Santander Private Banking

# There is no transition without transmission: the importance of the grid

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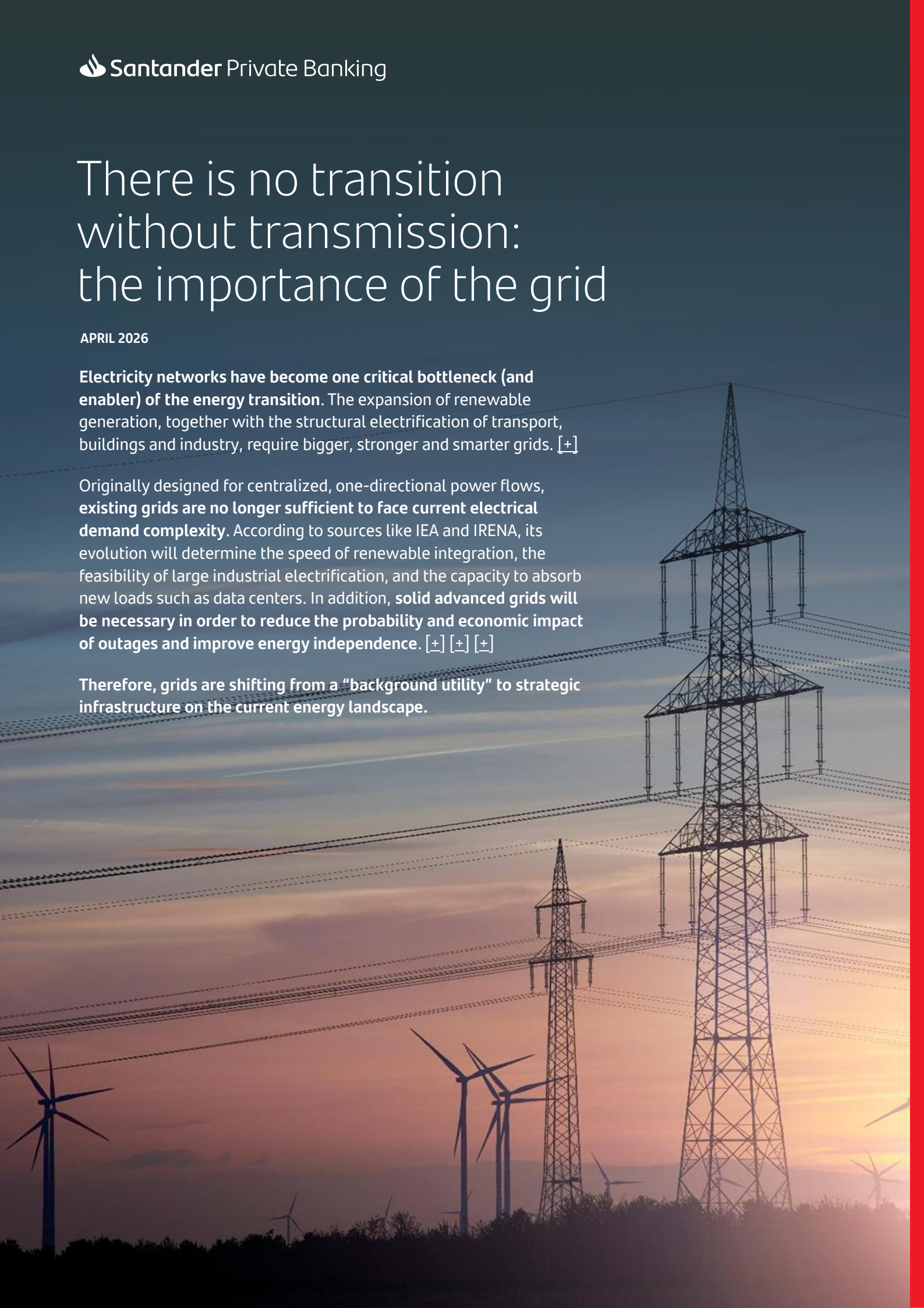
**Electricity networks have become one critical bottleneck (and enabler) of the energy transition**. The expansion of renewable generation, together with the structural electrification of transport, buildings and industry, require bigger, stronger and smarter grids. [+]

Originally designed for centralized, one-directional power flows, **existing grids are no longer sufficient to face current electrical demand complexity**. According to sources like IEA and IRENA, its evolution will determine the speed of renewable integration, the feasibility of large industrial electrification, and the capacity to absorb new loads such as data centers. In addition, **solid advanced grids will be necessary in order to reduce the probability and economic impact of outages and improve energy independence**. [+] [+] [+]

**Therefore, grids are shifting from a "background utility" to strategic infrastructure on the current energy landscape.**



# Key Facts Page

### An essential asset that needs to be updated[1]

The interconnected system that transports and distributes electricity from generation sources to end users is often decades old and designed around traditional sources of power

### Electricity: key to current economies

Electricity demand increase drivers include electrification, industrial demand, cooling/heating systems, and the expansion of data centers and AI

>3.5% electricity demand annual expected growth until 2030[2]

### Modern grids for the energy transition

Renewables are scaling faster than networks[3], making grid capacity a key limiting factor for the energy transition

% of renewable power in areas like APAC, Africa or Middle East is expected double by 2030 (vs 2023)

### Reliable and resilient grids to avoid outages

Ageing assets, extreme weather or cyber attacks can increase outage risk. Grid investing also supports countries energy independence

USD 100 bn: current global annual cost from outages[4]

### The investment gap[5] is significant

Annual spending should increase significantly from current levels to keep pace with demand growth and decarbonization targets

USD 650bn annual investment needed by 2035[6] and 80 million km of new/refurbished grid needed by 2040

### Modernization is multidimensional

Core infrastructure, capacity enabling components, digital and software, efficiency improvement and elements to increase flexibility

Energy efficiency costs less than half[7] vs. new generation + grid investments

### Innovative solutions[8] around the grid

Some examples include: micro and minigrids for local resilience, supergrids for enhanced efficiency, dynamic line rating and virtual power lines for flexibility, compensation devices for control

### Regulated returns[9] playing the electrification megatrend

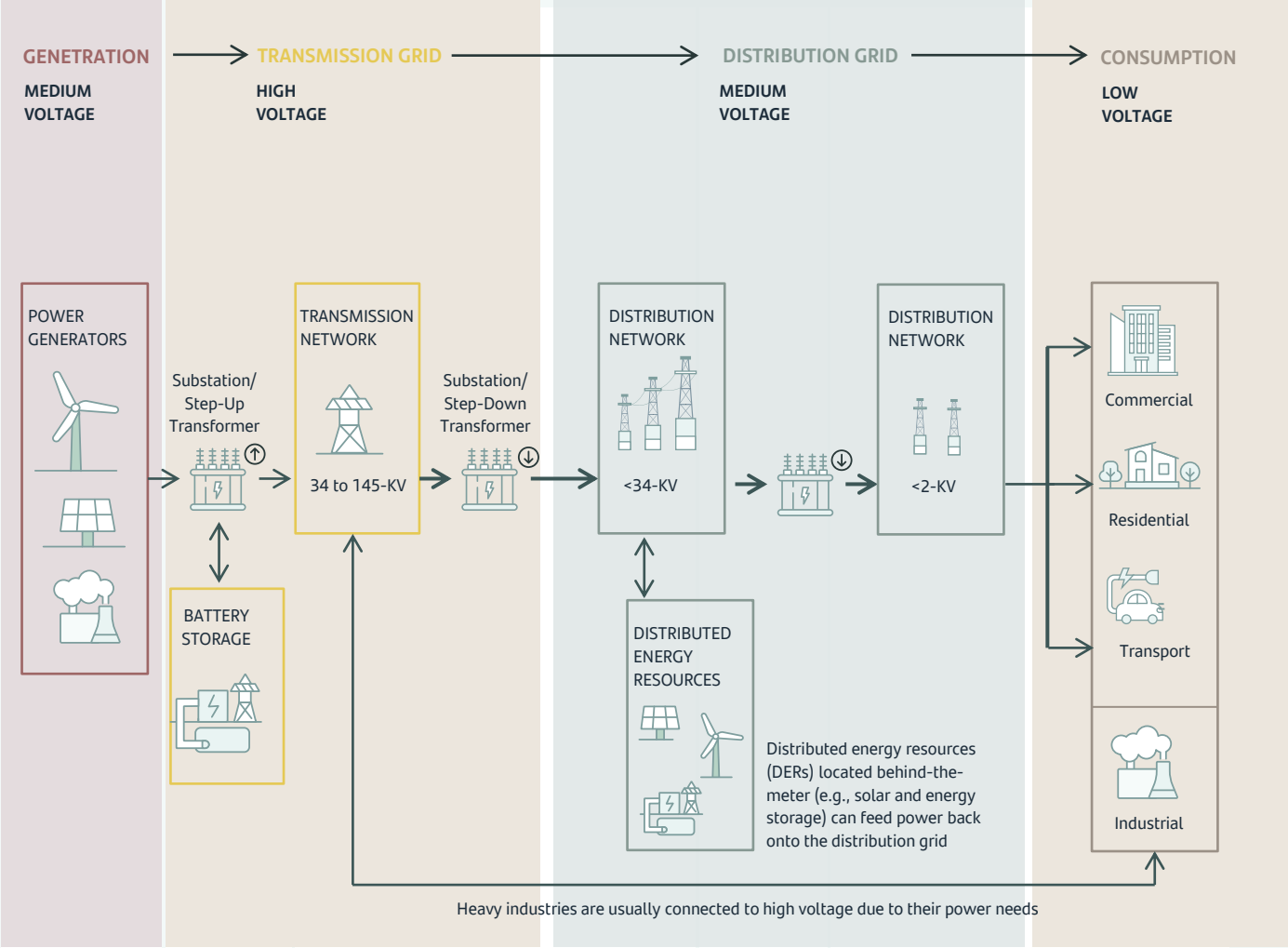
Grids are undergoing a structural transformation. Capturing their stable returns will depend on long-term planning, sustained investment and more efficient permitting processes

Sources: 1 IRENA [+], 2 IEA [+], 3 IEA [+], 4 IEA [+], 5 WEF [+], 6 IEA [+], 7 WEF [+], 8 IRENA [+], 9 IEA [+]

# 1. Power grids in a changing energy landscape

The "grid" is the interconnected system that **transports and distributes electricity from generation sources to end users.** It includes high-voltage transmission lines, substations/transformers, and medium/low-voltage distribution networks, plus the control/communication systems that keep frequency and voltage stable. [+]

**Figure 1: How does electricity get to consumers?**
Sources: US department of Energy [+], European court of auditors [+], and Endesa [+]




**Generation**
Turns primary energy sources (coal, natural gas, wind, etc.) into electrical energy

**Transmission**
Moves large amounts of electricity relatively long distances at very high voltages

**Distribution**
Transformers in substations lower voltage then power is distributed over short distances to the consumer

**Consumption**
Electrical energy is used to power lights, heating, AC, appliances, EVs etc.

Current electrical grid systems are often decades old infrastructure designed around **traditional sources of power** (coal, gas, nuclear, hydro) **when it was transported in one direction from large plants to consumers.** [+] The current context challenges how energy is transported and balanced due to:

## 1.a. Increasing **demand**

Electricity has become essential to modern life and demand keeps growing at high pace. Drivers include electrification, industrial demand, cooling/heating systems, etc. **Global power demand is expected to grow by more than 3.5% per year on average to 2030**. [+] In addition, climate change driving unprecedented heat is also pushing global energy demand, highlighting the need to design demand-responsive, resilient grids and larger power generation capacity in climate-sensitive regions. [+]

The rapid expansion of **AI and data centers** adds further pressure to power systems. The challenge for the grid on this sense is not only to **build more capacity, but also to use existing networks more efficiently** (digital optimization, better forecasting, storage coordination and more flexible system management). [+]

**Figure 2: Electricity demand by regions and technology in the Announced Pledges Scenario (APS [+])**

Source: OECD on IEA report [+]

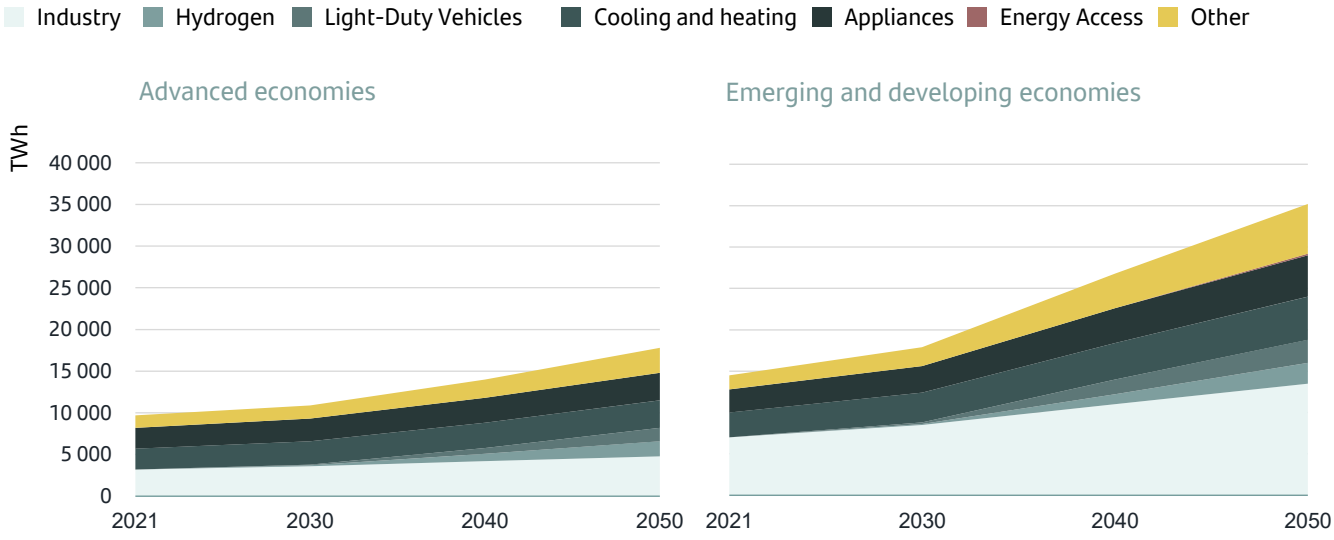
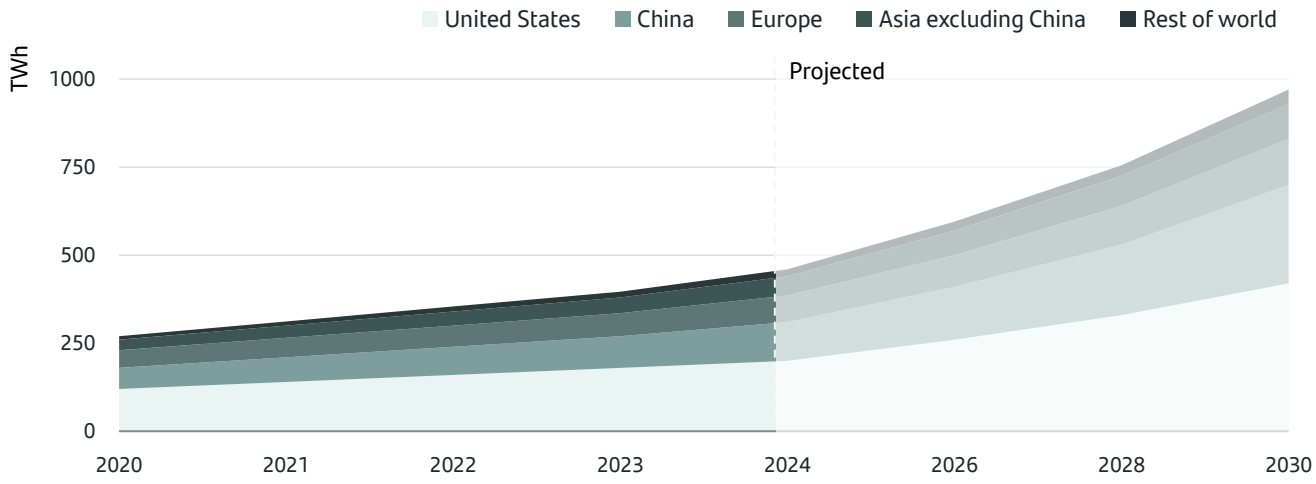



**Figure 3: Data centers electricity consumption projection**

Source: IEA [+]

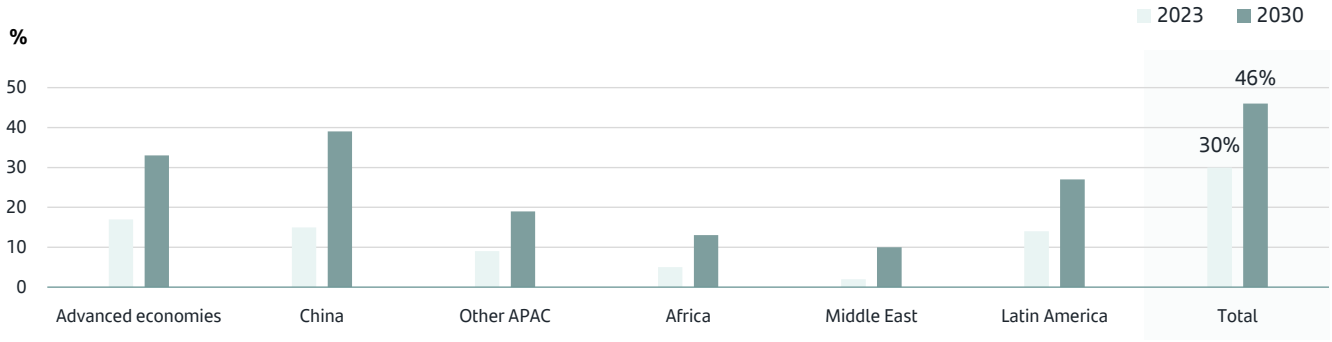


# 1.b. **Transition** technologies need flexible grids

Electricity demand is increasing but **renewable technologies facing it should grow faster than traditional ones in order to meet Net Zero ambitions**. As most economies shift towards lower carbon emission technologies, the expansion of solar and wind increases pressure on the grid, requiring **greater operational flexibility and stronger inter-regional connections.** [+]

**Figure 4: Share of renewables in power generation expected by region**

Source: IEA [+] and European Commission

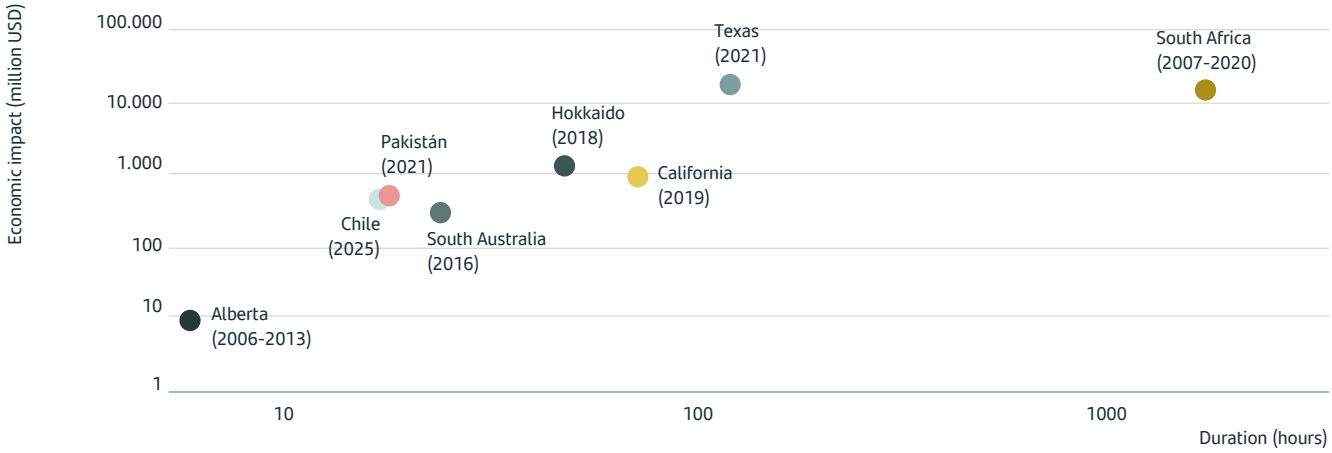



# 1.c. Reliable and resilient power: **outages** costs

Ageing assets [+], extreme weather [+] or cyber attacks [+] can increase this risk. The IEA estimates that **outages already cost around USD 100bn per year globally** [+]. Equipment to reinforce automation, advanced forecasting, and real-time control become essential to maintain frequency/voltage stability and to safely integrate distributed energy resources (such as rooftop solar, behind-the-meter batteries, EV charging and demand response). Strong energy grids also **boost countries energy independence**. [+]

**Figure 5: Economic impact versus duration for recent electricity blackouts**

Source: IEA [+]




# 1.d. There is a **timing** mismatch

Grid infrastructure often takes **5–15 years to** plan, permit and complete, while renewables projects typically take **1–5 years** to build and EV charging infrastructure **less than 2 years**. [+]

# 2. Building blocks for the future grid

In order to accommodate current context, the grids must become:

LARGER

**Grids need to expand in capacity and reach**
Remote renewables and the interregional transfer needs will require new transmission corridors and substations to connect, together with new interconnectors and cross border links where relevant. [+]

RENEWED

**Ageing assets need to be renewed**
Lines renewal, transformers and protection equipment need to be modernized an updated for distribution effectiveness. [+]

SMARTER

**Improved control and digitalization**
Advanced monitoring, automated substations, distribution management systems and grid edge visibility are needed to safely enable power and avoid blackouts. [+]

Smarter grids can also make more efficient use of existing network capacity. [+]

FLEXIBLE

**Systems should accommodate different generation technologies**
Solar PV and wind require more flexible grids to accommodate the changes in output. This includes deploying grid-enhancing technologies and unlocking the potential of demand response and energy storage. [+]

RESILIENT

**Cybersecurity and physical resilience**
become core design constraints as digital control expands, and outage costs rise. [+]

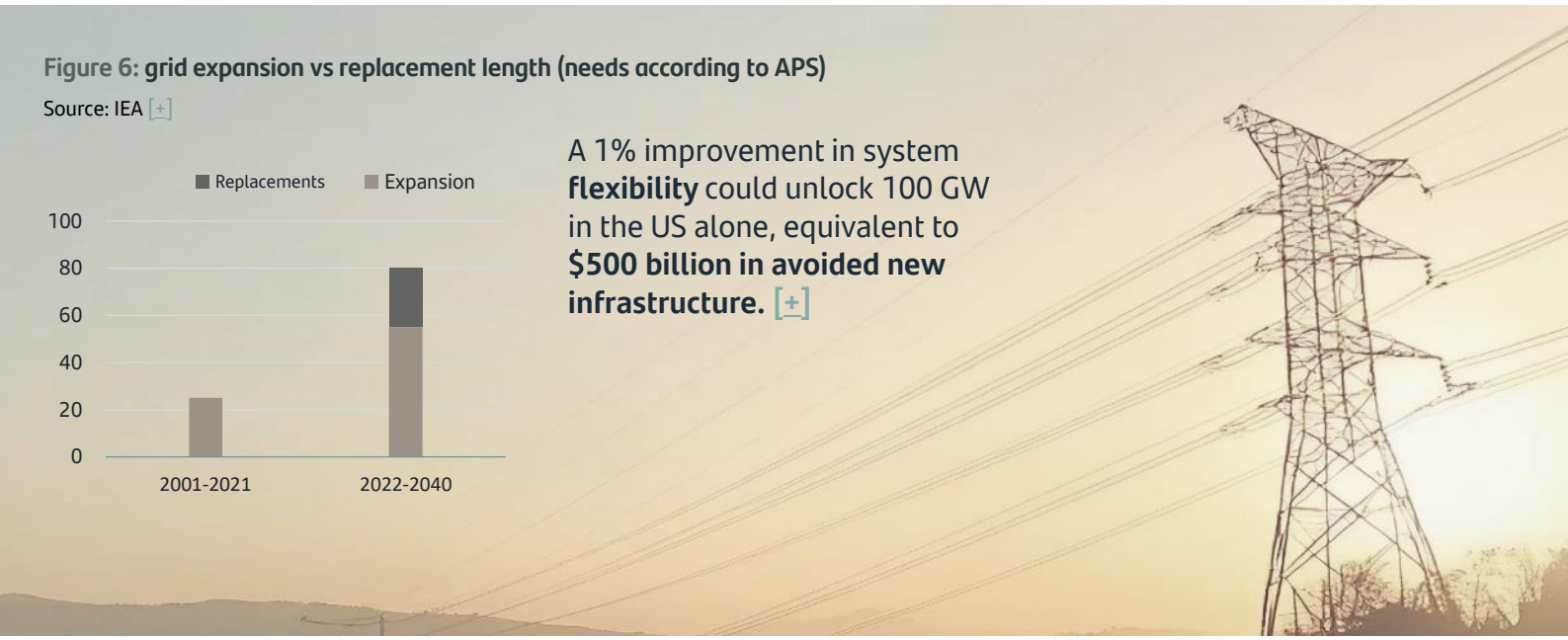
**Over 80 million kilometers of grids** to be added or refurbished by 2040, in order to reaching national goals. This is equivalent of the actual entire existing global grid [+]

**Figure 6: grid expansion vs replacement length (needs according to APS)**

Source: IEA [+]




A 1% improvement in system **flexibility** could unlock 100 GW in the US alone, equivalent to **$500 billion in avoided new infrastructure.** [+]

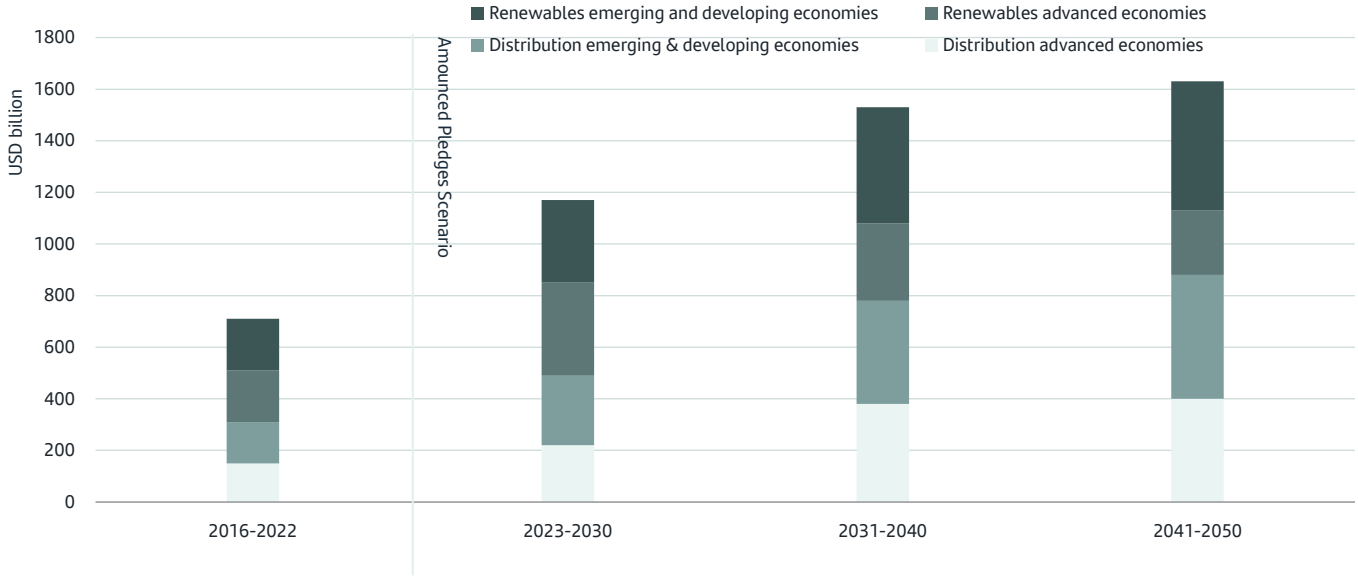


# 3. Where does this sit in the value chain?

According to IEA, based on national climate targets, grid investment needs to rise to over **USD 650bn per year by 2035** (**doubling** from current levels of c. USD 400bn per year). [+] **According to BloombergNEF** net-zero scenario lens estimates, annual grid investment should reach **USD 811bn by 2030**. [+] **This makes grid development a relevant investment theme**, as power systems will require sustained spending on network expansion, modernization and flexibility over many years. The gap is particularly visible in developing economies, where grid investment, excluding China, has declined in recent years. [+]

**Figure 7: average annual investments in renewables and grid by area (Announced pledged scenario)**

Source: IEA [+]




## 3.a. Focus areas

**Core infrastructure**
transmission and distribution assets will expand; returns in this area are typically regulated and long-term generating stable recurring revenues [+]

**Capacity enabling components**
equipment and engineering such as high voltage cables, transformers, switchgear, power electronics, and substation equipment will grow [+]

**Digital and software**
advanced distribution management, DER orchestration, cybersecurity, sensors, forecasting, and automation will be key for a automated and digital management/control systems [+]

**Elements to increase flexibility**
such as storage, demand response systems, efficiency increase solutions, etc. [+]

**Energy efficiency costs less than half**
what comparable new generation + grid investments would cost per unit of energy. Additionally with a much faster time to market (often under a year). [+]

## 3.b. Main bottleneck for grid renewal/building projects are: [+]

**Permitting**
Long lead times (often a decade) remain the primary cause of delays in transmission expansion

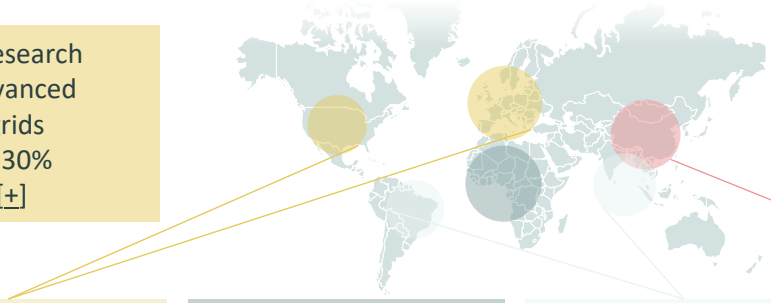
**Procurement**
Lead times have lengthened materially: 2–3 years for cables, up to 4 years for large power transformers, etc.

**Hardware costs**
Cable prices have nearly doubled since 2019, while transformer prices rose by around 75%

These issues together with potential **regulatory and execution risk result in project delays and over costs**. In addition, when finally constructed, the grid updates often become somewhat insufficient due to constantly increasing demand. [+] Payback period for transmission assets vary from 20 to 40 years. [+]

## 3.c. Global needs differ by regions: [+]

Stanford research reveals advanced economy grids operate at 30% utilization [+]



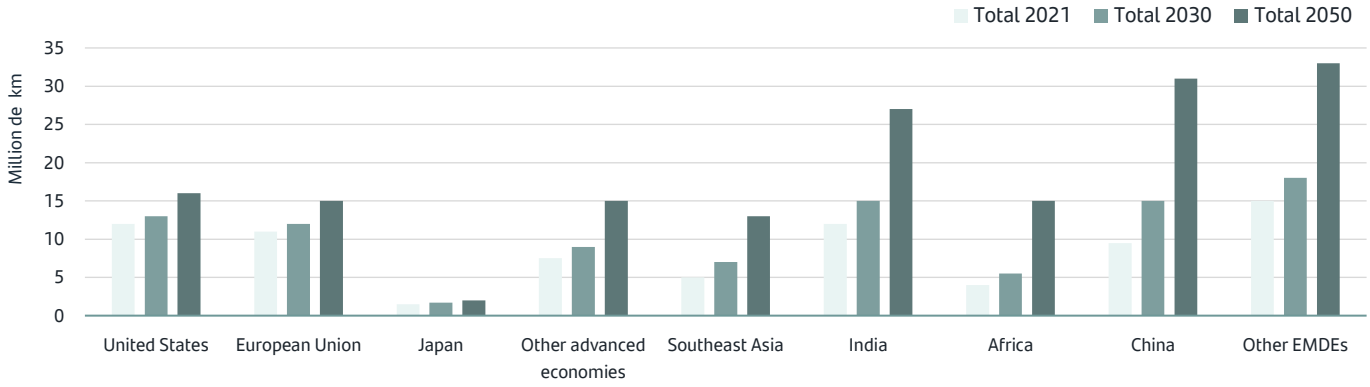
**United States and Europe**
Facing grid-related bottlenecks rather than outright infrastructure deficits. Key constraints: long interconnection queues (notably in the US), permitting delays for new lines, and ageing infrastructure [+] [+]

**Sub-Saharan Africa**
Dual challenge of structural infrastructure deficits and reliability constraints. Limited transmission and distribution networks, combined in some cases with insufficient generation capacity, result in frequent and prolonged outages, (notably in Nigeria and South Africa)

**Emerging markets (India, Southeast Asia, Brazil)**
The rapid electrification, industrialization and renewable deployment are outpacing the development of the grid creating a structural infrastructure gap

**China**
Positioned as a leader in grid deployment and modernization, particularly through its deployment of ultra-high-voltage transmission. Strong coordination between generation and transmission planning has enabled large-scale expansion [+]

**Figure 8: Installed line length, transmission and distribution, by region in the APS**
Source IEA [+]



# 4. Improving the grid through innovation

## 4.a. Micro / minigrids development

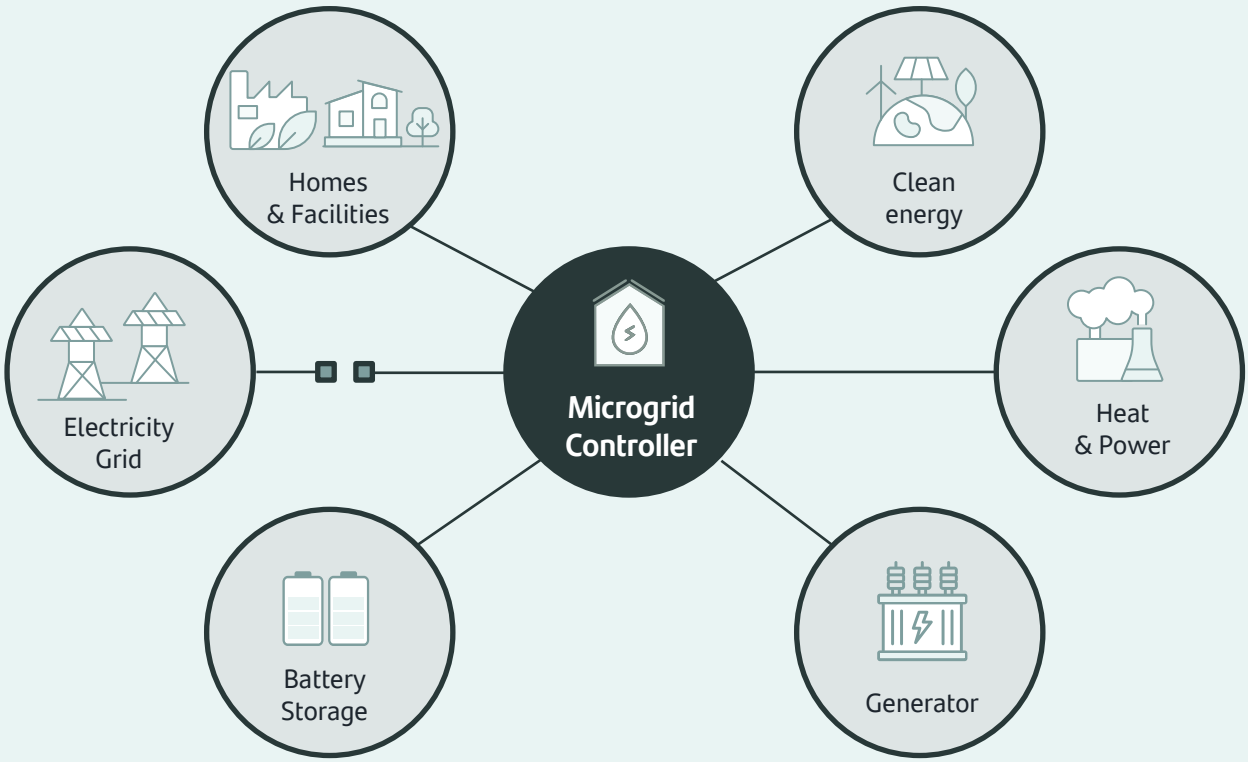
From small grids with generation capacities of a few kilowatts up to 100 MW systems that can cost-effectively power whole communities in remote areas. [+] These systems include solar panels, wind turbines or batteries. [+]

**Fast deployment**
can usually be planned and built much more quickly than centralized grid expansion projects. They can be connected to existing grids, making them more environmentally sustainable and economically resilient to future expansions of the main grid.

**Energy security**
these grids can operate independently for the main grid, securing a backup in case of outage.

**Key for developing countries**
where large numbers of people currently lack access to electricity or depend on expensive and often unreliable diesel generators. Apart from enabling essential services, can also unleash new waves of businesses and entrepreneurial activity, from food processing to services like hotels education or health care. Solar has proven to be the least-cost option, in addition to its ease of deployment and scalability.

**Figure 9: Main elements in a microgrid**
Source: WEF [+]



## 4.b. Supergrids

large grids that connect different countries or even different regions, enabling them to share their power resources and establish regional power markets. This minimizes losses by operating at higher voltages using direct current (DC) transmission lines. [+]

### For countries with large renewable resources

Supergrids could enable the export of green electricity (e.g. from Africa to Europe). A number of supergrids already have been constructed, such as China's 3 293 kilometer-long, high-voltage (1100 kV) DC transmission line from Changji to Guquan. [+]

### Challenges

Long construction times, large upfront investments and the need to interface high-voltage DC lines with existing AC grids. Also a widespread implementation will require strong shared regulatory rules when the grids cross national borders (easier in countries with centralized decision making such as China or India)

## 4.c. The virtual power line (VPL)

It is based in two storage systems, one upstream at the renewable generation site and the other one at consumption point. [+]

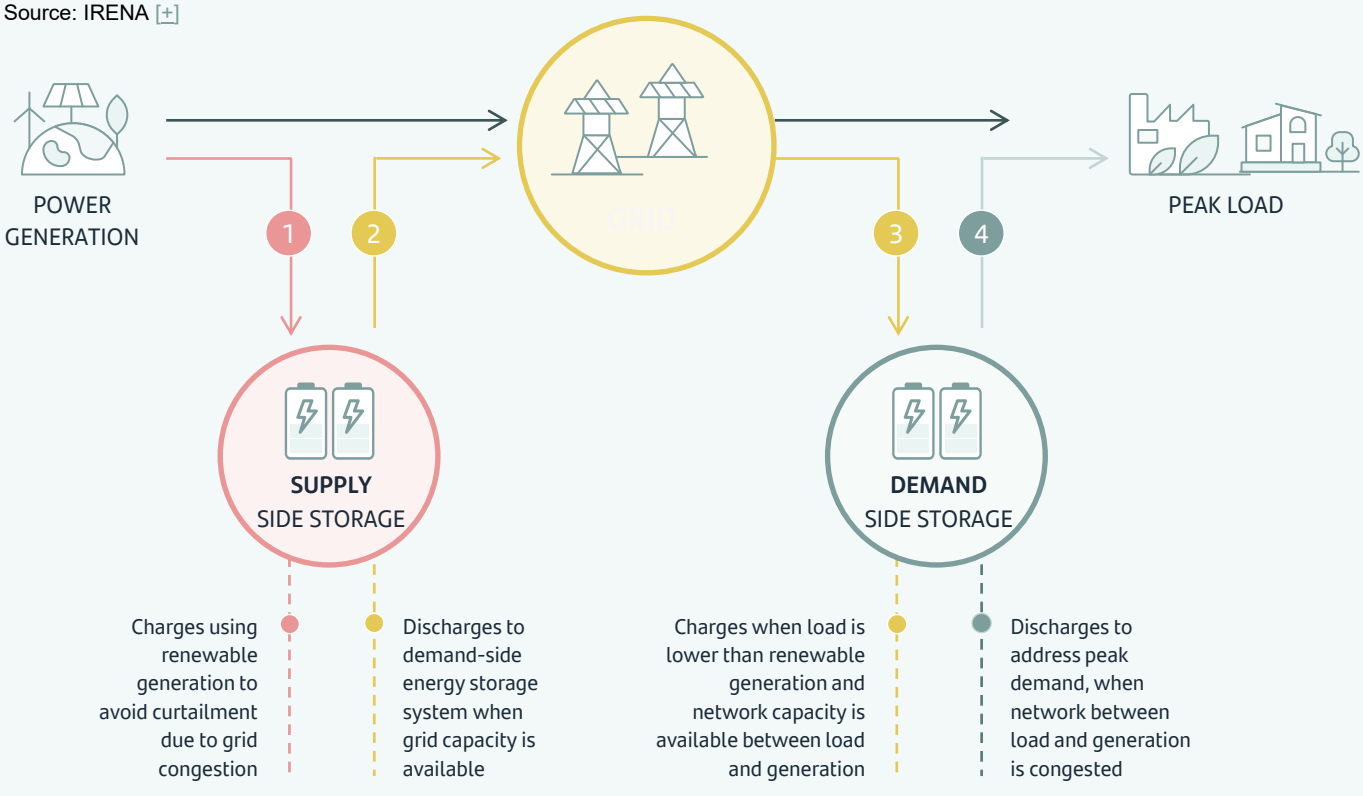
### Benefits

Apart from the energy efficiency, batteries provide frequency or voltage regulation, improved reliability and ability to meet higher peak loads.

### Challenges

These systems require higher levels of digitalization and clear regulations on the use and ownership of the storage systems used in the VPLs

**Figure 10: virtual power line**
Source: IRENA [+]



## 4.d. Dynamic line rating (DLR)

DLR is a system that can improve the flexibility and integration of renewables through monitoring and modifying the current-carrying capacity of transmission lines based on real-time weather conditions. [+]

**Context**
The safe capacity of a line can vary greatly depending on the cooling/ heating from wind, temperature, precipitation, solar radiation and other weather conditions.

**Benefits**
in can increase the capacity of existing transmission lines by 30% in the line's current by transmission system operators in Europe, and it is particularly beneficial for transmission lines that carry power from wind facilities because higher wind speeds provide more cooling, and thus more capacity, at the same time as they increase VRE generation. With reliable hours-ahead to days-ahead forecasting, DLR can provide the emergency capacity for all remaining in-service lines, contributing to system planning.

**Other enhanced weather forecasting**
increase the stability of the grid, improve plant scheduling and help define commitments required from thermal or storage plants. For hydropower, for example, more accurate forecasting enables better basin management.

## 4.e. Compensation devices

Match different power generation sources output with the voltage and frequency of the grid and to provide reactive power support. [+]

1. **Flexible AC transmission systems (FACTS)**
help achieve precise and quicker voltage support by reducing the need for reactive power

2. **Synchronous condensers**
similar to conventional generators but use electricity to create a spinning inertial reserve of few seconds in case of fault

3. **Fast-acting devices**
provide quick frequency responses by actively injecting power and reducing load in low-inertia systems

4. **Advanced grid and power flow controllers**
fine-tuning the control of the power flows within grid lines

# 5. Conclusion

**Electricity grids are going through a structural shift.** No longer just a background utility — they are becoming a key enabler of electrification and decarbonization. As renewable energy expands and electricity demand rises, grids must integrate intermittent generation, support new sources of demand (as AI or EVs), and remain reliable in a more complex and climate-exposed environment.

But there is a clear challenge, while demand and renewable deployment are accelerating, grid development is slower and capital intensive, which is creating bottlenecks for the energy transition. Countries should focus on **long-term planning, sustained investment and efficient permitting processes to keep their energy systems stable and competitive**, and to unlock further renewable growth supporting economic electrification.

For investors, grids should be seen as **core infrastructure**. They typically operate under **regulated frameworks**, offering visible and relatively stable returns [±], while being directly exposed to one of the most important **structural trends of the next decades: electrification**. Finally, **the grid of the future goes beyond traditional transmission and distribution assets. It also includes the broader ecosystem of enabling technologies** — such as digitalization, grid management software, storage integration, forecasting tools and efficiency solutions — all of which are critical to make the system work.

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# Sources


- Bloomberg — China grid spending hits record as Beijing tackles bottlenecks — https://www.bloomberg.com/news/articles/2026-02-03/china-grid-spending-hits-record-as-beijing-tackles-bottlenecks
- BloombergNEF — Readying the global power grid for net zero — https://about.bnef.com/insights/clean-energy/readying-the-global-power-grid-for-net-zero/
- BloombergNEF — Significant investment needed to ready the global power grid for net zero — https://about.bnef.com/insights/clean-energy/significant-investment-needed-to-ready-the-global-power-grid-for-net-zero-bloombergnef-report/
- European Commission — Commission press release on European grids — https://ec.europa.eu/commission/presscorner/detail/en/ip_25_2945
- European Commission — European grids — https://energy.ec.europa.eu/topics/infrastructure/european-grids_en
- European Court of Auditors — Report RV-2025-01 — https://www.eca.europa.eu/ECAPublications/RV-2025-01/RV-2025-01_EN.pdf
- Endesa — How the electric system works: generation, transmission and distribution — https://www.endesa.com/es/la-cara-e/red-electrica/funcionamiento-sistema-electrico-generacion-transmision-distribucion
- Energy.gov — Electricity Grid Backgrounder — https://www.energy.gov/sites/default/files/2023-11/FINAL_CESER%20Electricity%20Grid%20Backgrounder_508.pdf
- Eurelectric — Gridlock to grid growth — https://www.eurelectric.org/blog/gridlock-to-grid-growth/
- Eurelectric — What is flexibility in the power sector? — https://www.eurelectric.org/in-detail/what-is-flexibility-in-the-power-sector/
- Forbes — Is the US headed for a power grid crisis? — https://www.forbes.com/sites/rrapier/2025/09/07/is-the-us-headed-for-a-power-grid-crisis/
- GI Hub — Underinvestment in social, water and waste infrastructure: an opportunity for private investors — https://www.gihub.org/infrastructure-monitor/insights/underinvestment-in-social-water-and-waste-infrastructure-an-opportunity-for-private-investors/
- Hitachi Energy — Upgrading aging assets helps enhance reliability and safety of Liaoning's grid — https://www.hitachienergy.com/news-and-events/customer-stories/upgrading-aging-assets-helps-enhance-reliability-and-safety-of-liaonings-grid
- IEA — Electricity Grids and Secure Energy Transitions (Executive Summary) — https://www.iea.org/reports/electricity-grids-and-secure-energy-transitions/executive-summary
- IEA — Economic impact versus duration for recent electricity blackouts — https://www.iea.org/data-and-statistics/charts/economic-impact-versus-duration-for-recent-electricity-blackouts
- IEA — Energy demand from AI — https://www.iea.org/reports/energy-and-ai/energy-demand-from-ai
- IEA — Energy efficiency 2023: Doubling progress on energy efficiency — https://www.iea.org/reports/energy-efficiency-2023/doubling-progress-on-energy-efficiency-infographic
- IEA — Global electricity demand is set to grow strongly to 2030, underscoring need for investments in grids and flexibility — https://www.iea.org/news/global-electricity-demand-is-set-to-grow-strongly-to-2030-underscoring-need-for-investments-in-grids-and-flexibility
- IEA — Announced Pledges Scenario (APS) — https://www.iea.org/reports/global-energy-and-climate-model/announced-pledges-scenario-aps
- IET — DOI 10.1049/joe.2018.8383 — https://digital-library.theiet.org/doi/10.1049/joe.2018.8383#:~:text=3.1.&text=In%20this%20section%2C%20the%20cost,a%2040-year%20substation%20life.
- IRENA — 2024 Year in Review: Climate-driven Global Renewable Energy Resources and Energy Demand — https://www.irena.org/Publications/2026/Jan/2024-Year-in-Review-Climate-driven-Global-Renewable-Energy-Resources-and-Energy-Demand
- IRENA — Innovation Landscape: Sustainable development — https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2026/Jan/IRENA_INN_Innovation_Landscape_sustainable_development_2026.pdf
- IRENA — Year-in-review 2024/2025 — https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2026/Jan/IRENA_WMO_PAR_Year-in-review_2024_2025.pdf
- MDPI — The Evolving Landscape of Advanced Oxidation Processes in Wastewater Treatment: Challenges and Recent Innovations — https://www.mdpi.com/2227-9717/13/4/987
- Moving the grid forward - https://movingthegridforward.co.uk/about-the-upgrade#:~:text=Britain's%20path%20to%20energy%20self,security%20for%20generations%20to%20come.
- NICS UMA — Syrmakesis 2022 paper — https://www.nics.uma.es/pub/papers/Syrmakesis2022.pdf
- OECD — Electricity Grids and Secure Energy Transitions — https://www.oecd.org/content/dam/oecd/en/publications/reports/2023/10/electricity-grids-and-secure-energy-transitions_9559dcb0/455dd4fb-en.pdf
- ResearchGate — Grid modernization and transitioning toward sustainability: An in-depth survey of the latest transformative directions in modern power systems — https://www.researchgate.net/publication/396521965_Grid_modernization_and_transitioning_toward_sustainability_An_in-depth_survey_of_the_latest_transformative_directions_in_modern_power_systems
- Roland Berger — Digital cables: The key to grid modernization and smart grids — https://www.rolandberger.com/en/Insights/Publications/Digital-cables-The-key-to-grid-modernization-and-smart-grids.html
- ScienceDirect — Article S2212428421000025 — https://www.sciencedirect.com/science/article/abs/pii/S2212428421000025
- ScienceDirect — Article S1944398624131207 — https://www.sciencedirect.com/science/article/pii/S1944398624131207
- ScienceDirect — Article S2095633923000904 — https://www.sciencedirect.com/science/article/pii/S2095633923000904
- ScienceDirect — Article S259017452400268X — https://www.sciencedirect.com/science/article/pii/S259017452400268X
- ScienceDirect — Article S2772375525002151 — https://www.sciencedirect.com/science/article/pii/S2772375525002151
- ScienceDirect — Article S2589914725000714 — https://www.sciencedirect.com/science/article/pii/S2589914725000714
- UNESCAP — Electricity grids and secure energy transitions — https://www.unescap.org/sites/default/d8files/event-documents/Electricity%20grids%20and%20secure%20energy%20transitions%20by%20Yinglun%20Teng%2C%20Energy%20Analyst%2C%20IEA.pdf?utm_source=chatgpt.com
- U.S. Department of Energy — Electricity Grid Backgrounder — https://www.energy.gov/sites/default/files/2023-11/FINAL_CESER%20Electricity%20Grid%20Backgrounder_508.pdf
- WEF — Grid infrastructure for an electrified future — https://www.weforum.org/stories/2026/01/grid-infrastructure-electrified-future/
- WEF — Microgrids: renewable power — https://www.weforum.org/stories/2022/05/what-are-microgrids-renewable-power/
- WEF — Powering cyber resilience in the energy sector — https://www.weforum.org/stories/2025/05/powering-cyber-resilience-energy-sector/
- YouTube — Video reference 6Bh6MXHqL7k — https://www.youtube.com/watch?v=6Bh6MXHqL7k

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