EU** Climate & Energy targets and enable Green Deal, (2) Estimate **power distribution investments at EU level**, and (3) outline **policy and regulatory recommendations for distribution power grids to enable an efficient Energy Transition.**

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1 To achieve the Energy Transition targets, significant efforts are needed in electrification, emission-free generation and energy efficiency

Key messages

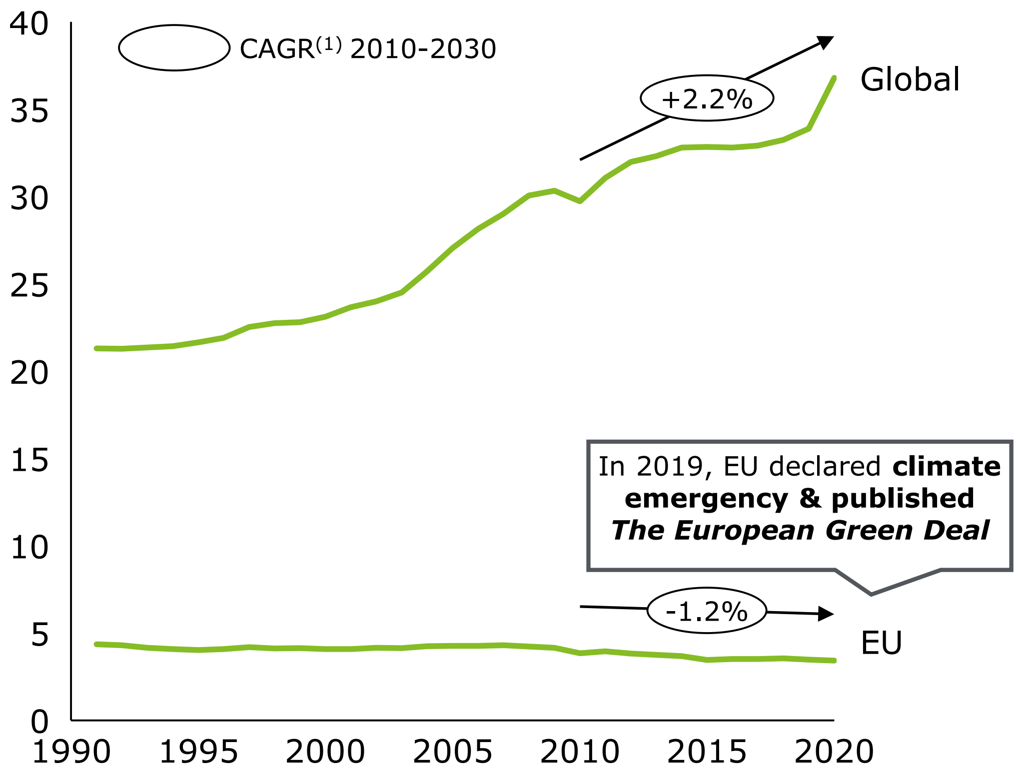
- **EU has developed policies and targets** for the decarbonisation of the energy system. To achieve Energy Transition goals, **significant efforts are needed in electrification, emission-free generation and energy efficiency at European level**:
  - **~510 GW of new renewable capacity would be installed at EU27+UK level (~70% connected to distribution grids)**, which implies **~940 GW of cumulative capacity by 2030**
  - **EU27+UK electricity demand would reach ~3,530TWh** by 2030 (~1.8% CAGR 2017-2030), with **50-70m of EVs** (20-25% of passenger cars fleet)
  - **Peak demand and electricity demand would grow at different paces depending on flexibility(1), among other drivers**

- **Power Distribution Grids are a critical element in the European Energy Transition. Distribution grids are:**
  - The **base for electrification** and capacity expansion,
  - The **connecting point for renewables** plants,
  - The **enabler for flexibility** and demand management, and
  - A key **element to enable customer participation** in the Energy Transition

(1) Flexibility measures can be classified as load flexibility measures (e.g. demand response), generation flexibility measures (any generator which voluntarily increases/decreases its production to create flexibility) and storage flexibility measures (e.g. batteries for EV), in which new market players, such as aggregators, will appear

1 Global CO_2 emissions keep increasing despite efforts to curb them down to accelerate decarbonisation; EU Parliament has declared climate emergency

CO_2 emissions
(billion tons CO_2)



European Green Deal main initiatives

Emissions	• **Increase 2030 emission reduction target to 50-55%** of 1990 levels • **Zero net carbon emissions by 2050** • **90% transport emissions reduction by 2050**
Sustainable growth	• **Decouple economic growth** from resource use • **Put Europe in new path of sustainable and inclusive growth**

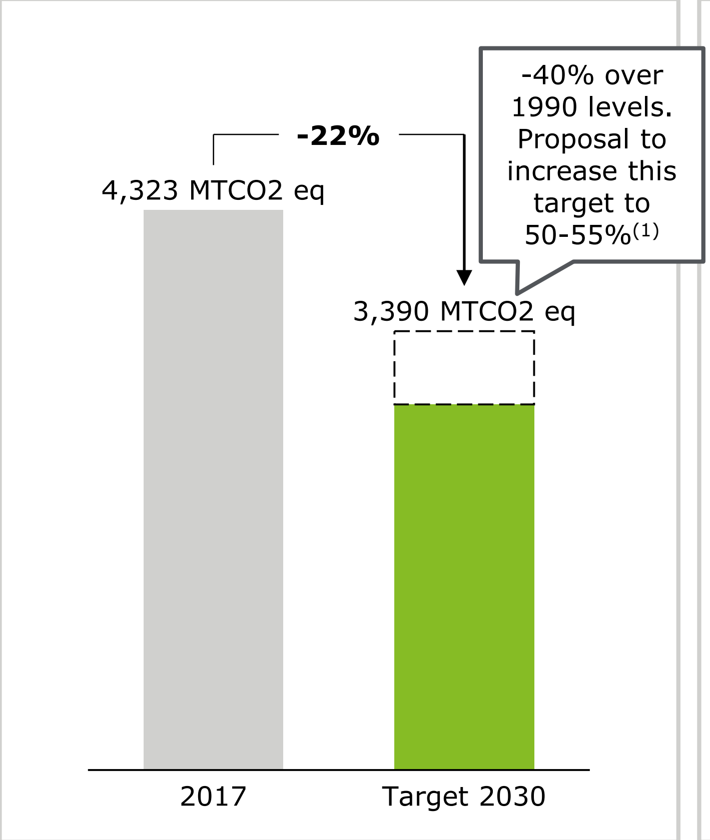
To achieve this emission reduction target, EU and individual countries need to deploy comprehensive energy policy packages

(1) Compound Annual Growth Rate
Source: Bloomberg; EU Green deal; Monitor Deloitte

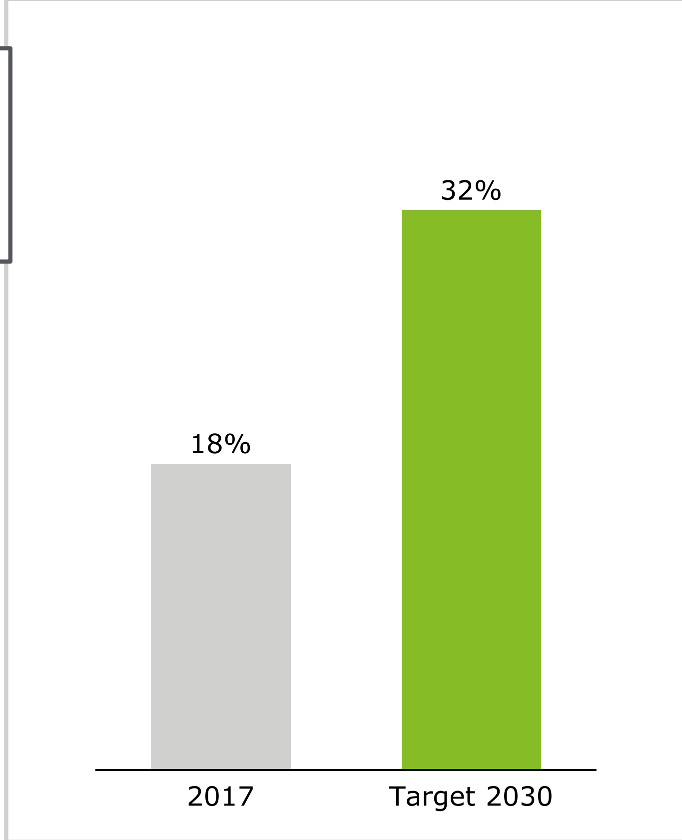
1 European Union has committed to ambitious targets for economy decarbonisation by 2030

EU27+UK targets by 2030

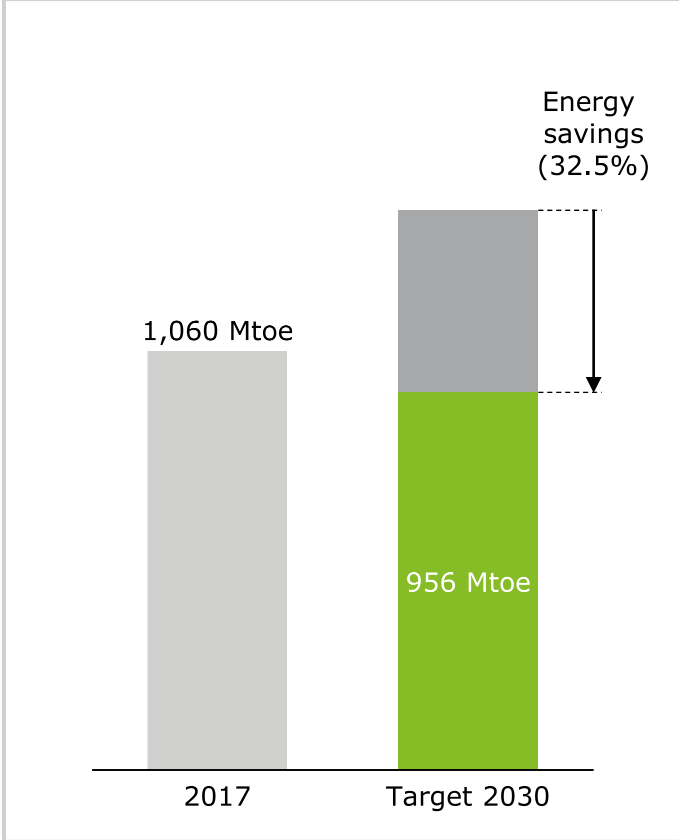
GHG emissions



Share of renewable energy over final energy consumption



Increase in energy efficiency (reduction of final energy consumption vs. baseline projections)



(1) According to European Commission 2030 Climate Target Plan, GHG emissions target is expected to be updated by the third quarter of 2020. Scenario compiled in this Investment Outlook considers EU targets in force in the second quarter of 2020 (i.e. GHG emission reduction of 40% compared to 1990 levels)

Source: European Commission; European Environment Agency; Monitor Deloitte

1 We have designed a 2030 scenario aligned with EU decarbonisation in 2050

EU27+UK energy transition levers by 2030

a Electrification

- **+40-50m[1] heat pumps**
- **50-70m electric vehicles**
- **+335 TWh (add. demand) industrial and P2X**

b Emission-free generation

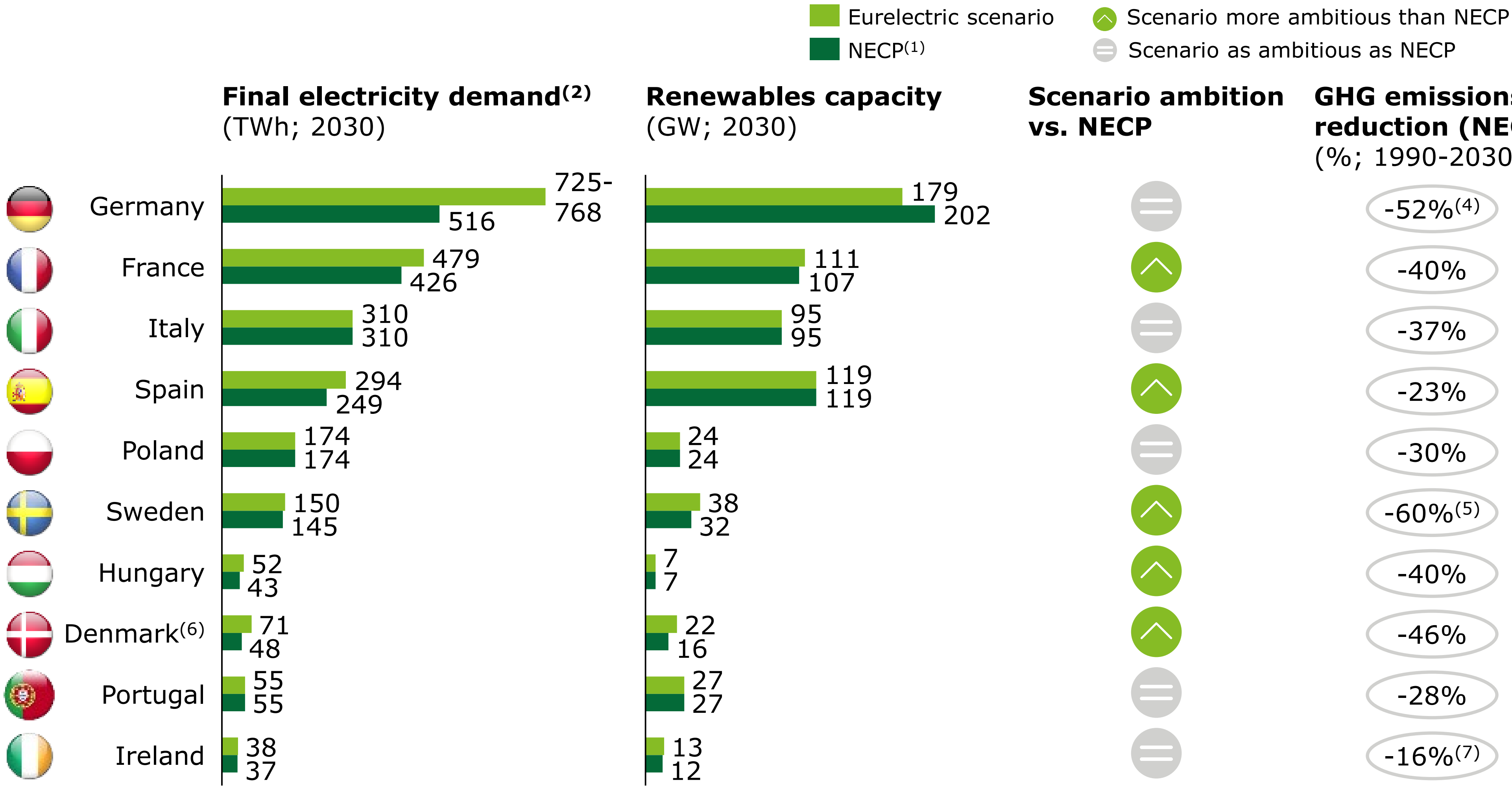
- **+470 GW centralised renewable**
- **+40 GW self-consumption**
- **~70%** renewable capacity **connected to distribution grids**

c Energy efficiency and conservation

- **Diversify EV charging** Enable >50% EV charging in off-peak hours
- Foster the **roll-out of smart meters** Enable greater grid visibility and new services

(1) Estimated heat pumps for residential sector. The figure considers that electricity growth in residential sector is mainly related to new heat pumps
Source: Monitor Deloitte

1 … and our scenario is, at least, as ambitious as current NECPs regarding GHG emissions reduction targets

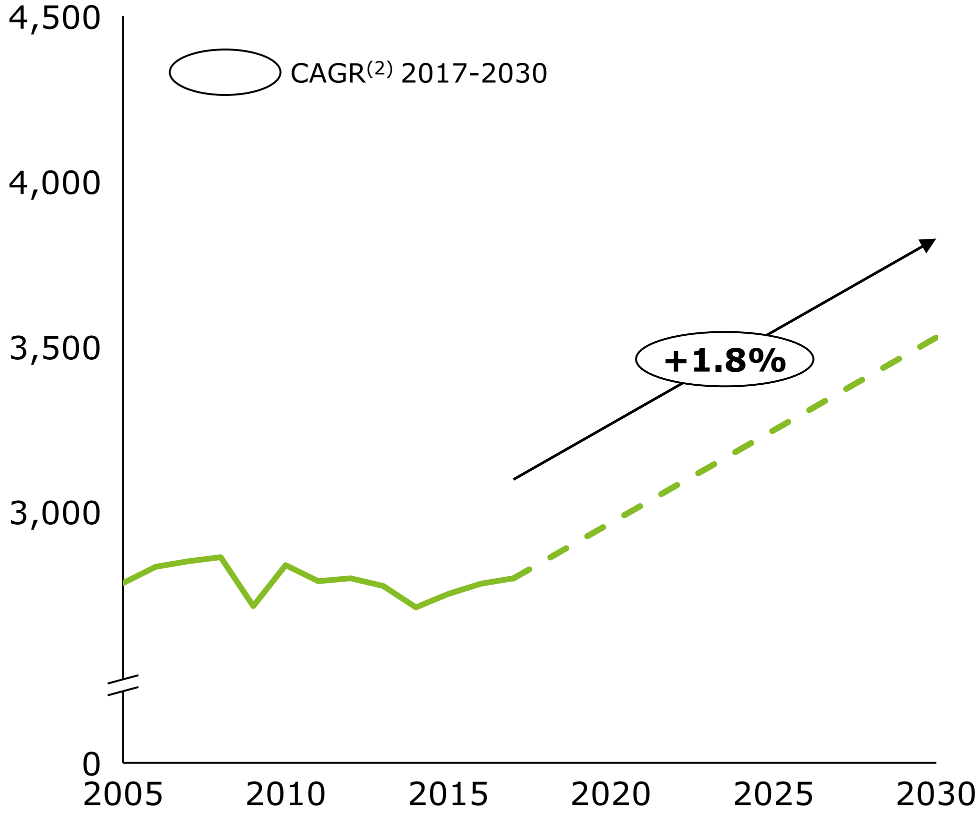


Power grids are a key enabler of the main decarbonisation drivers during the Energy Transition

(1) In case data are not explicitly shown in NECPs, figures have been estimated or extrapolated from NECP data; (2) Electricity demand at the end-consumer point. It also includes power-to-X (~95 TWh); (3) Without LULUCF (not specified in the case of Poland GHG emission target); (4) German scenario achieves the same ambition level than NECP with higher electricity demand and lower RES; (5) Estimated considering 43% GHG emissions reduction for ETS sectors and 63% for non-ETS sectors in Sweden; (6) Eurelectric scenario achieves a 70% reduction target, in accordance with the Danish Climate Law adopted by the Parliament in December 2019; (7) Ireland has committed to achieve a 7% annual average reduction in GHG between 2021 and 2030 (the NECP is being updated to include this ambition but has not been published)
Source: NECPs; DSOs and associations; EEA; European Commission; Monitor Deloitte

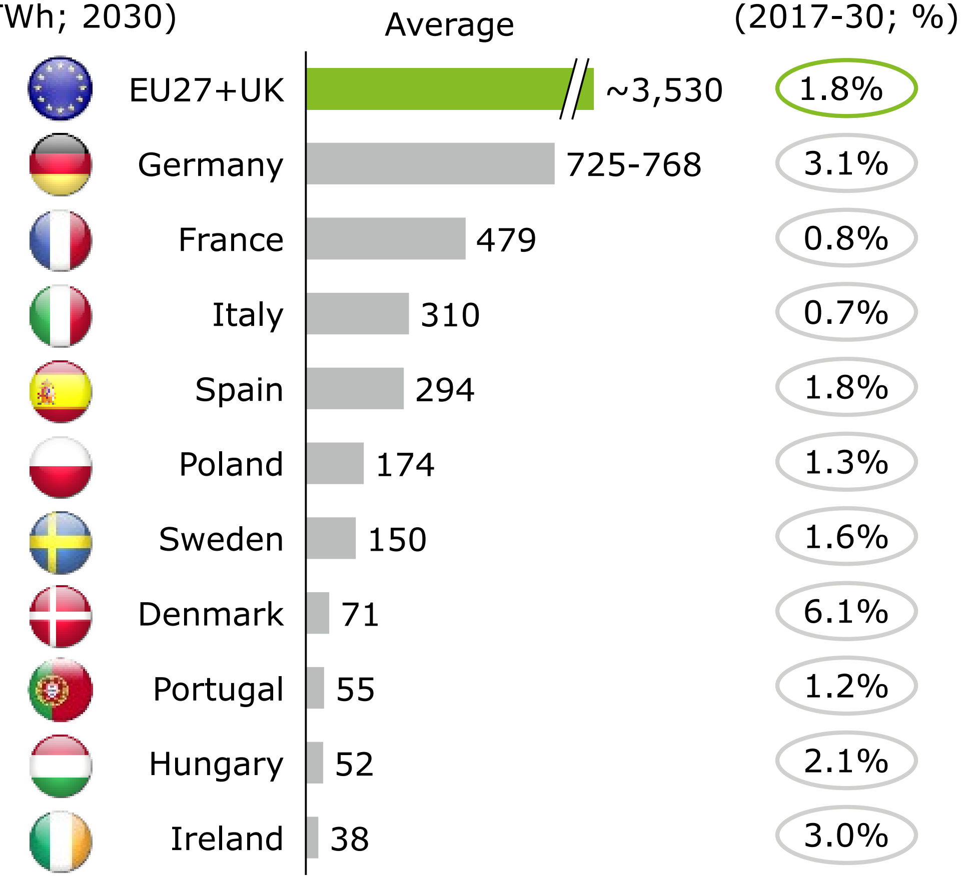
1 Total electricity demand is expected to rise significantly by ~1.8% per year by 2030

EU27+UK final electricity demand[1]
(TWh; 2005-2030)



Final electricity demand per country[1]
(TWh; 2030)

CAGR[2]
(2017-30; %)

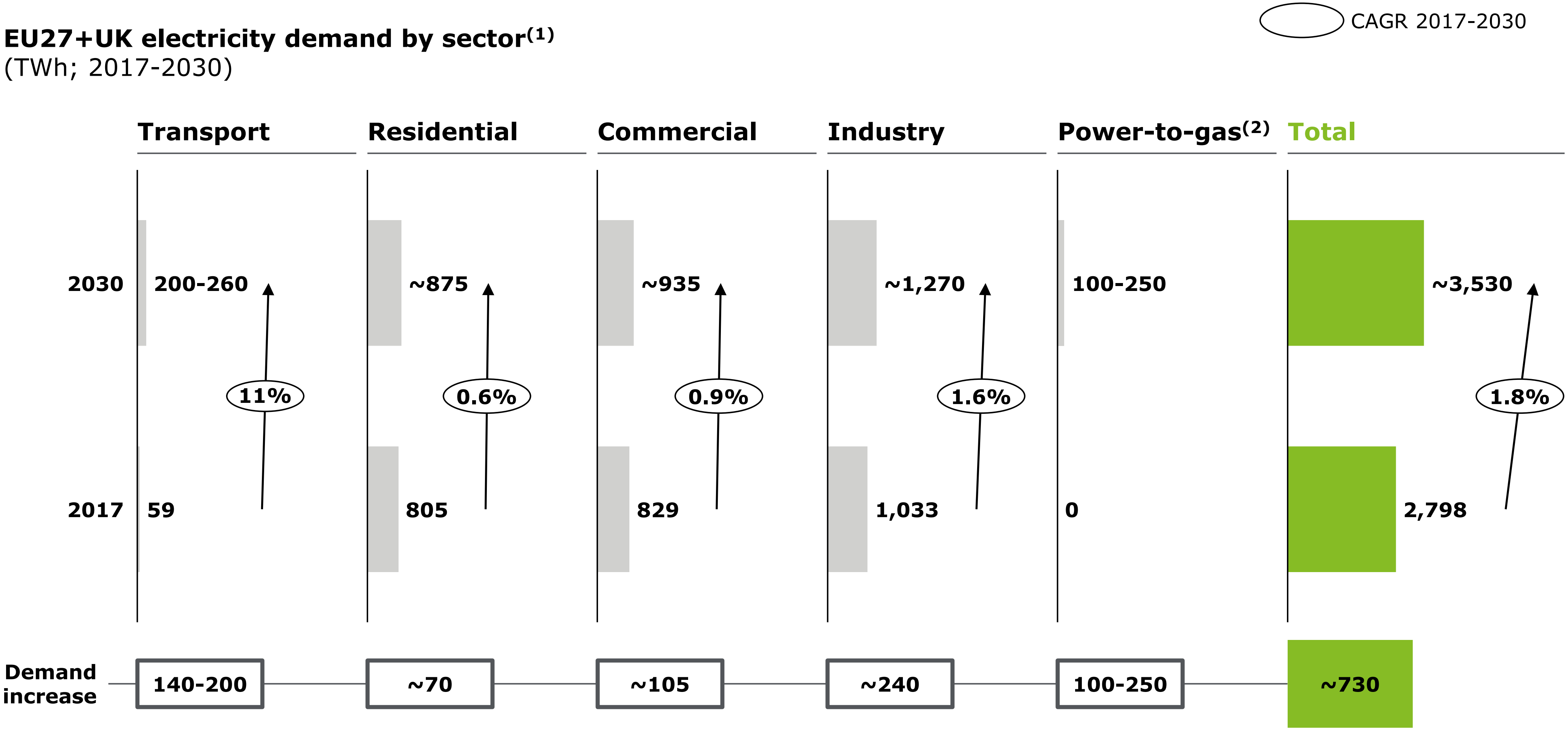


Distribution power grids will require reinforcements and additional transformation capacity in substations to integrate effectively the expected demand growth and ensure quality of supply

(1) Electricity demand at the end-consumer point. It also includes power-to-X (~95 TWh)
(2) Compound Annual Growth Rate, as used throughout this document
Source: Eurelectric; DSOs and associations; iea; Monitor Deloitte

1 a All sectors would contribute to electricity demand growth; with strongest increase in transport due to EV penetration

EU27+UK electricity demand by sector[1]
(TWh; 2017-2030)



(1) Fishing, agriculture and other sectors are not shown
(2) Power-to-gas electricity demand will depend on the implementation of the EU Hydrogen Strategy
Source: Eurelectric; DSOs and associations; iea; Monitor Deloitte

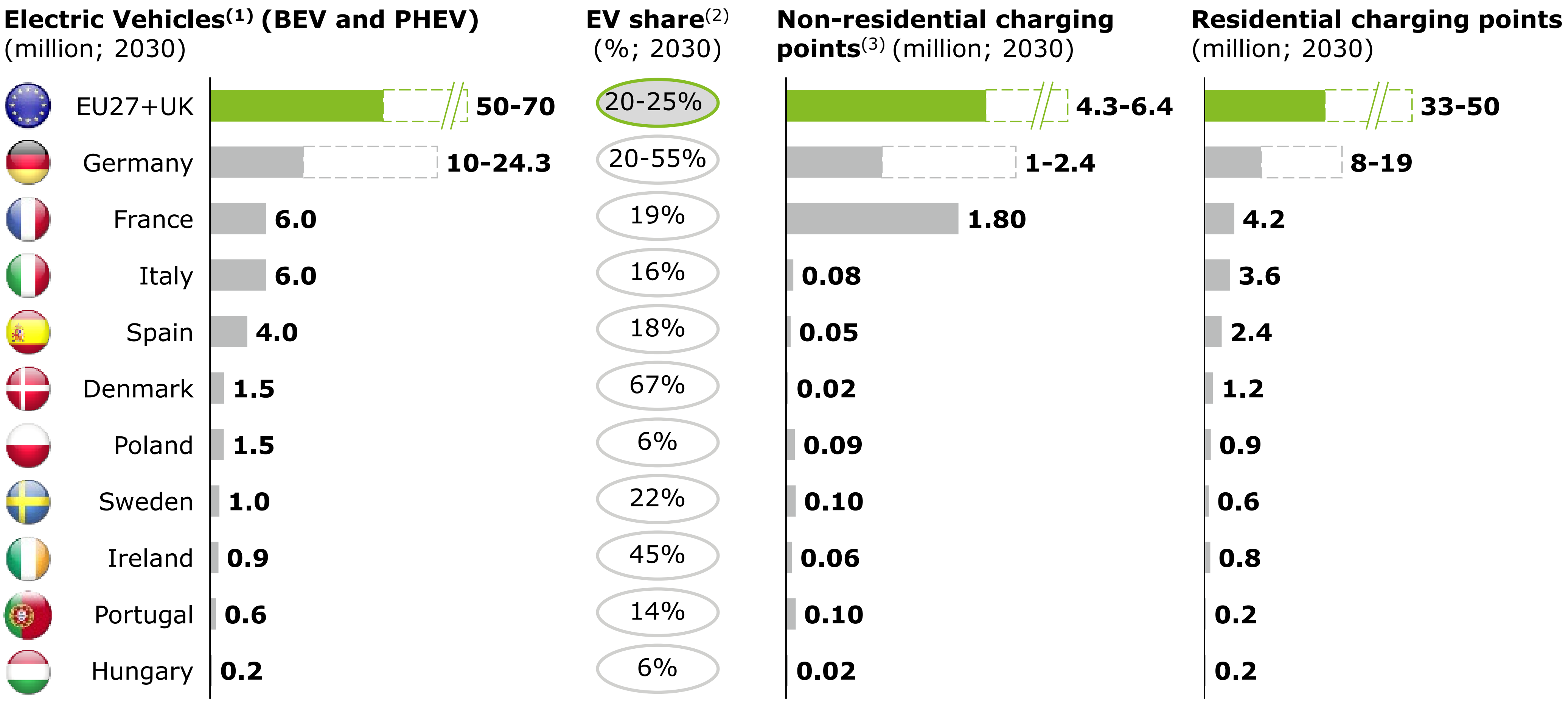
1 b 510 GW of new renewable capacity would be installed at EU27+UK level, ~70% will be connected to the distribution grids

Country	Renewable capacity additions[1] (GW; 2017-2030)	New RES connected to distribution grid[2] (%; 2017-2030)	Self-consumption capacity additions[3] (GW; 2030)	Cumulative renewable capacity[4] (GW; 2030)
EU27+UK	~510	~70%	~40	~940
Germany	98	~93%	9.0	179
Spain	65	~25%	2.3	119
France	65	~85%	~1	111
Italy	42	~83%	~0	95
Denmark	15	~37%	0.2	22
Poland	15	~67%	6.6	24
Portugal	14	~56%	1.9	27
Sweden	12	~30%	n.a.	38
Ireland	10	~43%	0.2	13
Hungary	6	~90%	n.a.	7

New renewable capacity will require connections and reinforcements in grid infrastructure, protection systems for bidirectional flows and advanced monitoring and prediction tools

(1) Additional back-up generation capacity (e.g. gas turbines, etc.) is assumed to be connected to transmission grids
(2) Power distribution grids' voltage levels depend on the country
(3) It has been considered renewable capacity connected behind the meter
(4) Renewable capacity comprises hydro, solar PV and CSP, wind onshore and offshore, biomass and other renewables
Source: Eurelectric; DSOs and associations; Monitor Deloitte

1 EVs would reach 50-70m by 2030, which would require 4.3-6.4m non-residential and 33-50m residential charging points



Cooperation is key for efficient EV integration, e.g. users (e.g. smart charging adoption), OEMs (e.g. competitive EVs design), operators (e.g. value added serv.) and DSO (e.g. grid investments)

(1) Impact on electricity demand, residential charging points and investments from lower EV range in Germany (10mn EV) are extrapolated from figures for higher EV range (24.3mn EV)
(2) It considers that car fleet will remain steady between 2017 and 2030
(3) It includes public and semi-public charging points (i.e. at a company's or supermarket's parking lot)
Source: Eurelectric; DSOs and associations; Monitor Deloitte

Peak demand and electricity demand grow at different paces depending on flexibility services, and consumer flexibility among other drivers

1
c

Peak demand (GW; 2017-2030)	2017	2017-2030 increase	Total	**Peak demand**[1] (CAGR; 2017-2030)	**Electricity demand**[1] (CAGR; 2017-2030)
Germany	79	44	**123**	3.5%	3.2%
France	~100		**~100**	~0%	0.8%
Italy	57	5	**62**	0.6%	0.7%
Spain	41	8	**49**	1.4%	1.8%
Poland	24	4	**28**	1.2%	1.3%
Sweden	26	2	**28**	0.6%	1.6%
Denmark	6	7	**13**	5.8%	6.1%
Hungary	6.6	2.8	**9.4**	2.7%	2.1%
Portugal	8.5	0.5	**9**	0.4%	1.2%
Ireland	4.9	1.5	**6.4**	1.9%	3.0%

Countries should deploy flexibility through load, generation or storage related measures[2], depending on technical (e.g. ramp response) and economical and regulatory conditions (e.g. saving potential, conducive framework)

(1) Peak demand represents maximum instant electricity demand in a year. If peak demand grows at lower rate than electricity demand, this means that electricity demand is growing at lower rates during peak hours than off-peak hours. This can happen due to different growths among sectors, energy efficiency or flexibility mechanisms that flatten demand curve
(2) Flexibility measures can be classified as load flexibility measures (e.g. demand response), generation flexibility measures (any generator which voluntarily increases/decreases its production to create flexibility) and storage flexibility measures (e.g. batteries for EV)
Source: Eurelectric; DSOs and associations; Monitor Deloitte

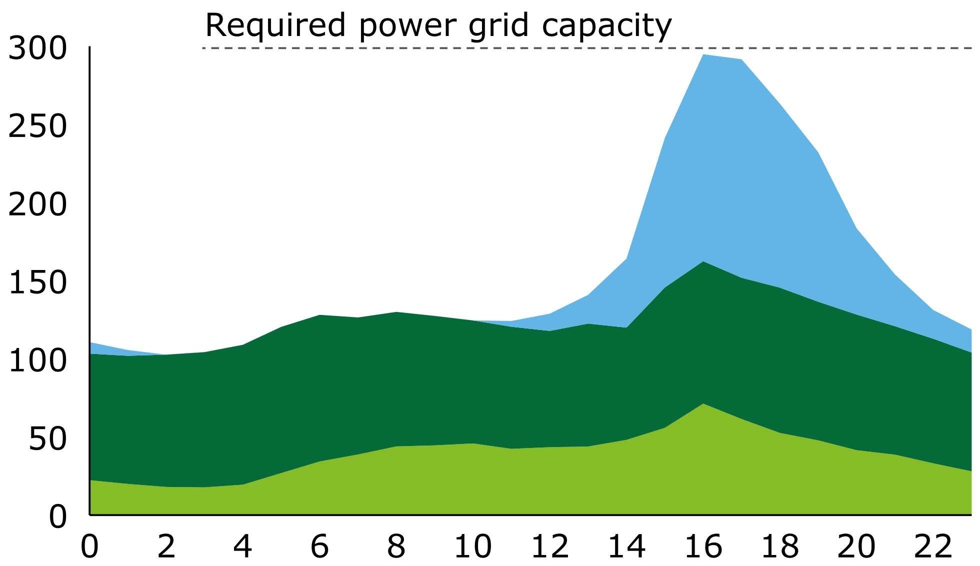
1 C

Flexibility[1] could reduce some investment needs in power grids; however, it is under some uncertainties (e.g. regulation, adoption), and there are trade-offs to consider

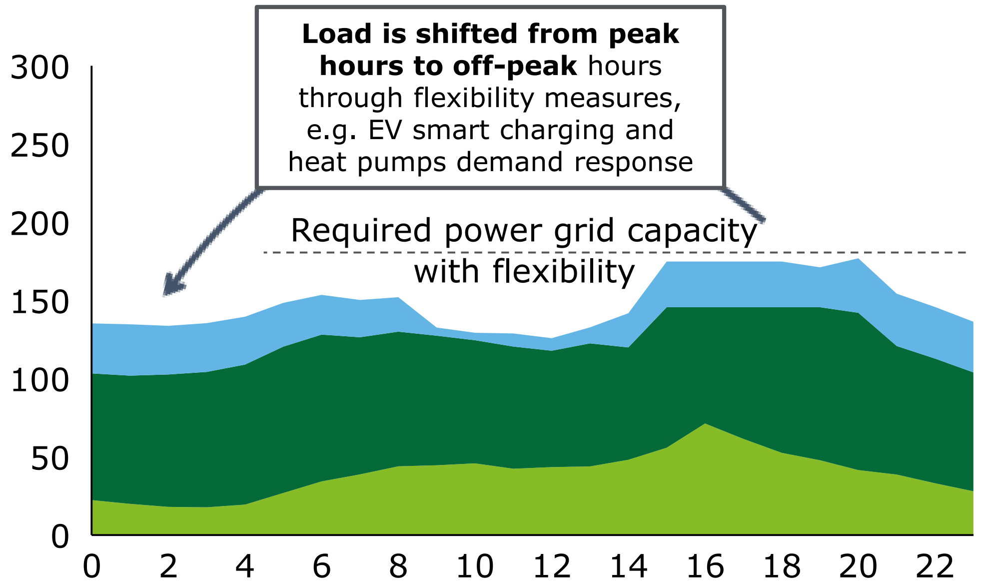
ILLUSTRATIVE EXAMPLE

Illustrative average hourly electricity consumption in the low-voltage grid in the residential sector[2]
(kW)

Example without representative load flexibility measures



Example with representative load flexibility measures



Electric vehicles | Individual Heat Pumps | Other residential consumption

Flexibility could be a key factor for power system cost optimisation, but there is still uncertainty about its potential impact and will depend on the development of regulation, markets, etc.

(1) Flexibility can include load flexibility measures (e.g. demand response), generation flexibility measures (any generator which voluntarily increases/decreases its production to create flexibility) and storage flexibility measures (e.g. batteries for EV). This example focuses on load flexibility measures.
(2) Simplified example to show how flexibility works when it is available in the system. Low voltage feeder with 48 houses, with each house having a heat pump and a BEV with a 3,7 kW (single phase) charger

Source: Dansk Energi; Monitor Deloitte

2 Distribution System Operators face challenges to deliver the Energy Transition

Key messages

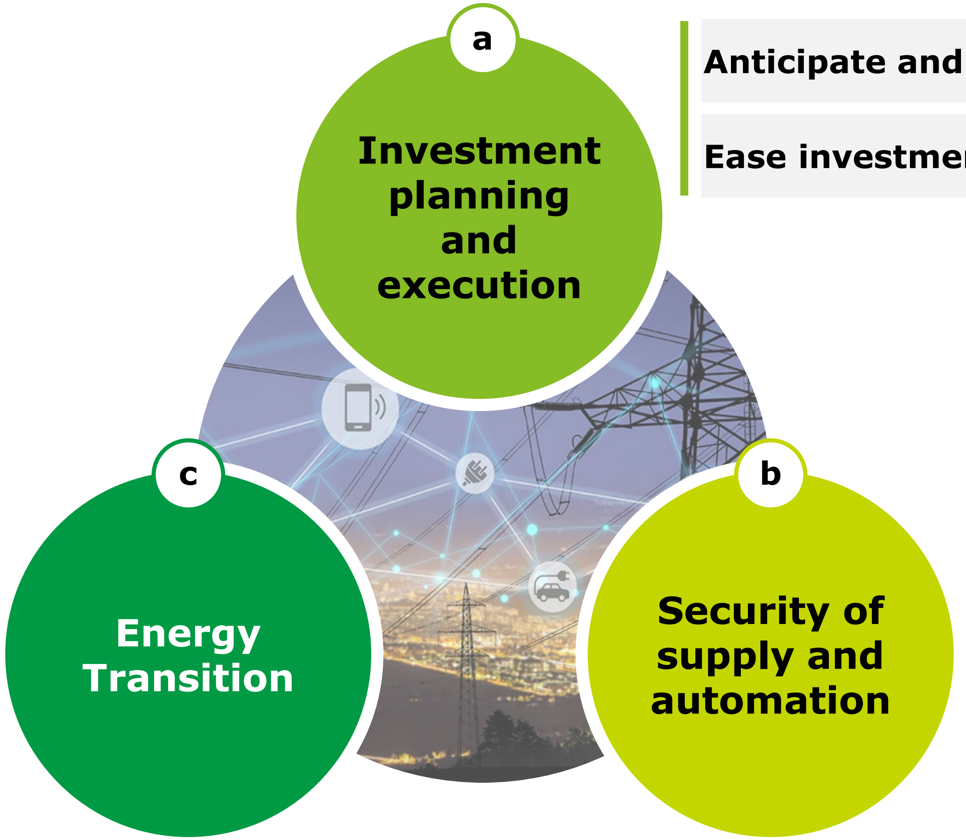
- **Investment planning and execution** present challenges for DSO to optimise and ease investments:
  - **Anticipate and optimise investments**: monitor grid to anticipate investment needs and optimise planning, etc.
  - **Ease investment execution**: mitigate administrative barriers, reduce execution time, etc.

- **Security of supply and automation** have challenges for DSO around 5 elements:
  - **Modernise grid and smart meters deployment**: mitigate technological obsolescence, increase monitoring at consumer point and LV grid, enable flexibility (e.g. demand response, generation flexibility, EV batteries flexibility)
  - **Enhance grid stability**: reduce equipment saturation, control grid instability in LV grid, grid imbalances, etc.
  - **Increase resilience**: ensure quality of supply while natural disasters/extreme weather events increase
  - **Enhance data management**: collect, validate, store, protect and process large amounts of data efficiently
  - **Improve cybersecurity:** protection against a growing number and sophistication of cyberattacks

- **Energy Transition** bears new challenges for DSOs to integrate massive amounts of new renewables and DER, and flexibility:
  - **Optimise system operation routines with ever increasing levels of variable RES:** control grid imbalances due to higher variable RES penetration, etc.
  - **Integrate distributed resources:** digitalise third-parties to integrate distributed resources, etc.
  - **Enable demand-side participation:** manage increase of peak demand, etc.

2 Power distribution grids are facing several challenges regarding investments, security of supply and automation, and the Energy Transition

Main power grid challenges



a – Investment planning and execution
- Anticipate and optimise investments
- Ease investment execution

b – Security of supply and automation
- Modernise grid and smart meters deployment
- Enhance grid stability
- Increase resilience
- Enhance data management
- Cybersecurity

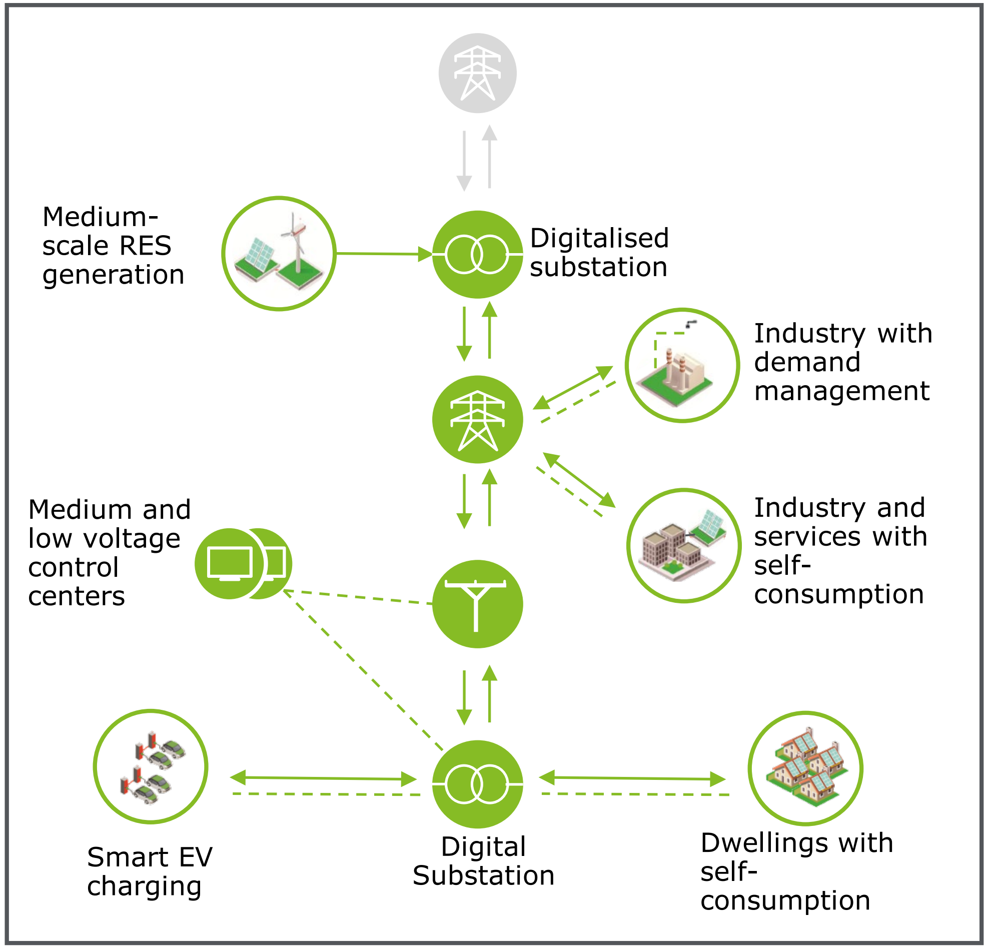
c – Energy Transition
- Integrate variable RES generation
- Enable demand-side participation
- Integrate distributed resources

2 a Optimisation of grid planning and anticipation of investments are key to reduce power grid investments needs within the Energy Transition

Challenges associated to optimise grid planning and develop an agile investment cycle

- **MV/LV grid information does not have enough granularity** regarding key parameters, e.g.
  - Smart meter data
  - Grid parameters (e.g. voltage)
- **LV asset data bases does not enable massive data management**, e.g. to understand more accurately investment needs
- **Grid congestion and technical imbalances in existing equipment, e.g.**
  - LV local imbalances due to **consumption connections to a single phase**
  - MV/LV power grid saturation due to **growth in residential, service or industrial consumption** in recent years
  - Saturations of substations due to **high connection of renewables in specific areas**

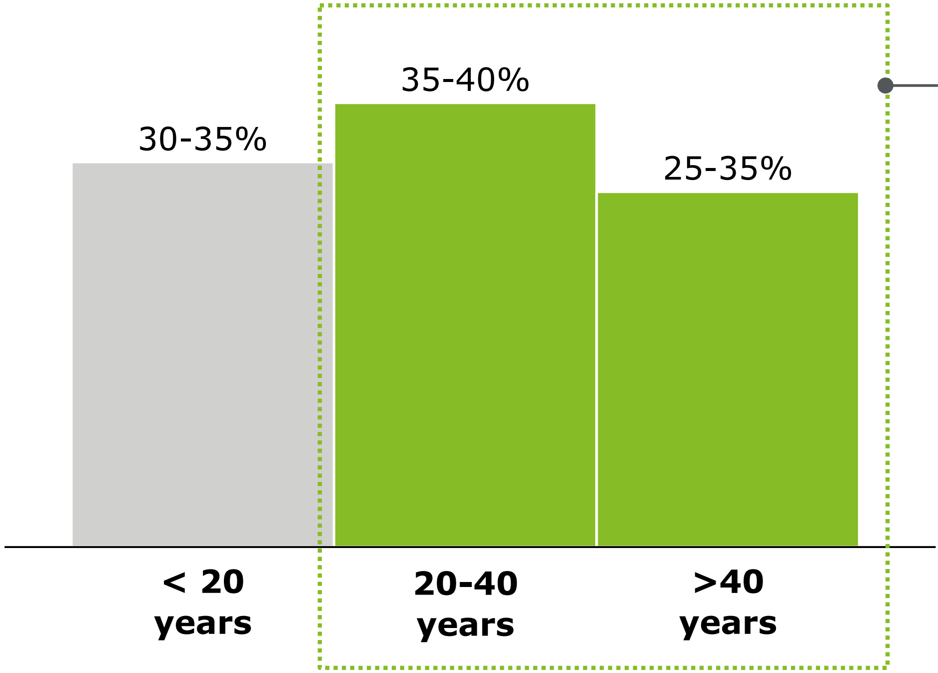
Power Distribution Grid of the Future



Source: Monitor Deloitte

2 b Power distribution grid is ageing and may present an increasing risk of technological obsolescence, especially MV and LV power lines

Average age of the LV power lines in 2020
(% of power lines)



Key aspects related to power grids ageing towards 2030

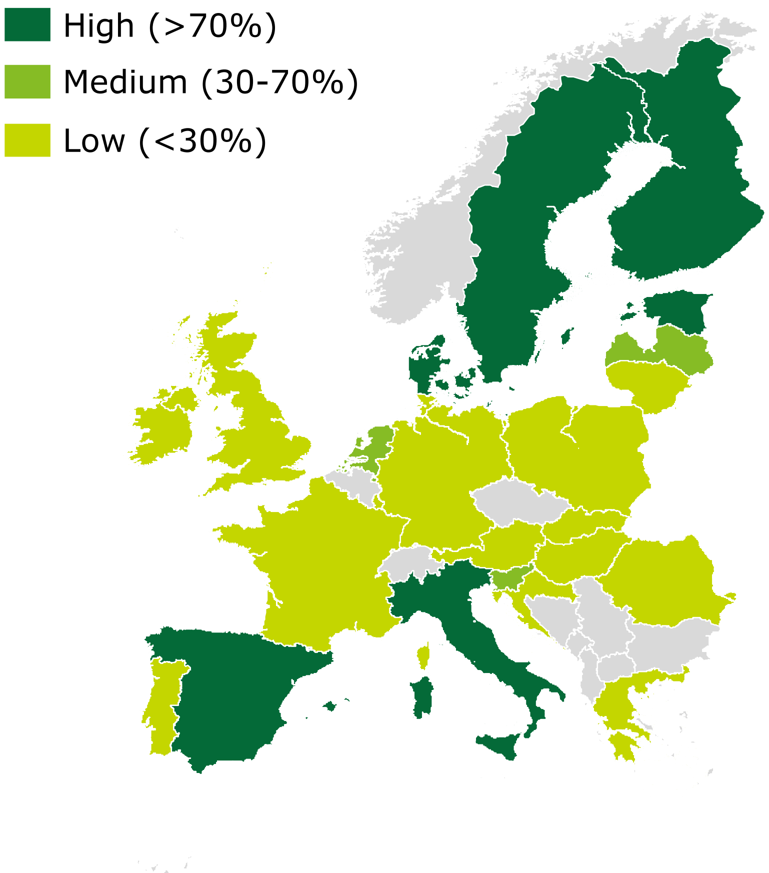
- **There may be growing investment needs related to modernisation towards 2030** at EU level
- If assets are not replaced after their useful life, **40-55%[1] of the assets could be >40 years old by 2030** at EU level
- Modernisation needs vary depending on **power grid expansion time pattern at national level**, e.g. countries that had an economic expansion in the 90s (e.g. Denmark), may present a maximum of replacement needs around 2030

It is key to plan equipment replacements to ensure compatibility with new digital assets (e.g. digitalised switchgear) and avoid obsolescence, to maintain high levels of power grid robustness

(1) 2030 figures have been estimated considering that half of the equipment in the range 21-40 years in 2020 will be >40 years in 2030
Source: Eurelectric; DSOs and associations; Monitor Deloitte

2 b Smart meters are key to increase distribution grid observability, optimise grid investments and enable flexibility services

Smart meters penetration rate in EU27+UK countries(1)
(%; 2017)



Representative benefits of smart meters to the power system

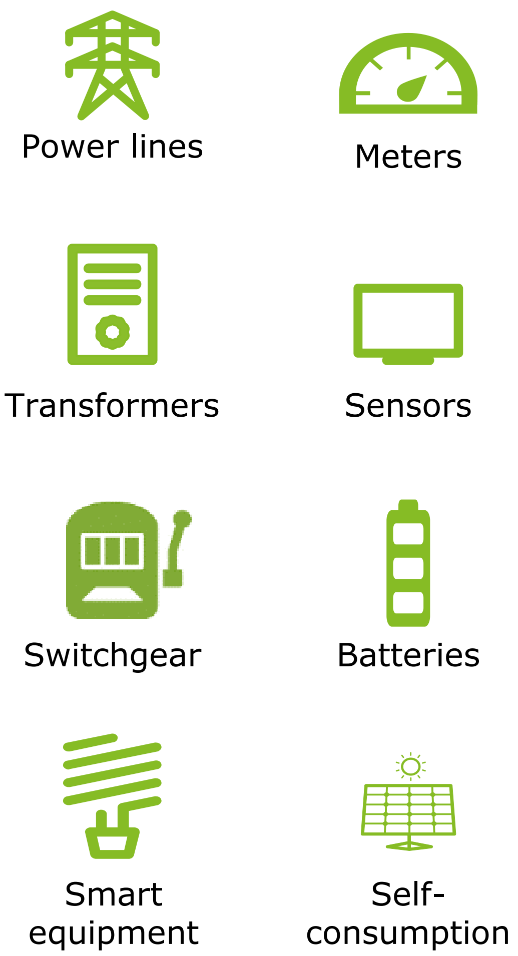
Accurate and transparent information	• **More transparent, accurate, secure and faster access to data** related to LV and MV grids • **Greater observability of the LV and MV distribution grid** key parameters (consumption, voltage, frequency) • **Enabler of two way communication** for maintenance and control
Cost optimisation	• **Optimisation of the distribution grid planning, management and maintenance,** through monitoring and remote control with faster access to data • **Fraud prevention** and detection • **Consumption optimisation by end-customers**
Flexibility services	• Key enabler to foster **demand participation** (through real-time monitoring) **and the development of new flexibility services** (e.g. smart charging, generation flexibility, EV batteries flexibility)

(1) It does not include data from Belgium, Bulgaria and Czech Republic
Source: European Commission; Monitor Deloitte

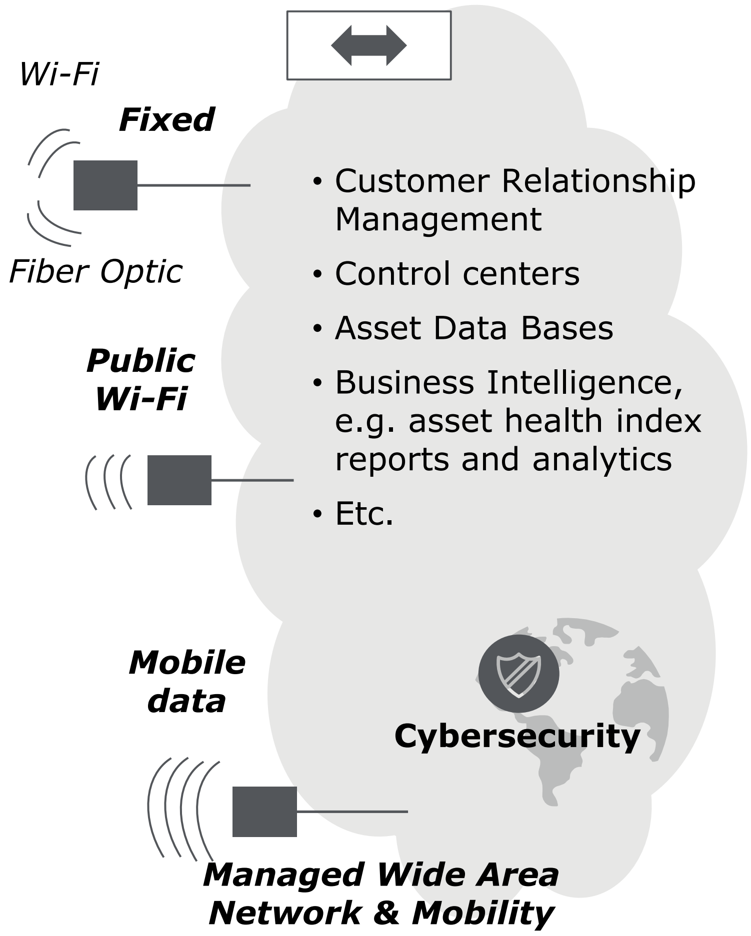
2 b A holistic data management model performed by the DSO is key to enable an efficient power distribution activity

Representative elements related to data management by DSOs

Representative managed devices



Connectivity - Smart Grid Network



Core tasks

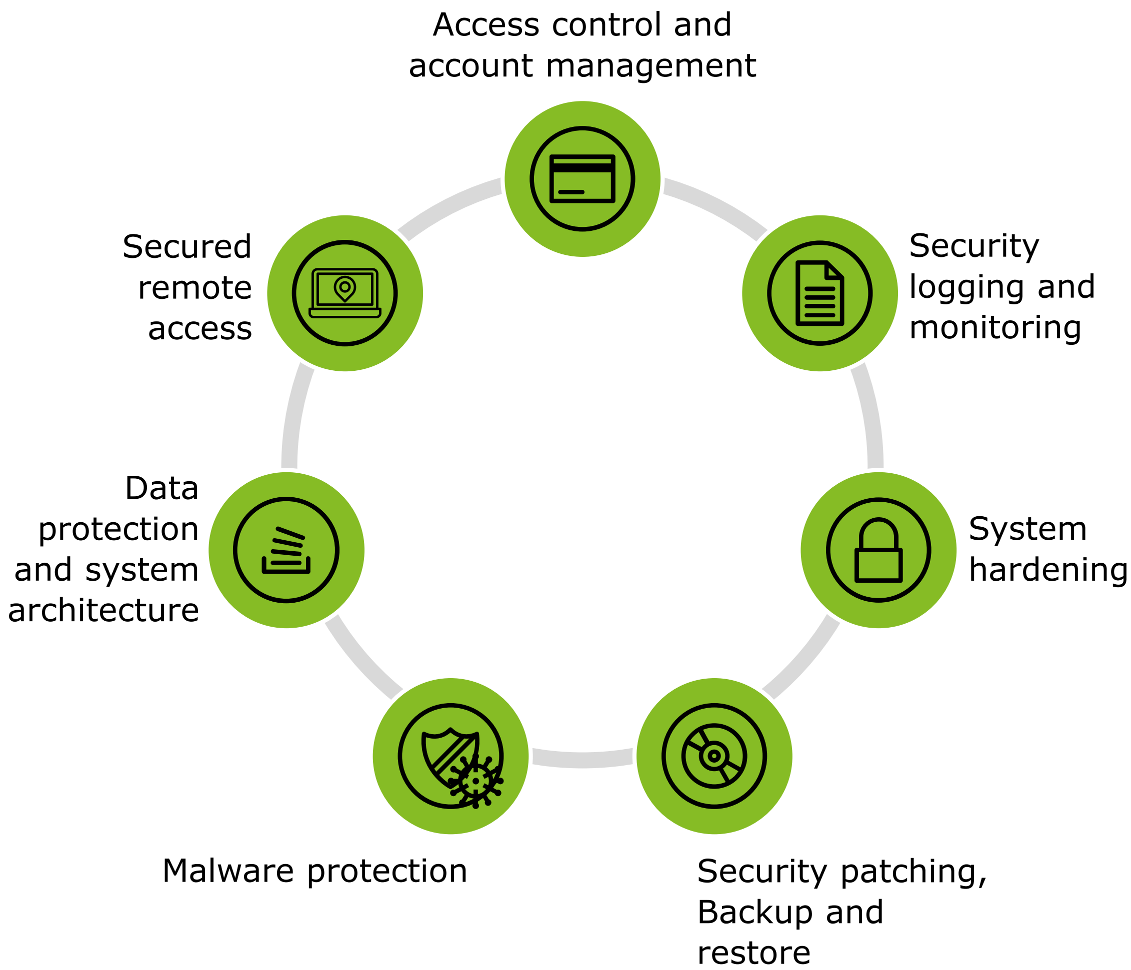
- **Collect** key variables from customers and power distribution grids (voltage, frequency, etc.)
- **Validate** the collected data to ensure accuracy
- **Store** the information in a safe and efficient cloud storage that ensures transparency with key players (e.g. customers, regulator, TSOs)
- **Protect** the information against cyberattacks (e.g. malware protection, safety communication protocols, etc.)
- **Process** the data to optimise the usage and investments in power distribution grids (e.g. foster flexibility)

2 b Cybersecurity risks may impact power grids; mitigation requires holistic measures to address them

Examples associated with cybersecurity attacks to power grids

- **United Kingdom (May 2020):** power grid company suffered a cyberattack targeting IT systems that affected operations (email accounts blocking)
- **Portugal (April 2020):** hackers accessed systems and claimed to have obtained 10TB of sensitive data from a from a power utility in order to ask for a ransom (€10m)
- **ENTSO-E (March 2020):** European Network of Transmission System Operators suffered a cyberattack that impacted its operations at its internal network
- **Ireland (August 2017):** hackers installed a malicious software used by an Irish power retailer, accessing to encrypted company's communications
- **Ukraine (December 2015):** hackers are able to compromise information systems of three DSOs and temporarily disrupt the power supply to +230k consumers

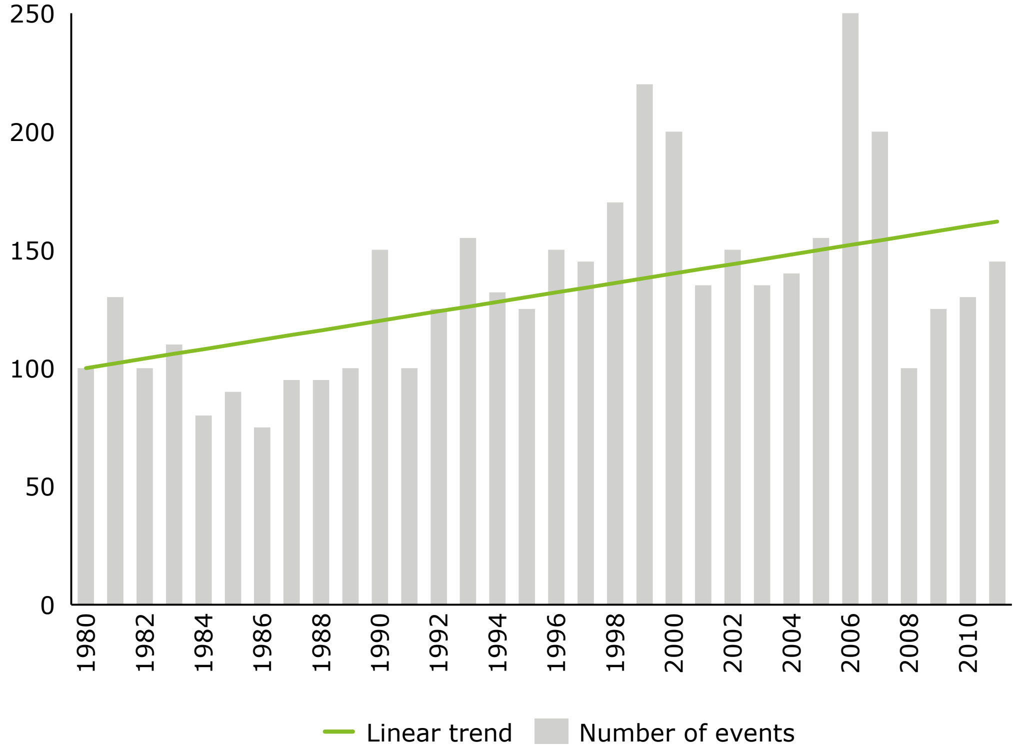
Representative cybersecurity measures



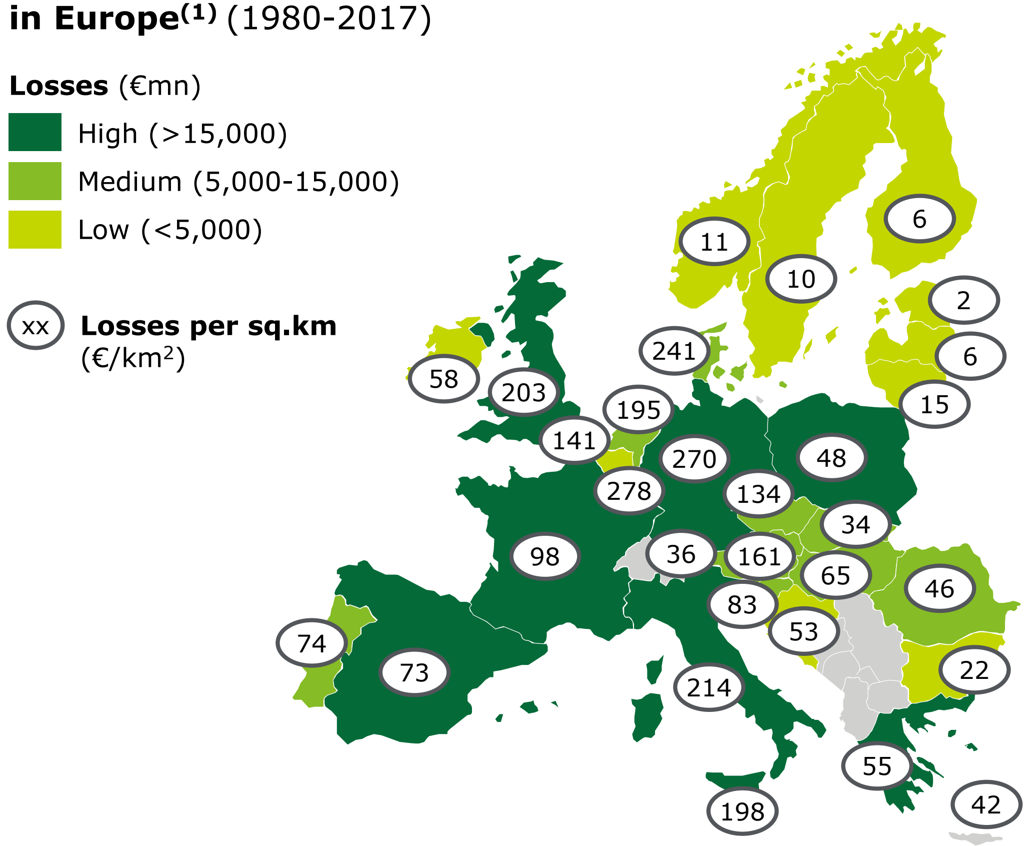
Source: Siemens; Monitor Deloitte

2 b The increase in natural disasters and extreme weather events makes it necessary to invest in more resilient grids to ensure security of supply

Natural disasters in Europe[(1)]
(number of events)



Impacts of extreme weather and climate related events in Europe[(1)] (1980-2017)



Resiliency is key for climate change adaptation, but also for building stronger and safer energy infrastructures at European level

(1) European Economic Area (EEA) member countries from 1980 to 2011. It includes geophysical events (earthquake, tsunami, volcanic eruption), hydrological events (flood, mass movement), meteorological events (storm), climatological events (heat wave, cold wave, drought, forest fire). Ireland should present a single figure for extreme weather events; however, the information source only distinguish between Republic of Ireland and United Kingdom (including Northern Ireland), as it is shown in the map
Source: European Environment Agency; DSOs and associations; Monitor Deloitte

DSOs need to ensure efficient operation with high amounts of variable renewable generation

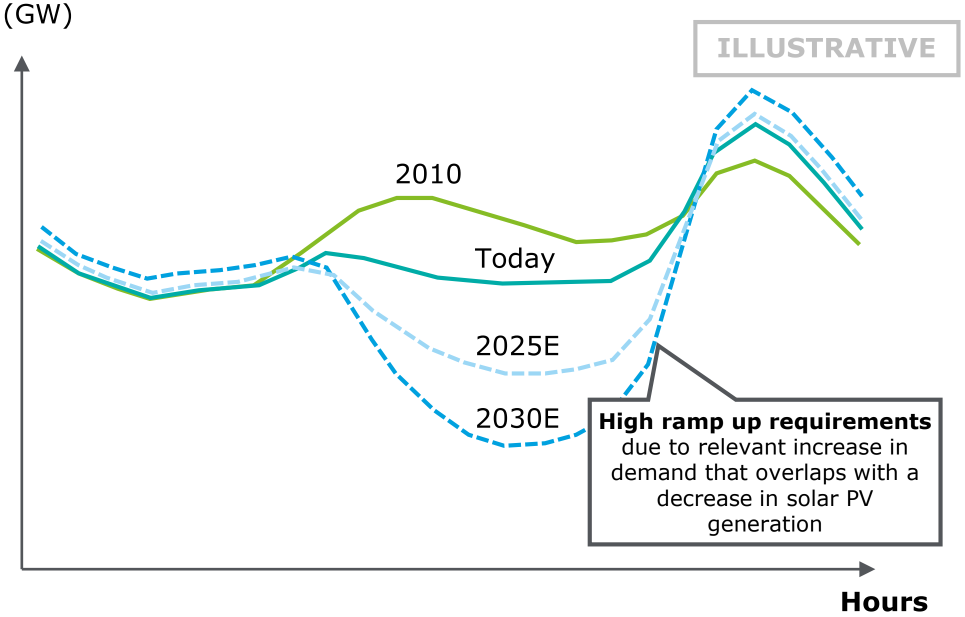
2 C

Challenges related to integration of variable renewable generation

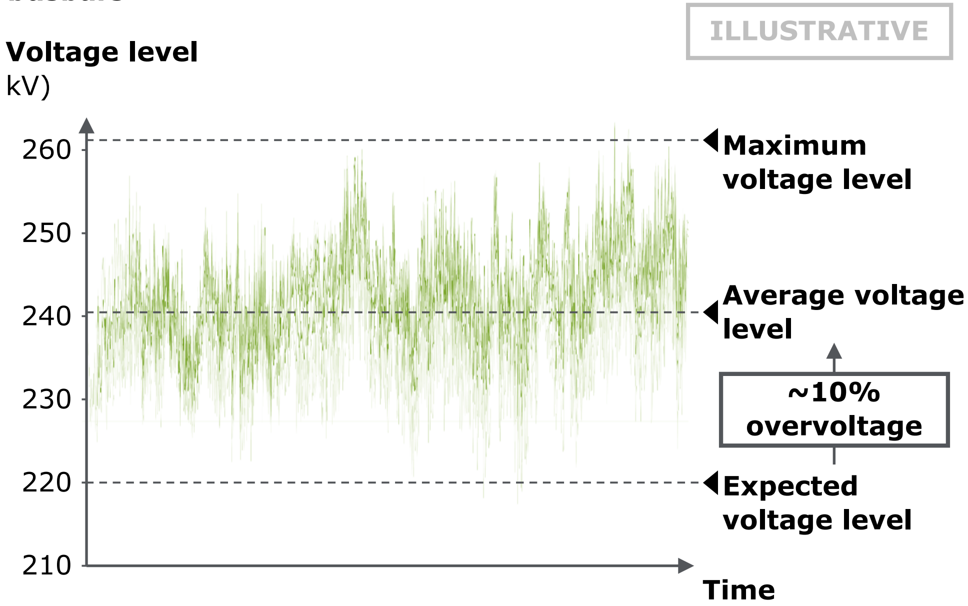
- **Monitoring and control more volatile** grid parameters with impact in security of supply (i.e. voltage, frequency)
- **Manage increasing line and substation aging** due to more volatile power flow
- **Re-dispatch self-consumption** at power distribution grid level

- **Manage grid parameters surges in real time** that may lead to increased aging in lines and substations
- **Facilitate the integration of greater variable renewable generation** (e.g. self-consumption, wind onshore)
- **Enable the operation of renewable generation at distribution level** (e.g. redispatch)

Net hourly demand[1] within a representative day (GW)



Real time voltage readings at representative High Voltage busbars



(1) Hourly demand minus variable renewable generation (e.g. wind, solar, etc.)
Source: Monitor Deloitte

2 c Distributed Energy Resources (DER) integration requires, among other equipment[1], digitalisation, automation and communication across the MV/LV grid

Simplified scheme of self-consumption and smart charging integration in power distribution network

Smart Equipment and Usage

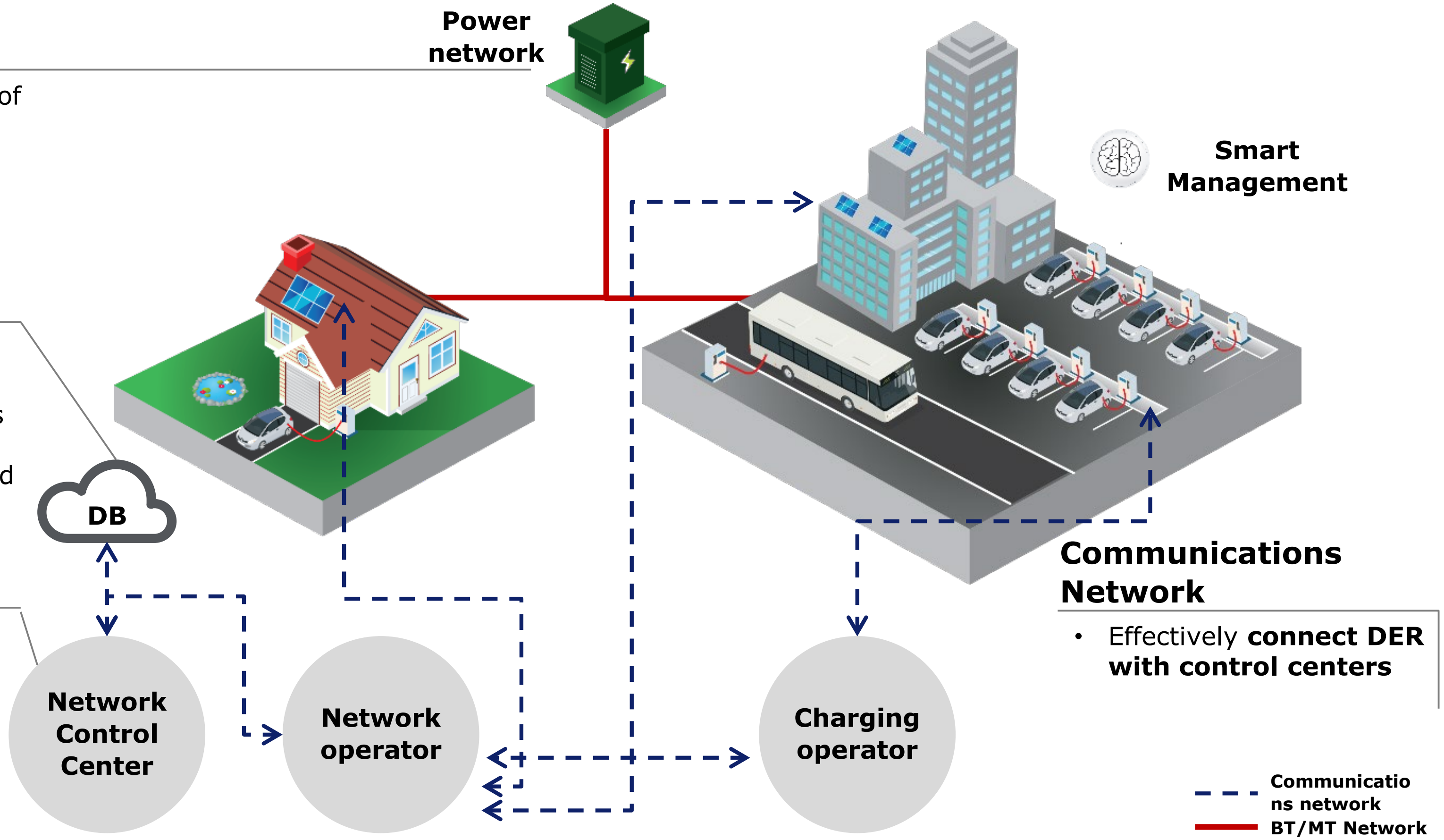
- **Monitoring and remote control** of power grid and DER (EV charging, self-consumption, distributed and large scale storage)

Information Systems

- **Cloud data storage and energy management software/systems** to process information and optimize the integration of DER with demand

Advanced Algorithms

- **Self-learning algorithms** with collected data from DER



Communications Network

- Effectively **connect DER with control centers**

Smart charging systems coupled with distribution grid digitalisation could significantly reduce the investments needed in power grids

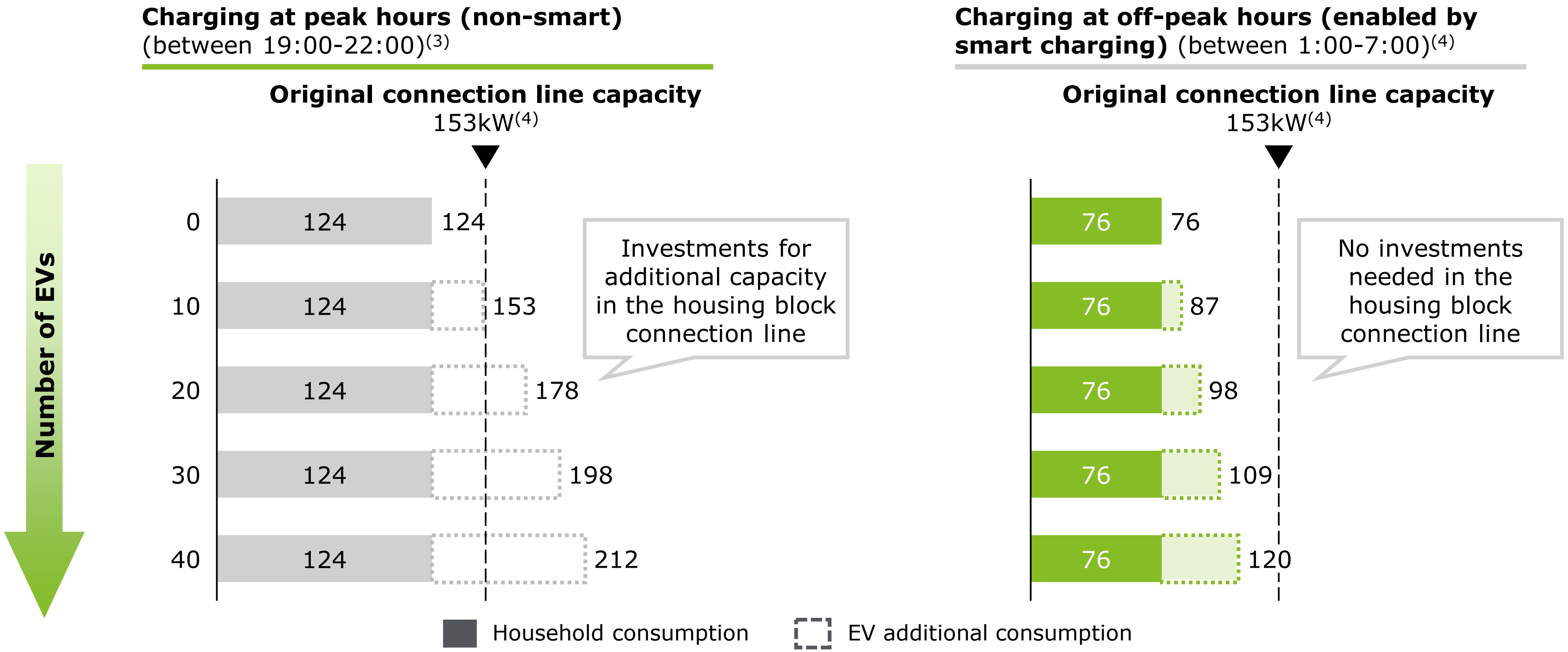
(1) For example, new equipment such as line up-ratings and transformers for short circuit ratings driven by inverters
Source: Eurelectric; DSOs and associations; Monitor Deloitte

Flexibility will influence some grid investments to integrate higher electrification and renewable penetration, but there are trade-offs between local/system considerations, and between grid/customer needs

2
C

ILLUSTRATIVE

Impact of EV smart charging[1] in the saturation of a connection line in a housing block [2]
(kW)



Regulatory policies should enable appropriate cost-reflective tariffs (e.g. related to time of usage, demand rate or variations on same) to develop flexibility measures

(1) Smart charging involves the process of charging to reduce avoidable and costly spikes in power demand and the use of EV batteries as storage to deliver valuable services to the power system, e.g. to maximise local integration of renewable energy sources (and thus, reducing investment needs in power grids); (2) It considers a 40 dwelling building with a maximum capacity of 6 kW per dwelling and a simultaneity of 62% (simultaneity without EV). The building include a parking with 40 slots. A maximum charging capacity of 3,7 kW per charger has been considered; (3) At peak hours, each households consumes 3,1 kWh without EVs. EV charging simultaneity reduces along with EV penetration, from 80% (10 EVs) to 60% (40 EVs); (4) At off-peak hours, each households consumes 1,9 kWh without EVs. EV charging simultaneity is reduced to 30% thanks to smart charging
Source: Monitor Deloitte

2 Distribution grids will require transformational assets to mitigate power grid challenges: security of supply, automation and enabling the Energy Transition

Equipment	**Upgrading/renewal of existing assets and advance protection systems** to provide extra capacity	**Digital substations/ transformers, advanced sensors and smart meters** to enhance grid monitoring, stability and control	**Redundant equipment, underground lines and back-up storage** (e.g. batteries) to increase security of supply	**Drones** for power grid geographical mapping and optimising maintenance
IT/OT Systems	**Systems** with faster access to data for grid management at **local/node level** (e.g. SCADA) and **edge computing**	**GIS and mapping systems,** including grid capacity maps and power flow analysis tools	**Cloud data storage and management** systems	**Cybersecurity software solutions** (e.g. malware protection)
Communications	**Telecommunication infrastructure** (e.g. optic fiber, mobile/broadband network)	**Communication protocols with third-party physical assets/systems**, including, aggregators or ESCOs	**Communication protocols** to connect DSO systems with renewable generators	
Advanced analytics	**Prediction** of load curve, generation or natural disasters	**Management and control** of the grid	**Predictive maintenance**	**Cybersecurity software solutions** (e.g. malware protection)

Source: Eurelectric; DSOs and national associations; Monitor Deloitte

3 Power distribution grids require investments of 375-425 billion euros in 2020-2030 in EU27+UK

Key messages

- **375-425[1] billion euros of investments in the power distribution grids** will be needed in EU27+UK in 2020-2030, considering:
  - Estimation is based on **empirical data provided by 10 Distribution System Operators (DSOs),** and **represents the particularities** of the EU countries
  - **DSOs have analysed and collected data on 8 key investment drivers** that reflect investment needs of power distribution grids
  - **Flexibility measures** (e.g. diversify EV charging over time) that **increase the cost-effectiveness of the investment scenario**
- **Annual investment effort is 50-70% higher than historical data** to support renewable integration (+510 GW), increase in power demand (1,8% annual growth), increase flexibility (e.g. diversify EV charging to enable >50% EV charging in off-peak hours) or voltage uprating. The **grid investments growth (+50-70%) is lower than** total **investments growth needed in the entire energy sector (+100%)** to reach out carbon neutrality. Distribution investment impact on **electricity cost will grow (CAGR~1.5%) lower than the inflation rate target at EU level (2%)**
- Power distribution grid investments provide **relevant benefits to society** around **sustainability** (i.e. allow electric mobility deployment and renewables), **competitiveness** (i.e., enable electricity price reduction and fuel import reductions, due to higher electrification with renewables), **economy** (i.e., manufacturing activity and quality jobs) and progress towards **customer centricity** (i.e., new services)
- An **increase GHG reduction target**, from current targets to a 50-55% reduction in 2030, **would result in a marginal impact on grid investments (~8%)**

(1) Total investment figures correspond to EU27+UK, extrapolated from the information provided by the DSOs of 10 countries (~70% of EU electricity demand). Figures represent the investments developed by Distribution System Operators in power grids and do not cover a systemic perspective
(2) The primary objective of the ECB's monetary policy is to maintain price stability. The ECB aims at inflation rates of below, but close to, 2% over the medium term.

3 Power distribution grids require an integrated and coordinated investment program in 8 key drivers

Electrification of buildings & industry

- Thermal uses in residential and services, including electric heating
- Industry
- New customers

Electrification of mobility

- Road transport**:** electric vehicles
- Maritime transport (*cold ironing*)
- Railway transport

Emission-free generation

- New centralised renewable capacity connected to distribution grids
- New self-generation capacity

Resilience

- Investments (e.g. redundancy, underground lines) related to expected increase of natural disasters (e.g., floods, earthquakes, etc.) or extreme weather events

Modernisation

Replacement of the grid infrastructure that reaches the end of its useful life

Digitalisation and automation

- Active system management, including IT/OT systems and algorithms
- Digitalisation of substations
- Digitalisation of control centers and current communication systems
- Cybersecurity
- Digitalisation of third-parties (e.g. self-consumers)
- Integration of smart meters in all key business processes

Smart meters

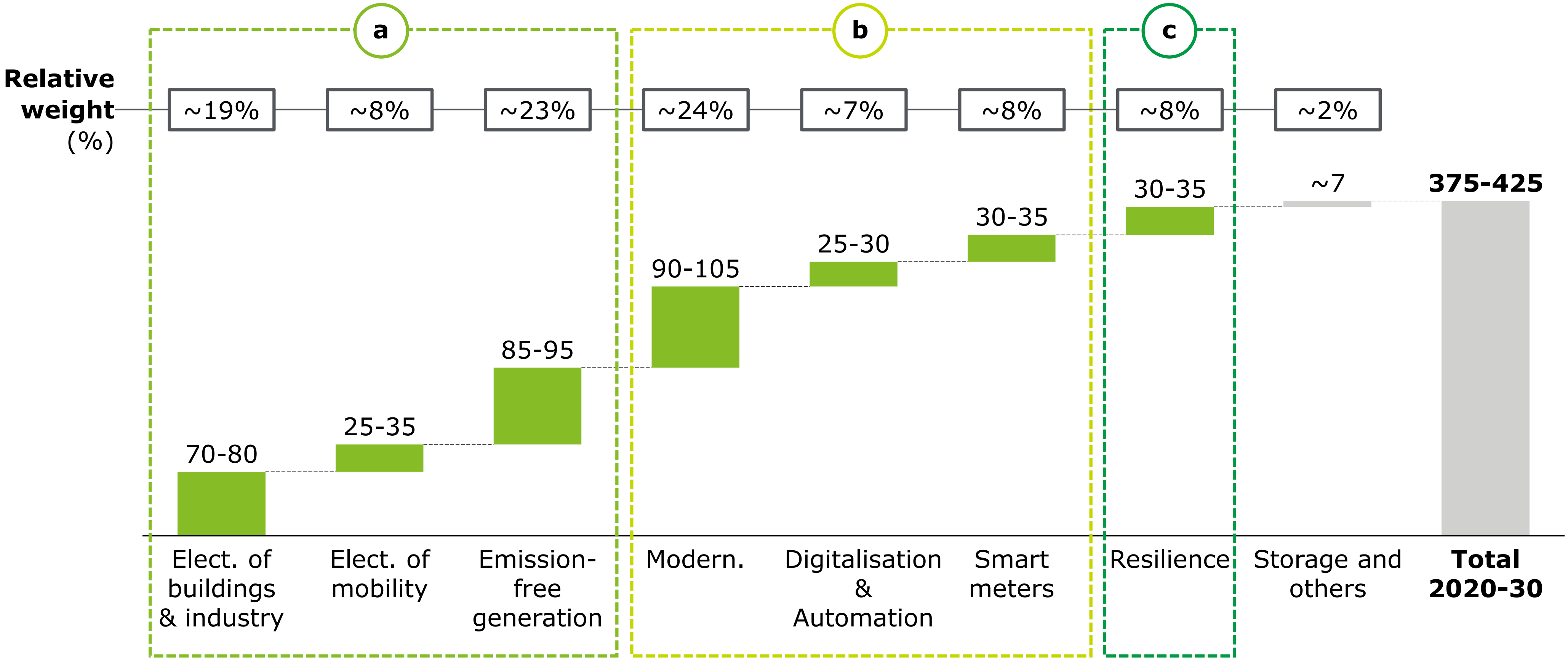
- Smart meters deployment, including second generation of smart meters

Storage & others

- Large scale storage connected to distribution grid
- Other minor investments for grid activity

3 Distribution grids will require 375-425 €bn of investments during 2020-2030 in EU27+UK

EU27+UK DSO investments in power distribution grids breakdown per relevant investment drivers
(nominal €bn; 2020-30)



We consider cost-effectiveness in our scenario through load flexibility measures, e.g. smart EV charging (i.e. diversified EV charging) reducing the economic impact of electrification of mobility

Source: DSOs and national associations; Monitor Deloitte

Electrification and decarbonisation will require new power lines, reinforcements and additional transformer capacity

3 a

Country	**Investments in distribution grids due to electrification and renewables by country** (nominal €bn; 2020-30)	**Final electricity demand** (CAGR; 2017-2030)	**Electric Vehicles (BEV and PHEV)** (million; 2030)	**RES connected to distribution grid** (GW; 2017-2030)
EU27+UK	**180-210**	1.8%	50-70	+360
Germany	69-71[1]	3.2%	10-24.3	+91
France	25	0.8%	6.0	+55
Italy	10	0.7%	6.0	+35
Poland	9	1.3%	1.5	+10
Spain	9	1.8%	4.0	+16
Sweden	6	1.6%	1.0	+3
Ireland	3	3.0%	0.9	+4
Denmark	2	6.1%	1.5	+6
Hungary	1	2.1%	0.2	+6
Portugal	1	1.2%	0.6	+8

Variable renewables are a main driver for these investments, but they will improve EU competitiveness (e.g. lower generation cost) and sustainability (e.g. GHG reduction)

(1) ~65% of German investments are focused on the integration of 91 GW of renewable generation in the power distribution grid
Source: DSOs and national associations; Monitor Deloitte

3 a Investments to integrate electrification and renewables will depend on several drivers, including the Energy Transition ambition

Power scenario investment driver	Hypotheses sensitivities	Investment variation per sensitivity[2] (nominal €bn)	Drivers that impact on differences in investments among countries
Electrification of buildings & industry[1]	**+40 TWh** of final electricity demand	**3-7.5**	• **Increase of new electricity customers** connected to power distribution grids • **Residential and housing sector structure** (building blocks vs individual houses)
Electrification of mobility	**+5 million of Electric Vehicles**	**2-4.5**	• **Share of EV owners with access to private residential charging point** • **Non-residential charging infrastructure costs** (power grid capacity, charging capacity per point, location in urban areas vs motorways) • **Smart charging ambition** (e.g. diversify EV charging)
Emission-free generation	**+50 GW of RES** capacity **connected to distribution grid**	**3-7**	• Power **facility features (e.g. size, technology)** • **Voltage level** at which the plant is connected to • **Geographical concentration** • **Distance** between facilities and distribution power grid

Investment variation is based on overall cost per driver for the 10 countries analysed and also depend on the power grid typology (e.g. share of underground lines) and other local specificities (e.g. equipment costs)

(1) It includes residential, commercial and industrial sectors
(2) Estimation considering 30th and 70th percentiles on the data from 10 participating countries. It is not a marginal cost
Source: Eurelectric; DSOs and associations; iea; Monitor Deloitte

3 b Replacement of obsolete infrastructure and increase of digitalisation levels are key to ensure security of supply and efficient grid management

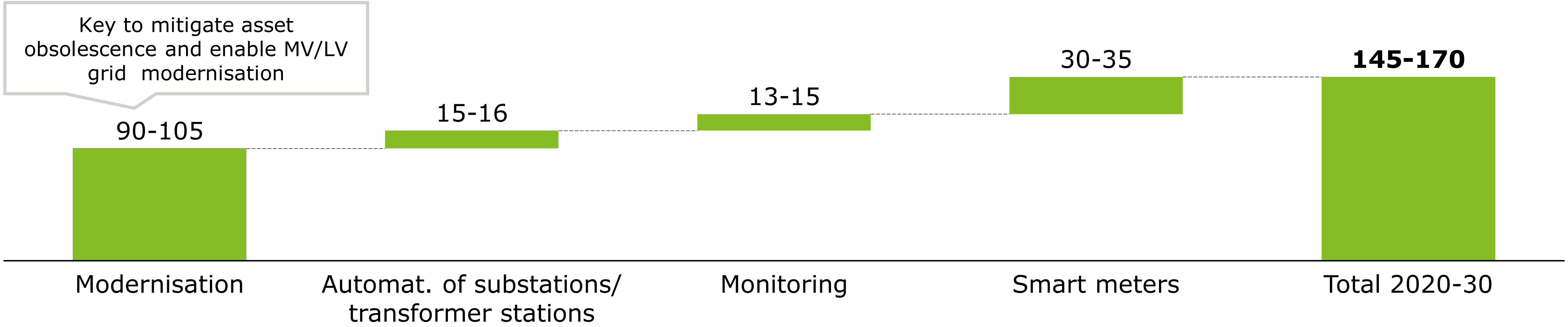
	Investments in modernisation, digitalisation and smart meters per country (nominal €bn; 2020-30)	**Distribution circuit length** (thousands km; 2013)	**LV/MV transformers >40 years old** (%; 2020)	**Penetration of smart meters**[(1)] (%; 2017)
EU27+UK	**145-170**			
Germany	30	1,773	12%	~0%
Italy	19	1,105	n.a.	99%
France	19	1,293	20%	22%
Spain	12	695	28%	93%
Poland	10	774	17%	8%
Sweden	6	529	20%	100%
Denmark	3	172	25%	70%
Ireland	3	168	9%	~0%
Portugal	3	223	8%	25%
Hungary	2	162	32%	1%

Examples of **relevant variables related to modernisation, digitalisation and smart meter investment** level per country

(1) Countries are expecting that smart meters will reach +80% of EU end-consumers by 2030
Source: CEER; Eurelectric; DSOs and national associations; Monitor Deloitte

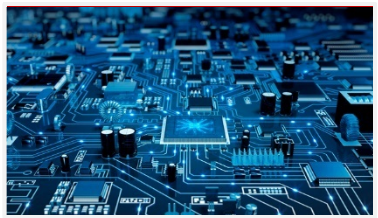
3 b ~40% of the total accumulated investment needs to be allocated to modernisation, digitalisation and smart meters deployment

Breakdown of investments in modernisation, automation, monitoring and smart meters deployment
(nominal €bn; 2020-30)



- **Replacement and modernisation of grid assets** (e.g. lines, transformation centers), to maintain high levels of robustness

- **Automation of substations at distribution level**, including remote control of substations



- **Grid monitoring** to improve efficiency and security of supply
- **Data management** (storage, processing, cybersecurity, etc.)

- **Smart meters (1st and 2nd generation)** to enable customers' monitoring and increase observability of LV grid

Digitalisation will increase grid observability and enable smarter and increasing cost-effective power grids (e.g. due to big data exploitation for grid planning and operation)

Source: DSOs and national associations; Monitor Deloitte

3 C Electricity is critical part of the backbone of European modern society and grid resiliency will be key to climate change adaptation

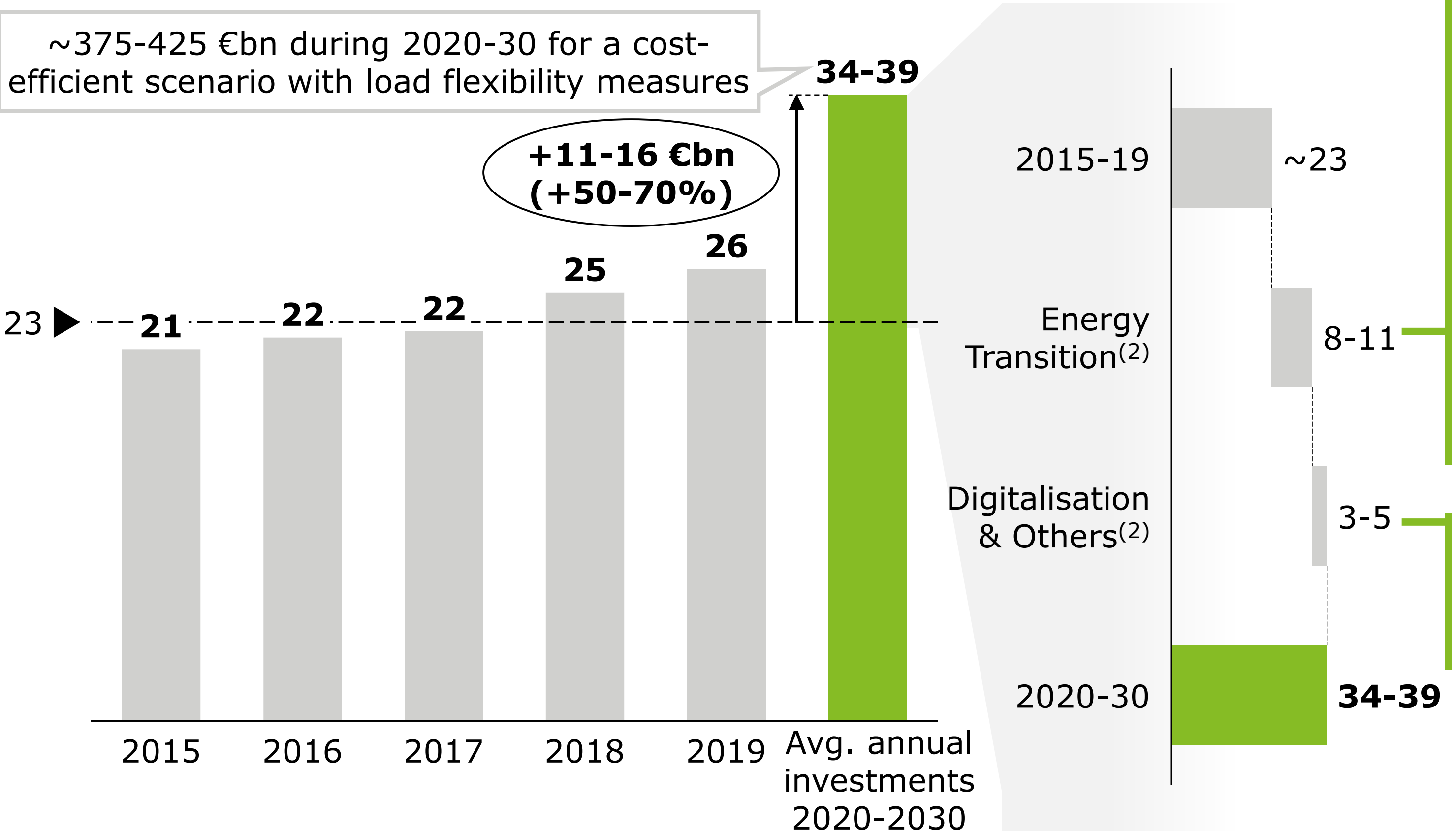
Investments in resilience per country (nominal €bn; 2020-30)		Resilience programs
EU27+UK	**30-35**	
Poland	4.9	• **Ambitious plan to replace overhead lines with underground cables** for the entire MV network to reach the EU average ratio in 2040
Germany	4.4	• **Structurally integrated in their investment plan** as replacements and new lines are mostly underground
France	4.3	• **Resilience plan** to ensure electricity supply under extreme weather events (floods, storms, snow, etc.)
Sweden	4.0	• **Program to shift overhead lines to underground lines and to add capacity**, to reduce the impact of weather events in grids
Italy	2.1	• **Plan to increase resilience** promoted by NRA since 2017 through a set of **incentives based on output indicators**
Spain	1.9	• Becoming of great importance due to more frequent extreme weather events. The plan will be focused on **increasing share of underground lines**
Portugal	0.5	• Becoming of great importance due to more frequent extreme weather events and low share of underground line
Hungary	0.3	• Resilience plan aims to increase **share of underground lines** to improve service quality under extreme weather, add additional capacity and lower opex costs
Denmark	0.3	• Resilience is **not a focal point** of the investment plan as there is already a **high share of underground lines**
Ireland	0.2	• In the context of a relatively **benign climate** and few extreme weather events, the resilience program includes **flood protection and continuity programs**

Resilience investments depend on technical (e.g. grid voltage levels, share of underground lines) and economical aspects (e.g. incentives, impact of extreme weather events)

Source: DSOs and national associations; Monitor Deloitte

3 The foreseen investment rises by 50-70% within 2020-2030 mainly due to electrification, renewable integration and digitalisation

EU27+UK annual investments in power distribution grids(1) and key drivers
(nominal €bn; 2015-2030)



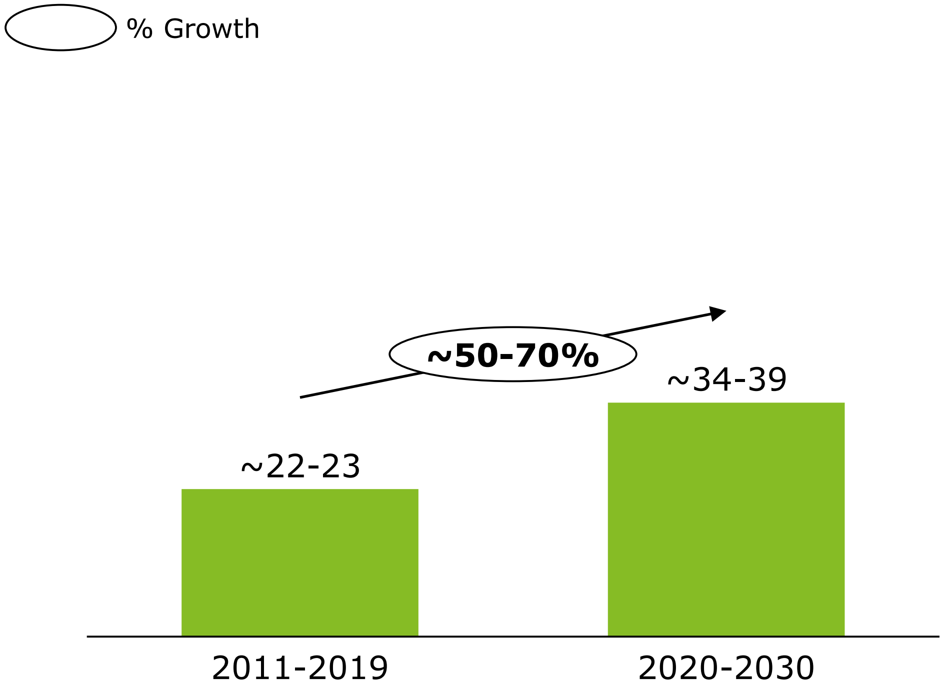
- **+1.8% increase in electricity demand 2020-2030** vs. ~0.2% increase in 2015-2019(3)
- **50-70m new Electric Vehicles** in 2020-2030 (included in +1.8% electricity demand increase)
- **+320 GW centralised renewable** capacity connected to distribution grids and **+40 GW self-consumption** renewable in 2020-2030 (+27 GW annually vs. +13 GW in 2015-2018)
- **+50% of EV charging occurs during off-peak** hours due to **demand management measures**

Investments in power distribution grids will sustain 440-620k quality jobs per year in EU27+UK (e.g. R&D, engineering, construction, etc.)

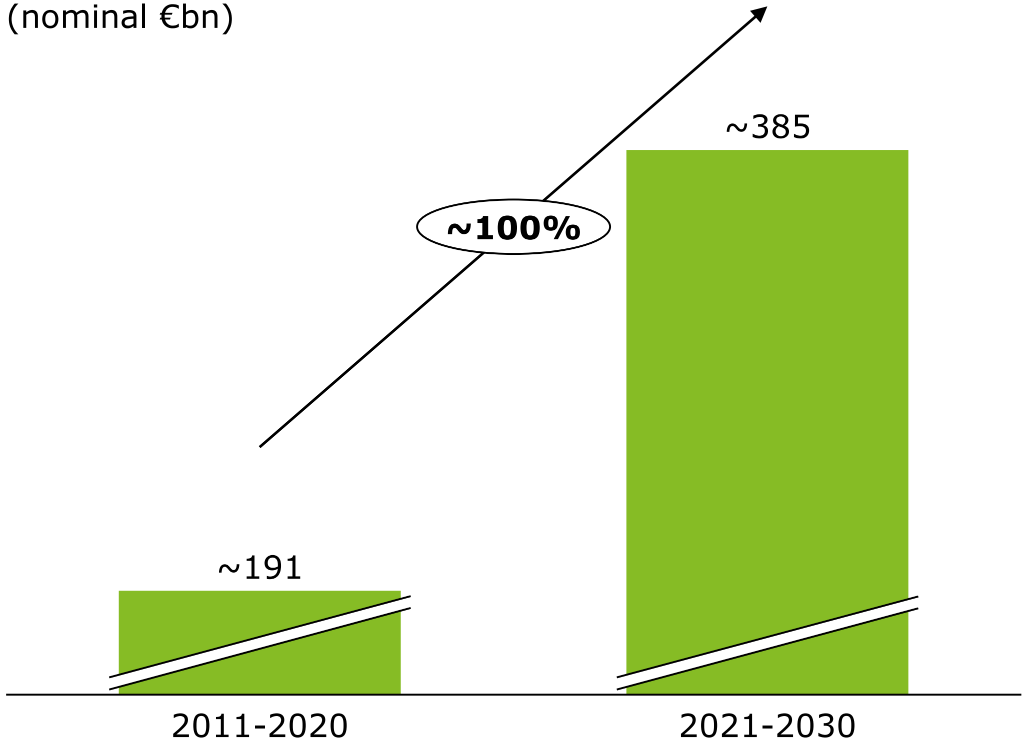
(1) It includes the investments executed by DSOs; (2) Incremental investments in Energy Transition have been estimated by keeping constant unitary investment costs in distribution grids during 2015-2030. It considers ~80% of total renewable capacity in 2015-2019 was connected to distribution grids; (3) Eurostat provisional data for 2019
Source: Eurelectric; Eurostat; iea; DSOs and national associations; Monitor Deloitte

3 The grid investments growth is lower than the overall investments growth needed in the entire energy sector to reach decarbonisation targets

Average annual investments in power distribution grids according to Investment Outlook[1]
(nominal €bn)



Average investments for EU decarbonisation according to EC existing Targets[2] scenario, excluding transport
(nominal €bn)

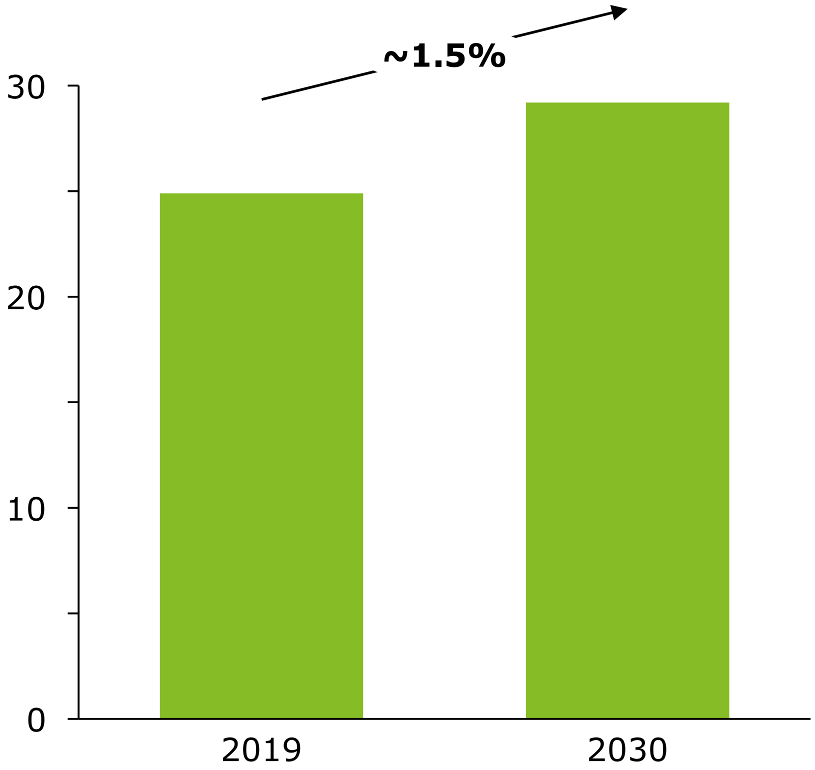


Annual investments in distribution grids will grow ~60% within 2020-2030 (Invest. Outlook), which is lower than the expected energy investments growth ~60-100% for decarbonisation

(1) It includes the investments executed by DSOs
(2) European Commission BSL scenario, with 46% GHG emission reduction by 2030. Figures are EU27 average values for the midpoint of each period (2015 and 2025) in €bn nominal. It excludes Transport sector investments. Supply side (e.g. grids, power generation, boilers) and demand side (e.g. buildings, industrial equipment) investments related to energy sector.
Source: European Commission; Eurelectric; Eurostat; European Central Bank; DSOs and associations; Monitor Deloitte

3 Grid investments will have a marginal impact on electricity costs in the short term

Estimation of distribution investment impact on electricity cost per electricity unit[1]
(€nominal/MWh; EU27+UK)



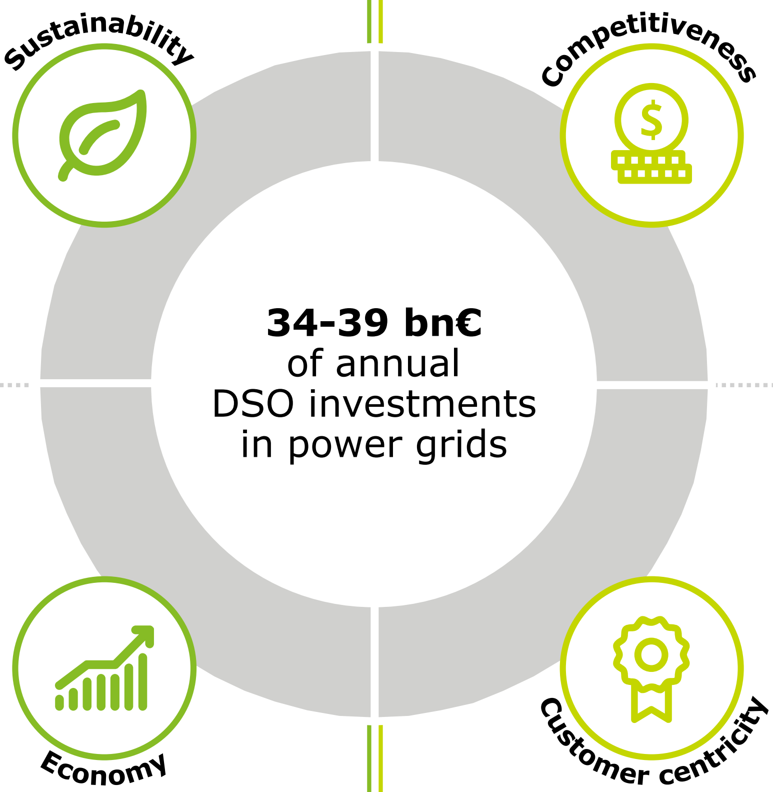
....but will ultimately help lower the total energy bill

- Distribution investment impact on **electricity cost will grow (CAGR~1.5%) lower than the inflation** rate target at EU level (2%)
- **Investments in power grids are a no regret option bringing short and long term benefits:**
  - **Reduce incremental investments needs and tariff impact in the long term,** considering also the efficiency effect from grid modernisation and digitalisation,
  - **Enable renewable deployment and electrification that will ultimately reduce total energy bill**, (i.e. through lower marginal cost of renewable generation, cost savings via heat pumps, e-vehicles)
  - **Enable flexibility measures that increase cost-effectiveness** and may also contribute to reduce tariff impact

(1) Rough estimate taking into consideration available DSO input. 2019 final power demand has been estimated considering Investment Outlook scenario and DSOs assessments
Source: Eurelectric; DSOs and associations; Monitor Deloitte

3 Distribution grid investments will bring widespread benefits to society and contribute to the EU economic recovery and the Energy Transition

Benefits from the development of power distribution grids as enablers of the Energy Transition



Sustainability

- **17-22 bn€ of average annual savings in CO_2 emissions[(1)]** to enable 50-55% GHG emissions reduction compared to 1990 level
- **40-140 bn€ of annual savings in external costs** of health issues and **58,000 premature deaths** avoided[(2)]
- **460 Mtoe of final energy consumption will be reduced**[(3)] by 2030**,** achieving a 32.5% of efficiency target

Economy

- **30-35 bn€** (~90% of investments) **of** annual revenue that may **potentially be captured by EU companies** (manufacturers and service providers)
- **440-620k quality jobs per year[(4)]** related to DSO grids (R&D, O&M, etc.) promoting local cohesion and economies
- Territorial cohesion and **promotion of local and regional economies**
- **~0.2-0.3% of current EU GDP** in annual investments in power distribution grids
- **~120 €/Customer in 2020[(5)]** in annual investments in power distribution grids. It may decrease as the numbers of customers would increase due to increasing electrification

Competitiveness

- **Renewable deployment and electrification will ultimately reduce total energy bill**, (i.e. through lower marginal cost of renewable generation, cost savings via heat pumps, e-vehicles)[(6)]
- **+175 bn€ annual savings in fuel import costs[(7)]** (current EU energy dependency is 55-60%)

Customer centricity

- **~40 GW of self-consumption** capacity additions
- **50-70 m EVs** and **smart charging**
- **New services:** storage, electric heating, smart appliances and demand aggregators

(1) Estimated according to EU 2030 Target vs. European Environment Agency scenario with existing measures (this scenario implies a GHG emission reduction of 5% by 2030 compared to 2020). 6,500-8,000 MtCO2 eq will be abated in 2020-2030. CO2 price considered: 30€/tCO2 eq; (2) According to European Commission Clean Air Package. Major air pollutants considered are particulate matter (PM), O3, SO2, NOx, NH3, VOC and CH4; (3) Estimated according to EU 2030 Target of final energy consumption by 2030 (956 Mtoe) and the 32,5% energy efficiency target; (4) Representative ratio used for job creation: 12-17 jobs per million EUR invested; (5) Customer data from JRC report on DSOs (2019); (6) Also representative LCOEs may be +50% lower for renewables (onshore wind, solar PV) compared to fossil fuels; (7) Representative (minimum) value according to European Commission (benefits of climate action analysis) estimation for the period 2011-2050 (175-320 bn€ annually)
Source: European Commission; JRC; EEA; IRENA; Eurostat; Monitor Deloitte

3 An increase GHG reduction target would result a marginal impact on grid investments (~8%)

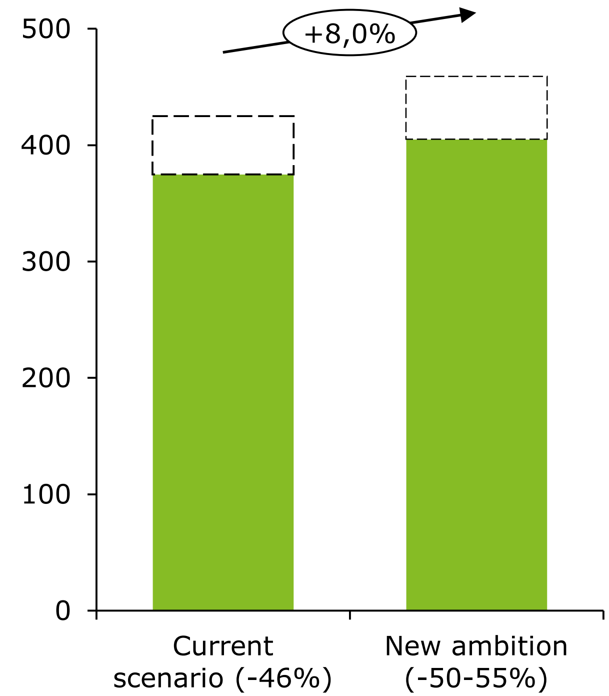
Impact on EU27+UK due to increasing the ambition towards 2030[2]

46% → **GHG reduction (Invest. Outlook and European Commission scenario sets**[3]**)** → 50-55%

Investment driver	Impact
Electrification of buildings & industry[1]	**Up to additional 150 TWh**
Electrification of mobility	**Up to additional 10 mn electric vehicles**
Emission-free generation	**+110-120 GW**
Modernisation, digitalisation and automation	**Investment drivers not affected by an increase in emissions reduction targets**
Smart meters	
Resilience	
Storage and others	

EU27+UK power grid investments 2020-2030

(€nominal billion)



50-55% GHG reduction ambition will imply +25-30 bn€ of additional investments[4] **(+8% compared to current ambition) that is mainly driven by the increase of renewable connection**

(1) It includes residential, commercial and industrial sectors
(2) Impact on main energy model and investment drivers for 2 scenario sets with different hypothesis, i.e. electrification vs. energy efficiency focus
(3) 2 scenario sets have been considered: 1) European Commission scenarios: BSL scenario vs. MIX, MIX50, REG, CPRICE scenarios (decarbonization through energy efficiency and renewables), and 2) Investment Outlook scenario vs. consistent scenario to increase ambition to ~55% GHG emission reduction (decarbonization through electrification and renewables)
(4) Investment Outlook report investment ratios were computed to deliver the estimation

Source: European Commission; Eurelectric; DSOs and associations; Monitor Deloitte

4 Policy and regulatory recommendations

Key messages

- **Regulatory recommendations[1] in investment planning and execution:**
  - **Flexible and adaptative national planning frameworks aligned with Energy Transition**, removing inadequately regulated investment limits
  - **Facilitate access by DSOs to EU funds,** and investments in power **distribution grids enabled as eligible for EU post-COVID recovery plans**
  - **Involve local communities properly** (e.g. deploying training activities for workers that belong to local communities)
  - **Agile and simple authorisation and permit** granting procedures (e.g. silent-consent administrative procedures for DSO investment authorisations, specific procedures to mitigate barriers for strategic projects)

- **Regulatory recommendations[1] to enable the Energy Transition, as well as security of supply and automation:**
  - **Provide DSOs with new role through the development of EU-wide regulatory frameworks on cyber security and data management** and through a timely and complete implementation of the Clean Energy Package at national level
  - **Forward-looking remuneration**, to enable cost-effective remuneration and incentive models at national level to enable grid transformation and Energy Transition, not only focusing on short term cost savings
  - **Flexibility development through the definition of roles, infrastructure, economic signals and information exchange** procedures at European and national level, ensuring **EU interoperability**
  - **Efficient tariff structures** should be defined to **optimise long-term investments** and **facilitate power system economic sustainability** at national level

(1) Recommendations at national level have been developed based on a transversal understanding of the regulatory needs for all the countries to facilitate a common baseline; therefore, their individual further development at national level should consider each market specificities

4 Over the next 10 years, power grid activity will be transformed to execute investment, improve security of supply and enable the Energy Transition

	Today	DSOs, NRAs and planning bodies efforts towards 2030
Plan and execute investments	• **~23 bn€ annual of investments** in power distribution grids • **~1-2 years on average** from investment planning to execution of LV grid assets	• **~36 bn€ annual of investments** in power distribution grids **(+50-70% increase vs. historical average)** • **Relevant time reduction** in planning and execution to speed up the Energy Transition
Improve security of supply and automation	• **~35% of smart meters** (2017) • **<15% of digitalisation** of LV power distribution grid • **Tariffs do not unlock power system efficiency potential**	• **>80% of smart meters** • **~100% of digitalisation** of LV power distribution grid • **Advanced tariff methodology and grid products** to enable electrification and the use of **flexibility** measures (e.g. demand response, generation flexibility, EV batteries flexibility)
Enable the Energy Transition	• **<1m of EVs and charging points** • **~470 GW** of renewable capacity generation (2018)	• **~70m of EVs, ~56m of charging points** • **~940 GW** of renewable capacity generation

European and national policies/regulation need to adapt to foster power grid transformation process

Source: Eurelectric; DSOs and national associations; Monitor Deloitte

4 Regulatory action is needed at European and national level to mitigate key distribution grid challenges and enable the Energy Transition

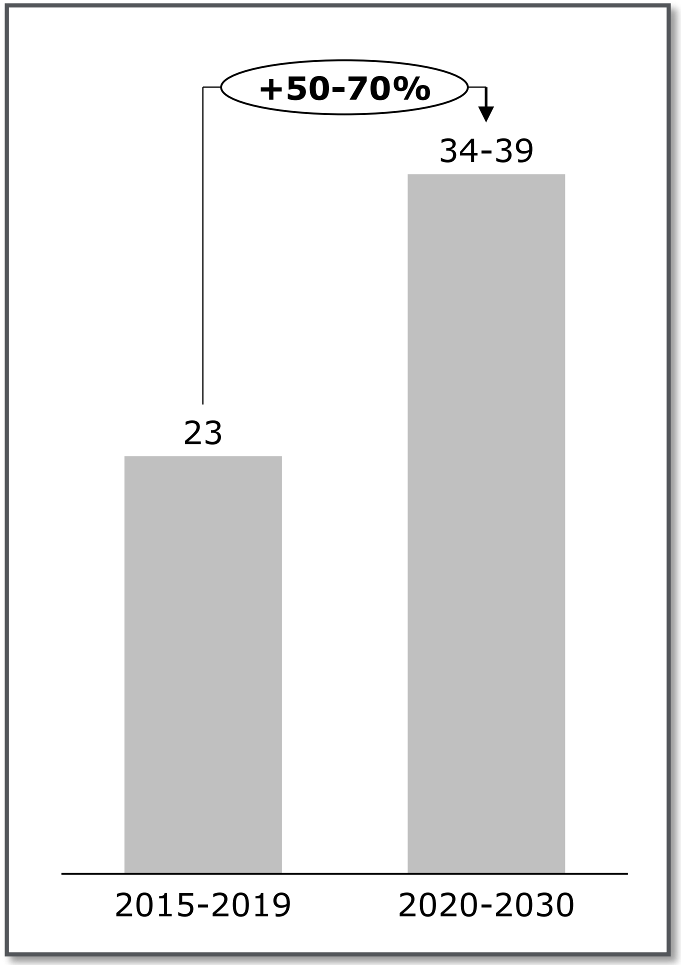
European level | National level

Main challenges		Policy issues	Regulatory actions[1]	Policy level
Plan and execute investments	**a Planning**	**Low long-term visibility and lack of planning** on power distribution grid investments related to Energy Transition	**Facilitate flexible and adaptative national planning frameworks** aligned with the Energy Transition and **remove inadequately regulated investment limits** that may jeopardise the Energy Transition	National level
	b Funding	**Barriers for DSOs to apply for EU funds** and need to **unlock contribution of grids to post-COVID recovery**	**Facilitate access by DSOs to EU funds** (i.e. Multiannual Financial Framework 2021-2027[2]) and prioritise investments in power **distribution grids in EU post-COVID recovery plans**	European level; National level
	c Execution	**Bureaucratic delays** in local permits or environmental authorisations related to grid investments	**Simplify and accelerate authorisation and permit granting processes, facilitating proper involvement of local communities** (e.g. silent-consent procedures for authorisation of DSO invest.)	National level
Improve security of supply and automation	**d DSO role**	**Lack of development of the DSO role principles** established by the Clean Energy Package	**Facilitate a EU General Framework** for cybersecurity and data management, as well as **speed-up Clean Energy Package implementation at national level**, including DSO/TSO responsibilities	European level; National level
	e Remune-ration	**Historic costs and low exposure to disruptions** are intrinsic features of current remuneration models	**Enable forward-looking remuneration, to deliver a cost-effective remuneration and incentive models** at national level to enable grid transform. and the Energy Transition, not only focusing on short term cost savings	National level
Enable the Energy Transition	**f Flexibility**	**Absence of (or in progress) comprehensive regulatory frameworks** around flexibility	**Develop roles, smart infrastructure, economic signals** (e.g. tariffs, grid products) **and information exchange procedures** under EU interoperability principles	European level; National level
	g Tariffs	**Electricity tariffs should be more cost-reflective** and ensure that customers pay for the electricity and grid capacity used	**Enable efficient tariff structures** that **optimise long-term power system investments and** facilitate **power system economic sustainability**	National level

(1) It includes an indication of the administrative level (i.e. EU or national level) on which efforts should be made to develop the recommendation. Depending on the country and the action, national recommendations should be developed by different actors (e.g. regulator, ministry department); (2) Including Cohesion Funds, Connection Europe Facility-Energy, Invest-EU
Source: Eurelectric; DSOs and national associations; Monitor Deloitte

4 a b c Facilitate national planning frameworks aligned with the Energy Transition, as well as agile authorisation processes and efficient access to EU funds

Annual investments in distribution grids EU27+UK (nominal €bn; 2015-2030)



Regulatory recommendations

Planning	• **Facilitate flexible and adaptative national planning frameworks** to: – **Guide grid planning according to climate targets** and adapt investment deployment to the Energy Transition – **Avoid planning bottlenecks and inefficiencies to mitigate investment delays**, including anticipatory planning provisions • **Remove regulated investment limits that may jeopardise the required increase of CAPEX** to enable the Energy Transition
EU funding for grid projects	• **Facilitate access by DSOs to EU funds** (i.e. Multiannual financial framework 2021-2027[1]), ensuring **proper cost recognition of funded assets** and enabling **eligibility of power distribution grids** • **Prioritise and facilitate inclusion of investments in power distribution grids** in the **Next Generation EU post-COVID recovery plans[1]**, since grid investments: – Will contribute to a **more sustainable and competitive economy**, and therefore to **post-COVID recovery** – Are **crucial to the success** of Europe's **green and digital transition**
Authorisa-tion and permit granting processes	• **Simplify and accelerate authorisation and permit granting processes** (e.g. through silent-consent procedures for DSO investment authorisations, speed-up procedures for strategic projects such as high priority line projects to integrate renewables) • **Set out adequate information provisions for grid access applicants** (e.g. inform "closed" nodes to avoid unnecessary workload related to grid access authorisation on those nodes) • **Align regulatory action on cost/remuneration review and deadlines** with the Energy Transition targets and milestones

(1) Including Cohesion Funds, Connection Europe Facility-Energy, Invest-EU
(2) For example, under the Recovery and Resilience Facility, Member States should prepare National Recovery and Resilience Plans for 2021-2023 prior to be approved by EU Institutions
Source: Eurelectric; DSOs and national associations; Monitor Deloitte

4d DSO role should include the development of EU General Frameworks and national actions to speed-up Clean Energy Package deployment

Key regulatory initiatives		Regulatory recommendations
European Union General Frameworks	**Holistic cybersecurity risk mitigation**	• **EU long-term cybersecurity strategy** to enable secure data management at power system level
	Efficient data management	• **EU data management framework adaptable to the specific needs of the countries, to develop DSO responsibilities and capabilities** (e.g. LV grid observability by providing access to DER deployment plans, generation schedules, flexibility management)
Key elements at national level to be considered by National Regulatory Authorities (NRA)	**Transparent information exchange**	• **Advanced procedures and codes for information exchange among different key players, including the TSO** (e.g. procedures to access relevant data for grid management ensuring security of sensitive information)
	Neutral service provision by DSO	• **Advanced procedures and codes for flexibility** and smart metering services
	Effective coordination between DSO and TSO	• **Framework to develop responsibilities and coordination guidelines,** considering DSOs' role principles or new core tasks in the Energy Transition (e.g. DER re-dispatch, real-time monitoring, data governance, cooperation with TSO/ENTSOE for planning)
	Innovation	• **Framework to prioritise actions** (e.g. advanced analytic tools, new technologies, data hubs) and set out **required schemes** (e.g. incentives, sandboxes)

Source: Eurelectric; DSOs and national associations; Monitor Deloitte

4 e Enable cost-effective remuneration and incentive models at national level to enable grid transform. and the Energy Transition, not only cost reduction

	Current issues	Regulatory recommendations
Principles	• Remuneration is **designed for a low disruptive environment** and **does not capture future power grid costs** • **Benchmarking models focused on short term cost reduction**	• **Enable forward-looking remuneration schemes that focus in effectiveness** and enable adaptation to disruption and the Energy Transition, but not only short term DSO cost reduction. The implemented specific **regulatory mechanisms should be predictable and stable in the outcome,** taking into account the asset depreciation. • **Remunerate adequately transformational assets** (e.g. rate of return for innovative investments or useful life for digital assets)
Incentives	• **Skewed towards short term cost reduction**; remuneration does not consider benefits related to Energy Transition for incentive definition • **Increased pressure for OPEX reduction leading to lower incentive to enable power system cost optimisation**, with risk of not incentivising flexibility and new technologies	• Facilitate **incentives for both CAPEX and OPEX**, taking into account the different nature of regulatory treatment. Regulators should **acknowledge an increase of operational costs in the deployment of new innovative network technologies** whenever it is the most efficient solution, considering long-term system-wide benefits • **Evaluate benefits related to the Energy Transition** (i.e. through a proper cost-benefit analysis), **grid losses, fraud prevention, resiliency and structural** development criteria (e.g. medium to long-term benefits across the value-chain, including output based incentives when appropriate) • **Enable technology neutral incentives**, to foster that DSOs invest in the most optimal solutions, whether it is delivered by flexibility or grid assets. The remuneration of the expenses due to the implementation of innovative initiatives should be guaranteed and could be based on output methodology
Process	• **Delays in the development of regulatory reviews** that may jeopardise investments required for the Energy Transition	• **Facilitate adaptive remuneration review processes**, to ensure that approved investments and remuneration adapt to potential Energy Transition disruptions • **Reduce remuneration/cost review process duration** to avoid putting Energy Transition investments at risk (e.g. reduce delays in revenue cap definition)

Source: Eurelectric; DSOs and national associations; Monitor Deloitte

4 f Develop roles, infrastructure, economic signals and information exchange procedures at European and national level, ensuring EU interoperability

Key regulatory initiatives	Regulatory recommendations
Cross border integration and interoperability	• **Facilitate a EU regulatory framework** that ensures market interoperability and cross border integration of flexibility
Roles	• **Define responsibilities** among parties (e.g. consumers, micro-generators, storage operators, aggregators, grid operators, regulator) to deliver flexibility services
Smart Infrastructure	• **Assess flexibility[1] potential across power system infrastructures** and create a plan to exploit it (e.g. locations, facilities, new technologies) depending on particularities of the grid infrastructure (e.g. spare capacity, resilience, age)
Economic signals	• **Facilitate the right incentives for DSOs and market players** to ensure**:** – **An optimal mix** between investments and flexibility, **that minimises the long-term costs and maximises benefits for society** – **Cost recovery with an appropriate margin/return for the DSO**, including required ICT and infrastructure costs • **Develop mechanisms (e.g. tariffs, grid products) for flexibility providers,** that enable efficient price signals, depending on country conditions
Information	• **Enable efficient data exchange and coordination procedures among parties** for optimal utilisation of resources, as well as the secure and efficient operation

(1) Flexibility measures can be classified as load flexibility measures (e.g. demand response), generation flexibility measures (any generator which voluntarily increases/decreases its production to create flexibility) and storage flexibility measures (e.g. batteries for EV)

Source: Eurelectric; DSOs and national associations; Monitor Deloitte

4 g Define efficient tariff structures that optimise long-term investments and facilitate economic sustainability of the power system at national level

Regulatory recommendations

Efficient tariff structures

- **Design efficient tariff structures at national level** adapted to local conditions of the market/grid, based on the **general principles at EU level** (cost reflectiveness, cost recovery, transparency, simplicity, non-discrimination, reflection of the value for flexibility, technology neutrality, efficiency, support electrification), including:
  - Tariffs should only be used to **cover grid costs** and not other costs
  - Tariff structure should always be **technology neutral** in order to avoid cross subsidisation
  - Tariff should **allocate adequately grid costs to power grid users**, e.g. according to **consumption/generation profile**, power **demand rate**, power **grid structure** - voltage levels or geographical areas -, **time**
- Provide **incentives to system users to participate efficiently in power system management**, e.g. provide market players with a signal of the resulting costs imposed on the grid when consumption occurs

Power system economic sustainability

- Reflect **actual investment costs incurred so far**, and mitigate potential tariff deficits (e.g. structural shortfalls of revenues in the electricity system) that may put future DSOs investments at risk
- Design tariffs to mitigate the risk that **new power system user profiles** (e.g. self-consumer) **negatively affect the economic sustainability of the power system and/or produce distortions**, e.g. minimise cross-subsidies between different categories of users

Contents

Model structure for Investment Outlook assessment

Investment drivers

- Electrification of current uses
- Electrification of mobility
- Emission-free generation
- Resilience
- Modernisation/ Updating
- Storage
- Digitalization

Energy System understanding

Energy variables

What macro-variables determine the power system?

Current data to consider:

- Current power capacity
- Etc.

Initial hypothesis:

- Required additional renewable generation
- Etc.

Other, (DSO market share, past investments, etc.)

Power System Hypothesis

How does each variable impact on the future evolution of power system?

Hypothesis to be defined:

- Electric demand per segment
- Distributed generation
- Etc.

Illustrative example

Residential increase of connection power

Power Grid modelling

Assets

What type of facilities/equip-ments will be deployed?

For example:

- New lines
- Equipment for digitalisation and automation
- Etc.

Illustrative example

Additional lines (or reinforcements) due to power increase

Unit cost

What is the unit cost estimate for each facility/ equipment?

For example:

- Unit cost per incremental line
- Unit cost per incremental transformation capacity
- Etc.

Illustrative example

Unit cost per additional line (or reinforcements)

Grid Investment Plan

Illustrative example

M€ in lines

Key data for Investment Outlook assessment

Power trends and assumptions from models developed	**Information on technical and economic investment parameters**

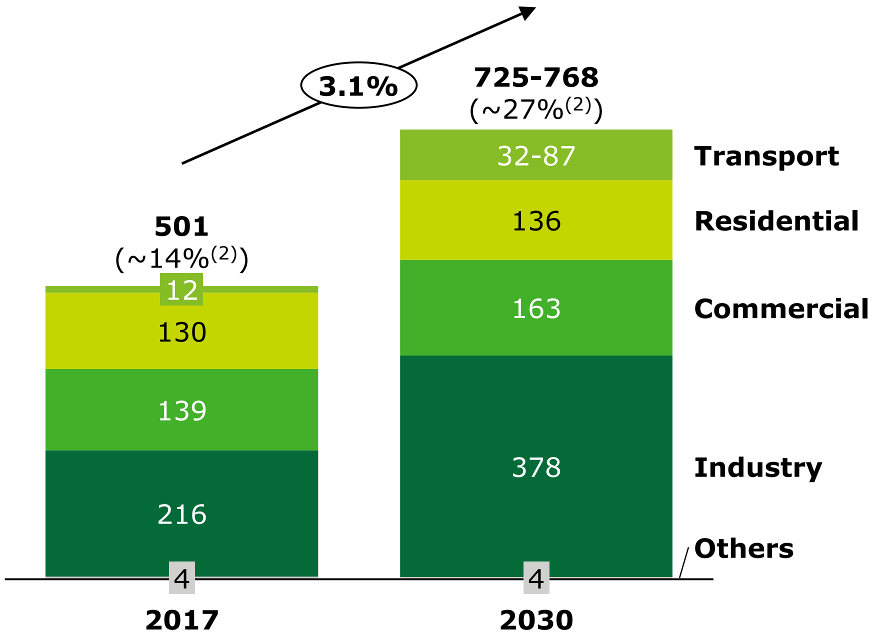
Contents

Power Scenario for Germany by 2030

ESTIMATIONS BASED ON EURELECTRIC DATA

Final electricity demand by sector
(TWh; 2017-2030)

	2017	2030
Renewable capacity[1] (GW)	**115**	**179**
Peak demand (GW)	**79**	**~123**



Key power system insights

- **+98GW of new renewables capacity** (it includes 9GW of new self-consumption capacity)
- **90-95%** of new renewable capacity **connected to distribution** grids due to renewable generation will be composed mainly by **small solar PV installations of <2MW connected to the rural grid**

- **>50% of EVs charge during off-peak hours** (specially at night)

- **Electrification in transport** will be led by a **high penetration of Electric Vehicles** and charging points by 2030**:**
  - **10-24.3 million of EVs** (BEV and PHEV)[3]
  - **1-2.4 million non-residential charging points** including ~0.36 million of semi-public charging points (i.e. at a company´s or supermarket´s parking)
  - **8-19 million residential charging points**

- **Electrification in industry** will be driven by:
  - **Power-to-gas** which is 30-40% increase in electrification(~53 TWh of final electricity consumption in 2030)
  - **Economic growth, electrification of thermal uses** (e.g. space heating, hot water, etc.) and **others** (e.g. information and communication technologies in industry)

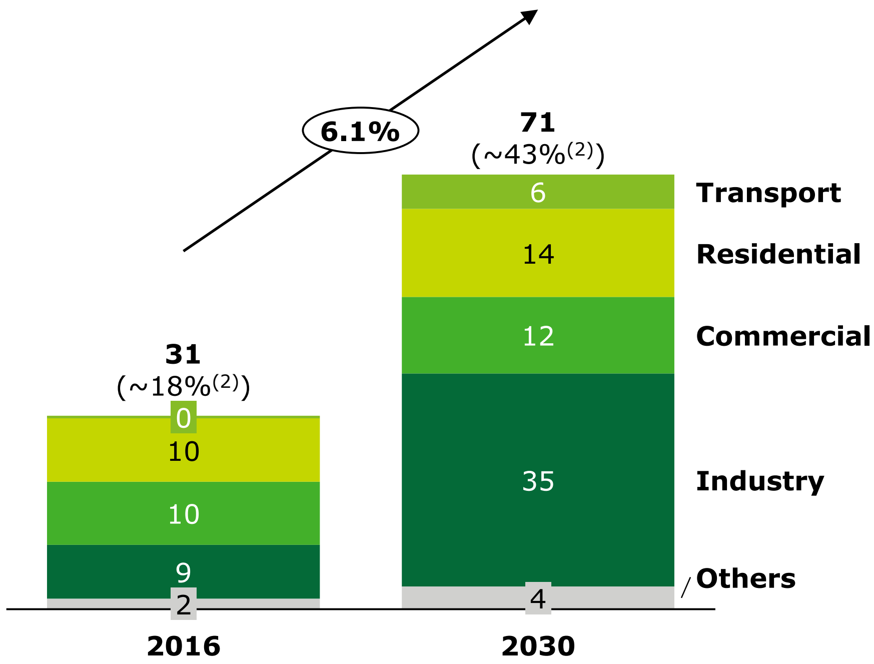
(1): It includes Wind (onshore and offshore), Solar, Hydro, Biomass and Other Renewables;(2): Country electrification rate (final electricity consumption over final energy consumption); (3): Low range (10m) communicated by German Ministry for Transport, high range (24.3m) matches the requirements of the German carbon budget objective for transport
Source: iea; eurelectric; Monitor Deloitte analysis

Power Scenario for Denmark by 2030

ESTIMATIONS BASED ON EURELECTRIC DATA

Final electricity demand by sector
(TWh; 2016-2030)

	2016	2030
Renewable capacity[1] (GW)	7	22
Peak demand (GW)	6	~13



Key power system insights

- **+15GW of new renewables capacity** (it includes 0.2GW of new self-consumption capacity)
- **~37% of new** renewable capacity connected to **distribution grids**
- It is expected **2.4 GW of power to gas** connected in the **distribution grid by 2030**

- **80% of EVs** charge during off-peak hours
- **~60% of the increase** in peak demand occurs in **industry**

- **Electrification in transport is driven by:**
  - **1.5 million of EVs** (BEV and PHEV) than increase final electricity consumption by 3.5-4 TWh
  - **22k non-residential charging points**, of which ~19k are normal public charging points in cities (<22kW)
  - **1.2 million residential charging points**

- **Electrification in residential** sector is mainly led by **heat pumps deployment** (heat pump consumption increases by 3-3.5 TWh)

- **Electrification in industry** is driven by:
  - **Power to gas:** increases final electricity consumption by 10-11 TWh, of which 8-9 TWh will be at distribution level
  - **Data centers:** increase final electricity consumption by 7-8 TWh
  - **Industry heat pumps:** increase final electricity consumption by 2-2.5 TWh

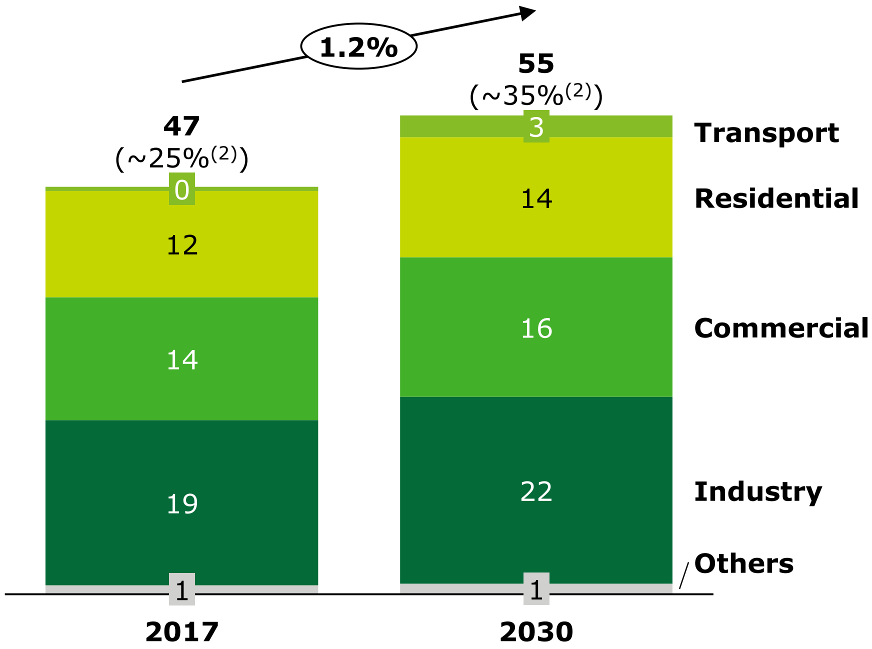
(1): It includes Wind (onshore and offshore), Solar, Hydro, Biomass and Other Renewables;(2): Country electrification rate (final electricity consumption over final energy consumption)
Source: iea; eurelectric; Monitor Deloitte analysis

Power Scenario for Portugal by 2030

ESTIMATIONS BASED ON EURELECTRIC DATA AND NECPs

Final electricity demand by sector
(TWh; 2017-2030)

	2017	2030
Renewable capacity[1] (GW)	13	27
Peak demand (GW)	8.5	9



Key power system insights

- **+14GW of new renewables capacity** (it includes 1.9GW of new self-consumption capacity). 55-60% of new capacity are small solar installations[3]
- **50-60% of new renewable capacity connected to distribution grids**
- **Solar and wind technologies each account for ~34%** of total installed renewable capacity by 2030

- **50% of EVs** smart charge during off-peak hours and with a profile that reduces renewable energy surpluses

- **Electrification in transport** will be led by the **penetration of Electric Vehicles and charging points:**
  - **0.64 million of EVs** (BEV and PHEV)
  - **0.1 million** non-residential charging points
  - **0.2 million** residential charging points (~30% of EV owners hold a charging point at home)

- It has been considered a homothetic growth in the residential, industrial and commercial sectors

(1): It includes Wind (onshore and offshore), Solar, Hydro, Biomass and Other Renewables;(2): Country electrification rate (final electricity consumption over final energy consumption)
(3): It considers coal phase out by 2025 (1.8 MW installed by 2020)
Source: iea; eurelectric; Monitor Deloitte analysis

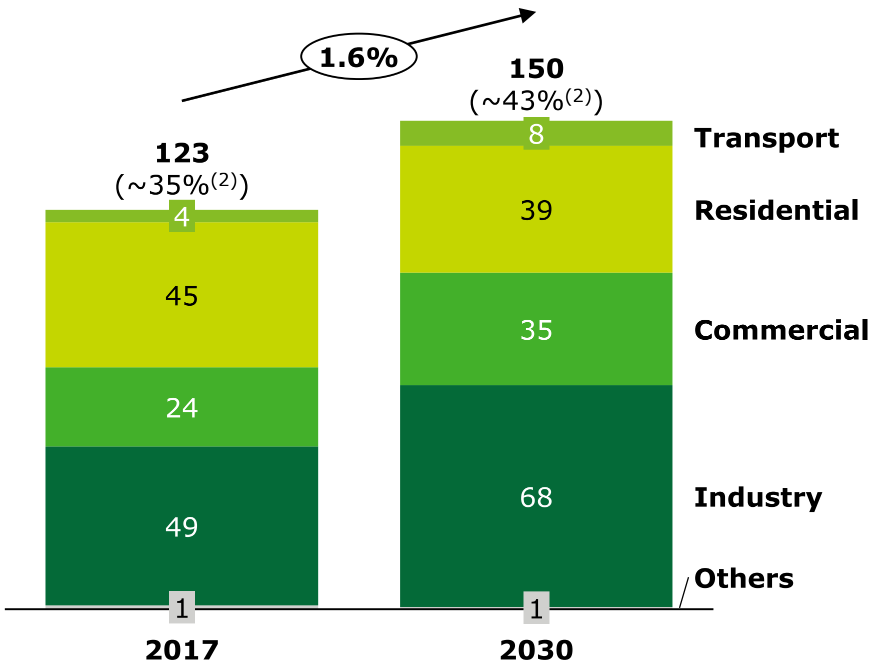
Power Scenario for Sweden by 2030

ESTIMATIONS BASED ON EURELECTRIC DATA

Final electricity demand by sector

(TWh; 2017-2030)

	2017	2030
Renewable capacity[1] (GW)	**26**	**38**
Peak demand (GW)	**26**	**~28**



Key power system insights

- **+12GW of new renewables capacity**
- **~30% of new renewable capacity** connected to **distribution grids**

Transport:
- **1.0 million of EVs** (BEV and PHEV)
- **0.1 million non-residential** charging points
- **0.6 million residential** charging points

Residential:
- ~0.5GW increase in peak demand

Commercial:
- ~0.4GW increase in peak demand

Industry:
- ~0.9GW increase in peak demand

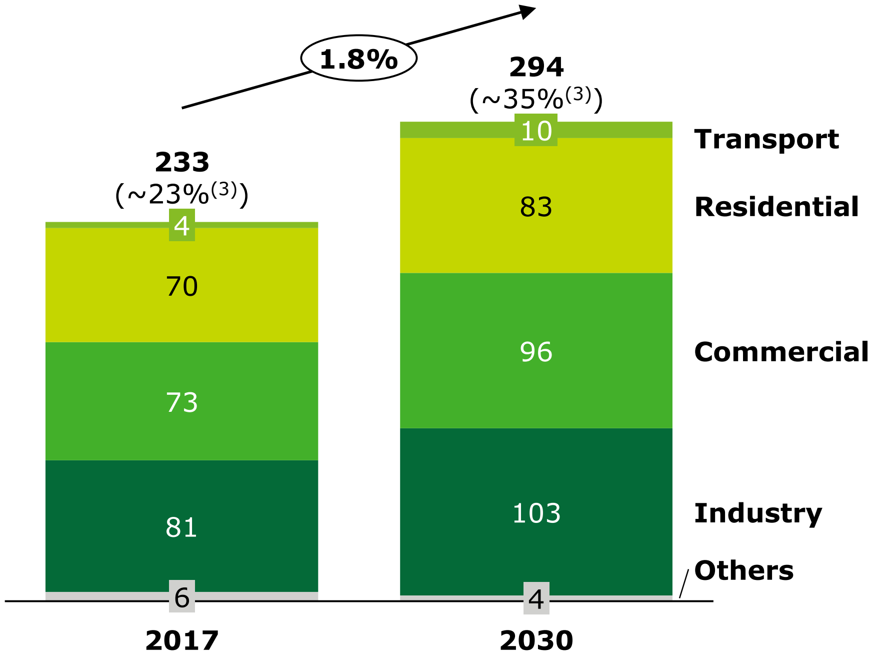
(1): It includes Wind (onshore and offshore), Solar, Hydro, Biomass and Other Renewables;(2): Country electrification rate (final electricity consumption over final energy consumption)
Source: iea; eurelectric; Monitor Deloitte analysis

Power Scenario for Spain by 2030

ESTIMATIONS BASED ON EURELECTRIC DATA AND NECPs

Final electricity demand by sector
(TWh; 2017-2030)

	2017	2030
Renewable capacity[1] (GW)	**51**	**119**[2]
Peak demand (GW)	**41**	**~49**



Key power system insights

- **+65GW of new renewables capacity** (it includes 2.3GW of new self-consumption capacity)
- **20-30% of new renewable** capacity connected to distribution grids
- **+70% of new renewables generation** plans are connected to the transmission grid due to **their large size**

- **~75% of EVs charge** during off-peak hours, specially at night

- **Electrification in transport** will be led by the **penetration of Electric Vehicles** and charging points by 2030:
  - **4.0 million of EVs** (BEV and PHEV)
  - **40k public charging points** in urban areas; **8k charging points in electric charging stations**
  - **2.4 million residential** charging points

- Electrification in residential and commercial buildings driven by the **deployment of heat pumps,** as it has strong potential in Mediterranean areas
- **~120k renovations per year in residential sector**

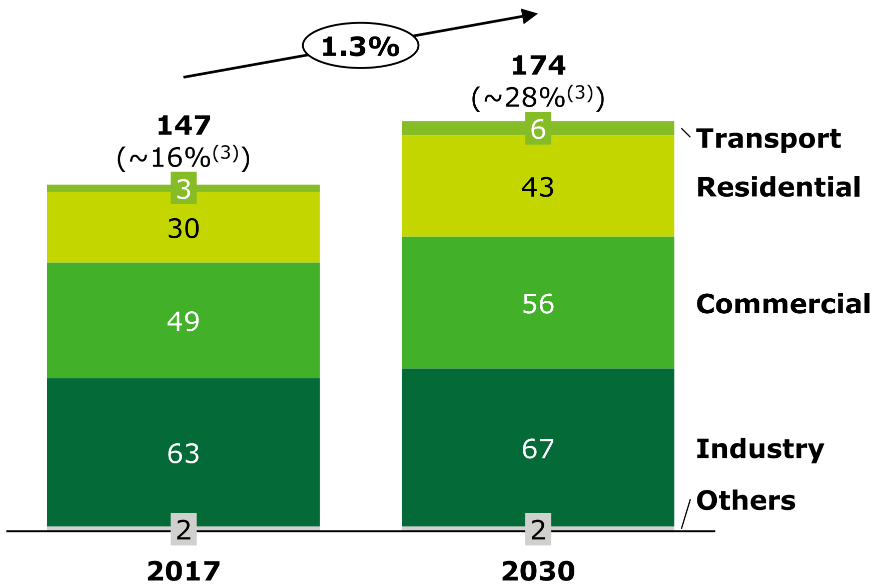
(1): It includes Wind (onshore and offshore), Solar, Hydro, Biomass and Other Renewables; (2) It includes 3 GW of additional pumping capacity; (3): Country electrification rate
Source: iea; eurelectric; PNIEC; Monitor Deloitte analysis

Power Scenario for Poland by 2030

ESTIMATIONS BASED ON EURELECTRIC DATA AND NECPs

Final electricity demand by sector
(TWh; 2017-2030)

	2017	2030
Renewable capacity[1] (GW)	9	24[2]
Peak demand (GW)	24	~28



Key power system insights

- **+15GW of new renewables capacity** (it includes 6.6GW of new self-consumption capacity), of which **3.6 GW will be offshore wind farms**
- **67% of new renewable** capacity connected to **distribution grids**
- **Renewable generation by 2030** will be composed mainly by **~6.6 small solar PV installations**

- **>90% of EVs charge** during off-peak hours, specially at night

- **Electrification in transport** will be led by the **penetration of Electric Vehicles** and charging points by 2030:
  - **1.5 million of EVs** (BEV and PHEV)
  - **91k non-residential** charging points
  - **0.9 million residential** charging points

- **Electrification in residential sector is driven by a ~17% expected growth in new customers by 2030**. (e.g. in 2019 there has been ~226 new customers)

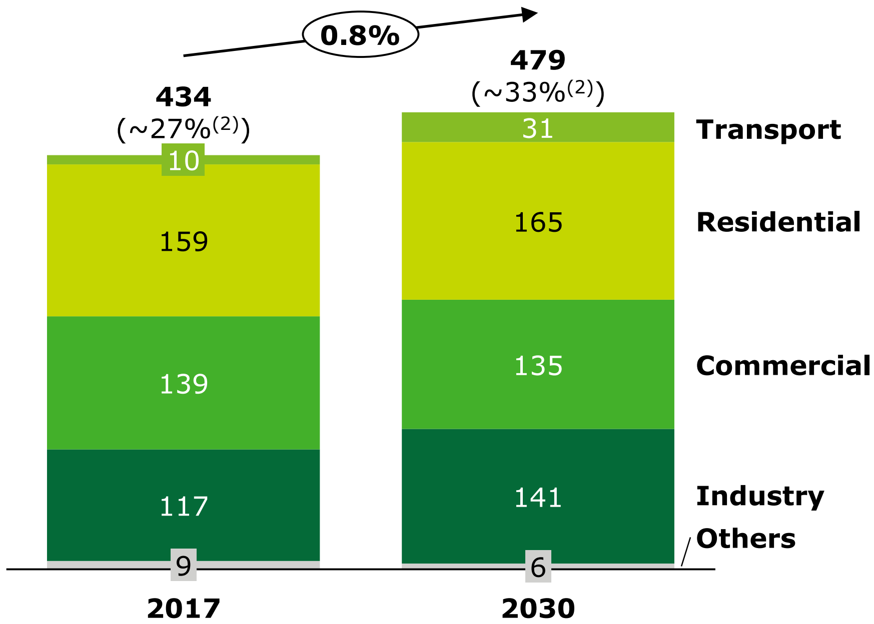
(1): It includes Wind (onshore and offshore), Solar, Hydro, Biomass and Other Renewables; (2) It considers not coal phase-out; (3): Country electrification rate (final electricity consumption over final energy consumption)
Source: iea; eurelectric; ARE; Monitor Deloitte analysis

Power Scenario for France by 2030

ESTIMATIONS BASED ON EURELECTRIC DATA

Final electricity demand by sector
(TWh; 2017-2030)

Renewable capacity[1] (GW)	**46**	**111**
Peak demand (GW)	**>100**[3]	**~100**



Key power system insights

- **+65GW of new renewables capacity** (it includes ~1GW of new self-consumption capacity) of which ~5GW is Wind Offshore
- **80-90% of new renewable capacity connected to distribution grids**

- **Peak demand will increase locally** mainly **depending on weather events** as peak demand is usually on the coldest day of the year
- **>80% of EV** charge during off-peak hours

- **Electrification in transport** will be led by the **penetration of Electric Vehicles** and charging points by 2030**:**
  - **6.0 million of EVs** (BEV and PHEV)
  - **1.8 million non-residential charging points, mainly at offices** to charge companies' EVs during the night to be used on the following working day
  - **4.2 million residential charging points**

- **Final electricity consumption in residential** is driven by:
  - **+~400 new customers to be integrated in residential sector: 50%** in **buildings of dwellings** and **50%** in **individual houses**
  - **Renovations:** According to he NECP, the pace of renovation reaches **~ 370k full renovations per year**

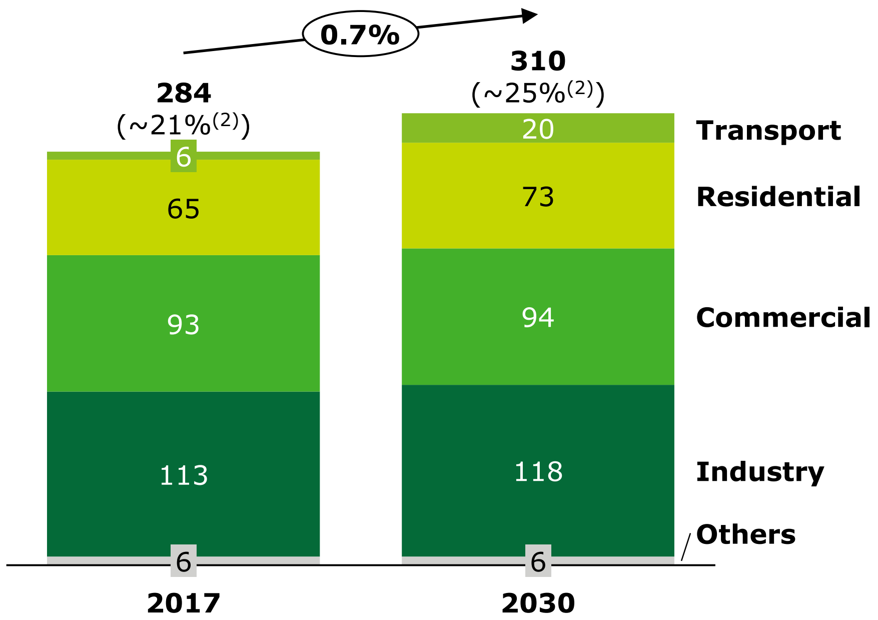
(1): It includes Wind (onshore and offshore), Solar, Hydro, Biomass and Other Renewables; (2): Country electrification rate (final electricity consumption over final energy consumption);
(3): Peak demand of an extreme event that happened in 2012
Source: iea; eurelectric; Monitor Deloitte analysis

Power Scenario for Italy by 2030

ESTIMATIONS BASED ON EURELECTRIC DATA AND NECPs

Final electricity demand by sector
(TWh; 2017-2030)

	2017	2030
Renewable capacity[1] (GW)	58	95
Peak demand (GW)	57	~62



Key power system insights

- **+42GW of new renewables capacity**
- **~80-85% of new renewable capacity connected to distribution grids**

- **Electrification in transport** will be led by the **penetration of Electric Vehicles** and charging points by 2030:
  - **6 million of EVs** (BEV and PHEV)
  - **80k non-residential** charging points
  - **3.6 million residential** charging points

- **~ 1 million of households will require additional connection capacity** to charge their vehicles
- According to NECP, energy consumption in residential sector will be led by a **significant building renovation rate increasing electrification of the sector**, mainly with regard to heating

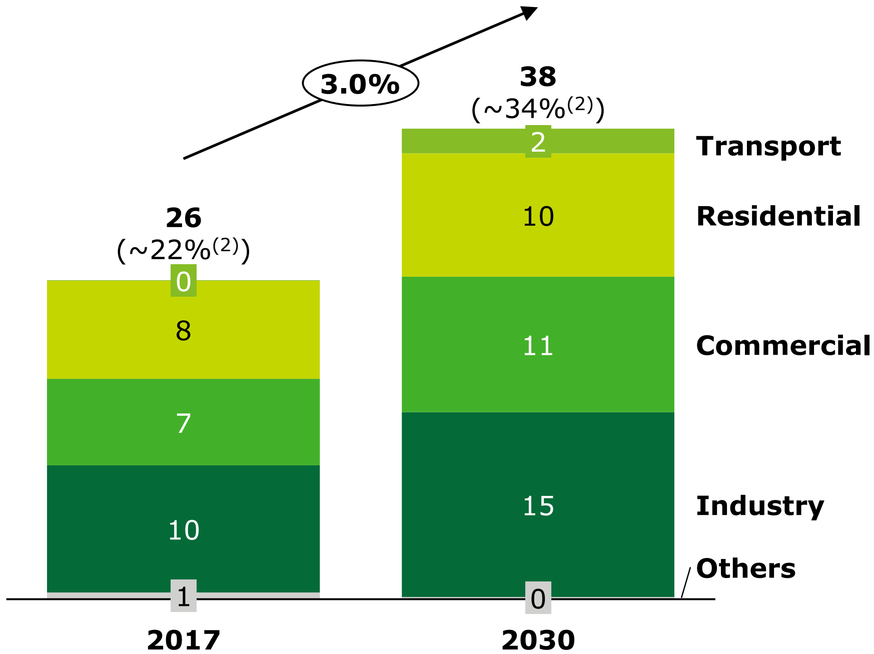
(1): It includes Wind (onshore and offshore), Solar, Hydro, Biomass and Other Renewables;(2): Country electrification rate (final electricity consumption over final energy consumption)
Source: iea; eurelectric; Monitor Deloitte analysis

Power Scenario for Ireland by 2030

ESTIMATIONS BASED ON EURELECTRIC DATA

Final electricity demand by sector
(TWh; 2017-2030)

	2017	2030
Renewable capacity[1] (GW)	4	13.2
Peak demand (GW)	5	~6.4



Key power system insights

- **+10GW of new renewables capacity** (it includes 0.2GW of new self-consumption capacity)[3]
- **40-45% of new renewable** capacity connected **to distribution grids**

- **Electrification in transport** will be led by the **penetration of Electric Vehicles** and charging points by 2030:
  - **0.9 million of EVs** (BEV and PHEV). ~45% of total fleet
  - **60k non-residential** charging points
  - **0.8 million residential charging points**, ~ 90% of EV users own a charging point due to the large proportion of individual houses and the high share of rural population

- **Electrification in residential sector** is mainly driven by:
  - The installation of **200k heat pumps** in new buildings
  - The installation of **400k heat pumps** in existing buildings

- **Electrification in commercial buildings** is driven by the installation of **25k heat pumps**

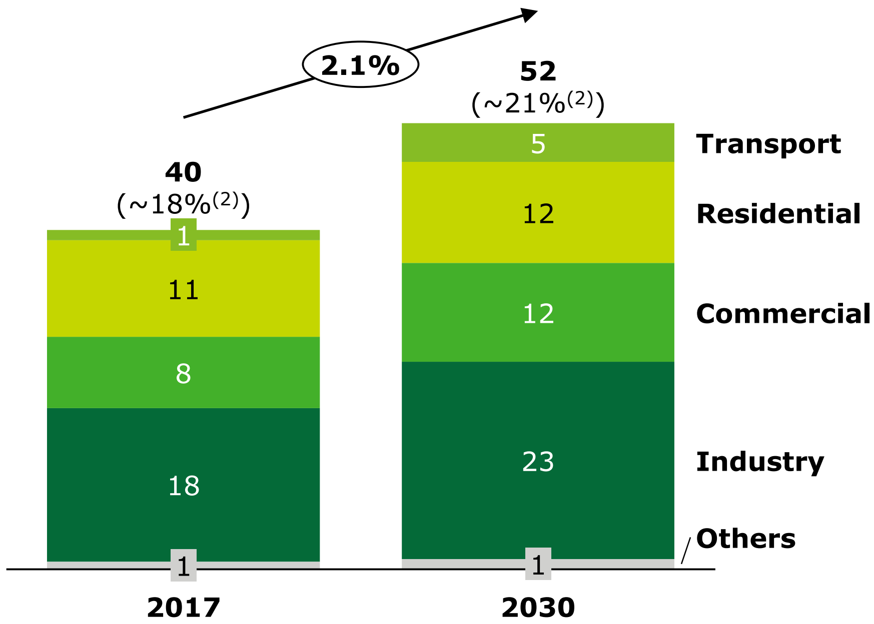
(1): It includes Wind (onshore and offshore), Solar, Hydro, Biomass and Other Renewables;(2): Country electrification rate (final electricity consumption over final energy consumption);
(3): Ireland is committed to deliver a complete phase-out of coal (by2025) and peat-fired electricity generation (2028)
Source: iea; eurelectric; Monitor Deloitte analysis

Power Scenario for Hungary by 2030

ESTIMATIONS BASED ON EURELECTRIC DATA

Final electricity demand by sector
(TWh; 2017-2030)

	2017	2030
Renewable capacity[1] (GW)	0.3	6.5
Peak demand (GW)	7	~9



Key power system insights

- **+6GW of new renewables capacity**
- **90% of new renewable** capacity connected to **distribution grids**
- **~80%** of total renewable capacity by 2030 will be **solar PV**

- **~36% of the increase** in peak demand occurs **in residential sector**

- **Electrification in transport** will be led by the **penetration of Electric Vehicles** and charging points by 2030:
  - **0.2 million of EVs** (BEV and PHEV)
  - **18k non-residential** charging points
  - **0.2 million residential** charging points
- According to government´s plan ~5% of vehicles will be purely electric by 2030, **after which further steep growth is expected**

- **Electrification in residential and commercial** sectors is expected due to the **deployment of existing technologies** (e.g. heat pumps)

- **Electrification in industry** is led by a **high economic growth** expected for the period

(1): It includes Wind (onshore and offshore), Solar, Hydro, Biomass and Other Renewables;(2): Country electrification rate (final electricity consumption over final energy consumption)
Source: iea; eurelectric; Monitor Deloitte analysis

Contents

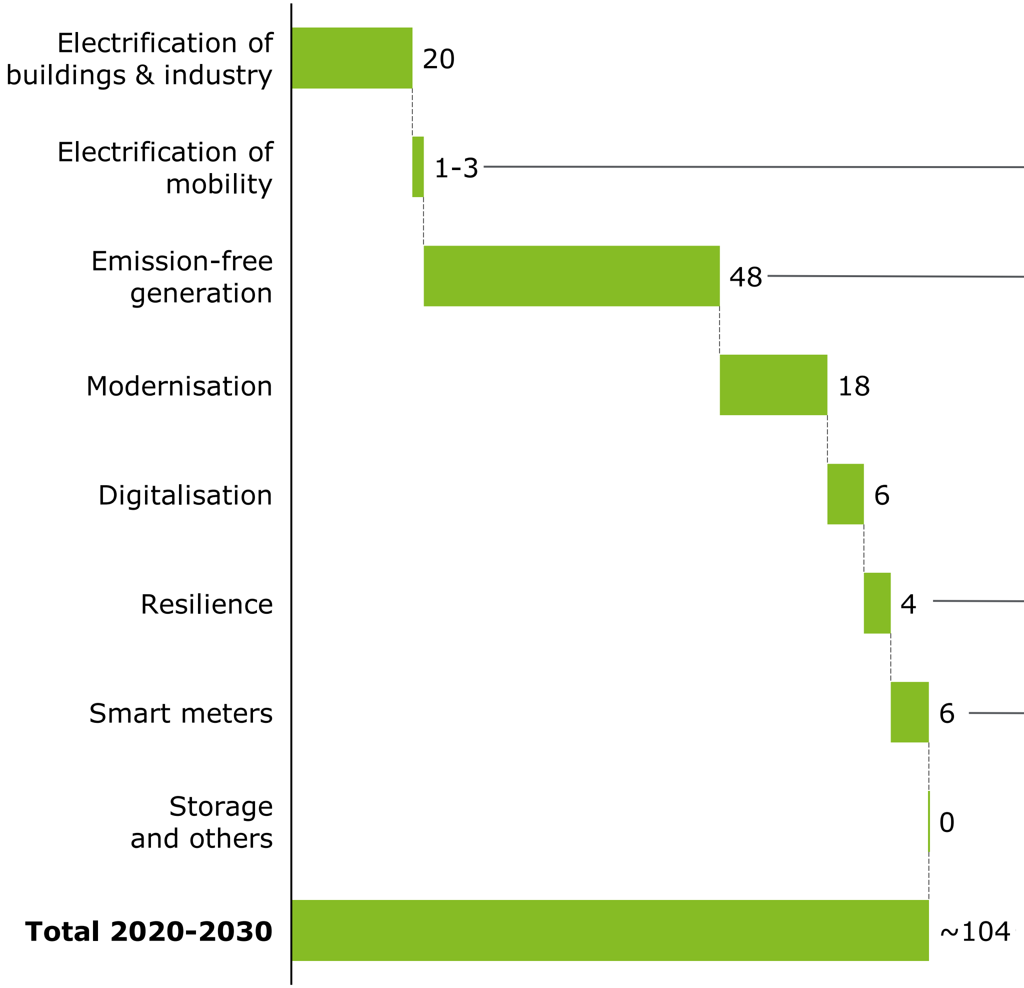
Investments at national level depend on several factors, including the Energy Transition ambition, power grid age and technical architecture

Overall DSO investments in power distribution grids (nominal €bn; 2020-30)		**Investments share** (% investments): **Electrif. and renewables**	**Modern. and resilience**	**Digitalisation and others**
EU27+UK	**375-425**	50%	33%	17%
Germany	~104	67%	21%	12%
France	49	50%	31%	19%
Italy	31	31%	40%	29%
Poland	25	37%	45%	18%
Spain	22	39%	41%	20%
Sweden	16	37%	54%	9%
Ireland	6	38%	31%	31%
Denmark	6	33%	52%	15%
Portugal	5	23%	34%	43%
Hungary	3	35%	56%	10%

Source: DSOs and national associations; Monitor Deloitte

Investments per country - Germany

Overall investments in power distribution grids
(nominal €bn; 2020-30)



Key insights

- Most of the **charging points are expected to be deployed in urban areas**
- **Urban grids are robust and have spare capacity** to integrate most of the charging points

- Renewable generation will be composed mainly by **small solar PV installations of <2MW** connected to the rural grid
- **Rural grids have strong development/modernisation needs** to integrate VRES

- **High current share of underground lines** (~80%)

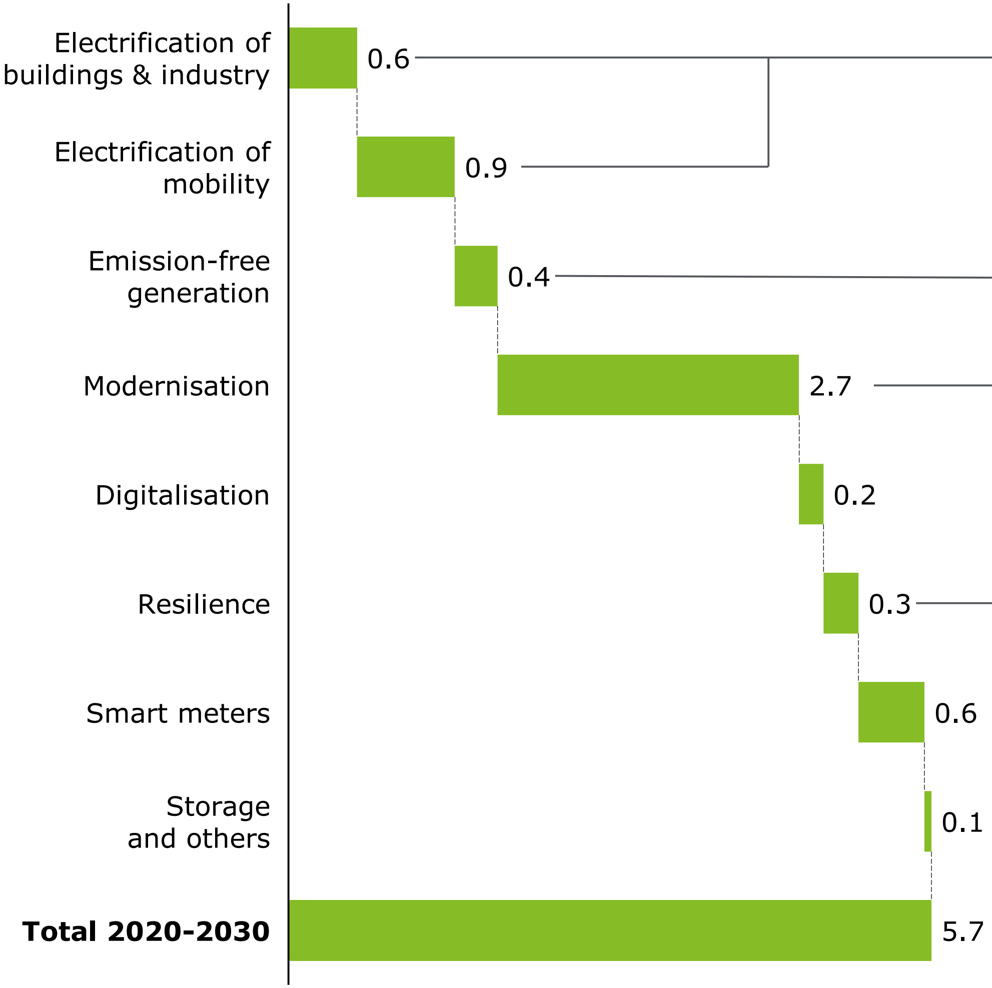
- **Expected full deployment** of smart meters by 2030 (currently ~0%)

- **>90% of the new grid lines are underground**

Source: DSOs and national associations; Monitor Deloitte

Investments per country - Denmark

Overall investments in power distribution grids
(nominal €bn; 2020-30)



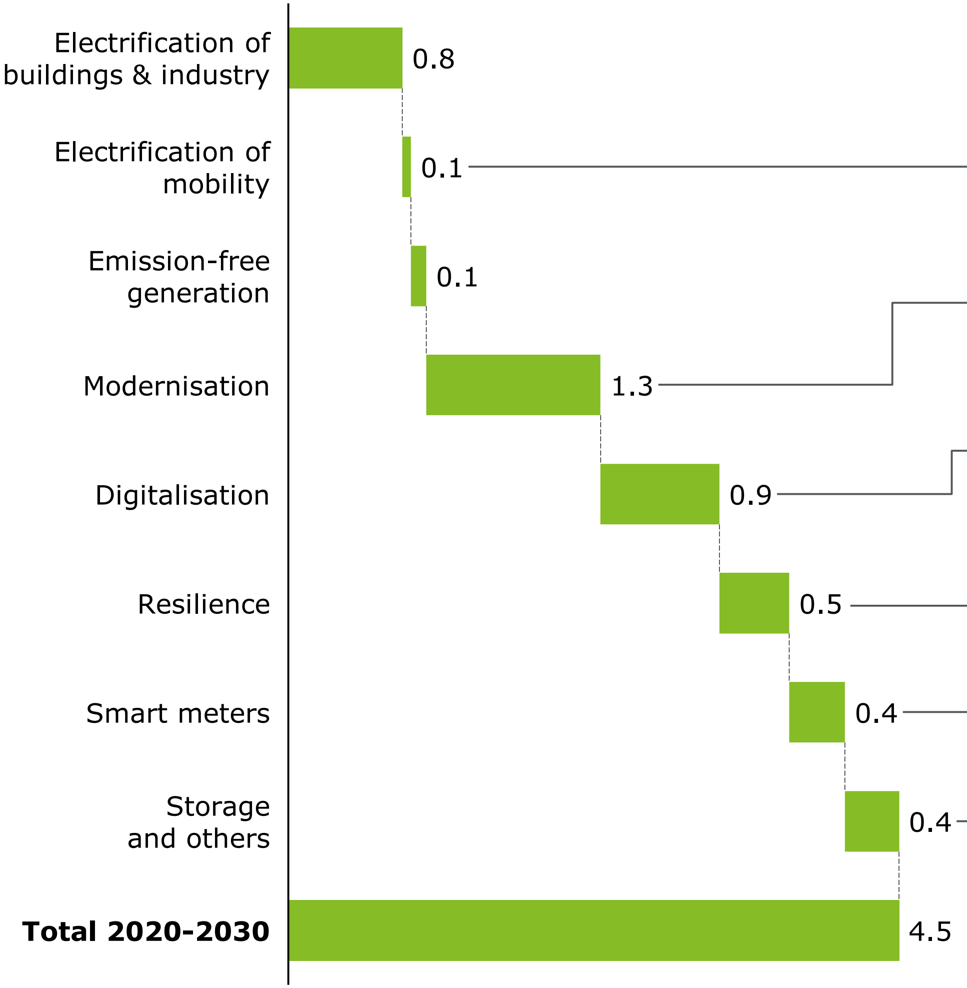
Key insights

- Electricity demand is expected to grow **6.1% CAGR,** with **1.5m of electric vehicles** (~67% of car fleet)
- Renewable capacity **connected to the distribution grid will more than double over the next decade**
- Investments are **based on historic investments** in replacement of grid infrastructure
- **High current share of underground lines** (~80%)
- Expected deployment of **2nd generation of smart meters**
- **Majority of new grid lines are underground**

Source: DSOs and national associations; Monitor Deloitte

Investments per country - Portugal

Overall investments in power distribution grids
(nominal €bn; 2020-30)



Key insights

- The **grid has capacity to integrate the majority of the charging needs by 2030**, considering the deployment of smart charging schemes
- **50% of EVs smart charge during off-peak hours** and with a profile that reduces renewable energy surpluses

- **Programs of grid rehabilitation and replacement** due to the ageing assets currently in operation

- **Automation improvement in substations** and implementation of **automation/digitalisation in secondary substations** (MV/LV); digital assets for **grid management** (e.g. SCADA and ADMS)

- Investment in grid resiliency due to the **increasing frequency of extreme climate events** and current **low** share of **underground lines (<30%)**, although requiring further regulatory and incentive alignment

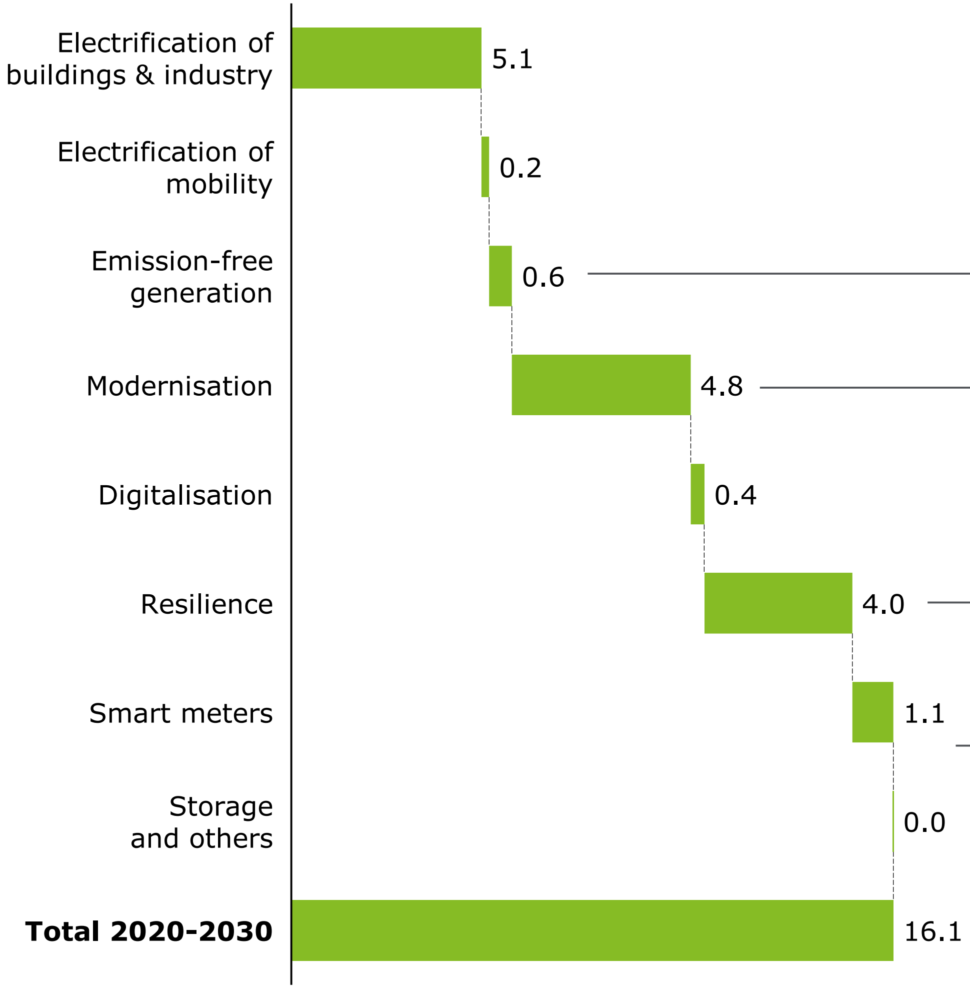
- Expected **full deployment of smart meters** (current roll-out is ~40%)

- **Includes the investment in public lighting** (grid expansion, rehabilitation and public lighting efficiency)

Source: DSOs and national associations; Monitor Deloitte

Investments per country - Sweden

Overall investments in power distribution grids
(nominal €bn; 2020-30)



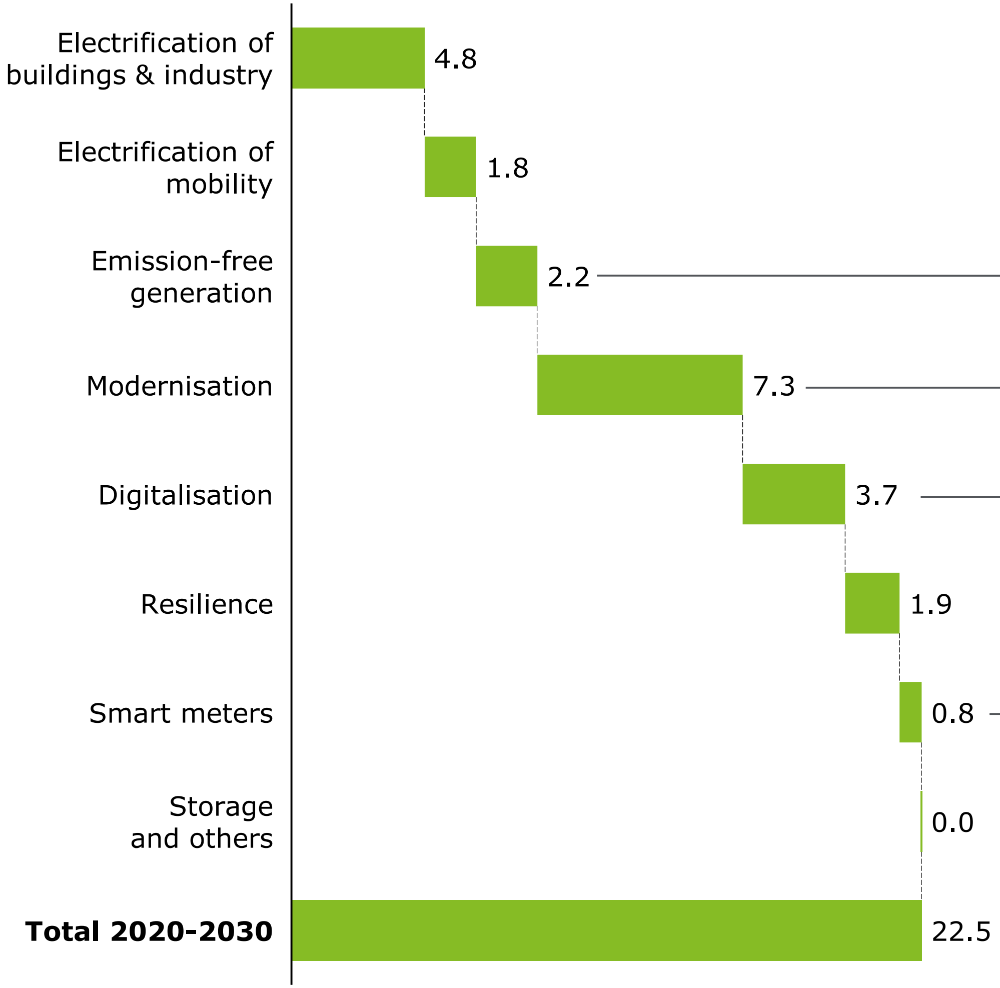
Key insights

- Most of the generation capacity (~70%) is expected to be **connected to the transmission grid**
- High investments due to the **current age structure** of the grid and its **architecture** (long grids to cover long distances among consumption-generation centers)
- Grid has been **affected by weather events** in the last years. There is a **plan to shift overhead lines to underground lines and to add capacity**
- Expected **deployment of 2nd generation smart meters**

Source: DSOs and national associations; Monitor Deloitte

Investments per country - Spain

Overall investments in power distribution grids
(nominal €bn; 2020-30)



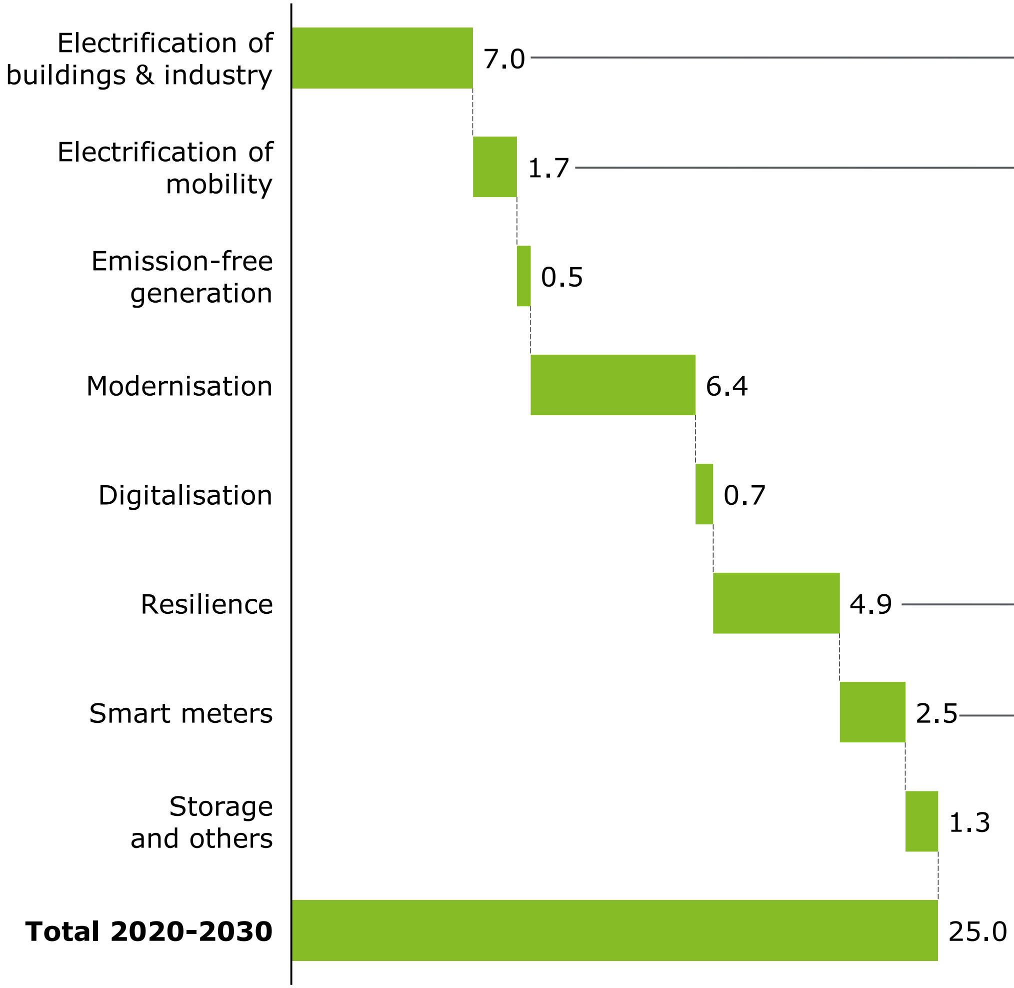
Key insights

- Most of the generation capacity (~75%) is expected to be **connected to the transmission grid**
- High investments due to **current age structure** of the distribution grids, specially **low-voltage**
- High investments in digitalisation to make grids a key **enabler for the Energy Transition** and **integrate efficiently high volume of variable RES generation and DER resources**
- **Already reached full deployment** of smart meters

Source: DSOs and national associations; Monitor Deloitte

Investments per country - Poland

Overall investments in power distribution grids
(nominal €bn; 2020-30)



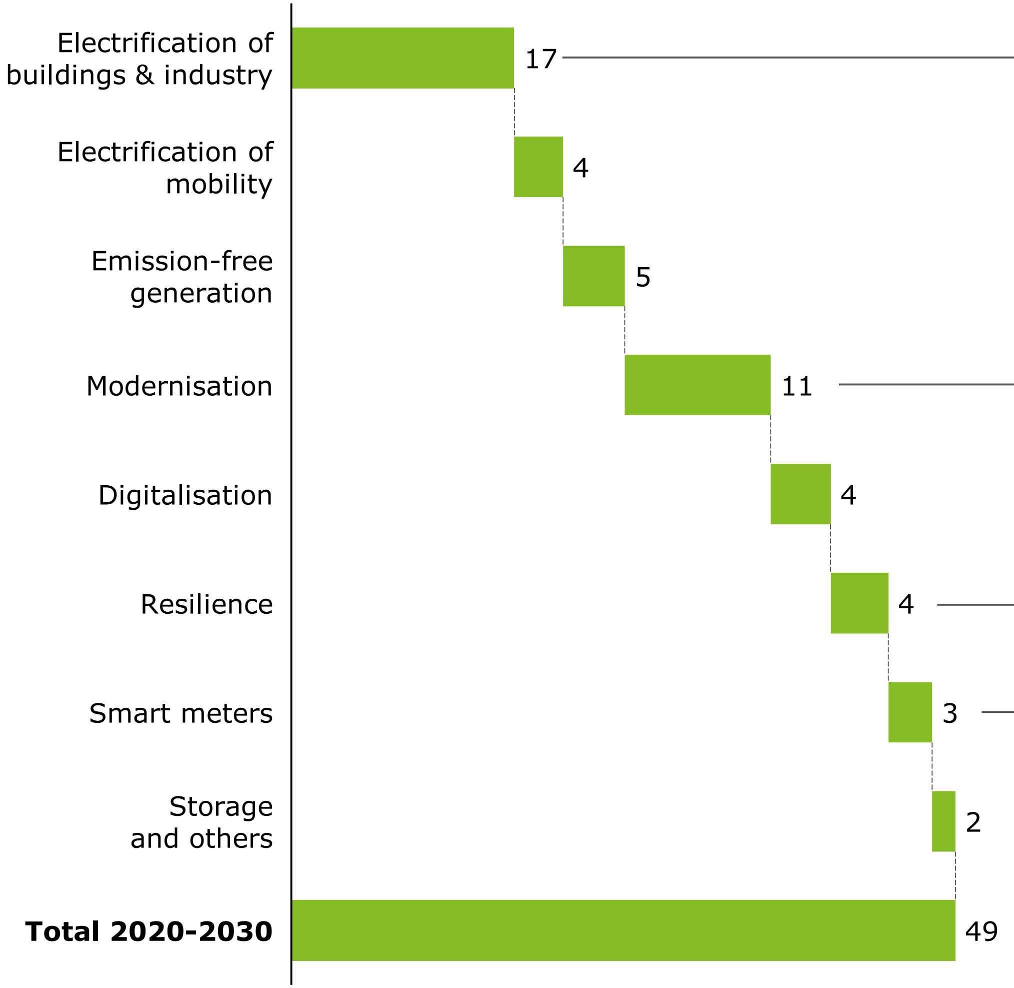
Key insights

- **High expected growth in new customers (~ 17%) and lower current electrification share**
- **Low impact of charging infrastructure** in the grids as most of **residential charging is assumed to happen at off-peak hours** (specially at night)
- Plan to improve grid resilience due to **increasing number of extreme events. Ambitious plan to replace overhead lines with underground cables** for the entire MV network to reach the EU average ratio in 2040 (a priority in Poland)
- **Expected 80% deployment of smart meters by 2030**

Source: DSOs and national associations; Monitor Deloitte

Investments per country - France

Overall investments in power distribution grids
(nominal €bn; 2020-30)



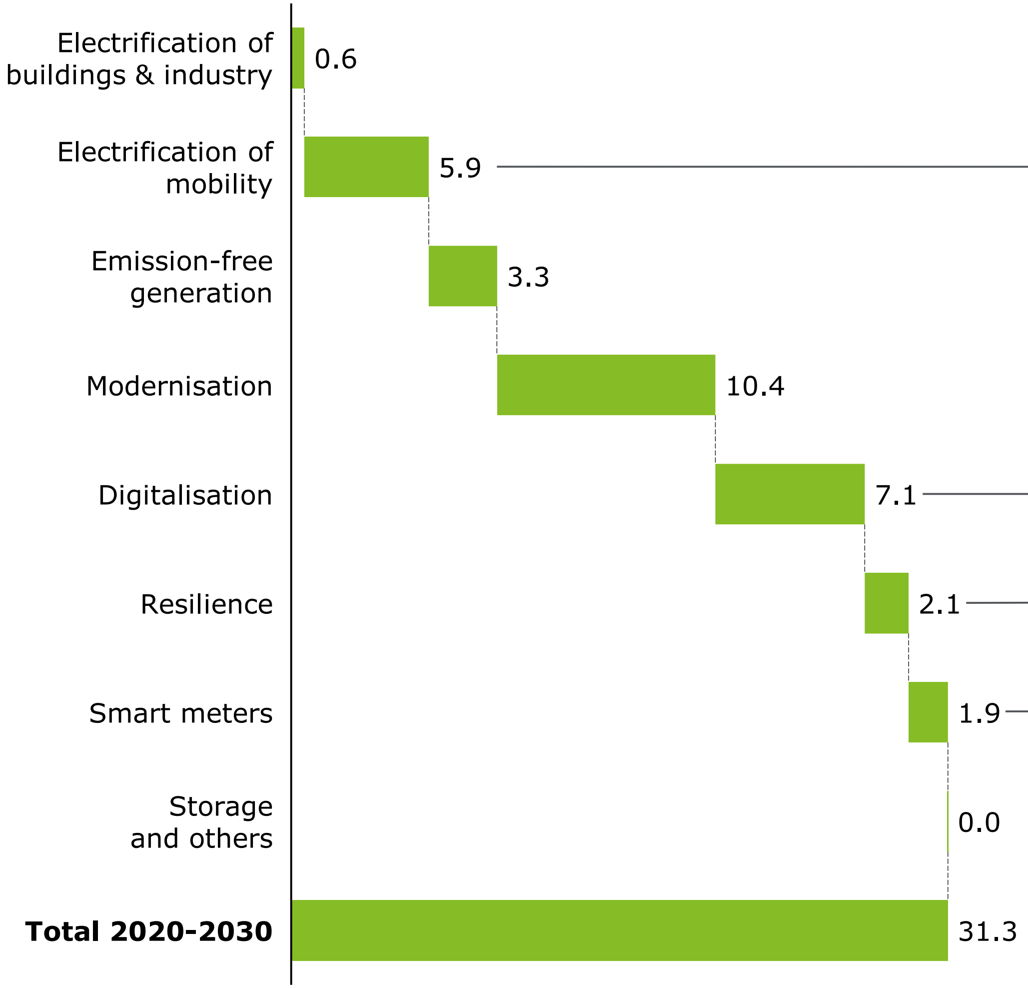
Key insights

- Majority in the **residential sector**, to integrate the expected **400,000 new consumers per year** (50% in buildings of dwellings, 50% in individual houses)
- Plan to **replace assets which performance is decreasing**, based on **past investments and an expected annual growth** of this investment driver
- A **resilience plan** to ensure electricity supply under extreme weather events (floods, storms, snow, etc.)
- **Linky program** to develop full deployment of smart meters (the program already started in 2018)
- **It does not include communities investments on the grid (~9.5 bn€)**

Source: DSOs and national associations; Monitor Deloitte

Investments per country - Italy

Overall investments in power distribution grids
(nominal €bn; 2020-30)



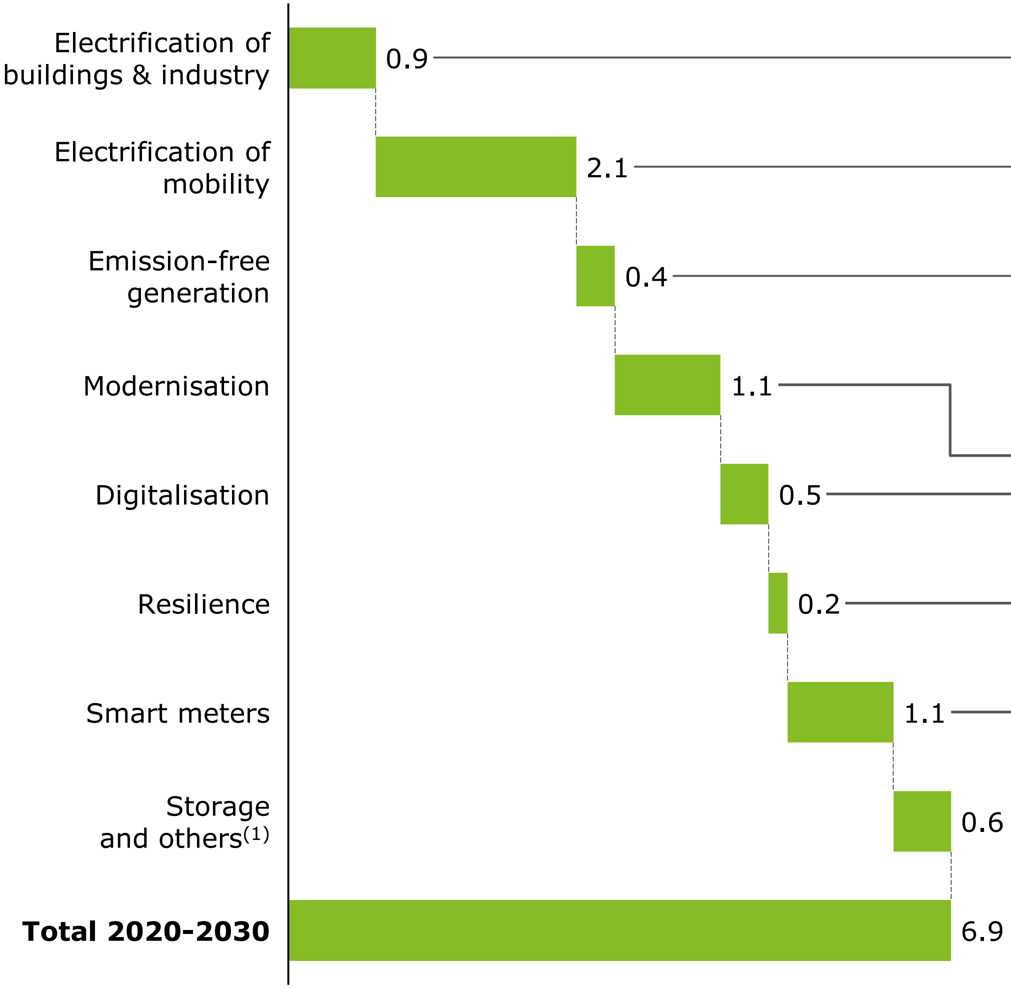
Key insights

- **~30% of the households** with an electric vehicle will require **additional connection capacity** to charge their vehicles
- **~85% of the investments in digitization** contributes to offer higher flexibility services
- **Plan to increase grid resilience** against increasing number of extreme events. There is a specific **output-based incentive scheme for resiliency**
- Plan to deploy **second generation of smart meters**

Source: DSOs and national associations; Monitor Deloitte

Investments per country - Ireland

Overall investments in power distribution grids
(nominal €bn; 2020-30)



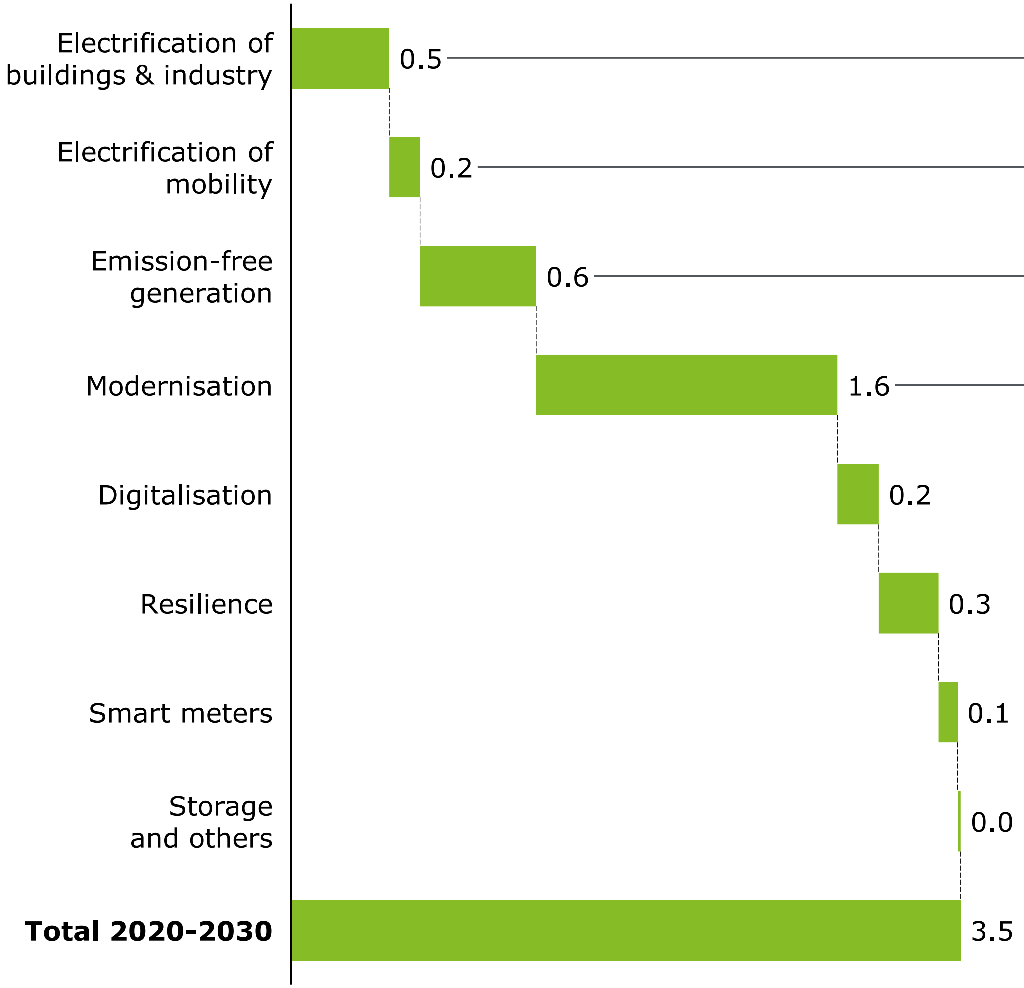
Key insights

- It includes **600,000 domestic heat pumps** (200,000 new build & 400,000 existing buildings) and **25,000 installed in commercial buildings**
- Large proportion of residential charging points due to **rural spread of customers** resulting in **high investments to reinforce LV grid** in particular
- Part of the grid connections is **built and financed by renewable developers**, limiting the DSO investment needs to integrate renewable generation
- High investments due to the **age and loading** of the grid and its **architecture** (long radial feeders covering long distances)
- **Automation improvement in substations** and implementation of **automation/digitalisation in secondary substations** (MV/LV); digital assets for **grid management** (e.g. SCADA)
- Relatively **benign climate** and few extreme weather events, resilience plan is focused on flood protection
- Program for **full deployment of smart meters** (current deployment is ~4%)

(1) Investments in storage are expected to be 0€
Source: DSOs and national associations; Monitor Deloitte

Investments per country - Hungary

Overall investments in power distribution grids
(nominal €bn; 2020-30)



Key insights

- Increasing demand for grid development due to the **economic growth** and the expected **spread of new technologies** (e.g. heat pumps) in this period
- Major EV penetration is **expected after 2030**
- Renewable capacity is expected to **increase x6 by 2030. 90% of new renewable capacity will be connected to the distribution grids** (~5 GW)
- Renewal of the grid to **ensure quality of service** in a increased demand of electrification and renewables

Source: DSOs and national associations; Monitor Deloitte

Manufacturing processes and advanced electrical equipment capabilities will deliver technological improvements in the power distribution grids

Manufacturing processes (e.g. *Industry 4.0 paradigm*)	• **Digital technologies** to improve equipment manufacturing efficiency (e.g. Big Data and analytics) • **"Multi-physical" (computer simulations) model trials** that reduce development costs • **Production Automation** (e.g. 3D printing) • **Advanced supervision of product quality** (e.g. through Artificial Intelligence) • **Recycling/reuse of components** (e.g. copper or aluminium in transformers) • **Advanced and more efficient materials** (e.g. amorphous materials in transformers, Composites alloys for structures or Superconductors)
Advanced capabilities (e.g. through operations digitalisation or advanced equipment)	• **Digitalisation of field operations will increase mobility and efficiency, as well as work-crew flexibilisation** (e.g. retainer simplification) • **Better automation and control capabilities in electrical equipment,** that allows for remote and automatic manoeuvring, as well as data and information management to **increase investment efficiency** • **Advanced O&M with impact in costs, e.g. advanced electrical equipment:** • Reduces the need to perform **field inspections** • **Reduces costs of operation and maintenance** and labour-related risks • **Improving quality of supply with impact in costs**, e.g. **representative R&D projects on advanced smart grids benefits:** – Reduced **field intervention cost** – Reduced power **losses by equipment modernisation**

Power Distribution grid annual investment indicators (2020-2030)

(1) Data for final electricity consumption is a 2017-2030 average. As computed in Investment Outlook report
(2) 2019 data for Nominal GDP. Nominal GDP for EU27+UK is an estimation
(3) 2020 data for Metering Point
Source: The Economist Intelligence Unit; Eurelectric; DSOs and associations; Monitor Deloitte

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