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.
Acknowledgments

This report was jointly prepared by Eurelectric, Monitor Deloitte together with power grid companies, country power utilities associations and E.DSO. The contributing authors were Laureano Alvarez, Joaquin Chico, Carmelo Renobales, Javier Alvarez, Alberto Amores (Monitor Deloitte) and the Steering Committee members were Anders Stouge (Dansk Energi), Rémy Garaude-Verdier (Enedis), Joachim Schneider (E.ON SE), Michael Wilch (E.ON SE), Imre Veisz (EON-Hungarian), Akos Szentkereszty (NKM Energy), Gráinne O’Shea (ESB Networks), Filippo Stefanelli (ACEA SpA), Piotr Ordyna (Tauron Dystrybcuca S.A.), Rui Goncalves (EDP Distribuição), Sandra Pinto (EDP SA), Pedro Gonzalez (aelec), Jacobo Alvarez (aelec), Jakob Eliasson (Vattenfall), Henrik Wingfors (Energiforetagen).

The report was supervised by Pierre Braun (Eurelectric) with the standing support of Paul Wilczek (Eurelectric) and Knud Perdersen (Radius). The coordination of the report benefitted from essential support of Alyson Lizin (Eurelectric). Thanks to Evgeniya Nikolova and Gael Glorieux of the Eurelectric Communication Department.

Many experts contributed actively, provided technical inputs, commented on the work and reviewed the report. Their active inputs and comments were of great value. They include: Zsolt Balint (EON-ELMŰ), Serena Cianotti (Enel), Pierre Cochet (Enedis), Frederik Dalgaard Andersen (Radius), Manuel Delgado (Naturgy), Gonçalo Faria (EDP), Zoltan Hadju-Benkö (NKM Energy), Marcus Halvarsson (Vattenfall), Kasper Jessen (Evonet), Rene Kuczkowski (Ene), Wlodzimierz Lewandowski (GKPGE), Juan Marco (E.DSO), Filip Marott Sundram (Dansk Energi), Kieran O’Neill (ESB Networks), Pablo Arguelles Tuñon (EDP Spain).

The report benefitted from valuable inputs from Eurelectric colleagues including Kristian Ruby, Henning Häder, Louise Rullaud, Sarah Herbreteau and Gilda Amorosi.
Table of contents

1. EU energy model and power system scenario 2020-2030
2. Distribution System Operators challenges to progress towards the Energy Transition
3. Power distribution grids Investment Outlook 2020-2030
4. Policy and regulatory recommendations
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
Global CO₂ emissions keep increasing despite efforts to curb them down to accelerate decarbonisation; EU Parliament has declared climate emergency.

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

**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

---

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

© 2020 Monitor Deloitte
European Union has committed to ambitious targets for economy decarbonisation by 2030

### EU27+UK targets by 2030

<table>
<thead>
<tr>
<th></th>
<th>GHG emissions</th>
<th>Share of renewable energy over final energy consumption</th>
<th>Increase in energy efficiency (reduction of final energy consumption vs. baseline projections)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>2017</strong></td>
<td>4,323 MTCO2 eq</td>
<td>18%</td>
<td>1,060 Mtoe</td>
</tr>
<tr>
<td><strong>Target 2030</strong></td>
<td>3,390 MTCO2 eq</td>
<td>32%</td>
<td>956 Mtoe</td>
</tr>
</tbody>
</table>

- **GHG emissions**: -22% -40% over 1990 levels. Proposal to increase this target to 50-55% (1)

- **Share of renewable energy over final energy consumption**: 32%

- **Increase in energy efficiency**: Energy savings (32.5%)

(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**

<table>
<thead>
<tr>
<th>Levers</th>
<th>Action</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>a. Electrification</strong></td>
<td>+40-50m(^{(1)}) heat pumps</td>
<td></td>
</tr>
<tr>
<td></td>
<td>50-70m electric vehicles</td>
<td></td>
</tr>
<tr>
<td></td>
<td>+335 TWh (add. demand) industrial and P2X</td>
<td></td>
</tr>
<tr>
<td><strong>b. Emission-free generation</strong></td>
<td>+470 GW centralised renewable</td>
<td></td>
</tr>
<tr>
<td></td>
<td>+40 GW self-consumption</td>
<td></td>
</tr>
<tr>
<td></td>
<td>~70% renewable capacity connected to distribution grids</td>
<td></td>
</tr>
<tr>
<td><strong>c. Energy efficiency and conservation</strong></td>
<td>Diversify EV charging</td>
<td>Enable &gt;50% EV charging in off-peak hours</td>
</tr>
<tr>
<td></td>
<td>Foster the roll-out of smart meters</td>
<td>Enable greater grid visibility and new services</td>
</tr>
</tbody>
</table>

---

\(^{(1)}\) 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
... 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**
(TWh; 2005-2030)

<table>
<thead>
<tr>
<th>Year</th>
<th>2005</th>
<th>2010</th>
<th>2015</th>
<th>2020</th>
<th>2025</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>EU27+UK</td>
<td>2,700</td>
<td>3,000</td>
<td>3,200</td>
<td>3,900</td>
<td>4,500</td>
<td>5,000</td>
</tr>
</tbody>
</table>

**Final electricity demand per country**
(TWh; 2030)

- **EU27+UK**: ~3,530 (1.8% CAGR)
- **Germany**: 725-768 (3.1%)
- **France**: 479 (0.8%)
- **Italy**: 310 (0.7%)
- **Spain**: 294 (1.8%)
- **Poland**: 174 (1.3%)
- **Sweden**: 150 (1.6%)
- **Denmark**: 71 (6.1%)
- **Portugal**: 55 (1.2%)
- **Hungary**: 52 (2.1%)
- **Ireland**: 38 (3.0%)

**CAGR** (2017-30; %)
- **EU27+UK**: 1.8%
- **Germany**: 3.1%
- **France**: 0.8%
- **Italy**: 0.7%
- **Spain**: 1.8%
- **Poland**: 1.3%
- **Sweden**: 1.6%
- **Denmark**: 6.1%
- **Portugal**: 1.2%
- **Hungary**: 2.1%
- **Ireland**: 3.0%

**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

© 2020 Monitor Deloitte
All sectors would contribute to electricity demand growth; with strongest increase in transport due to EV penetration.

**EU27+UK electricity demand by sector**

<table>
<thead>
<tr>
<th>Sector</th>
<th>2017</th>
<th>2030</th>
<th>Increase (2017-2030)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transport</td>
<td>59</td>
<td>200-260</td>
<td>11%</td>
</tr>
<tr>
<td>Residential</td>
<td>805</td>
<td>~875</td>
<td>0.6%</td>
</tr>
<tr>
<td>Commercial</td>
<td>829</td>
<td>~935</td>
<td>0.9%</td>
</tr>
<tr>
<td>Industry</td>
<td>1,033</td>
<td>~1,270</td>
<td>1.6%</td>
</tr>
<tr>
<td>Power-to-gas</td>
<td>0</td>
<td>100-250</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>2,798</td>
<td>~3,530</td>
<td>1.8%</td>
</tr>
</tbody>
</table>

*(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

© 2020 Monitor Deloitte
510 GW of new renewable capacity would be installed at EU27+UK level, ~70% will be connected to the distribution grids.

<table>
<thead>
<tr>
<th>Renewable capacity additions (GW; 2017-2030)</th>
<th>New RES connected to distribution grid (GW; 2017-2030)</th>
<th>Self-consumption capacity additions (GW; 2030)</th>
<th>Cumulative renewable capacity (GW; 2030)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EU27+UK</td>
<td>~510</td>
<td>~70%</td>
<td>~940</td>
</tr>
<tr>
<td>Germany</td>
<td>98</td>
<td>~93%</td>
<td>179</td>
</tr>
<tr>
<td>Spain</td>
<td>65</td>
<td>~25%</td>
<td>119</td>
</tr>
<tr>
<td>France</td>
<td>65</td>
<td>~85%</td>
<td>111</td>
</tr>
<tr>
<td>Italy</td>
<td>42</td>
<td>~83%</td>
<td>95</td>
</tr>
<tr>
<td>Denmark</td>
<td>15</td>
<td>~37%</td>
<td>22</td>
</tr>
<tr>
<td>Poland</td>
<td>15</td>
<td>~67%</td>
<td>24</td>
</tr>
<tr>
<td>Portugal</td>
<td>14</td>
<td>~56%</td>
<td>27</td>
</tr>
<tr>
<td>Sweden</td>
<td>12</td>
<td>~30%</td>
<td>38</td>
</tr>
<tr>
<td>Ireland</td>
<td>10</td>
<td>~43%</td>
<td>13</td>
</tr>
<tr>
<td>Hungary</td>
<td>6</td>
<td>~90%</td>
<td>7</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Electric Vehicles (BEV and PHEV) (million; 2030)</th>
<th>EV share (EV share; 2030)</th>
<th>Non-residential charging points (million; 2030)</th>
<th>Residential charging points (million; 2030)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EU27+UK</td>
<td>50-70</td>
<td>20-25%</td>
<td>4.3-6.4</td>
</tr>
<tr>
<td>Germany</td>
<td>10-24.3</td>
<td>20-55%</td>
<td>1-2.4</td>
</tr>
<tr>
<td>France</td>
<td>6.0</td>
<td>19%</td>
<td>1.80</td>
</tr>
<tr>
<td>Italy</td>
<td>6.0</td>
<td>16%</td>
<td>0.08</td>
</tr>
<tr>
<td>Spain</td>
<td>4.0</td>
<td>18%</td>
<td>0.05</td>
</tr>
<tr>
<td>Denmark</td>
<td>1.5</td>
<td>67%</td>
<td>0.02</td>
</tr>
<tr>
<td>Poland</td>
<td>1.5</td>
<td>6%</td>
<td>0.09</td>
</tr>
<tr>
<td>Sweden</td>
<td>1.0</td>
<td>22%</td>
<td>0.10</td>
</tr>
<tr>
<td>Ireland</td>
<td>0.9</td>
<td>45%</td>
<td>0.06</td>
</tr>
<tr>
<td>Portugal</td>
<td>0.6</td>
<td>14%</td>
<td>0.10</td>
</tr>
<tr>
<td>Hungary</td>
<td>0.2</td>
<td>6%</td>
<td>0.02</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Peak demand (GW; 2017-2030)</th>
<th>2017</th>
<th>2017-2030 increase</th>
<th>Peak demand (1) (CAGR; 2017-2030)</th>
<th>Electricity demand (1) (CAGR; 2017-2030)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany</td>
<td>79</td>
<td>44 123</td>
<td>3.5%</td>
<td>3.2%</td>
</tr>
<tr>
<td>France</td>
<td>~100</td>
<td>~100</td>
<td>~0%</td>
<td>0.8%</td>
</tr>
<tr>
<td>Italy</td>
<td>57</td>
<td>62</td>
<td>0.6%</td>
<td>0.7%</td>
</tr>
<tr>
<td>Spain</td>
<td>41</td>
<td>49</td>
<td>1.4%</td>
<td>1.8%</td>
</tr>
<tr>
<td>Poland</td>
<td>24</td>
<td>28</td>
<td>1.2%</td>
<td>1.3%</td>
</tr>
<tr>
<td>Sweden</td>
<td>26</td>
<td>28</td>
<td>0.6%</td>
<td>1.6%</td>
</tr>
<tr>
<td>Denmark</td>
<td>6</td>
<td>13</td>
<td>5.8%</td>
<td>6.1%</td>
</tr>
<tr>
<td>Hungary</td>
<td>6.6</td>
<td>2.8 9.4</td>
<td>2.7%</td>
<td>2.1%</td>
</tr>
<tr>
<td>Portugal</td>
<td>8.5</td>
<td>0.5 9</td>
<td>0.4%</td>
<td>1.2%</td>
</tr>
<tr>
<td>Ireland</td>
<td>4.9</td>
<td>1.5 6.4</td>
<td>1.9%</td>
<td>3.0%</td>
</tr>
</tbody>
</table>

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
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 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**

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

### Main power grid challenges

<table>
<thead>
<tr>
<th>a</th>
<th>Investment planning and execution</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Anticipate and optimise investments</td>
</tr>
<tr>
<td></td>
<td>Ease investment execution</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>b</th>
<th>Security of supply and automation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Modernise grid and smart meters deployment</td>
</tr>
<tr>
<td></td>
<td>Enhance grid stability</td>
</tr>
<tr>
<td></td>
<td>Increase resilience</td>
</tr>
<tr>
<td></td>
<td>Enhance data management</td>
</tr>
<tr>
<td></td>
<td>Cybersecurity</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>c</th>
<th>Energy Transition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Integrate variable RES generation</td>
</tr>
<tr>
<td></td>
<td>Enable demand-side participation</td>
</tr>
<tr>
<td></td>
<td>Integrate distributed resources</td>
</tr>
</tbody>
</table>
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**

- Digital substation
- Medium-scale RES generation
- Industry with demand management
- Industry and services with self-consumption
- Medium and low voltage control centers
- Smart EV charging
- Dwellings with self-consumption

---

Source: Monitor Deloitte

© 2020 Monitor Deloitte
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):

- 30-35% < 20 years
- 35-40% 20-40 years
- 25-35% >40 years

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. 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)

- **High (>70%)**
- **Medium (30-70%)**
- **Low (<30%)**

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

© 2020 Monitor Deloitte
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**
- Power lines
- Meters
- Transformers
- Sensors
- Switchgear
- Batteries
- Smart equipment
- Self-consumption

**Connectivity - Smart Grid Network**
- Wi-Fi
- Fiber Optic
- Mobile data

**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)
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 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

Source: Siemens; Monitor Deloitte
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) 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.

**Impacts of extreme weather and climate related events in Europe** (1980-2017)

<table>
<thead>
<tr>
<th>Losses (€mn)</th>
<th>High (&gt;15,000)</th>
<th>Medium (5,000-15,000)</th>
<th>Low (&lt;5,000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Losses per sq.km (€/km²)</td>
<td>278</td>
<td>300</td>
<td>310</td>
</tr>
</tbody>
</table>

Resiliency is key for climate change adaptation, but also for building stronger and safer energy infrastructures at European level.
DSOs need to ensure efficient operation with high amounts of variable renewable generation

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** within a representative day (GW)

<table>
<thead>
<tr>
<th>Year</th>
<th>2010</th>
<th>Today</th>
<th>2025E</th>
<th>2030E</th>
</tr>
</thead>
<tbody>
<tr>
<td>High ramp up requirements due to relevant increase in demand that overlaps with a decrease in solar PV generation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Real time voltage readings at representative High Voltage busbars**

<table>
<thead>
<tr>
<th>Voltage level (kV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum voltage level</td>
</tr>
<tr>
<td>Average voltage level</td>
</tr>
<tr>
<td>Expected voltage level</td>
</tr>
</tbody>
</table>

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

© 2020 Monitor Deloitte
Distributed Energy Resources (DER) integration requires, among other equipment, 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

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.

Impact of EV smart charging\(^{(1)}\) in the saturation of a connection line in a housing block \(^{(2)}\) (kW)

<table>
<thead>
<tr>
<th>Number of EVs</th>
<th>Household consumption</th>
<th>EV additional consumption</th>
<th>Original connection line capacity 153kW(^{(4)})</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>124</td>
<td>124</td>
<td>124</td>
</tr>
<tr>
<td>10</td>
<td>124</td>
<td>153</td>
<td>Investments for additional capacity in the housing block connection line</td>
</tr>
<tr>
<td>20</td>
<td>124</td>
<td>178</td>
<td>178</td>
</tr>
<tr>
<td>30</td>
<td>124</td>
<td>198</td>
<td>198</td>
</tr>
<tr>
<td>40</td>
<td>124</td>
<td>212</td>
<td>212</td>
</tr>
<tr>
<td>76</td>
<td>76</td>
<td>87</td>
<td>No investments needed in the housing block connection line</td>
</tr>
<tr>
<td>76</td>
<td>76</td>
<td>98</td>
<td>98</td>
</tr>
<tr>
<td>76</td>
<td>76</td>
<td>109</td>
<td>109</td>
</tr>
<tr>
<td>76</td>
<td>76</td>
<td>120</td>
<td>120</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Equipment</th>
<th>IT/OT Systems</th>
<th>Communications</th>
<th>Advanced analytics</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Upgrading/renewal of existing assets and advance protection systems</strong> to provide extra capacity</td>
<td><strong>GIS and mapping systems</strong> including grid capacity maps and power flow analysis tools</td>
<td><strong>Communication protocols with third-party physical assets/systems</strong>, including aggregators or ESCOs</td>
<td><strong>Prediction</strong> of load curve, generation or natural disasters</td>
</tr>
<tr>
<td><strong>Digital substations/transformers, advanced sensors and smart meters</strong> to enhance grid monitoring, stability and control</td>
<td><strong>Cloud data storage and management systems</strong></td>
<td><strong>Communication protocols</strong> to connect DSO systems with renewable generators</td>
<td><strong>Management and control</strong> of the grid</td>
</tr>
<tr>
<td><strong>Redundant equipment, underground lines and back-up storage</strong> (e.g. batteries) to increase security of supply</td>
<td><strong>Cybersecurity software solutions</strong> (e.g. malware protection)</td>
<td></td>
<td><strong>Predictive maintenance</strong></td>
</tr>
<tr>
<td><strong>Drones</strong> for power grid geographical mapping and optimising maintenance</td>
<td></td>
<td></td>
<td><strong>Cybersecurity software solutions</strong> (e.g. malware protection)</td>
</tr>
</tbody>
</table>

Source: Eurelectric; DSOs and national associations; Monitor Deloitte
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.
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
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)

Relative weight (%)

- Elect. of buildings & industry: ~19%
- Elect. of mobility: ~8%
- Emission-free generation: ~23%
- Modern. & Digitalisation: ~24%
- Smart meters: ~7%
- Resilience: ~8%
- Storage and others: ~2%

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

© 2020 Monitor Deloitte
Electrification and decarbonisation will require new power lines, reinforcements and additional transformer capacity

### Investments in distribution grids due to electrification and renewables by country (nominal €bn; 2020-30)

<table>
<thead>
<tr>
<th>Country</th>
<th>Investment (nominal €bn)</th>
<th>Final electricity demand (CAGR; 2017-2030)</th>
<th>Electric Vehicles (BEV and PHEV) (million; 2030)</th>
<th>RES connected to distribution grid (GW; 2017-2030)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EU27+UK</td>
<td>180-210</td>
<td>1.8%</td>
<td>50-70</td>
<td>+360</td>
</tr>
<tr>
<td>Germany</td>
<td>69-71(1)</td>
<td>3.2%</td>
<td>10-24.3</td>
<td>+91</td>
</tr>
<tr>
<td>France</td>
<td>25</td>
<td>0.8%</td>
<td>6.0</td>
<td>+55</td>
</tr>
<tr>
<td>Poland</td>
<td>9</td>
<td>1.3%</td>
<td>1.5</td>
<td>+10</td>
</tr>
<tr>
<td>Spain</td>
<td>9</td>
<td>1.8%</td>
<td>4.0</td>
<td>+16</td>
</tr>
<tr>
<td>Sweden</td>
<td>6</td>
<td>1.6%</td>
<td>1.0</td>
<td>+3</td>
</tr>
<tr>
<td>Ireland</td>
<td>3</td>
<td>3.0%</td>
<td>0.9</td>
<td>+4</td>
</tr>
<tr>
<td>Denmark</td>
<td>2</td>
<td>6.1%</td>
<td>1.5</td>
<td>+6</td>
</tr>
<tr>
<td>Hungary</td>
<td>1</td>
<td>2.1%</td>
<td>0.2</td>
<td>+6</td>
</tr>
<tr>
<td>Portugal</td>
<td>1</td>
<td>1.2%</td>
<td>0.6</td>
<td>+8</td>
</tr>
</tbody>
</table>

Variable renewables are a main driver for these investments, however they will improve EU competitiveness (e.g. through 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
Investments to integrate electrification and renewables will depend on several drivers, including the Energy Transition ambition.

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

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

© 2020 Monitor Deloitte
Replacement of obsolete infrastructure and increase of digitalisation levels are key to ensure security of supply and efficient grid management.

<table>
<thead>
<tr>
<th>Investments in modernisation, digitalisation and smart meters per country</th>
<th>Distribution circuit length (thousands km; 2013)</th>
<th>LV/MV transformers &gt;40 years old (%) 2020</th>
<th>Penetration of smart meters(1) (%) 2017</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>EU27+UK</strong></td>
<td><strong>145-170</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Germany</td>
<td>30</td>
<td>17%</td>
<td>~0%</td>
</tr>
<tr>
<td>France</td>
<td>19</td>
<td>20%</td>
<td>22%</td>
</tr>
<tr>
<td>Spain</td>
<td>12</td>
<td>28%</td>
<td>93%</td>
</tr>
<tr>
<td>Poland</td>
<td>10</td>
<td>17%</td>
<td>8%</td>
</tr>
<tr>
<td>Sweden</td>
<td>6</td>
<td>20%</td>
<td>100%</td>
</tr>
<tr>
<td>Denmark</td>
<td>3</td>
<td>25%</td>
<td>70%</td>
</tr>
<tr>
<td>Ireland</td>
<td>3</td>
<td>9%</td>
<td>~0%</td>
</tr>
<tr>
<td>Portugal</td>
<td>3</td>
<td>8%</td>
<td>25%</td>
</tr>
<tr>
<td>Hungary</td>
<td>2</td>
<td>32%</td>
<td>1%</td>
</tr>
</tbody>
</table>

(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

© 2020 Monitor Deloitte
~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)

<table>
<thead>
<tr>
<th>Component</th>
<th>2020-30 Investment (€bn)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modernisation</td>
<td>90-105</td>
</tr>
<tr>
<td>Automation of substations/transformer stations</td>
<td>15-16</td>
</tr>
<tr>
<td>Monitoring</td>
<td>13-15</td>
</tr>
<tr>
<td>Smart meters</td>
<td>30-35</td>
</tr>
<tr>
<td>Total 2020-30</td>
<td>145-170</td>
</tr>
</tbody>
</table>

- **Modernisation**
  - 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

- **Monitoring**
  - 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

© 2020 Monitor Deloitte
**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)

<table>
<thead>
<tr>
<th>Country</th>
<th>Investment (€bn)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EU27+UK</td>
<td>30-35</td>
</tr>
<tr>
<td>Poland</td>
<td>4.9</td>
</tr>
<tr>
<td>Germany</td>
<td>4.4</td>
</tr>
<tr>
<td>France</td>
<td>4.3</td>
</tr>
<tr>
<td>Sweden</td>
<td>4.0</td>
</tr>
<tr>
<td>Spain</td>
<td>1.9</td>
</tr>
<tr>
<td>Portugal</td>
<td>0.5</td>
</tr>
<tr>
<td>Hungary</td>
<td>0.3</td>
</tr>
<tr>
<td>Denmark</td>
<td>0.3</td>
</tr>
<tr>
<td>Ireland</td>
<td>0.2</td>
</tr>
</tbody>
</table>

**Resilience programs**

- **Ambitious plan to replace overhead lines with underground cables** for the entire MV network to reach the EU average ratio in 2040
- **Structurally integrated in their investment plan** as replacements and new lines are mostly underground
- **Resilience plan** to ensure electricity supply under extreme weather events (floods, storms, snow, etc.)
- **Program to shift overhead lines to underground lines and to add capacity**, to reduce the impact of weather events in grids
- **Becoming of great importance due to more frequent extreme weather events. The plan will be focused on increasing share of underground lines**
- **Becoming of great importance due to more frequent extreme weather events and low share of underground line**
- **Resilience plan aims to increase share of underground lines** to improve service quality under extreme weather, add additional capacity and lower opex costs
- **Resilience is not a focal point** of the investment plan as there is already a high share of underground lines
- **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

© 2020 Monitor Deloitte
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** (nominal €bn; 2015-2030)

- ~375-425 €bn during 2020-30 for a cost-efficient scenario with load flexibility measures
- +11-16 €bn (+50-70%) in 2015-19
- 34-39 €bn in 2020-30

**Key drivers**

- +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; ieaa; DSOs and national associations; Monitor Deloitte
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\(^{(1)}\)

<table>
<thead>
<tr>
<th>Year</th>
<th>Nominal €bn</th>
<th>% Growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011-2019</td>
<td>~22-23</td>
<td></td>
</tr>
<tr>
<td>2020-2030</td>
<td>~34-39</td>
<td></td>
</tr>
</tbody>
</table>

### Average investments for EU decarbonisation according to EC existing Targets\(^{(2)}\) scenario, excluding transport

<table>
<thead>
<tr>
<th>Year</th>
<th>Nominal €bn</th>
<th>% Growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011-2020</td>
<td>~191</td>
<td></td>
</tr>
<tr>
<td>2021-2030</td>
<td>~385</td>
<td>~100%</td>
</tr>
</tbody>
</table>

\(^{(1)}\) 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

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.
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\(^{(1)}\)
(\(\text{€nominal/MWh; EU27+UK}\))

\[\text{~1.5\%}\]

![Graph showing estimated distribution investment impact on electricity cost per electricity unit from 2019 to 2030.]

...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

© 2020 Monitor Deloitte
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

- **34-39 bn€ of annual DSO investments in power grids**
  - 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;
  - Also representative LCOEs may be +50% lower for renewables (onshore wind, solar PV) compared to fossil fuels;
  - Representative (minimum) value according to European Commission (benefits of climate action analysis) estimation for the period 2011-2050 (175-320 bn€ annually)

- **17-22 bn€ of average annual savings in CO2 emissions**
  - Estimated according to EU 2030 Target of final energy consumption by 2030 (956 Mtoe) and the 32.5% energy efficiency target

- **40-140 bn€ of annual savings in external costs**
  - Benefits from the development of power distribution grids as enablers of the Energy Transition

- **460 Mtoe of final energy consumption will be reduced**
  - By 2030, achieving a 32.5% of efficiency target

- **17-22 bn€ of average annual savings in CO2 emissions**
  - 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

- **460 Mtoe of final energy consumption will be reduced**
  - by 2030, achieving a 32.5% of efficiency target

- **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**
  - related to DSO grids (R&D, O&M, etc.) promoting local cohesion and economies

- **~0.2-0.3% of current EU GDP**
  - in annual investments in power distribution grids

- **~120 C €/Customer in 2020**
  - in annual investments in power distribution grids: It may decrease as the numbers of customers would increase due to increasing electrification

- **~40 GW of self-consumption capacity additions**

- **50-70 m EVs and smart charging**

- **New services:** storage, electric heating, smart appliances and demand aggregators

- **~120 C €/Customer in 2020**
  - in annual investments in power distribution grids: It may decrease as the numbers of customers would increase due to increasing electrification

- **~40 GW of self-consumption capacity additions**

- **50-70 m EVs and smart charging**

- **New services:** storage, electric heating, smart appliances and demand aggregators

- **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)

- **+175 bn€ annual savings in fuel import costs**
  - (current EU energy dependency is 55-60%)

(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
An increase GHG reduction target would result a marginal impact on grid investments (~8%)
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
Over the next 10 years, power grid activity will be transformed to execute investment, improve security of supply and enable the Energy Transition.

**Today**

- **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

- **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

- **Enable the Energy Transition**
  - <1m of EVs and charging points
  - ~470 GW of renewable capacity generation (2018)

**DSOs, NRAs and planning bodies efforts towards 2030**

- **Plan and execute investments**
  - ~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**
  - >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**
  - ~70m of EVs, ~56m of charging points
  - ~940 GW of renewable capacity generation

---

Source: Eurelectric; DSOs and national associations; Monitor Deloitte

© 2020 Monitor Deloitte
Regulatory action is needed at European and national level to mitigate key distribution grid challenges and enable the Energy Transition

### Main challenges

<table>
<thead>
<tr>
<th>Plan and execute investments</th>
<th>Policy issues</th>
<th>Regulatory actions$^{(1)}$</th>
<th>Policy level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planning</td>
<td>Low long-term visibility and lack of planning on power distribution grid investments related to Energy Transition</td>
<td>Facilitate flexible and adaptive national planning frameworks aligned with the Energy Transition and remove inadequately regulated investment limits that may jeopardise the Energy Transition</td>
<td>European level</td>
</tr>
<tr>
<td>Funding</td>
<td>Barriers for DSOs to apply for EU funds and need to unlock contribution of grids to post-COVID recovery</td>
<td>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</td>
<td>National level</td>
</tr>
<tr>
<td>Execution</td>
<td>Bureaucratic delays in local permits or environmental authorisations related to grid investments</td>
<td>Simplify and accelerate authorisation and permit granting processes, facilitating proper involvement of local communities (e.g. silent-consent procedures for authorisation of DSO invest.)</td>
<td>European level</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Improve security of supply and automation</th>
<th>Policy issues</th>
<th>Regulatory actions</th>
<th>Policy level</th>
</tr>
</thead>
<tbody>
<tr>
<td>DSO role</td>
<td>Lack of development of the DSO role principles established by the Clean Energy Package</td>
<td>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</td>
<td>European level</td>
</tr>
<tr>
<td>Remuneration</td>
<td>Historic costs and low exposure to disruptions are intrinsic features of current remuneration models</td>
<td>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</td>
<td>National level</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Enable the Energy Transition</th>
<th>Policy issues</th>
<th>Regulatory actions</th>
<th>Policy level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexibility</td>
<td>Absence of (or in progress) comprehensive regulatory frameworks around flexibility</td>
<td>Develop roles, smart infrastructure, economic signals (e.g. tariffs, grid products) and information exchange procedures under EU interoperability principles</td>
<td>European level</td>
</tr>
<tr>
<td>Tariffs</td>
<td>Electricity tariffs should be more cost-reflective and ensure that customers pay for the electricity and grid capacity used</td>
<td>Enable efficient tariff structures that optimise long-term power system investments and facilitate power system economic sustainability</td>
<td>National level</td>
</tr>
</tbody>
</table>

(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

© 2020 Monitor Deloitte
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)

<table>
<thead>
<tr>
<th>Year</th>
<th>2015-2019</th>
<th>2020-2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range</td>
<td>23</td>
<td>34-39</td>
</tr>
<tr>
<td>Percentage</td>
<td>+50-70%</td>
<td></td>
</tr>
</tbody>
</table>

### 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

- **Authorisation 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

© 2020 Monitor Deloitte
**Key regulatory initiatives**

<table>
<thead>
<tr>
<th>European Union General Frameworks</th>
<th>Regulatory recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Holistic cybersecurity risk mitigation</strong></td>
<td>• <strong>EU long-term cybersecurity strategy</strong> to enable secure data management at power system level</td>
</tr>
<tr>
<td><strong>Efficient data management</strong></td>
<td>• <strong>EU data management framework adaptable to the specific needs of the countries, to develop DSO responsibilities and capabilities</strong> (e.g. LV grid observability by providing access to DER deployment plans, generation schedules, flexibility management)</td>
</tr>
<tr>
<td><strong>Neutral service provision by DSO</strong></td>
<td>• <strong>Advanced procedures and codes for flexibility</strong> and smart metering services</td>
</tr>
<tr>
<td><strong>Effective coordination between DSO and TSO</strong></td>
<td>• <strong>Framework to develop responsibilities and coordination guidelines</strong>, 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)</td>
</tr>
<tr>
<td><strong>Innovation</strong></td>
<td>• <strong>Framework to prioritise actions</strong> (e.g. advanced analytic tools, new technologies, data hubs) and set out <strong>required schemes</strong> (e.g. incentives, sandboxes)</td>
</tr>
</tbody>
</table>

**Key elements at national level to be considered by National Regulatory Authorities (NRA)**

Source: Eurelectric; DSOs and national associations; Monitor Deloitte

© 2020 Monitor Deloitte

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

**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**

**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

**Process**
- **Delays in the development of regulatory reviews** that may jeopardise investments required for the Energy Transition

### Regulatory recommendations

**Principles**
- Enable forward-looking remuneration schemes that focus on **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**
- 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**
- **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
Develop roles, infrastructure, economic signals and information exchange procedures at European and national level, ensuring EU interoperability

<table>
<thead>
<tr>
<th>Key regulatory initiatives</th>
<th>Regulatory recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cross border integration and interoperability</td>
<td>• Facilitate a <strong>EU regulatory framework</strong> that ensures market interoperability and cross border integration of flexibility</td>
</tr>
<tr>
<td>Roles</td>
<td>• <strong>Define responsibilities</strong> among parties (e.g. consumers, micro-generators, storage operators, aggregators, grid operators, regulator) to deliver flexibility services</td>
</tr>
<tr>
<td>Smart Infrastructure</td>
<td>• <strong>Assess flexibility</strong>&lt;sup&gt;(1)&lt;/sup&gt; 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)</td>
</tr>
<tr>
<td>Economic signals</td>
<td>• <strong>Facilitate the right incentives for DSOs and market players</strong> to ensure:</td>
</tr>
<tr>
<td></td>
<td>‒ An <strong>optimal mix</strong> between investments and flexibility, that <strong>minimises the long-term costs and maximises benefits for society</strong></td>
</tr>
<tr>
<td></td>
<td>‒ Cost recovery with an appropriate margin/return for the <strong>DSO</strong>, including required ICT and infrastructure costs</td>
</tr>
<tr>
<td></td>
<td>• <strong>Develop mechanisms (e.g. tariffs, grid products) for flexibility providers</strong>, that enable efficient price signals, depending on country conditions</td>
</tr>
<tr>
<td>Information</td>
<td>• <strong>Enable efficient data exchange and coordination procedures among parties</strong> for optimal utilisation of resources, as well as the secure and efficient operation</td>
</tr>
</tbody>
</table>

<sup>(1)</sup> 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
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

Annex I. Methodological approach
Annex II. Power Scenario per country
Annex III. Investments per country
Model structure for Investment Outlook assessment

**Investment drivers**

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

**Key data for Investment Outlook assessment**

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

**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.

**Power Grid modelling**

- **Assets**
  - What type of facilities/equipment will be deployed?
    - For example:
      - New lines
      - Equipment for digitalisation and automation
      - Etc.

- **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**
  - Additional lines (or reinforcements) due to power increase
  - Unit cost per additional line (or reinforcements)

- **Illustrative example**
  - Residential increase of connection power

Illustrative example

M€ in lines

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

Annex I. Methodological approach
Annex II. Power Scenario per country
Annex III. Investments per country
Power Scenario for Germany by 2030

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

<table>
<thead>
<tr>
<th></th>
<th>2017</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>Renewable capacity (GW)</td>
<td>115</td>
<td>179</td>
</tr>
<tr>
<td>Peak demand (GW)</td>
<td>79</td>
<td>~123</td>
</tr>
</tbody>
</table>

### 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

© 2020 Monitor Deloitte
Power Scenario for Denmark by 2030

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

<table>
<thead>
<tr>
<th>Renewable capacity (GW)</th>
<th>7</th>
<th>22</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak demand (GW)</td>
<td>6</td>
<td>~13</td>
</tr>
</tbody>
</table>

**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: ie; eurelectric; Monitor Deloitte analysis

© 2020 Monitor Deloitte
Power Scenario for Portugal by 2030

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

<table>
<thead>
<tr>
<th>Sector</th>
<th>2017</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td>Commercial</td>
<td>14</td>
<td>16</td>
</tr>
<tr>
<td>Transport</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Industry</td>
<td>19</td>
<td>22</td>
</tr>
<tr>
<td>Others</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Renewable capacity (GW)
- 13
- 27

Peak demand (GW)
- 8.5
- 9

1.2% increase in demand

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.
- **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

ESTIMATIONS BASED ON EURELECTRIC DATA AND NECPs
## Power Scenario for Sweden by 2030

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

<table>
<thead>
<tr>
<th>Sector</th>
<th>2017</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>1</td>
<td>1.6%</td>
</tr>
<tr>
<td>Transport</td>
<td>123</td>
<td>150</td>
</tr>
<tr>
<td>Residential</td>
<td>45</td>
<td>39</td>
</tr>
<tr>
<td>Commercial</td>
<td>24</td>
<td>35</td>
</tr>
<tr>
<td>Industry</td>
<td>49</td>
<td>68</td>
</tr>
<tr>
<td>Others</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

### Key power system insights

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

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

### Estimations based on Eurelectric data

(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

© 2020 Monitor Deloitte
## Power Scenario for Spain by 2030

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

<table>
<thead>
<tr>
<th>Sector</th>
<th>2017</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>Renewable capacity (GW)</td>
<td>51</td>
<td>119</td>
</tr>
<tr>
<td>Peak demand (GW)</td>
<td>41</td>
<td>~49</td>
</tr>
</tbody>
</table>

### 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

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

<table>
<thead>
<tr>
<th>Sector</th>
<th>2017</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>147</td>
<td>30</td>
</tr>
<tr>
<td>Commercial</td>
<td>49</td>
<td>56</td>
</tr>
<tr>
<td>Industry</td>
<td>63</td>
<td>67</td>
</tr>
<tr>
<td>Others</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

**Renewable capacity**
(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
## Final electricity demand by sector (TWh; 2017-2030)

<table>
<thead>
<tr>
<th>Sector</th>
<th>2017</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transport</td>
<td>434</td>
<td>479</td>
</tr>
<tr>
<td>Residential</td>
<td>159</td>
<td>165</td>
</tr>
<tr>
<td>Commercial</td>
<td>139</td>
<td>135</td>
</tr>
<tr>
<td>Industry/Others</td>
<td>117</td>
<td>141</td>
</tr>
</tbody>
</table>

### Key power system insights

- **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 the NECP, the pace of renovation reaches ~370k full renovations per year

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

<table>
<thead>
<tr>
<th>Renewable capacity (GW)</th>
<th>46</th>
<th>111</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak demand (GW)</td>
<td>&gt;100 (3)</td>
<td>~100</td>
</tr>
</tbody>
</table>

**ESTIMATIONS BASED ON EURELECTRIC DATA**

(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

© 2020 Monitor Deloitte
Power Scenario for Italy by 2030

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

<table>
<thead>
<tr>
<th>Sector</th>
<th>2017</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>57</td>
<td>62</td>
</tr>
<tr>
<td>Transport</td>
<td>284</td>
<td>310</td>
</tr>
<tr>
<td>Commercial</td>
<td>93</td>
<td>94</td>
</tr>
<tr>
<td>Industry</td>
<td>113</td>
<td>118</td>
</tr>
<tr>
<td>Others</td>
<td>5</td>
<td>6</td>
</tr>
</tbody>
</table>

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

Estimations based on Eurelectric data and NECPs

(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

© 2020 Monitor Deloitte
### Power Scenario for Ireland by 2030

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

<table>
<thead>
<tr>
<th>Sector</th>
<th>2017</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transport</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Residential</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>Commercial</td>
<td>7</td>
<td>11</td>
</tr>
<tr>
<td>Industry</td>
<td>10</td>
<td>15</td>
</tr>
<tr>
<td>Others</td>
<td>0</td>
<td>2</td>
</tr>
</tbody>
</table>

- **Renewable capacity (1)** (GW)
  - 4
- **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**

#### Estimations based on Eurelectric data

- **Renewable capacity (1)** (GW)
  - 4
- **Peak demand (GW)**
  - 5
  - ~6.4

#### Electrification in transport
- will be led by the penetrations 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 (by 2025) and peat-fired electricity generation (2028)

Source: IEA; Eurelectric; Monitor Deloitte analysis

© 2020 Monitor Deloitte

Connecting the dots: Distribution grid investment to power the energy transition
Power Scenario for Hungary by 2030

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

<table>
<thead>
<tr>
<th></th>
<th>2017</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>Renewable capacity (GW)</td>
<td>0.3</td>
<td>6.5</td>
</tr>
<tr>
<td>Peak demand (GW)</td>
<td>7</td>
<td>~9</td>
</tr>
</tbody>
</table>

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

© 2020 Monitor Deloitte
Contents

Annex I. Methodological approach
Annex II. Power Scenario per country
Annex III. Investments per country
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% |
| 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
## Overall investments in power distribution grids
(nominal €bn; 2020-30)

<table>
<thead>
<tr>
<th>Category</th>
<th>Investment (bn)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrification of buildings &amp; industry</td>
<td>20</td>
</tr>
<tr>
<td>Electrification of mobility</td>
<td>1-3</td>
</tr>
<tr>
<td>Emission-free generation</td>
<td>48</td>
</tr>
<tr>
<td>Modernisation</td>
<td>18</td>
</tr>
<tr>
<td>Digitalisation</td>
<td>6</td>
</tr>
<tr>
<td>Resilience</td>
<td>4</td>
</tr>
<tr>
<td>Smart meters</td>
<td>6</td>
</tr>
<tr>
<td>Storage and others</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total 2020-2030</strong></td>
<td><strong>~104</strong></td>
</tr>
</tbody>
</table>

### 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

© 2020 Monitor Deloitte
**Investments per country - Denmark**

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

<table>
<thead>
<tr>
<th>Category</th>
<th>Investment (€bn)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrification of buildings &amp; industry</td>
<td>0.6</td>
</tr>
<tr>
<td>Electrification of mobility</td>
<td>0.9</td>
</tr>
<tr>
<td>Emission-free generation</td>
<td>0.4</td>
</tr>
<tr>
<td>Modernisation</td>
<td>2.7</td>
</tr>
<tr>
<td>Digitalisation</td>
<td>0.2</td>
</tr>
<tr>
<td>Resilience</td>
<td>0.3</td>
</tr>
<tr>
<td>Smart meters</td>
<td>0.6</td>
</tr>
<tr>
<td>Storage and others</td>
<td>0.1</td>
</tr>
<tr>
<td><strong>Total 2020-2030</strong></td>
<td><strong>5.7</strong></td>
</tr>
</tbody>
</table>

**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

© 2020 Monitor Deloitte
Investments per country - Portugal

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

- Electrification of buildings & industry: 0.8
- Electrification of mobility: 0.1
- Emission-free generation: 0.1
- Modernisation: 1.3
- Digitalisation: 0.9
- Resilience: 0.5
- Smart meters: 0.4
- Storage and others: 0.4
- Total 2020-2030: 4.5

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

© 2020 Monitor Deloitte
Investments per country - Sweden

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

<table>
<thead>
<tr>
<th>Category</th>
<th>Investment (€bn)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrification of buildings &amp; industry</td>
<td>5.1</td>
</tr>
<tr>
<td>Electrification of mobility</td>
<td>0.2</td>
</tr>
<tr>
<td>Emission-free generation</td>
<td>0.6</td>
</tr>
<tr>
<td>Modernisation</td>
<td>4.8</td>
</tr>
<tr>
<td>Digitalisation</td>
<td>0.4</td>
</tr>
<tr>
<td>Resilience</td>
<td>4.0</td>
</tr>
<tr>
<td>Smart meters</td>
<td>1.1</td>
</tr>
<tr>
<td>Storage and others</td>
<td>0.0</td>
</tr>
<tr>
<td><strong>Total 2020-2030</strong></td>
<td><strong>16.1</strong></td>
</tr>
</tbody>
</table>

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

© 2020 Monitor Deloitte
Investments per country - Spain

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

<table>
<thead>
<tr>
<th>Category</th>
<th>Investment (€bn)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrification of buildings &amp; industry</td>
<td>4.8</td>
</tr>
<tr>
<td>Electrification of mobility</td>
<td>1.8</td>
</tr>
<tr>
<td>Emission-free generation</td>
<td>2.2</td>
</tr>
<tr>
<td>Modernisation</td>
<td>7.3</td>
</tr>
<tr>
<td>Digitalisation</td>
<td>3.7</td>
</tr>
<tr>
<td>Resilience</td>
<td>1.9</td>
</tr>
<tr>
<td>Smart meters</td>
<td>0.8</td>
</tr>
<tr>
<td>Storage and others</td>
<td>0.0</td>
</tr>
<tr>
<td><strong>Total 2020-2030</strong></td>
<td><strong>22.5</strong></td>
</tr>
</tbody>
</table>

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

© 2020 Monitor Deloitte
Investments per country - Poland

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

<table>
<thead>
<tr>
<th>Category</th>
<th>2020-2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrification of buildings &amp; industry</td>
<td>7.0</td>
</tr>
<tr>
<td>Electrification of mobility</td>
<td>1.7</td>
</tr>
<tr>
<td>Emission-free generation</td>
<td>0.5</td>
</tr>
<tr>
<td>Modernisation</td>
<td>6.4</td>
</tr>
<tr>
<td>Digitalisation</td>
<td>0.7</td>
</tr>
<tr>
<td>Resilience</td>
<td>4.9</td>
</tr>
<tr>
<td>Smart meters</td>
<td>2.5</td>
</tr>
<tr>
<td>Storage and others</td>
<td>1.3</td>
</tr>
<tr>
<td>Total 2020-2030</td>
<td>25.0</td>
</tr>
</tbody>
</table>

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

© 2020 Monitor Deloitte
Investments per country - France

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

<table>
<thead>
<tr>
<th>Category</th>
<th>2020-2030 Investment (€bn)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrification of buildings &amp; industry</td>
<td>17</td>
</tr>
<tr>
<td>Electrification of mobility</td>
<td>4</td>
</tr>
<tr>
<td>Emission-free generation</td>
<td>5</td>
</tr>
<tr>
<td>Modernisation</td>
<td>11</td>
</tr>
<tr>
<td>Digitalisation</td>
<td>4</td>
</tr>
<tr>
<td>Resilience</td>
<td>4</td>
</tr>
<tr>
<td>Smart meters</td>
<td>3</td>
</tr>
<tr>
<td>Storage and others</td>
<td>2</td>
</tr>
<tr>
<td>Total 2020-2030</td>
<td>49</td>
</tr>
</tbody>
</table>

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

© 2020 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

connecting the dots: Distribution grid investment to power the energy transition 71

© 2020 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

© 2020 Monitor Deloitte
Manufacturing processes and advanced electrical equipment capabilities will deliver technological improvements in the power distribution grids

<table>
<thead>
<tr>
<th>Manufacturing processes (e.g. <em>Industry 4.0 paradigm</em>)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Digital technologies to improve equipment manufacturing efficiency (e.g. Big Data and analytics)</td>
</tr>
<tr>
<td>• “Multi-physical” (computer simulations) model trials that reduce development costs</td>
</tr>
<tr>
<td>• Production Automation (e.g. 3D printing)</td>
</tr>
<tr>
<td>• Advanced supervision of product quality (e.g. through Artificial Intelligence)</td>
</tr>
<tr>
<td>• Recycling/reuse of components (e.g. copper or aluminium in transformers)</td>
</tr>
<tr>
<td>• Advanced and more efficient materials (e.g. amorphous materials in transformers, Composites alloys for structures or Superconductors)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Advanced capabilities (e.g. through operations digitalisation or advanced equipment)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Digitalisation of field operations will increase mobility and efficiency, as well as work-crew flexibilisation (e.g. retainer simplification)</td>
</tr>
<tr>
<td>• 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</td>
</tr>
<tr>
<td>• Advanced O&amp;M with impact in costs, e.g. advanced electrical equipment:</td>
</tr>
<tr>
<td>• Reduces the need to perform field inspections</td>
</tr>
<tr>
<td>• Reduces costs of operation and maintenance and labour-related risks</td>
</tr>
<tr>
<td>• Improving quality of supply with impact in costs, e.g. representative R&amp;D projects on advanced smart grids benefits:</td>
</tr>
<tr>
<td>• Reduced field intervention cost</td>
</tr>
<tr>
<td>• Reduced power losses by equipment modernisation</td>
</tr>
</tbody>
</table>
Power Distribution grid annual investment indicators (2020-2030)

- **Annual investments per average Power Consumption**
  - 11.3 (€nominal/MWh)

- **Annual investments per Nominal GDP**
  - ~0.25%

- **Total annual investment per Metering Point in 2020**
  - 126 (€nominal/Metering Point)

---

(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
Future confident

To navigate the future with confidence, organizations need to make the right choices: clear, timely and inspirational choices that deliver growth in a dynamic, disrupted world. Monitor Deloitte’s strategy practitioners combine deep industry insights with cutting edge methods to help leaders resolve their most critical decisions, drive value, and achieve transformational success.

This report/document is strictly confidential and for internal Company use and it may not be delivered to third parties, third parties may not be allowed access to it and nor may it be referred to in communications without our prior written consent.

This document has been exclusively prepared for promotional purposes, based on certain public information and from the Entity, and reflects some comments of a general nature. Deloitte does not assume any type of responsibility to the Company or a third party as a consequence of the decisions or actions that can be adopted by the Company based on the content of this document.

Deloitte does not have control over the performance, reliability, availability or security of e-mail and shall not therefore be liable for any loss, delay, interception by third parties, corruption or alteration of the content of this report/document. In the event of a contradiction or conflict between the electronic version and the hard copy, the hard copy shall prevail.

Deloitte refers to Deloitte Touche Tohmatsu Limited, a UK private company limited by guarantee, and its network of member firms, each of which is a legally separate and independent entity. Please see www.deloitte.com/about for a detailed description of the legal structure of Deloitte Touche Tohmatsu Limited and its member firms.

© 2020 Deloitte Consulting, S.L.U.