Global Grid Targets: Enabling Decarbonisation

We call on all national governments, international institutions, financiers, industry and other key stakeholders to commit to Global Grid Targets, metrics to measure progress, and the supporting efforts required to reach them.

Meeting the 3XRenewables commitment by 2030 and the Paris Agreement goals will require a massive and rapid increase in investments in new and existing electricity grids. This is not just a technical necessity; it is a defining moment for our collective future.

This document serves both as a **call to action and a consultation paper**. We seek feedback on the proposed targets and metrics, with the aim of refining and finalizing them in the lead-up to COP29, where we hope to reach a consensus on the most effective metrics and supportive text.

Targets:

To meet long-term global energy and climate goals, we must pursue major grid infrastructure development with high ambition and 1.5°C outcomes in mind. We fully support and endorse COP29's call to **reach USD 700 billion in grid infrastructure investments by 2030** and **add or upgrade over 80 million kilometers of transmission and distribution lines by 2040**[1].

1 to be updated with a 2030 milestone on the path to the 2040 target.

Actions:

To stay on track to the 1.5°C target, ***immediate action*** is essential. Governments must prioritize the following actions over the next few years to ensure progress:

- **Upgrading Grids:** Modernizing grid infrastructure to handle increased renewable energy capacity and incentivizing investment in innovative and enhanced technologies.
- **Balancing Supply and Demand:** Implementing effective demand-side management strategies and promoting policies that support flexible demand response.
- **Planning:** Governments must adopt comprehensive, forward-thinking planning and permitting strategies to align energy policies with long-term climate goals.
- **Financing:** Creating favorable regulatory environments to facilitate anticipatory investments and mobilize both public and private capital to finance grid expansion and modernization.

Immediate action in these areas will not only position countries to meet their 2040 targets, but also unlock significant economic, social, and environmental benefits well before 2030.

To meet national energy and climate goals, global electricity demand needs to grow 20% more rapidly over the next decade compared to the previous one[2]. New and upgraded grids are essential to support such growth and connect renewable energy projects to the new demand. Tripling renewable capacity by 2030 depends on 93% of this growth coming from solar and wind energy. This requires increased grid capacity, advanced grid management systems, and infrastructure to manage the greater variability and distribution of green electrons.

At least 3,000 gigawatts (GW) of renewable energy projects are currently waiting in grid connection queues - a number equivalent to five times the solar and wind capacity added in 2022.

It is imperative that we transform electricity grids from potential bottlenecks into powerful enablers of the global energy transition. That is why we need global grid targets that will focus governments and industry action through 2030, 2035, and 2040.

Governments should start developing grid plans and targets, and include these in their updated Nationally Determined Contributions:

- Grid planning horizon should be extended, with a clear focus on Net Zero goals
- Transmission expansion plans should be updated at least every 2 years
- Investments need to ramp up – emerging market and developing economies (EMDEs) require with de-risking mechanisms and concessional support
- Planning and permitting reforms are needed to shorten delivery times
- Investment in smart grids, innovation and technology is necessary to optimize current grids, buy time for new infrastructure investments, and build resilience
- International collaboration on cross-border interconnection is crucial for cost-efficient renewable deployment and enhanced energy security
- Supply chains must be strengthened and diversified focus on developing skills

2 IEA (2023), Electricity Grids and Secure Energy Transitions

Metrics:

Tracking and development metrics are essential to measure progress and provide transparency and accountability on the road to achieving energy and climate goals. As a consultation paper, we propose a range of possibilities for grid development metrics:

- Time to connect renewable projects (in years)
- Grid capacity growth (in GW per km)
- Interconnectivity (in number and capacity of interconnections)
- System efficiency (in percentage of transmission and distribution losses reduction)
- Permitting timelines (in years)
- Penetration of renewables (in percentage of total installed capacity)
- Carbon dioxide (CO2) intensity (in grams of CO2 per kilowatt-hour - kWh - of energy produced)
- Grid reliability (in terms of SAIDI or SAIFI)
- International commitments (in number of targets and grid delivery plans included in international communications such as NDCs)
- Supply chain queue duration for key components (in years)
- Use of raw materials (in percentage of the total amount of materials)
- Curtailment of renewables (kWh per year)

(page 13 for reference on the grid development metrics)

Green Grids Initiative

A Call to Action

- The 3XRenewables by 2030 and wider Paris Agreement goals will not be met if electricity grids do not expand faster than current trends to 2030.
- We call on national governments to agree to 2030 Global Grid Targets, ideally by COP29, and to track the metrics over the coming years to measure progress.
- Beyond 2030 there will be an increasing need for the expansion, infrastructure development and improved efficiency of the electricity grid.
- Governments should start planning for their electricity grid needs now, assessing what will be required to deliver their commitments under the Paris Agreement, setting their individual targets, and implementing enabling policies to meet those targets. In particular, they should integrate grid targets within their new Nationally Determined Contributions, due to be submitted by February 2025.

Grid Infrastructure is Key to Tripling Renewables and Paris Agreement Success

The urgent need to address climate change and achieve net-zero carbon emissions in line with the Paris Agreement demands the rapid deployment of clean energy resources like wind and solar photovoltaics (PV). At COP28, the first global stocktake (GST) set a new objective to triple global renewable energy capacity to 11 TW by 2030 and transition away from fossil fuels. This goal was also specifically endorsed by more than 130 countries through the **COP28 Renewables and Energy Efficiency Pledge**[3], tripling today's installed capacity. However, while these commitments are necessary, they are not sufficient to achieve transformative change to a sustainable clean energy future.

The electricity sector accounts for 25% of global carbon emissions today. The International Energy Agency (IEA)[4] states that at least 3.000 gigawatts (GW) of RES projects are waiting in **grid connection queues**. This number unveils the pivotal role of grids as it is equivalent to five times the amount of solar PV and wind capacity added in 2022. This clearly highlights grid constraints as a critical barrier to achieving net zero emissions.

The International Renewable Energy Agency (IRENA) identifies grids as one of the key enablers for tripling renewable power capacity. It recommends that grid investments must be made 3-5 years ahead of RES investments to reduce overall system costs and congestion[5]. As can be seen in Figure 1, together with policy, supply chains, international cooperation and finance, **grid infrastructure is one of the pillars** requiring urgent actions to enable the energy transition.

3 Global Renewables and Energy Efficiency Pledge
4 IEA (2023), Electricity Grids and Secure Energy Transitions
5 (IRENA (2024), Tripling Renewable Power by 2030: The Role of the G7 in Turning Targets into Action, IRENA, Abu Dhabi)

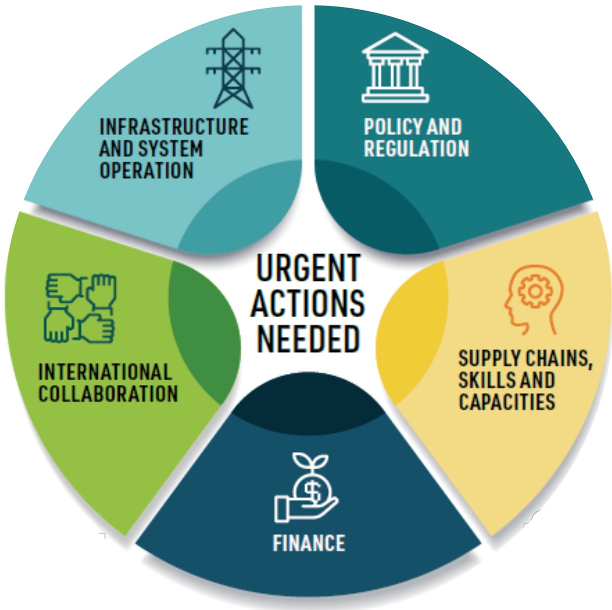

Figure 1 - Urgent actions for the energy transition
Source: IRENA(2024), Tracking COP28 outcomes: tripling renewable power capacity by 2030

To meet climate goals, it is estimated that an average annual investment of USD 500 billion will be necessary from 2016-2030, **exceeding USD 700 billion per year by 2030**[6]. Furthermore, to support a pathway to net-zero emissions, approximately USD 21 trillion will need to be invested in the electricity grid by 2050[7]. Figure 2 showcases the investment made in the year 2023 and the estimated requirements by 2030 to achieve the 1.5ºC scenario[8].

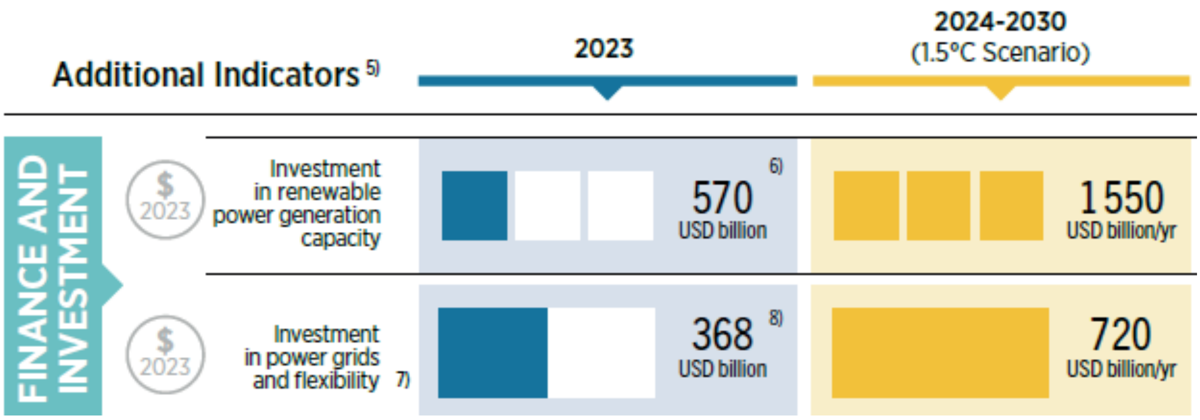

Figure 2 - Finance and Investment estimations
Source: IRENA(2024), Tracking COP28 outcomes: tripling renewable power capacity by 2030

In a different view, Figure 3 depicts the average **annual transmission and distribution investment** in both advanced economies and emerging market and developing economies (EMDEs). One can see the investments made in recent years and the needs for the future taking into consideration the Announced Pledges Scenario (APS) and Net Zero Emissions by 2050 (NZE) scenarios. Annual investment in grids more than triples in the NZE Scenario in EMDEs, including China[9].

6 IEA (2023), Electricity Grids and Secure Energy Transitions
7 BloombergNEF, "Global Net Zero Will Require $21 Trillion Investment In Power Grids"
8 IRENA (2024), Tracking COP28 outcomes: Tripling renewable power capacity by 2030, International Renewable Energy Agency, Abu Dhabi.
9 IEA (2023) Scaling Up Private Finance for Clean Energy in Emerging and Developing Economies

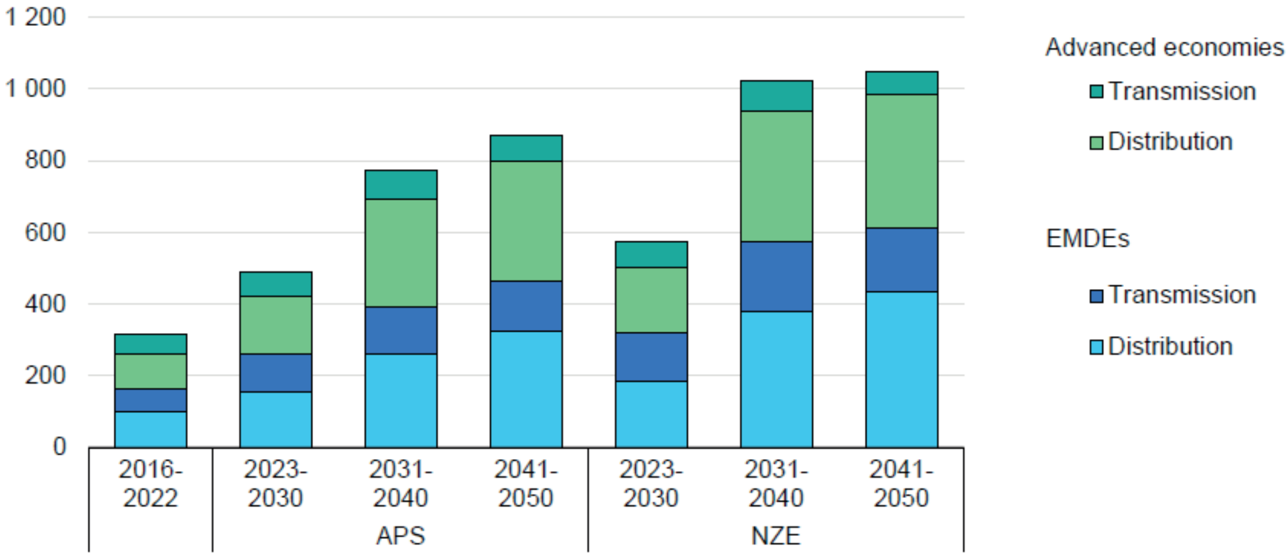

Figure 3 - Average annual transmission and distribution investment in EMDEs and advanced economies in the Announced Pledges Scenario and Net Zero Scenario, 2016-2050
Source: IEA (2022), World Energy Outlook 2022

Furthermore, the power sector is facing a mismatch between grid capabilities and the rapid deployment of variable renewables, leading to increased curtailment of wind and solar PV. Grid reinforcements are lagging behind with special attention to EMDEs[10]. Achieving national energy goals will require adding over **80 million kilometers of grid** infrastructure by 2040, which is equivalent to the entire existing global grid.

To also help with the mismatch, more **long duration energy storage** is needed at RES sites, substations and interconnections to provide congestion management support and grid services. Building new transmission is essential for meeting net zero carbon emission goals and the planning for transmission must be updated to include the value of long duration energy storage as a transmission asset.

The grid infrastructure is a **highly complex system** that extends well beyond just transmission and distribution lines. It encompasses the interaction between two main components: generation production and load demand. Distribution grids account for nearly 93% of total grid length[11]. In Figure 4 one can see a high-level view of the elements of power systems.

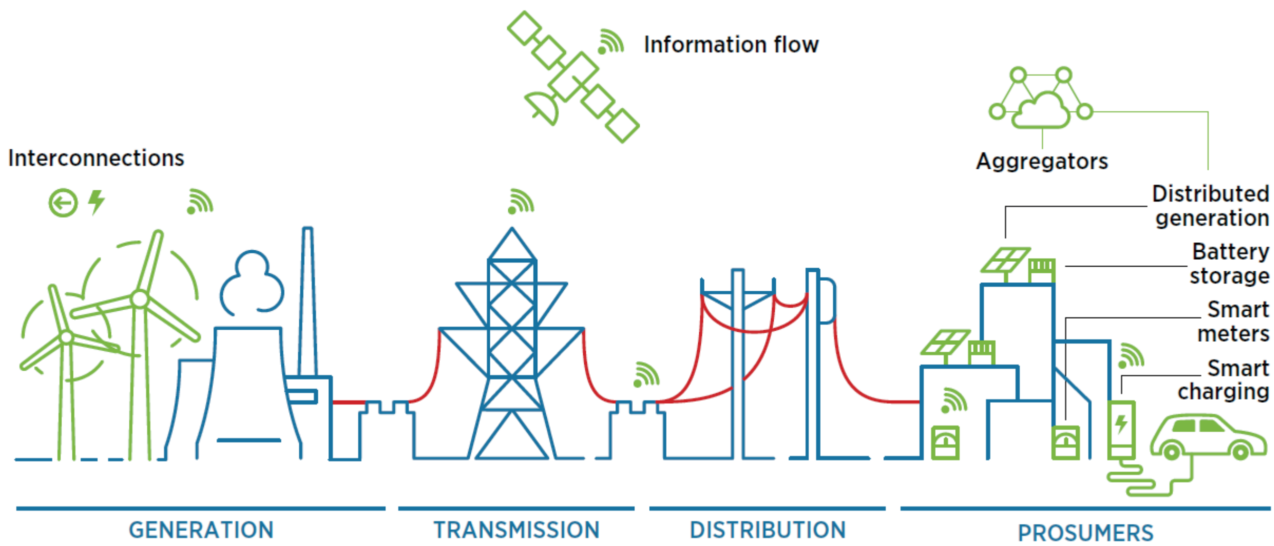

Figure 4 - Different aspects of power systems
Source: IRENA (2022), Grid codes for renewable powered systems

10 IRENA (2024), Tracking COP28 outcomes: Tripling renewable power capacity by 2030, International Renewable Energy Agency, Abu Dhabi.
11 IEA (2023), Electricity Grids and Secure Energy Transitions

The interconnection capability of national electricity grids is also a key enabler to accomplish the energy transition targets. Renewable generation introduces volatility and geographical bias to the system. Enhancing both regional and **cross-border interconnections** is crucial for grid stability, increased energy security, and improved flexibility in managing power demand and supply fluctuations. It also facilitates greater integration of RES.

Why is Grid Infrastructure Development Essential?

As we progress towards net-zero goals, wind and solar are expected to supply most of the world's electricity, accounting for 93% of the capacity additions needed to triple renewable energy by 2030. Integrating this amount of RES into the electricity grid presents **two main challenges**: i) uncertainty in power availability due to their non-dispatchable nature, and ii) capacity bottlenecks at connection points and congestion in specific areas of the grid.

To address the uncertainty introduced by RES in the power system, system operators (SOs) are increasingly relying on **advanced forecasting tools** to mitigate risks in grid management[12]. Additionally, to compensate for the non-dispatchable nature of RES, SOs can adopt various technologies such as long duration energy storage systems[13] or demand response programs.

Long duration energy storage (8+hours, intra day and intra week, months and years) provides renewable energy generation to meet 24/7 needs charging when there is excess solar and wind and discharging to the grid when need at peak times alleviating costs lost to curtailment and providing grid services like interia, frequency response, load following, peak shaving, and overall flexibility to meet supply and demand needs.

A major risk grids pose to the energy transition is **capacity bottlenecks**, which arise from both insufficient capacity at connection points and congestion in specific areas of the grid experiencing significant increases in renewable energy flows. The former issue is already causing long queues for grid connections, delaying the achievement of RES integration goals. The latter issue results in an undesired consequence: the curtailment of renewable energy.

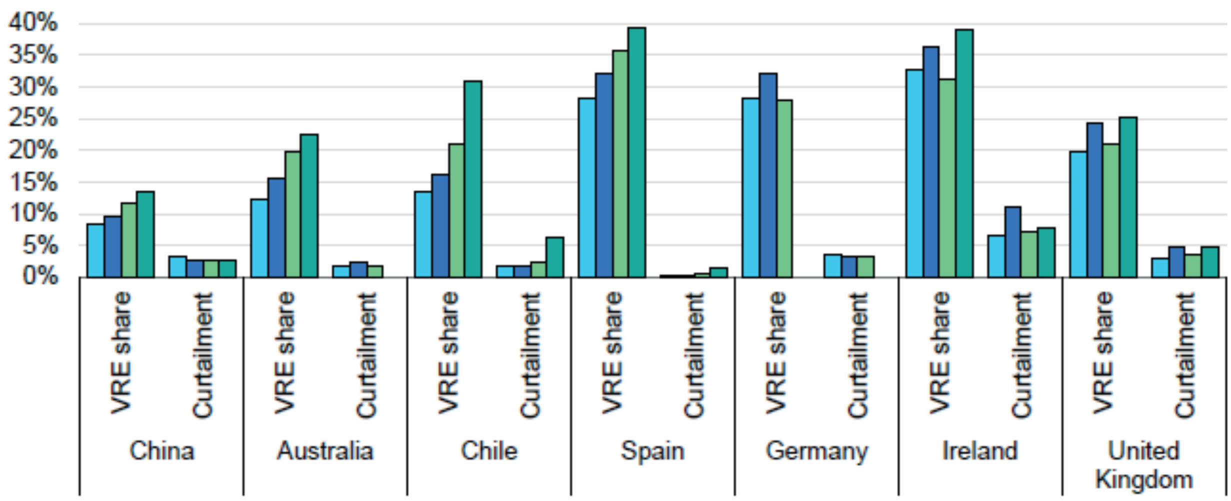

Figure 5 - Annual technical curtailment of variable renewables in selected countries, 2022
Source: IEA (2023), Electricity Grids and Secure Energy Transitions

12 ENTSO-E Transparency Platform, Generation Forecast
13 IEA (2024), Batteries and Secure Energy Transitions, IEA, Paris

Investing in grid infrastructure is crucial to facilitate the necessary RES installations. On one hand, it is essential to assess the current state of the electricity grid and make upgrades as needed. On the other hand, **long-term planning** is crucial to address future grid needs, considering the anticipated expansion of RES capacity over time. Planning should also consider the most efficient use of the new transmission capacity, with development of renewables and storage coordinated in order to maximize the use of new lines.

It is important to recognize that investment in the electricity grid involves more than just building lines, substations and transformers. While these are essential, modern investments also include **advanced technologies** such as flexible alternating current transmission systems (FACTS), DLR, and other grid enhancing technologies, as well as high-performance conductors and high-voltage direct current (HVDC) corridors, which help manage the flow of electricity more efficiently across long distances.

Beyond the physical infrastructure, we must also embrace a new era for power systems, **driven by innovation**. This new vision includes adopting emerging technologies, services, and methodologies that enhance grid efficiency and adaptability.

Why Set a Grid Infrastructure Target?

The commitments made by governments to accelerate the energy transition and rapidly develop renewable energy resources must be matched by massive investments in the electricity grid. This includes upgrading, expanding, modernizing, and digitalizing the existing grid infrastructure. The global tripling and Paris Agreement goals will not be met if the electricity grid does not expand faster than current trends to 2030. Setting specific **targets for electricity grids** development will provide clarity, direction, and accountability for policymakers, industry, investors, and stakeholders. A quantifiable target can be tracked, and progress measured. Additionally, grid targets offer context for necessary enabling policy measures and send a clear signal to all involved parties.

Setting a 2030 target for grids is an important signal, and it is also necessary to consider **longer-term objectives to meet decarbonisation goals**. Grids are, by nature, a complex topic due to their status as critical national assets and the way their infrastructure is owned, regulated, and operated. Thus, having clear targets for grids is important as it drives faster and more transparent improvements in grid capacity, reliability, and resilience.

At COP29, **countries should commit to setting grid targets** for 2030, 2035 and 2040 and agree on a process to determine the appropriate levels for these targets, as well as the specific grid vectors they should address. These grid targets relate to the growing integration of RES, mostly variable wind and solar, into the power mix.

This paper serves as a call to action on a global grid target as well as a consultation paper to assist the achievement of the energy and climate goals. Thus, we present: i) global **grid targets**; ii) **immediate actions** to stay on track of 1.5ºC and; iii) **metrics** to provide tracking and accountability capabilities.

Targets:

To meet long-term global energy and climate goals, we must pursue major grid infrastructure development with high ambition and 1.5°C outcomes in mind. We fully support and endorse COP29's call to **reach USD 700 billion in grid infrastructure investments by 2030** and **add or upgrade over 80 million kilometers of transmission and distribution lines by 2040**.

Actions:

To stay on track to the 1.5°C target, immediate action is essential. Governments must prioritize the following actions over the next few years to ensure progress:

- **Upgrading Grids:** Modernizing grid infrastructure to handle increased renewable energy capacity and incentivizing investment in innovative and enhanced technologies.
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Immediate action in these areas will not only position countries to meet their 2040 targets but also unlock significant economic, environmental, and social benefits well before 2030.

Metrics:

Tracking and development metrics are essential to measure progress and provide transparency and accountability on the road to achieving energy and climate goals. As a consultation paper, we propose a range of possibilities for grid development metrics:

- **Time to connect renewable projects (in years)**
- **Grid capacity growth (in GW per km)**
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- **System efficiency (in percentage of transmission and distribution losses reduction)**
- **Permitting timelines (in years)**
- **Penetration of renewables (in percentage of total installed capacity)**
- **Carbon dioxide (CO_2) intensity (in grams of CO_2 per kilowatt-hour - kWh - of energy produced)**
- **Grid reliability (in terms of SAIDI or SAIFI)**
- **International commitments (in number of targets and grid delivery plans included in international communications such as NDCs)**
- **Supply chain queue duration for key components (in years)**
- **Use of raw materials (in percentage of the total amount of materials)**
- **Curtailment of renewables (kWh per year)**

Alongside setting targets, it is important to **establish policies** that are fit-for purpose to achieve them. Prime among these is the need for long-term stable revenue mechanisms, which allows attraction of low-cost capital into this vital part of the decarbonisation transition.

Lastly, a global target **raises awareness** among stakeholders of the need for these actions to enable and accelerate deep and durable decarbonisation.

Different vectors for grid development

Achieving global decarbonization goals and meeting the ambitious target of tripling renewable energy capacity by 2030 requires a multifaceted approach to grid development. This involves addressing several critical vectors, each contributing to the overall effectiveness, resilience, and capacity of the electricity grid. In this section some of the most relevant grid vectors are addressed in the view of defining a global grid target.

The **expansion of grid infrastructure** is crucial to accommodate the growing RES installations. This involves constructing new transmission and distribution lines, upgrading transformers, and building additional substations to manage the increased energy flow and variability. As RES installations grow, particularly wind and solar, it is crucial to ensure that the grid has the capacity to transmit electricity from generation sites to demand centers without bottlenecks or delays.

The **digitalization** of both transmission and distribution networks is key to modernizing the grid. Grid mapping, remote monitoring, and control systems enhance the efficiency and reliability of electricity supply. By integrating digital tools, operators can optimize the performance of the grid, quickly identify and respond to issues, and manage the complexities introduced by distributed energy resources (DERs). This includes leveraging system solutions such as **virtual power plants**, which pool together energy devices like rooftop solar panels, batteries, and electric vehicles to provide distributed generation, storage, and demand management. Digitalization also facilitates advanced data analytics, enabling better forecasting and grid management.

A robust **innovation strategy** is essential for both incremental improvements and disruptive advancements in grid technology. Pilots focusing on technologies such as satellite imaging, drone inspections or, implementing mature innovative grid technologies such as Dynamic Line Rating (DLR) offers new ways to optimize grid performance and maintenance. These innovations not only enhance the operational efficiency of the grid but also reduce downtime and maintenance costs, providing a more resilient and adaptable infrastructure.

As the grid evolves, so too must the **workforce** that operates and maintains it. Training programs are needed to equip employees with the skills required for modern grid management, including digital tools and advanced technologies. Additionally, attracting new talent is critical to addressing the growing demand for expertise in areas such as renewable energy integration, cybersecurity, and grid automation.

Improving **grid operation** is pivotal to ensuring stability in an increasingly variable energy landscape. Enhanced voltage and frequency control mechanisms are necessary to accommodate the fluctuating inputs from RES. Moreover, integrating RES services into grid operations, such as ancillary services, can help balance supply and demand, ensuring a reliable electricity supply even as renewable penetration increases.

The global push for grid expansion and modernization has put significant strain on **supply chains**, particularly for key components like transformers. Utilities are already experiencing lead times of up to two years for transformers, highlighting the need for more resilient and efficient supply chains. Addressing these delays is critical to keeping pace with the required grid developments.

Enhancing **cross-border interconnection** is vital for improving grid resilience and energy security. By linking national grids, countries can share resources, balance supply and demand more effectively, and mitigate the impact of localized disruptions. Cross-border interconnections also enable the more efficient use of renewable resources by allowing excess energy generated in one region to be transmitted to where it is needed most.

To accelerate renewable energy deployment the creation of **Green Energy Zones** (GEZ) are essential. They can allow for streamline permitting and grid connection processes, reduce emissions, attract investment, create jobs, and improve local quality of life with cleaner energy. GEZs are often in regions with high renewable potential but low local demand or underdeveloped infrastructure.

To enhance the effectiveness of GEZs, **Green Energy Corridors** (GEC) are crucial to enable transporting renewable energy from these zones to areas with higher demand. This integration ensures efficient energy use, balances supply and demand, and helps harness excess energy where it is needed most.

A well-functioning **electricity market** is essential for incentivizing grid investments and ensuring the optimal integration of RES. Market reforms that promote flexibility, transparency, and competition can drive innovation and efficiency in grid operations. Additionally, electricity markets that reflect the true costs of grid services, long duration energy storage and RES integration can help allocate resources more effectively, supporting the overall goals of decarbonization and energy transition.

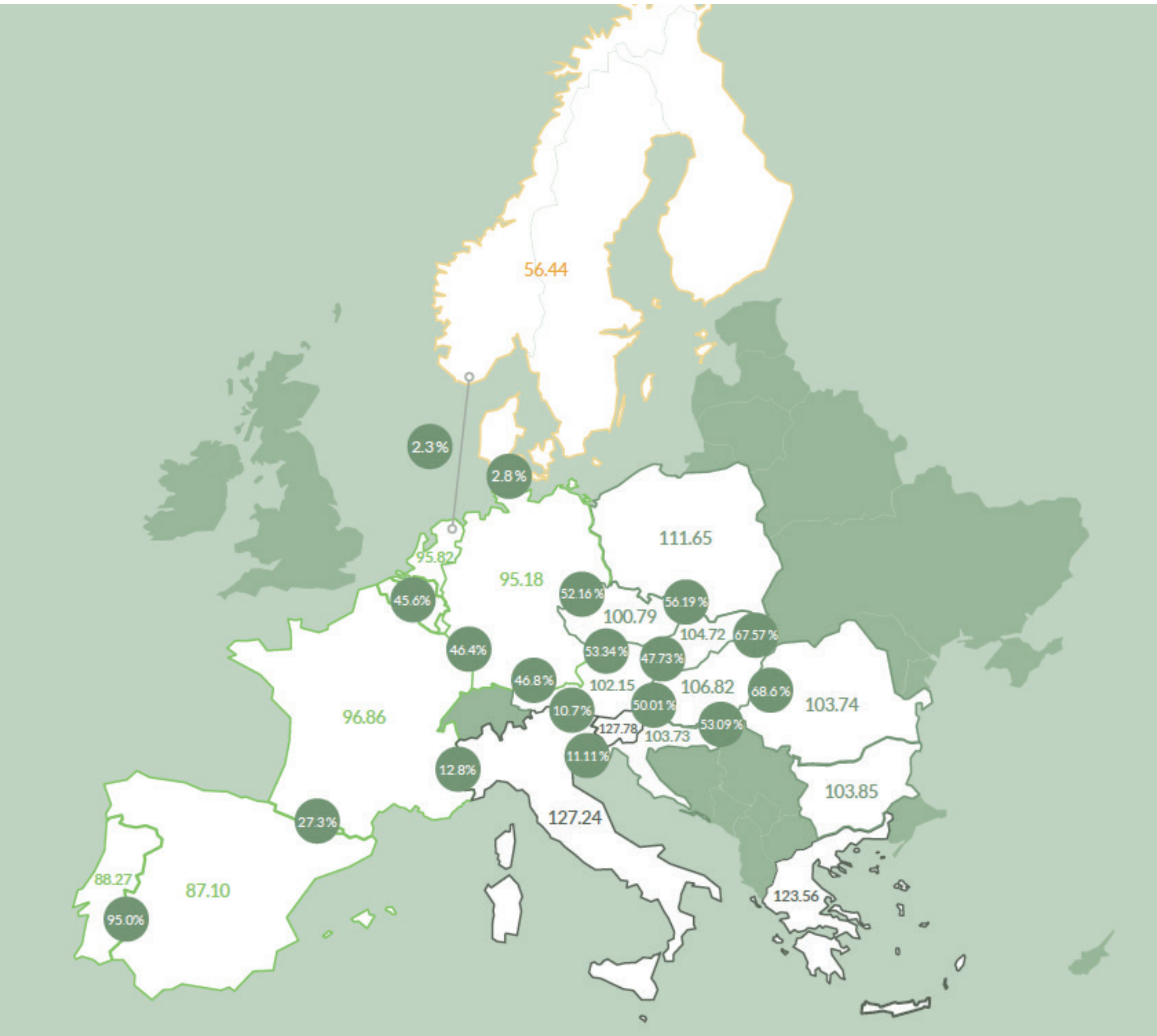

Figure 6 - 2023 Average prices in price areas in Europe in % of hours with a price difference of < €1/MWh
Source: OMI, Integrated Report OMI 2023

In a more decentralized approach, **mini-grids** are increasingly important, especially in EMDEs where traditional grid expansion faces financial and structural hurdles. These systems, powered by decentralized renewables, provide a reliable energy solution in areas where large scale transmission is constrained. They can operate independently, or with national grids, reducing transmission costs and enhancing energy access.

In addition, **public consultation** is essential to ensure community support, facilitate grid development and avoid backlash. Experiences from countries such as the UK and the USA highlight that neglecting local community input during the planning and construction of new grid infrastructure can lead to significant opposition and potential setbacks. Effective consultation helps to align projects with local needs and concerns. It also ensures that biodiversity and land use are carefully considered, minimizing emissions impacts and enhancing resilience.

The Imperative of International Cooperation

While national-level efforts are crucial for the development and modernization of grid infrastructure, the challenges we face extend beyond national borders. These challenges are best approached through collective efforts rather than by any single country. **Interconnection between countries** is crucial, not just for optimizing energy distribution and integrating renewable resources, but also for ensuring energy security on a regional and global scale. Collaborative system planning across borders will enable more efficient and resilient grids.

Moreover, the development of **supply chains** for the materials and technologies required to upgrade grids requires coordinated international efforts. **Innovation strategies** also benefit from global collaboration, whether through shared research initiatives or the adoption of best practices across different markets. Finally, establishing **global financing norms** is essential to attract the necessary investment, reduce risks, and create a more predictable environment for grid development.

By fostering greater international cooperation, we lay the groundwork for a truly global **effort to modernize electricity grids**, ensuring that no nation is left behind in the energy transition. This collective approach not only amplifies the impact of individual national efforts but also sets the stage for more ambitious and achievable global targets.

Metrics for Grid Development: An Overview

Metric	Why It's Important	Challenges & Opportunities
Time to connect renewable projects (in years).	Reducing connection queues. Faster connection timelines help integrate renewable energy more quickly.	Bureaucratic delays, complex processes. Streamline processes, adopt automated systems.
Grid capacity growth (in GW per km).	Higher grid capacity supports more renewable energy integration, unlocks capacity bottlenecks.	High costs, technical limitations. Use new materials and construction techniques.
Interconnectivity (in number and capacity of interconnections).	More interconnections enhance energy sharing and grid security across regions.	Political and logistical obstacles. Boost international collaboration.
System efficiency (in percentage of transmission and distribution losses reduction).	Reducing losses makes the grid more efficient and cost-effective. Measured as the percentage of energy lost during transmission.	Outdated infrastructure. Upgrade technology to cut losses. Leverage Operational improvement and Innovation.
Decrease permitting timelines (in years).	Decrease permitting timelines. Faster permits enable quicker grid expansion, reducing the time required for approvals to build new grid infrastructure.	Lengthy approvals, varying regulations. Reform regulations to speed up approvals.
Penetration of renewables (in percentage of total installed capacity).	Increase % renewables penetration, high shares of produced renewable energy, reduces CO_2 emissions and climate impact.	Integration and balancing energy sources. Invest in technology to manage variable energy.
Carbon dioxide (CO_2) intensity (in grams of CO_2 per kilowatt-hour - kWh - of energy produced).	Lower CO_2 intensity means cleaner, more sustainable energy. CO_2 emissions per unit of electricity generated. Consequence of grids allowing more renewables integration.	Transitioning from fossil fuels to renewables. Expand renewable energy to reduce CO_2.

Metric	Why It's Important	Challenges & Opportunities
Grid reliability (in terms of SAIDI or SAIFI)	SAIDI and SAFI measures the system interruption duration of electricity. This underpins the frequency and duration of power outages. Improved reliability ensures consistent power supply.	Aging infrastructure, extreme weather. Invest in resilient and smart grid technology. Leverage Operational improvement and Innovation.
International commitments (in number of targets and grid delivery plans included in international communications such as NDCs)	Inclusion of detailed grid development plans and targets to promote tracking and accountability. Aligns grid development with climate commitments.	Poor integration of goals and planning. Integrate grid plans into climate strategies.
Supply chain queue duration for key components (in years)	Availability and production capacity of essential grid components. Ensures timely upgrades and construction of grid infrastructure. Focus on tracking global capacity for key components and decrease length of order queues.	Disruptions and material shortages. Strengthen global supply chains and local production.
Use of raw materials (in percentage of the total amount of materials)	How efficiently materials are used in grid projects, taking advantage of recycled and reused materials. Reduces waste and lowers project costs.	Resource availability, recycling challenges. Improve recycling and material efficiency.
Curtailment of renewables (kWh per year)	Reducing curtailment allows more renewable energy to be used, increasing overall efficiency and reducing reliance on fossil fuels. Reflects the improvement on grid flexibility and infrastructure upgrades.	Capacity bottlenecks, outdated infrastructure. Invest in storage systems and real-time grid management to minimize energy waste.

Global Renewables Alliance — Climate Compatible Growth — Lucetia Group

iha international hydropower association — LDES Long Duration Energy Storage Council — Global Solar Council — GWEC Global Wind Energy Council — Green Hydrogen Organisation — IGA International Geothermal Association