

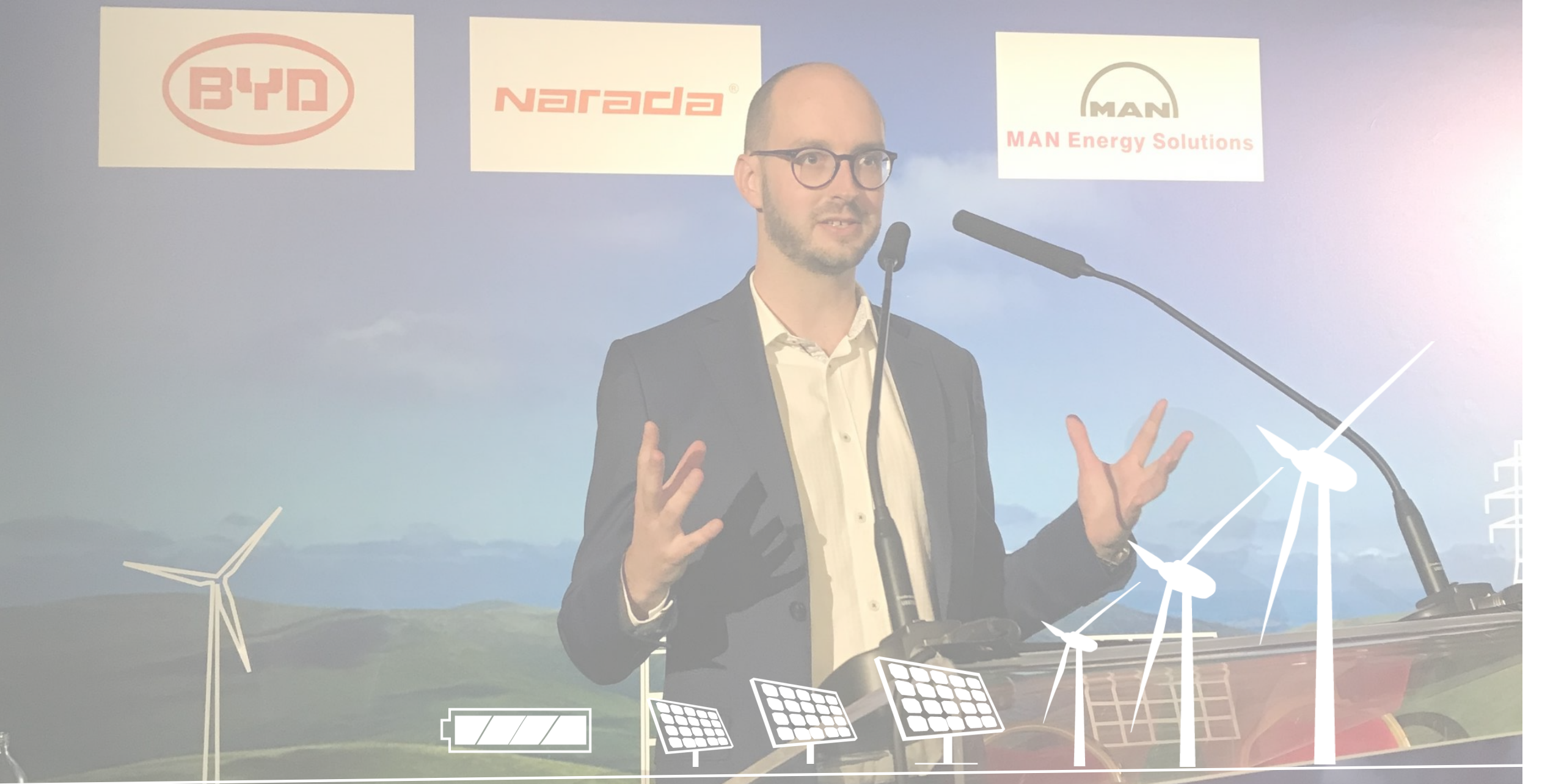


WHEN TRUST MATTERS

The Energy Transition Outlook – Power Grids

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2023



An independent assurance and risk management company

158
years

~12,000
employees

100,000
customers

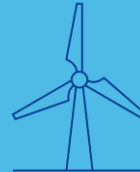
100+
countries

5% R&D
of annual revenue

**Ship and offshore
classification and advisory**



**Energy advisory, certification,
verification, inspection and
monitoring**



**Management system certification,
supply chain and
product assurance**



Software, platforms and digital solutions



Helping to navigate the many complex, interrelated transitions

Enabling a faster transition

We are committed to realizing the goals of the Paris Agreement, and support our customers to transition faster to a deeply decarbonized energy system

Energy system thinking

Our holistic knowledge and competence allows us to think across sectors and support the integration of all energy systems

Deep and broad domain expertise

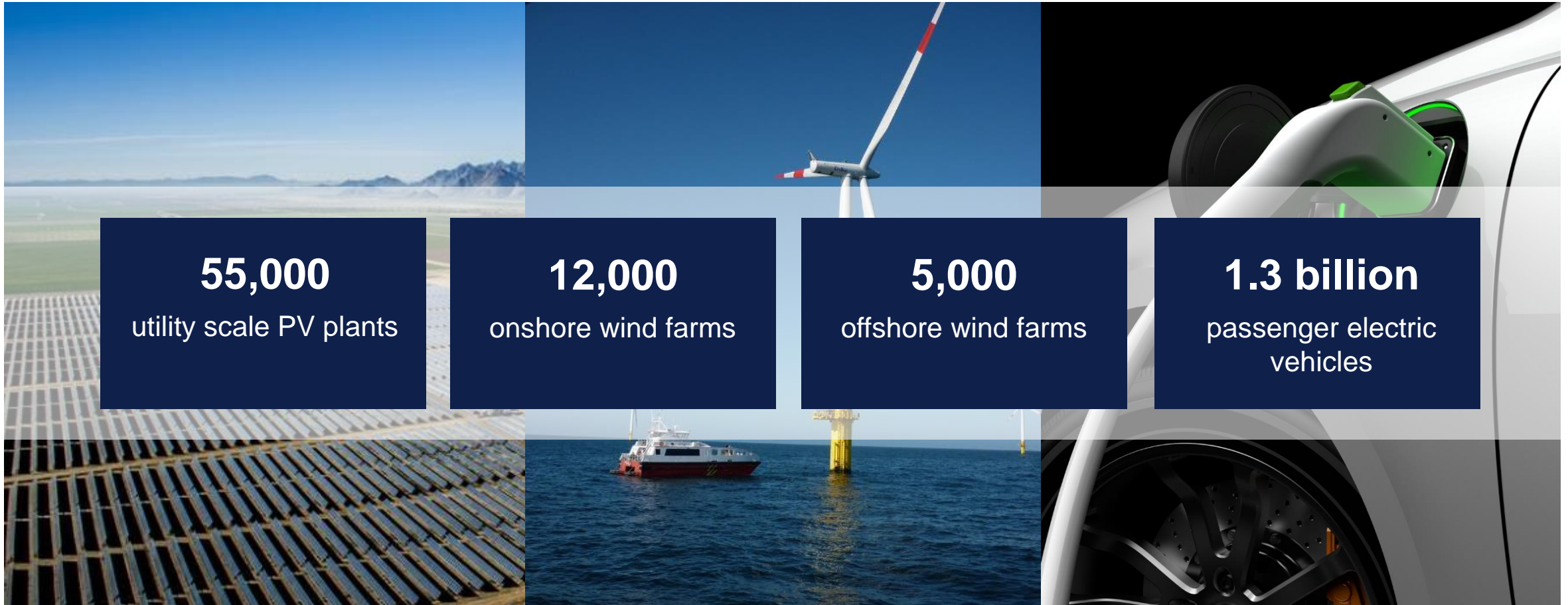
Our independent energy experts provide assurance across energy generation and production, transmission and distribution, and end use

A great deal of attention, investment, and policy is rightly focused on clean energy generation and the decarbonization of industry. But the role of power grids is sometimes under-appreciated and misunderstood

“Power Transmission is key to our clean energy future. If we address the barriers standing in the way of that future, it will lead to lower emissions, cleaner air, more jobs, fewer blackouts, more energy and economic security, and healthier communities.”

- Bill Gates, January 2023

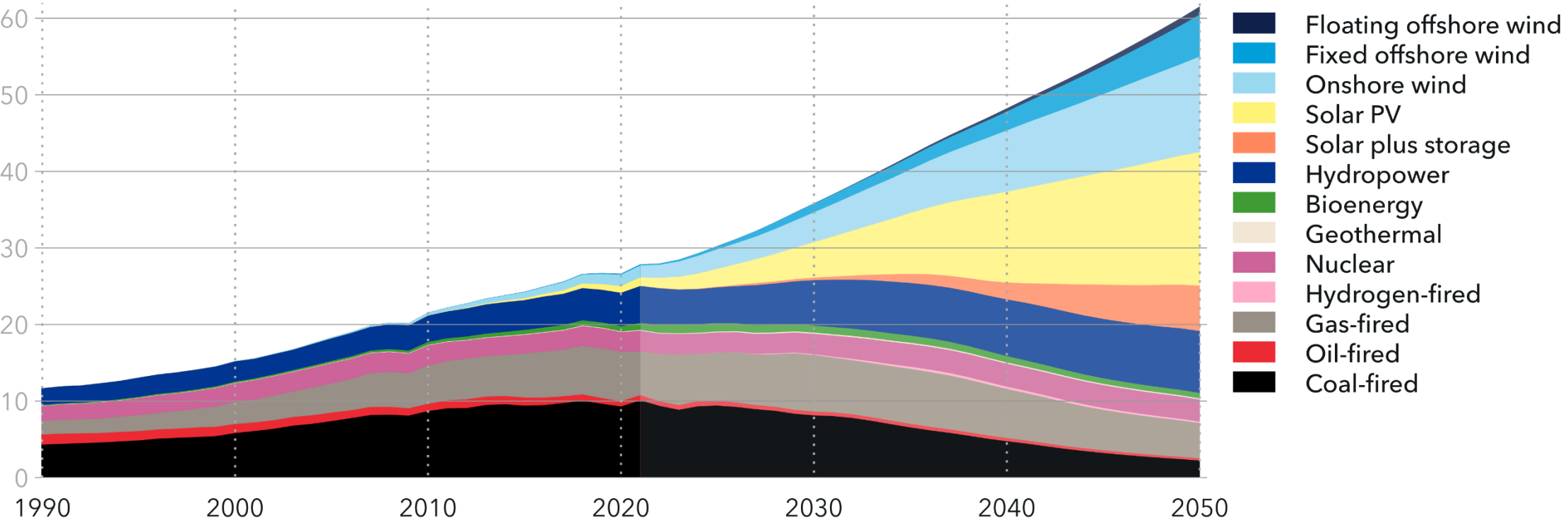
In 2050, the electricity system will be dramatically different than today



70% of renewables will come from solar and wind

World grid-connected electricity generation by power station type

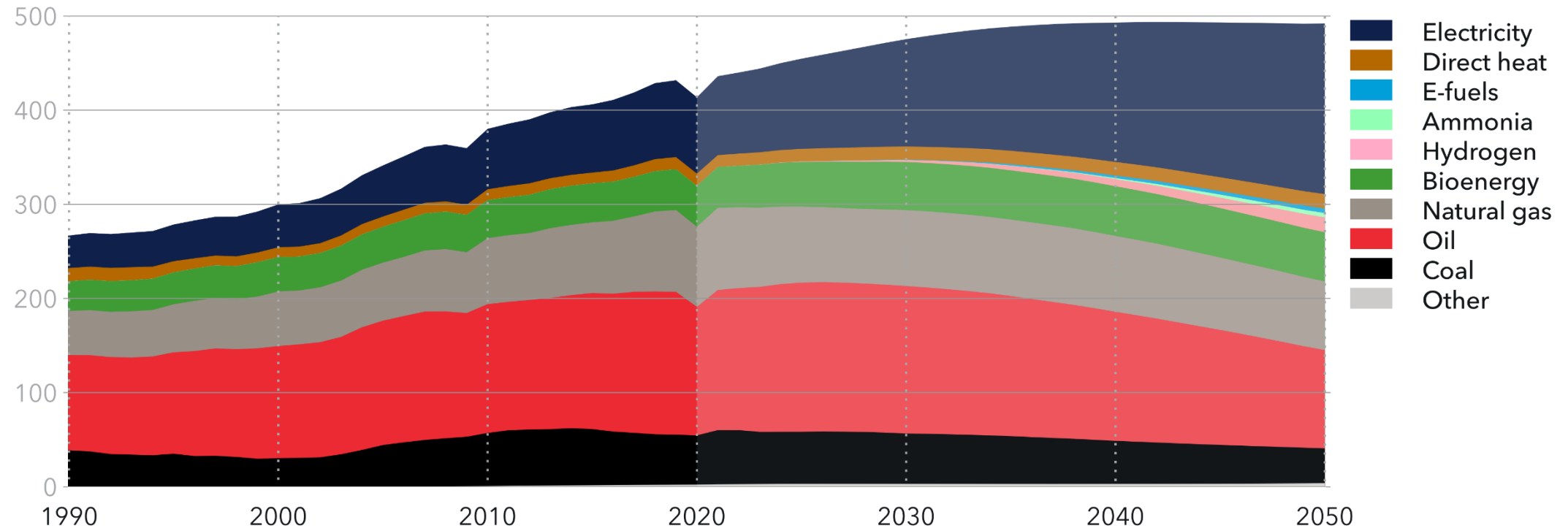
Units: PWh/yr



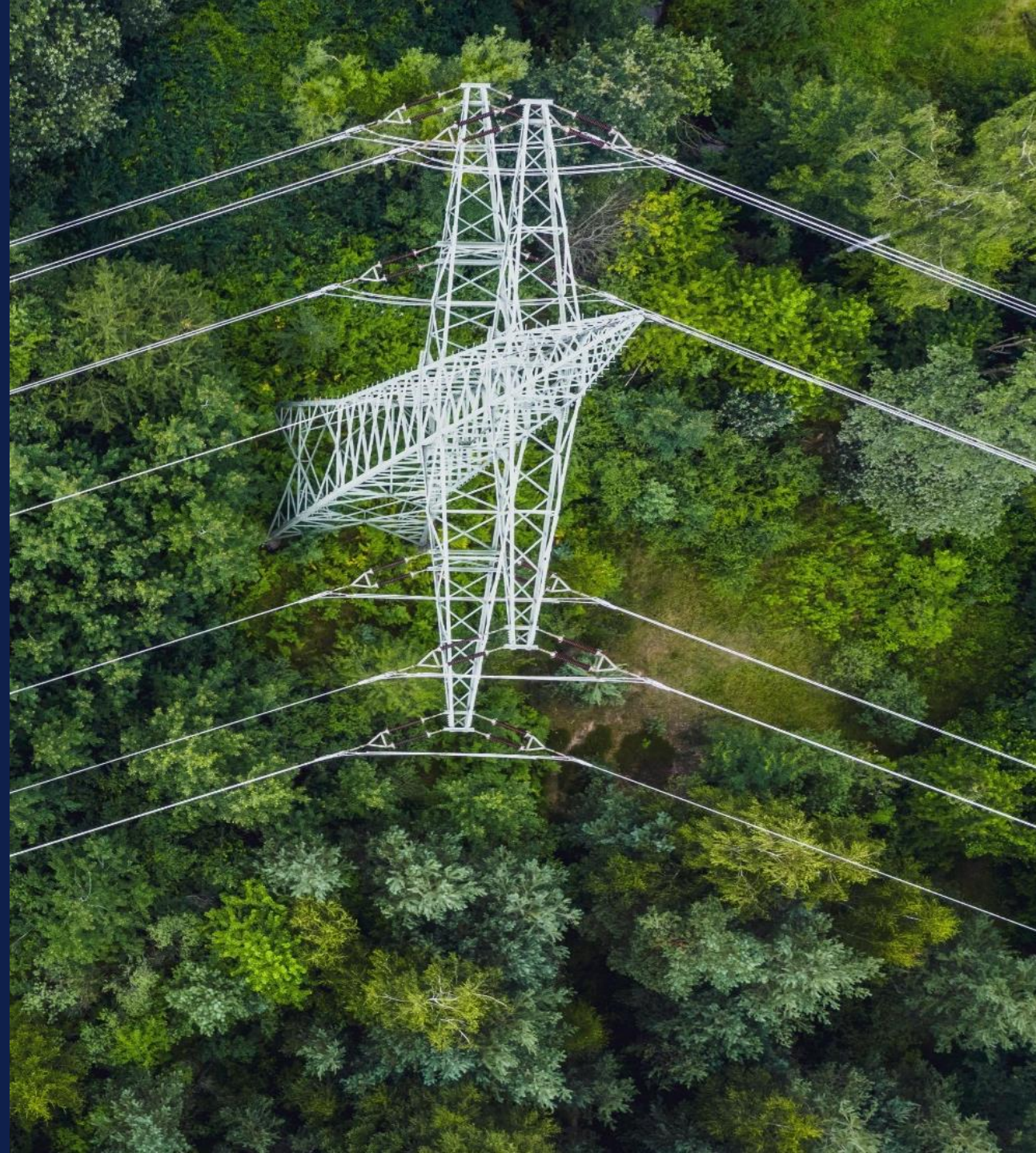
The share of electricity in the final energy demand mix doubles

World final energy demand by carrier

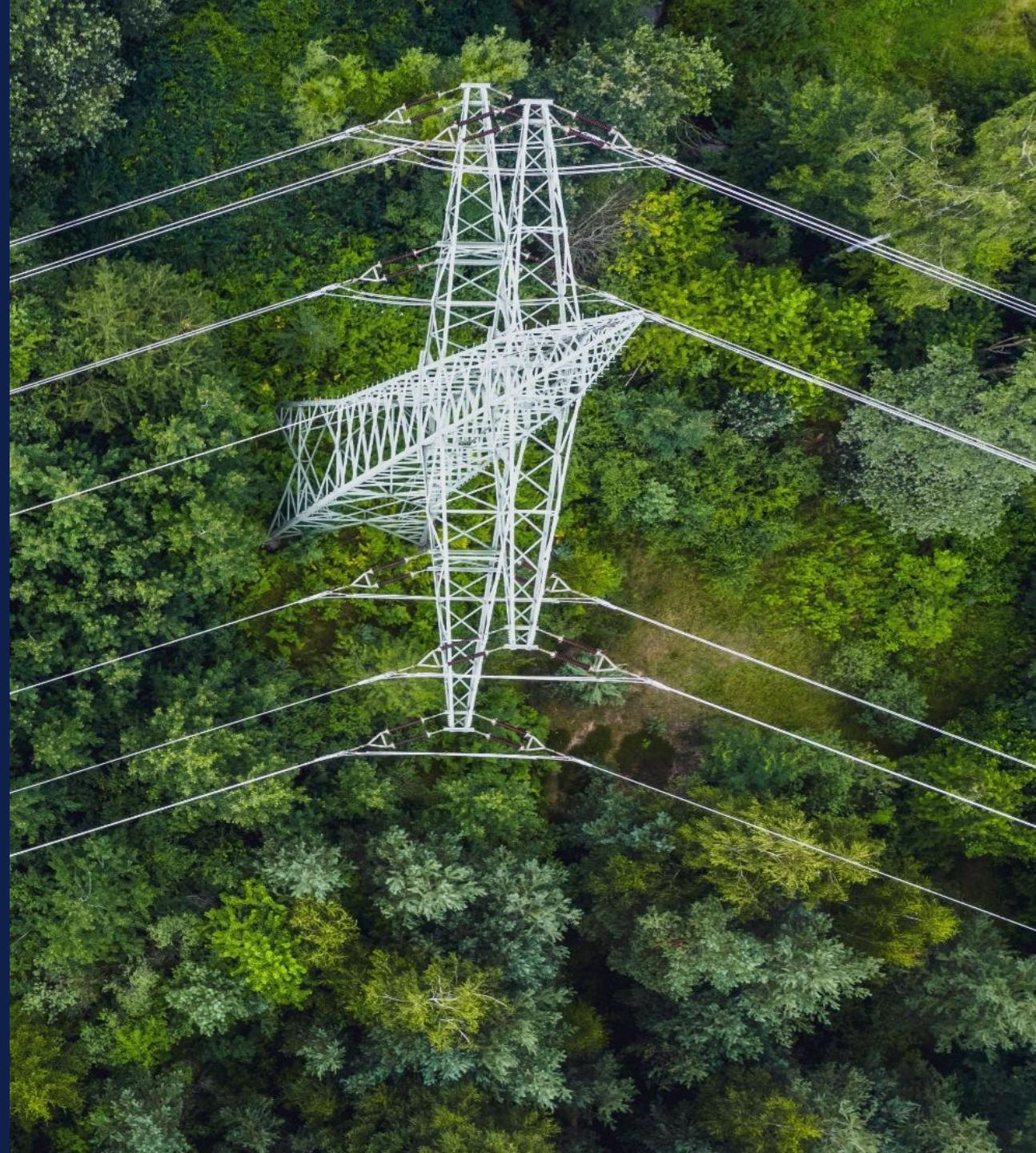
Units: EJ/yr



Our Power Grids around the world are changing



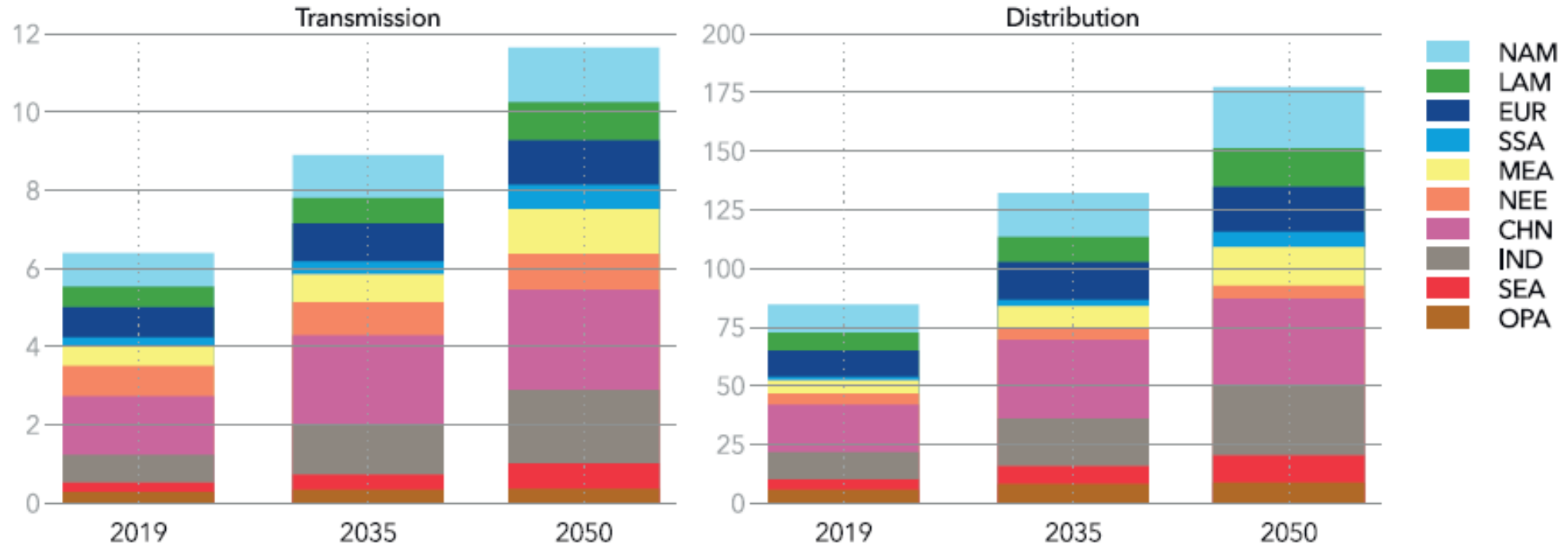
- **Growth of offshore wind** will require massive expansion of resilient transmission grids and introduction of (interoperable) HVDC / HVAC / hybrid grids
- Onshore DER and electrification drive the **expansion, reinforcement and enhanced complexity of system operations**
- **Networks need to be operated closer to limits** while maintaining reliability of aging assets
- **(Near) real-time decisions are needed to ensure cost effective reliability.** This requires the digital transformation, based on standardized data and information exchange, interoperability and modularity of IT/OT systems



World transmission lines will increase from just over 6 million circuit-kilometres in 2019 to almost 12 million by 2050

Transmission and distribution power-line length by region

Units: Million circuit-km

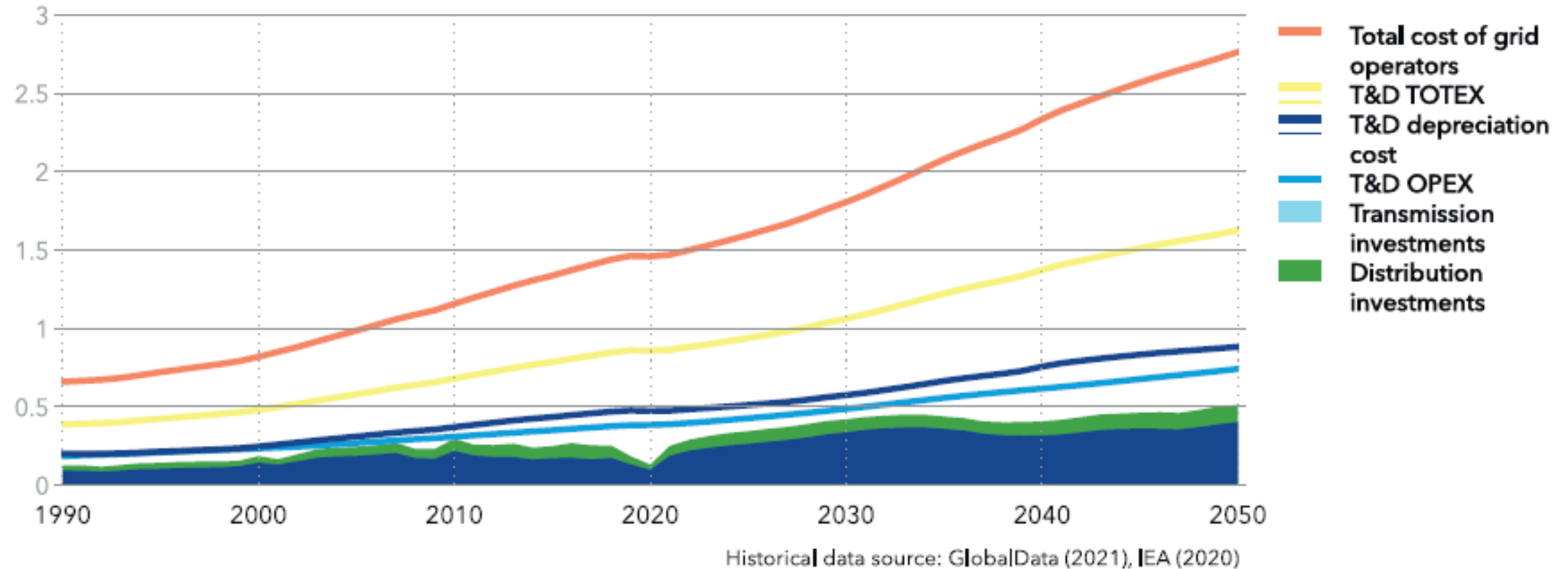


Historical data source: GlobalData (2021)

There will be a steady increase in grid investments until the 2030s, reaching levels of USD 400-500bn/yr.

World power grid investments, expenditures and total cost

Units: Trillion USD/yr



Accelerating Innovation and Digital Transformation

Investments are not only for grid expansion:

- Some 15% of grid investment will go into digital infrastructure
- To address the complexity of a more-decentralized power system and to support decision making in asset management and operations. Investments in digital tools will expand to enable collection of data and information from the grid and feed these to core processes. These tools include
 - Advanced analytical algorithms enhanced with machine learning
 - Asset conditions
 - IT infrastructure
 - Data Storage
 - Cyber security
 - Sensor arrays

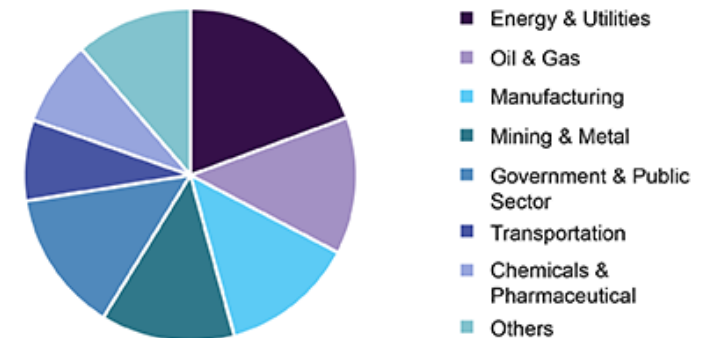


Digitalization: APM becomes solution for utilities to improve asset mgmt. and operations

- Utilities changing from **reactive to preventive and predictive** maintenance schemes by means of APM insights
- **Typical APM capabilities**
 - Condition monitoring, health indexing, predictive forecasting
 - Risk & reliability centred maintenance
- **Typical APM use cases**
 - Optimising substation maintenance and replacement plans
 - Optimising vegetation and wildfire management
 - Dynamic rating
 - Support power system planning
 - Develop real-time (and near-time) digital twins
- Both **cloud based and on-premise** solutions

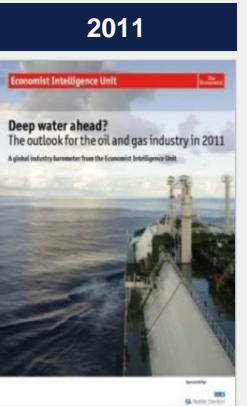
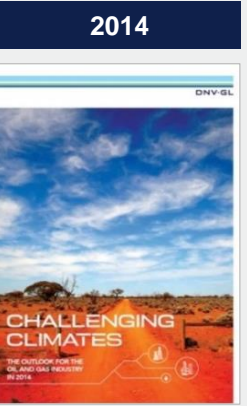
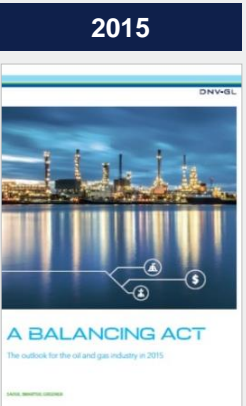
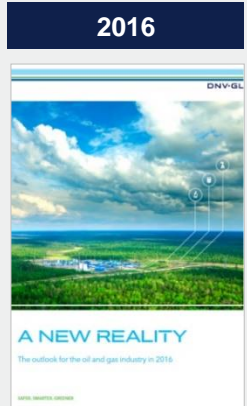
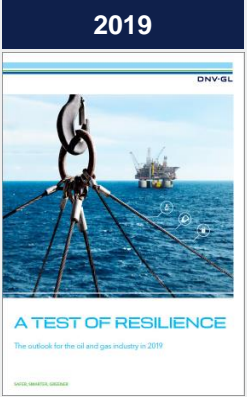
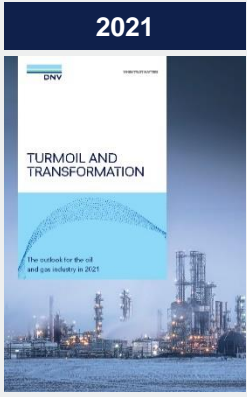
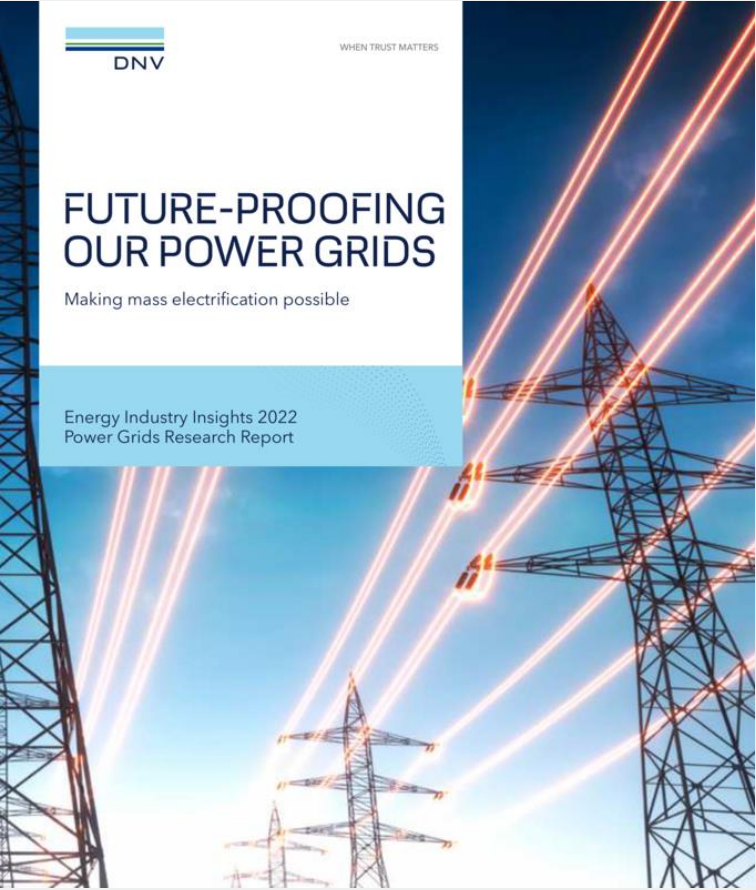


Global asset performance management market share, by vertical, 2018 (%)



Source: www.grandviewresearch.com

Part of our Industry Insights thought leadership series



The view from the transmission and distribution sector



401

senior energy
professionals surveyed



25%

of respondents
are C-level



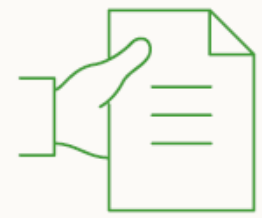
75

countries
represented



24%

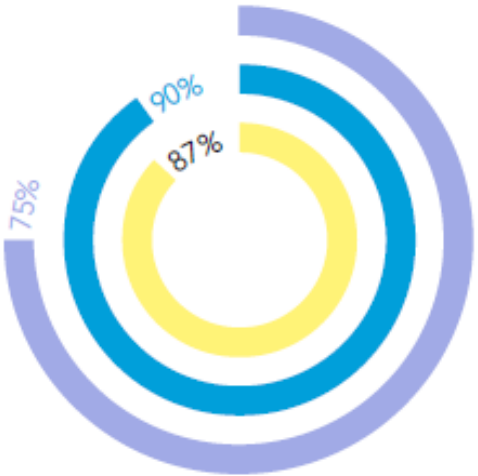
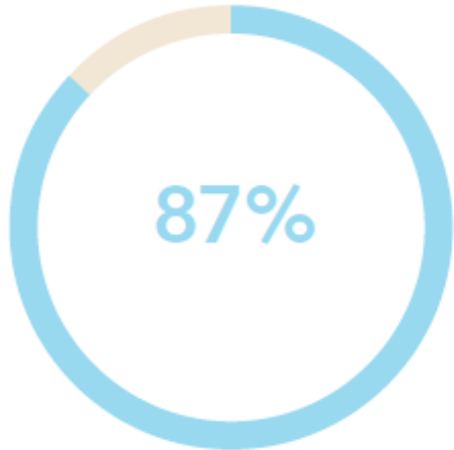
24% annual revenue
over USD 1 billion



9

in-depth
interviews

There's an urgent need for greater investment in the power grid



- Europe
- North America
- Asia Pacific

*The data shows the total respondents and regional split. Percentages reflect net agreement with the statement.

Power grids investment needs to grow by 50% in the next 10 years

This rapid investment is needed to support the influx of wind/solar and electrification of industry, transport and home appliances

15% of grid investments will be steered towards digital infrastructure, to address the complexity of a more decentralized power system

In terms of circuit-km, transmission lines will double and distribution lines more than double by 2050

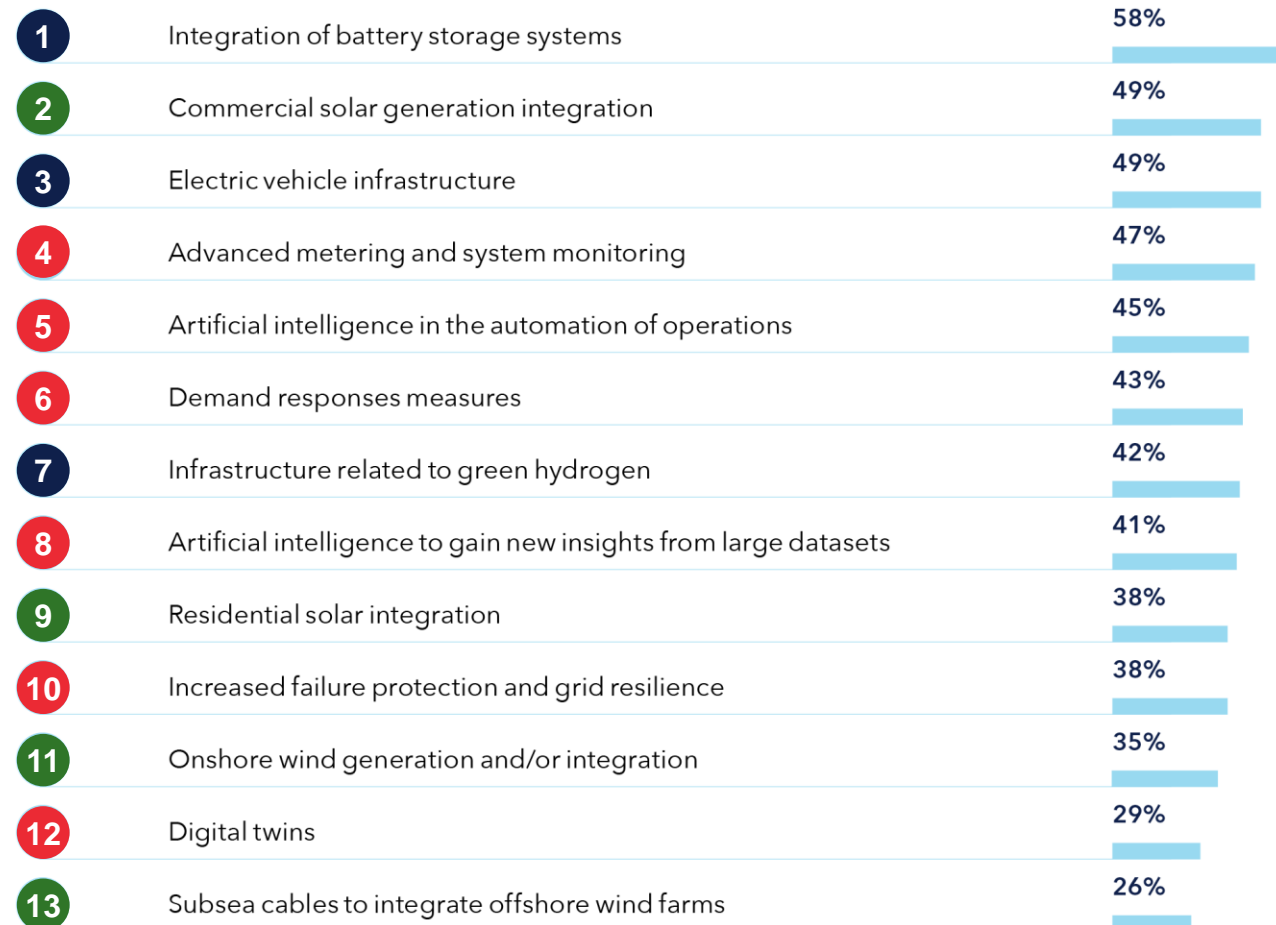
Investment priorities on the shorter term

● Storage and electrification

● Integration of RES

● Digitalization

Investment priorities over the next 12 months

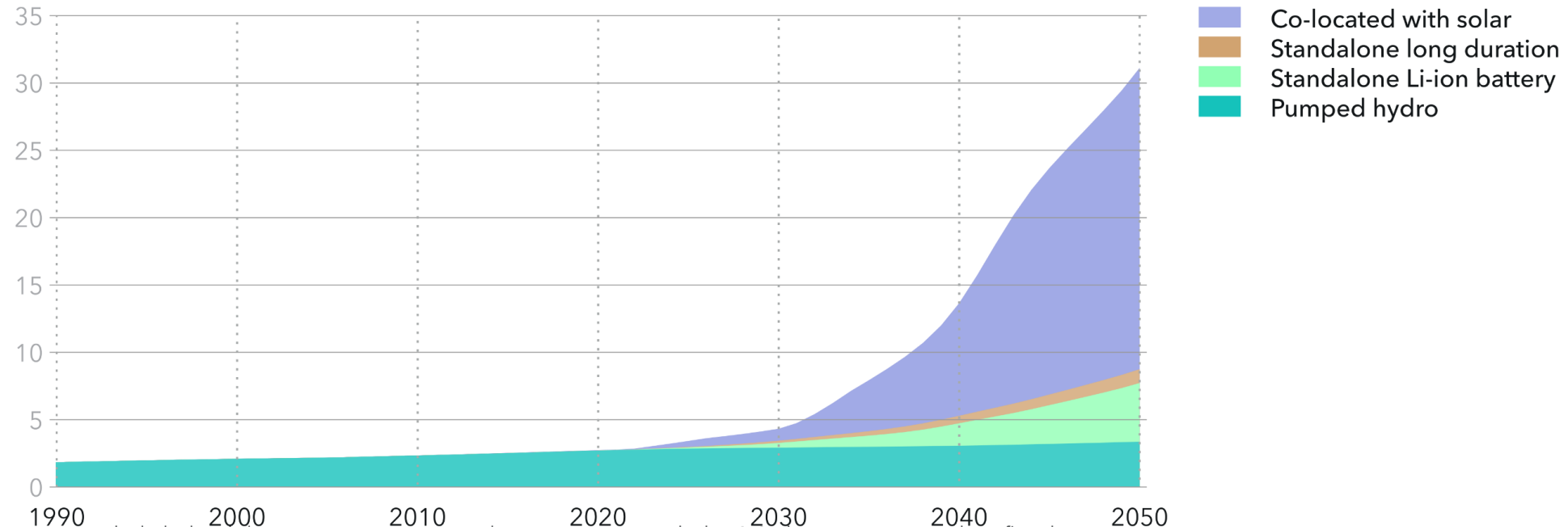


*Percentages reflect those that indicated they would be increasing investment in these areas in the year ahead.

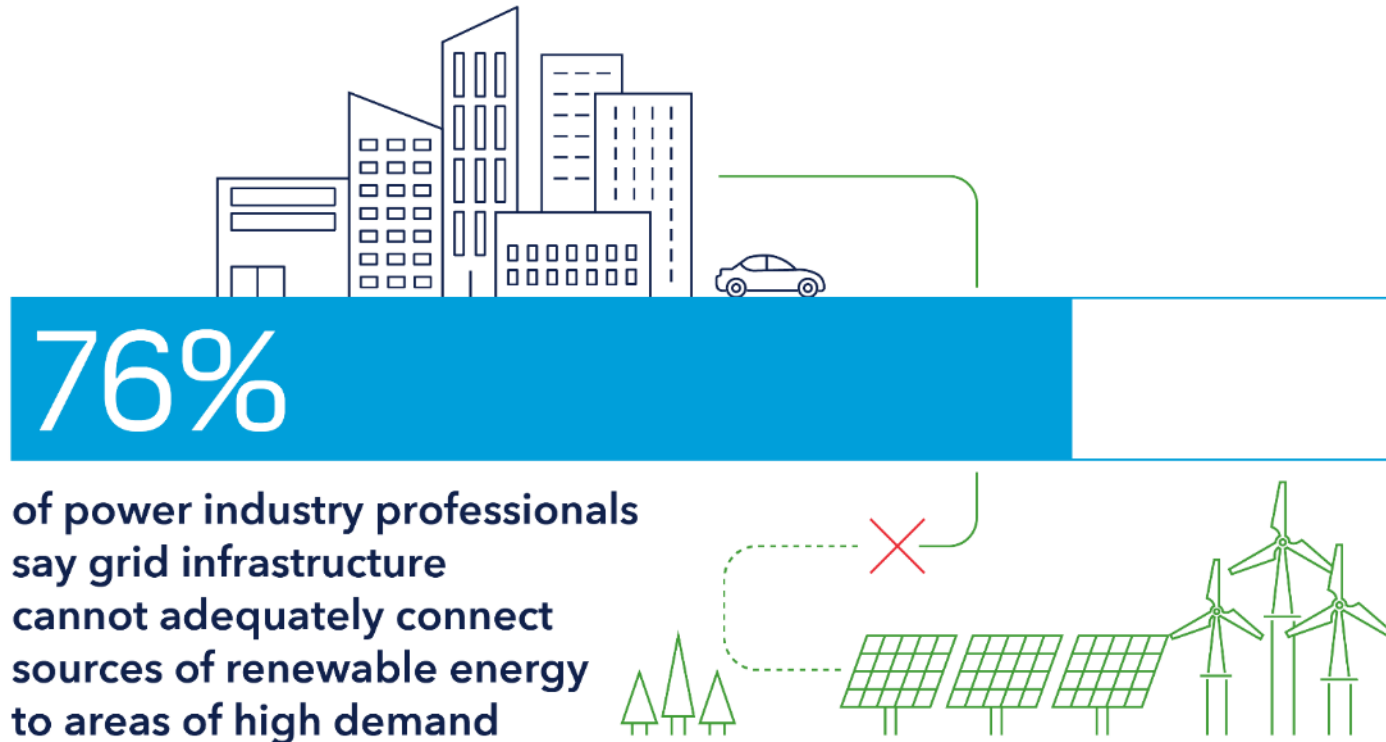
Storage is essential for the inclusion of variable renewables in electricity - 15% of standalone storage will be provided from EVs

World utility-scale electricity storage capacity

Units: TWh



Power grids cannot adequately connect renewable sources to areas of high demand





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