

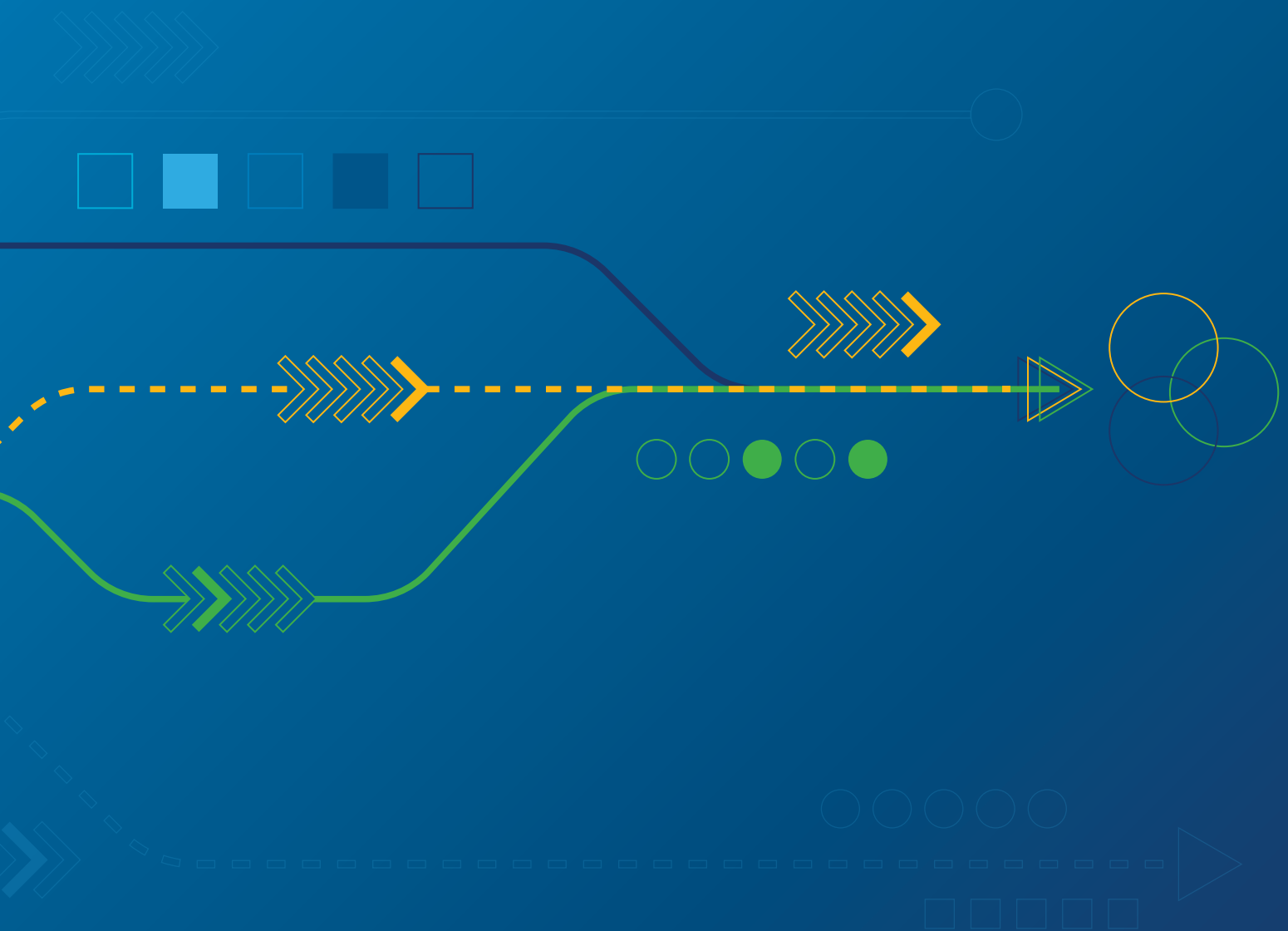


United Nations



UN-ENERGY POLICY BRIEF

Advancing Power System Connectivity in support of SDG 7



ABOUT UN-ENERGY POLICY BRIEF

The drafting of this UN-Energy Policy Brief was led by the Economic and Social Commission for Asia and the Pacific (UNESCAP), the Economic Commission for Europe (UNECE), and the United Nations Economic and Social Commission for Western Asia (UNESCWA) as members of UN-Energy. It builds on discussions at a UN-Energy meeting at technical level held on 10 May 2023 in New York, and on additional technical inputs from many other UN-Energy organisations.

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This work is a joint product of staff of various UN-Energy members and partners. The findings, interpretations, and conclusions expressed in this publication do not necessarily represent those of UN-Energy or any of its members or partners.

ABOUT UN-ENERGY

UN-Energy is the United Nations' mechanism for inter-agency collaboration in the field of energy established by the UN System Chief Executives Board for Coordination. It aims to promote coherence in the UN system's multi-disciplinary response to achieve Sustainable Development Goal 7 (SDG 7) in support of the 2030 Agenda for Sustainable Development and the Paris Agreement on climate change. The member organizations of UN-Energy are: FAO, IAEA, IFAD, UNCDF, UNCTAD, UN DESA, UNDP, UN ECA, UN ECE, UN ECLAC, UN ESCAP, UN ESCWA, UNESCO, UNEP, UNFCCC, UNFPA, UN-Habitat, UNICEF, UNIDO, UNITAR, UN-OHRLS, UN Women, World Bank, WHO, WMO, and partner organizations IRENA and SEforAll.

UN-Energy is co-chaired by Achim Steiner, Administrator of UNDP, and Damilola Ogunbiyi, Special Representative of the UN Secretary-General for Sustainable Energy for All. The UN-Energy secretariat is provided by UN DESA under the leadership of Li Junhua, UN Under-Secretary-General for Economic and Social Affairs.

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For further information, please contact:
UN-Energy Secretariat,
Department of Economic and
Social Affairs, United Nations
Website: <https://un-energy.org/>
Email: un-energy@un.org



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INTRODUCTION

From information and communications technology (ICT) to transport and trade, the concept of connectivity is relevant to many areas of global social and economic development. In energy, connectivity is a tool that can help countries reach a range of often-competing energy targets and policy goals.

Power system connectivity – interconnected power grids that cross boundaries both within and between countries – can increase access to renewable energy resources and facilitate their integration.

Connectivity can also help to optimize the use and sharing of power generation resources and enable economic development. In supporting increased universal access to energy services, it can also support increased gender equality.

Power sector connectivity faces several obstacles, however. These include a range of complex technical, political and institutional issues.

Such connectivity involves the integration of systems of critical importance to a country's real economy and national security. Power systems are also highly complex, dynamic systems in which demand and supply must be continuously balanced in order to avoid disruption or blackouts.

Successful connectivity efforts therefore require significant interjurisdictional collaboration across numerous stakeholder groups.

Currently, the degree of cross-border power system connectivity varies widely around the world.

KEY MESSAGES

Political will is a fundamental enabler of power system connectivity. Governments should therefore:

- Develop clear visions for the role of power system connectivity.
- Harmonize regulatory frameworks at the sub-region or regional level to facilitate development of common standards and codes.
- Reform energy pricing at the national level to reflect the true cost of energy, including its environmental and social costs.
- Further develop institutions to support multilateral collaboration on power system connectivity at the sub-regional and regional levels.
- Encourage market integration to enable countries to trade electricity more freely.

Ensuring that power system connectivity is fully leveraged as a tool for sustainable development is highly relevant to the Sustainable Development Goals (SDGs) of the 2030 Agenda for Sustainable Development. This is because such connectivity represents a low-cost tool to advance renewable energy, tackle climate change and increase economic development.

THE ROLE OF POWER SYSTEM CONNECTIVITY

1. Meeting global demand growth

According to the International Energy Agency (IEA), electricity demand in developed economies grew by an average of 0.4 per cent per year between 2005 and 2019, although average economic growth was 1.6 per cent per year. In emerging and developing economies, electricity demand growth averaged 5.7 per cent per year, while economic growth averaged 5.4 per cent per year, over the same period.

Globally, in 2022, average electricity demand growth slowed. However, increased electrification of end-uses such as transport, combined with expectations of increased economic growth in the medium- to long-term, mean that countries still need to find sustainable ways to meet significant future growth in electricity demand.

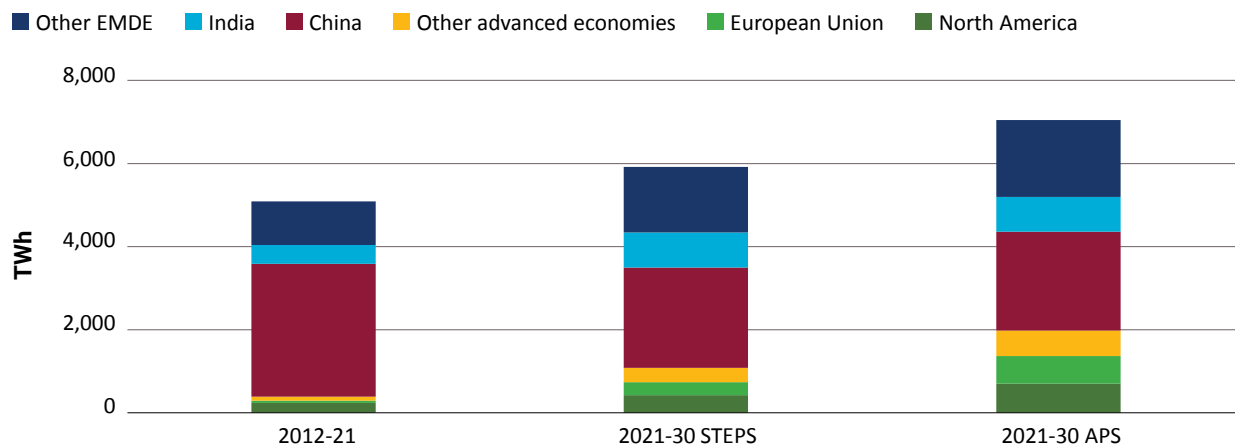
While in some parts of the world, electricity demand growth and economic development have partly decoupled, in Asia and the Pacific these two indicators are still very much interlinked. As the region continues to grow economically, for example, demand for air conditioning and other electricity-consuming devices is also expected to grow, increasing power demand per capita. The Asian Development Bank (ADB) estimates that in 2030, developing Asia will account for 43 per cent of global electricity demand. By then, China and India combined will constitute 64 per cent of the region's total power consumption.⁴

System balancing

The changing nature of electricity demand means that power system connectivity matters at the local and even household level.

FIGURE 1

Electricity demand growth by region and scenario, 2012–2030, terawatt hours (TWh)



Source: IEA World Energy Outlook 2022.³

As an example of this, one important way to tackle the challenge of integrating increasing shares of renewable energy sources – the short-term balancing of variable energy supply and demand – is to activate the potential of smart buildings.

This means integrating into the energy system as active market participants millions of decentralized consumption and generation units and devices. Methods of intelligent integration of these technologies include the provision of system services by electric vehicles (EVs), heat pumps and electrolysers. They also include the participation of decentralized units – such as distributed photovoltaic (PV) and home battery electric storage systems (BESS) – in local, regional or even national electricity markets.

By facilitating the development of distributed energy resources, digital technologies can be leveraged to improve the efficiency of buildings in several phases of their life cycle. This can be done in several ways, including via household solar PV panels and storage, creating better incentives for their installation and by making it easier for producers to store and sell surplus electricity and heat to the grid.

With respect to system-wide resource optimization, tools such as advanced distribution management systems (ADMS), distributed energy resource management systems (DERMS) and microgrid controllers are solutions thought to show significant prospects.

Vetting and verifying

One of the fundamental barriers to integration of distributed energy resources, however, is the issue of vetting and sharing key information about their attributes, capabilities, relationships and behaviours. This vetting in sharing is necessary to allow system-wide optimization in the first place. Just as banks need to perform 'know-your-customer' checks to verify the identity of potential clients and manage risks, grid operators need to qualify and register every asset that provides services to the electricity grid. Dynamic onboarding and dynamic status information in real-time remain the key problems: any device that wants to participate in a given electricity market must first establish a secure digital identity to coordinate with other systems and participants.

It is necessary that units within buildings, as well as their associated rights, are verified electronically in real time to ensure secure and dynamic interaction and the minimization of transaction costs. Digital personal and machine identities thus become an important linchpin in the context of energy-efficient and smart buildings. The goal of an energy economy that includes smart buildings is for decentralized units to be able to switch dynamically and with sovereignty between self-consumption, system services and trading markets. In this process, the more participants and the more frequent the interactions are (i.e., the larger and more liquid the markets) the more efficient, cost-effective and environmentally sound the energy system becomes.

Decentralized units can contribute to a higher utilization of the electricity grid by providing system services. The potential flexibility of buildings in low voltage grids must therefore be increased and further developed through concepts of digitization that are real-time capable and resilient, in a reactive grid management sense.

Overall, the integration of devices 'behind' the existing metering system requires a flexible and learning regulatory framework. The approval of such devices by competitive electricity trading markets is also required. The key step in this context is the provision of digital identities, allowing each decentralized unit to interact with the energy grid and participate in the energy market.⁵

Driving electric

Under both the stated policies scenario and the announced pledges scenario, EV fleets are also expected to become increasingly significant for power systems, possibly driving increments in peak power generation and transmission capacity. The latter may require integrating the EV charging process into the broader electricity network, using cars as mobile electricity storage units which could take the form of Vehicle-To-Grid (V2G), Vehicle-To-Home (V2H), Vehicle-To-Building (V2B) or even Vehicle-to-Everything (V2X) approaches.

Each charger type brings different challenges and opportunities for grid integration. While unmanaged and unpredictable charging, particularly during peak load times in the later afternoon/early evenings, threatens to overstress the grid, smart charging can account for price signals, available grid capacity, grid operator signals and end user preferences to turn the vehicle into an energy asset.

There are real opportunities, for example, to use aggregated, connected EVs to help flatten load curves, provide ancillary services – such as frequency balancing for the operators of transmission grids – manage grid congestion over large geographies and avoid renewables curtailment by shifting EV charging times throughout the day. V2G is an emerging technology that allows power to flow both to and from an EV. This can support these grid services even further, providing a storage asset of renewable and often low carbon electricity for domestic prosumers. It can also supply a source of resilient energy for homes in the case of a grid outage.⁶

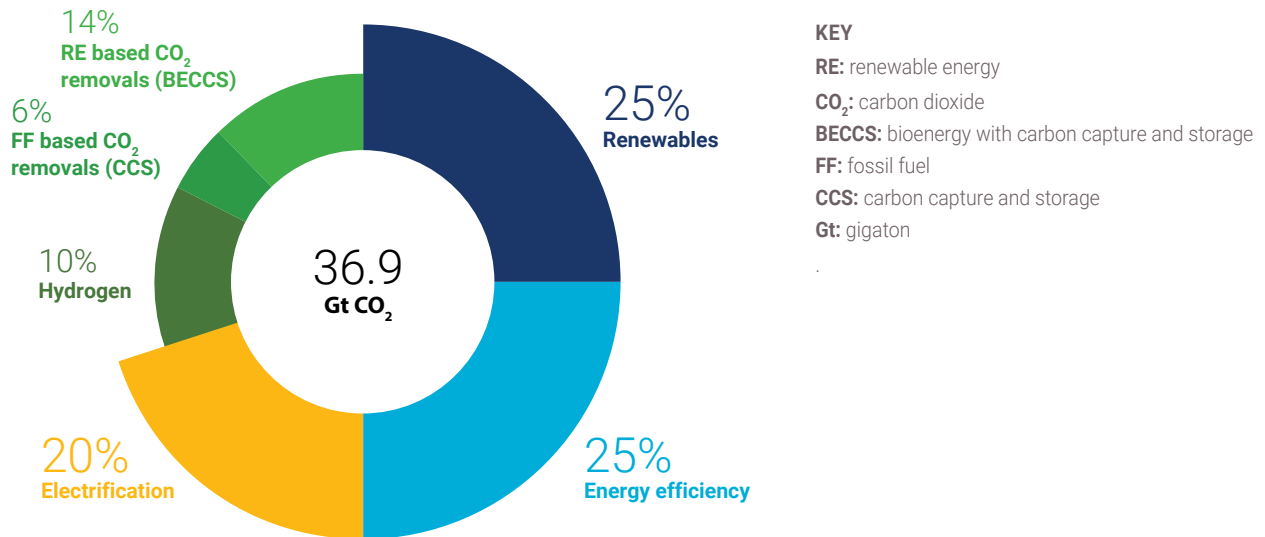
Intelligent charging management systems and connected vehicles, coupled with hourly forecasts, market signals and consumer preference data, could indeed be key to minimizing the upstream emissions of EVs. They could also be key to reaping related benefits, such as reducing peak power generation capacity needs, integrating variable renewables and making EVs more financially and environmentally attractive to end-users.

Some challenges still need to be addressed, however, especially with regard to regulations, load management and consumer engagement. Regarding the first of these, implementing real-time electricity tariffs, taking into account upstream emissions from all energy types used for mobility purposes, is a key challenge. Regarding load management, enhanced connectivity and machine learning algorithms are areas for further development. On consumer engagement, infrastructure development and innovative business models that will make the case for sustainable charging practices are also challenges to be addressed.⁷

Connectivity has an important role to play in ensuring that electricity demand growth is met in an affordable, secure and sustainable way. The efficient sharing of resources across jurisdictional boundaries allows demand growth to be met by the lowest cost generation sources and reduces the cost of maintaining security of supply. It also allows

FIGURE 2

Six components of the energy transition strategy



Source: IRENA World Energy Transitions Outlook.

for complementary collaboration between resource-poor and resource-rich countries. For example, by importing electricity, Singapore, which has limited available land and renewable energy potential, can meet rising demand and decarbonization goals simultaneously.



2. Increasing the deployment of renewable energy resources

Six components of the energy transitions strategy are laid out by the International Renewable Energy Agency (IRENA) in its “World Energy Transitions Outlook: 1.5°C Pathway”.⁸ When combined, these components should ensure that the world stays on track to meet its Paris Agreement targets.

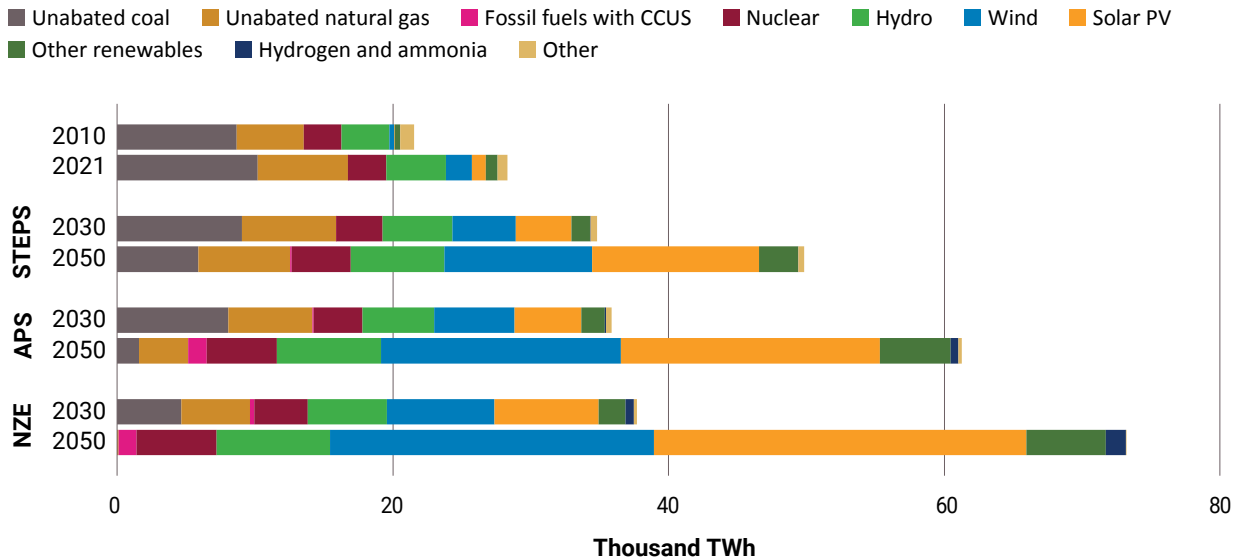
As shown in Figure 2, in this strategy renewable energy contributes a quarter of overall emissions reductions.

The IEA similarly notes that under a net-zero pathway, by 2050 almost 90 per cent of electricity generation globally would come from renewable sources. Wind and solar PV together would account for nearly 70 per cent, while electricity would account for almost 50 per cent of total energy consumption.⁹

Renewable energy deployment must therefore be scaled up in order to keep the world on track to meet its climate targets. Furthermore, as Figure 3 shows, scaling up renewable energy mostly means scaling up deployment of wind and solar PV. Connectivity, in combination with large-scale storage, is a critical tool for integrating such high shares of variable renewable energy.

FIGURE 3

Global electricity generation by source and scenario, 2010–2050



KEY: NZE: net-zero emissions, APS: announced pledges scenario, STEPS: stated policies scenario, CCUS: carbon capture, utilization and storage, PV: photovoltaic

Source: IEA World Energy Outlook 202.2

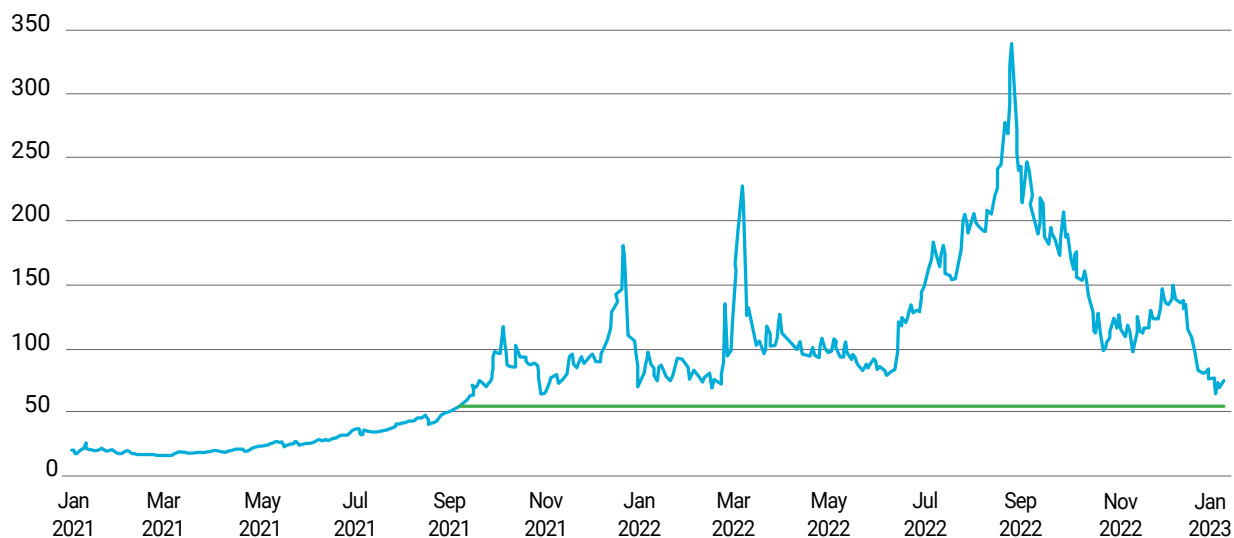
The variability of wind and solar PV resources derives from the fact that they are weather dependent technologies, with the level of generation in any given location varying by hour, day and season. Power systems that including high shares of renewable energy resources will therefore need to manage larger variations in generation than power systems based primarily on natural gas or coal generation.

While variability poses a challenge for power system planning and operations, connectivity offers a solution. Increasing the geographic size (or ‘balancing area’) of power systems allows them to take advantage of natural smoothing effects. For example, solar resources follow the movement of the sun, and therefore shift from east to west over the course of the day. Latitudinal connectivity therefore offers the possibility to extend the length of time that solar generation provides electricity. Similarly, wind resources vary across geographical areas, often in ways that are hard to predict far in advance. Larger power systems are therefore able to take advantage of wind power wherever and whenever it is produced.

The types of renewable resources and their relative scale are also distributed unevenly across jurisdictions. In South Asia, for example, India has vast solar resource potential, while the neighbouring countries of Bhutan and Nepal have significant hydro resources – well beyond the level they need to meet domestic demand. Connectivity can enable the hydro resources to complement the solar resources and offer a renewable source of balancing energy across all of the interconnected countries. This helps to meet decarbonization goals across the entire region, while also providing an important source of revenues for exporting countries.

FIGURE 4

Dutch front-month title transfer facility (TTF) natural gas futures, 2021–2023, (EUR/MWh)

Source: Investing.com¹⁰

3. Increasing energy security

Recovery from the COVID-19 pandemic and ongoing geopolitical tensions have led to a significant increase in energy prices, worldwide. Many countries are highly dependent on imports of natural gas, coal and even oil for electricity generation, making them vulnerable to such global price volatility, which can translate into higher domestic power bills.

From mid-2021 to the start of 2023, Europe, for example, experienced extreme volatility in gas prices. In euro (EUR) terms, these ranged from around EUR 30 per megawatt hour (MWh) at the start of the period to a peak of over EUR 300/MWh in late 2022, before falling back to around EUR 50/MWh at the start of 2023 (Figure 4).

Such unprecedented volatility, combined with a decrease in the supply of pipeline gas, has strengthened the case for the deployment of renewable energy as a domestic, reliable and robust source of primary energy. It has also strengthened the case for enhanced connectivity between the transmission systems of European states.

Data considering the impact of the most recent energy crisis are not yet available. However, the UNECE “Renewable Energy Status Report 2022”, which focuses on the status of renewables in 17 UNECE countries, shows that significant progress in renewable energy has been achieved in recent years, although its potential remains largely untapped.¹¹

Indeed, according to Eurostat, within the European Union, the share of renewable energy more than doubled between 2004 and 2021, to some 22 per cent.¹² It is expected that this trend will continue, and that renewable energy will expand its share at the expense of natural gas.

This is also in line with a global upward trend, which shows that renewable energy continues to grow at record levels, despite global uncertainties.

Yet, while recent years have seen unprecedented growth in the UNECE region’s use of renewable resources in the electricity sector, this has not been the case for the transport, heating and cooling sectors.

At the same time, public and private investment in renewables across the UNECE focus countries remains modest compared to global growth trends. This highlights the need for significant investment in renewables, along with a need for the development of policy options to facilitate their uptake.

Power system connectivity can help countries reduce their import dependency on fossil fuels, allowing for the substitution of fossil-fuel based electricity generation with renewable energy resources.

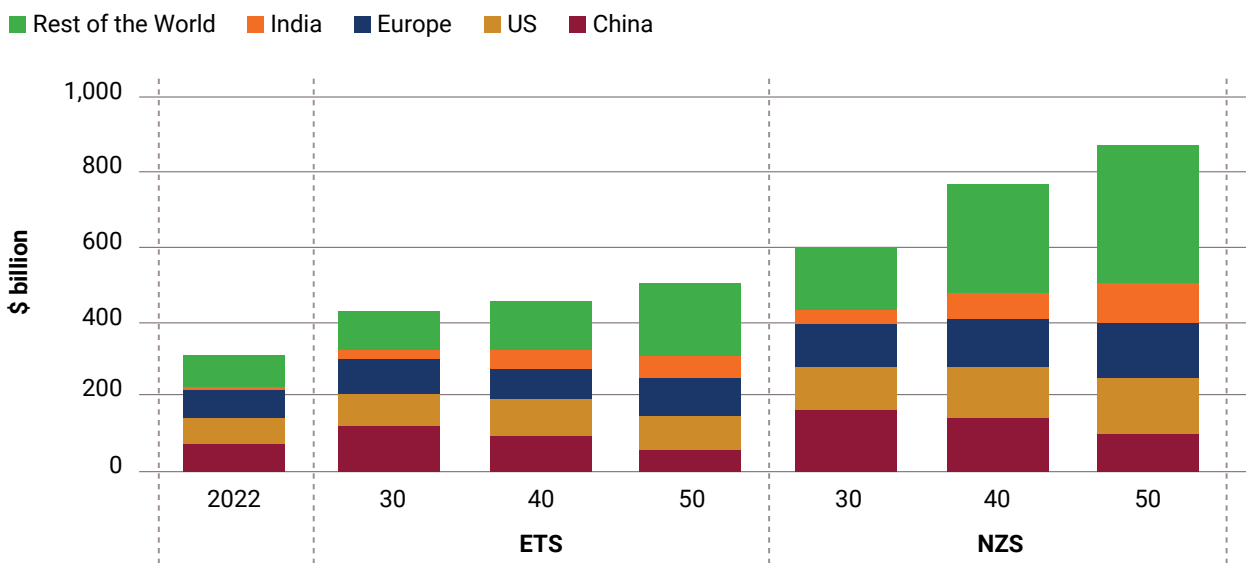
Secure power system connectivity, however, requires the deployment of grid infrastructure.

Bloomberg New Energy Finance (BloombergNEF) estimates that, between 2022 and 2050, in US dollar (US\$) terms, US\$ 21 trillion in grid investment is required to enable a net-zero scenario.

Adding to the complexity is the fact that grids tend to have longer development lead times compared to renewable energy assets. This means that in order to ensure that the grid is available when renewable energy needs to be integrated, there must be a long-term support plan for this – both within countries and across sub-regions and regions.

FIGURE 5

Global annual grid capital expenditure (CAPEX) by region, 2022–2050 (US\$ billions)



KEY: ETS: economic transition scenario, NZS: net-zero scenario

SOURCE: BloombergNEF.¹³

There are many examples of regional grid development plans around the world. These include the Ten-Year Network Development Plan for Electricity (TYNDP-E) in Europe, the African Continental Grid Master Plan (currently under development) and the various Association of Southeast Asian Nations (ASEAN) Interconnection Masterplan Studies (AIMS).

The picture is, however, highly fragmented. Some regions are developing plans rooted in international agreements, while others are primarily being developed by international organizations, non-governmental organizations (NGOs) or other stakeholders working to promote or accelerate connectivity.

Key factors enabling successful efforts to develop multi-jurisdictional grid plans include: the presence of regional institutions that facilitate discussion; planning and action across relevant countries; and, in the case of international grids, clear demonstrations of political support and the presence of intergovernmental agreements.

Globally, because grids are considered natural monopolies and because many transmission owners are nationally owned utilities, grids are primarily financed from government budgets. However, there are many examples across the world where private finance has been used to accelerate grid development. These include, but are not limited to Australia, Brazil, India, the United Kingdom and the United States. These examples can serve other countries as models of how to diversify sources of finance for grids. Such diversification can help lower costs and increase the scale of transmission development.

EXAMPLES OF CONNECTIVITY EFFORTS

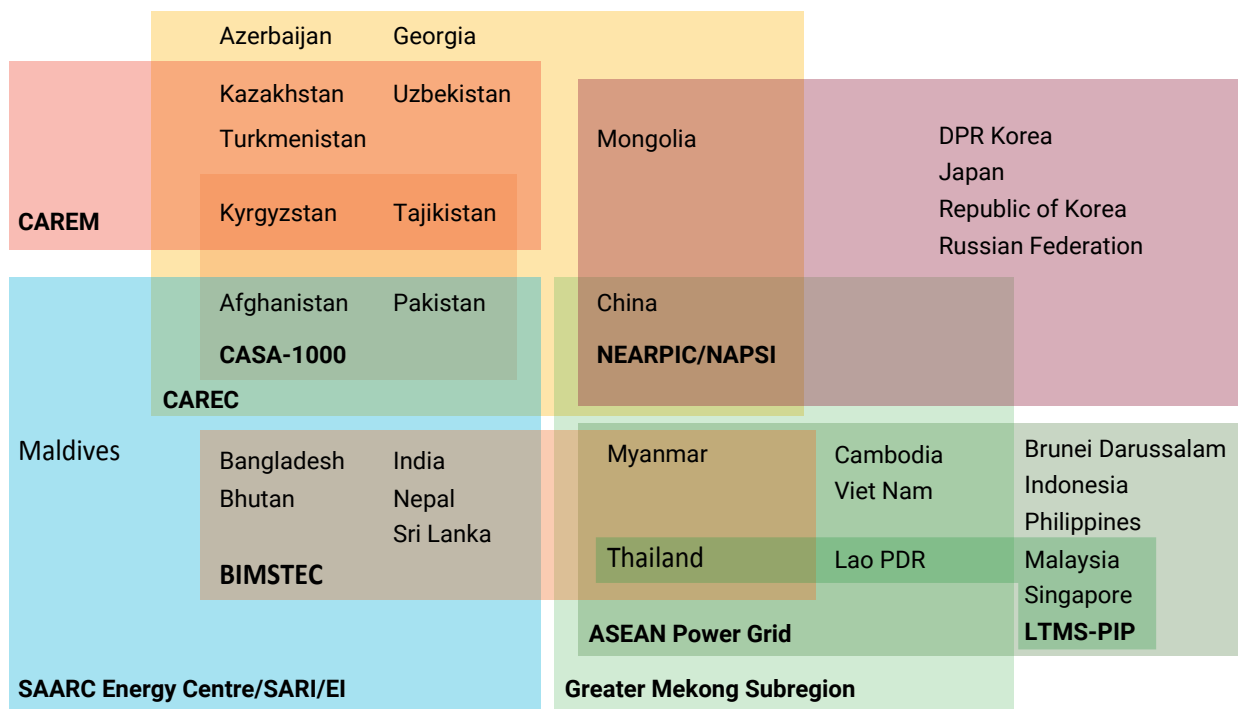
As noted above, power system connectivity efforts are at different stages of development around the world. In the Asia and the Pacific region there are many different initiatives on connectivity. Some of these overlap, while most of them remain at the study stage.

In terms of connectivity, South-East Asia is one of the most advanced parts of the Asia and the Pacific region.

The ASEAN Power Grid (APG) seeks to link together the grids of all 10 ASEAN member states, allowing them to flexibly trade electricity across borders, once it is fully developed. Yet, although the APG has been debated for many years and some transmission lines that it will utilize have been built, it still lacks the institutional development and consistent power system planning needed to accelerate implementation.

Within the APG, however, is an important example of how the region is moving beyond bilateral power trading: the Lao People's Democratic Republic-Thailand-Malaysia-Singapore Power Integration Project (LTMS-PIP). Through the LTMS-PIP, the Lao People's Democratic Republic is able to sell up to 100 megawatts (MW) of electricity per transaction to Singapore via Thailand and Malaysia. While this initiative represents an important example

FIGURE 6
Power system connectivity initiatives in the Asia and the Pacific region



***DPRK:** The Democratic People’s Republic of Korea, **LPDR** = Lao People’s Democratic Republic

KEY: **CAREM:** Central Asian Regional Electricity Market, **CAREC:** Central Asia Regional Economic Cooperation, **BIMSTEC:** Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation, **SAARC:** South Asian Association for Regional Cooperation, **SARI/EI:** South Asian Regional Initiative for Energy Integration, **NEARPIC/NAPSI:** Northeast Asia Regional Power Integration and Cooperation/Northeast Asia Power System Interconnection, **LTMS-PIP:** Lao People’s Democratic Republic, Thailand, Malaysia and Singapore Power Integration Project

SOURCE: UNESCAP Regional Trends Report 2022.

of multilateral trade, it is currently unidirectional and of limited flexibility. It is therefore seen as a pathfinder project, aiming toward the full development of multilateral, multidirectional power trade.

In Central Asia several initiatives also exist. Historically, this region had a fully integrated power system developed under the auspices of the Soviet Union. Due to this historical connectivity, some institutions remain. These include the coordination dispatch centre known as Energiya. This has the mandate to coordinate interstate central dispatch and remains active to this day. Since the collapse of the Soviet Union, however, connectivity in general in Central Asia has become fragmented. While many relevant building blocks are in place, connectivity must therefore be reinitiated and further developed, if the needs of the more sustainable power systems of the future are to be met.

In the Arab region, several power system connectivity initiatives exist, including the Gulf Cooperation Council Interconnection Authority (GCCIA). This has the mission of creating a resilient interconnection grid and ensuring power security and economic benefits for the six Gulf states.¹³ Other initiatives in the region include the Eight Country Interconnection Project between Egypt, Iraq, Jordan, Lebanon, Libya, Palestine, the Syrian Arab Republic and Turkey. In addition, there is the Maghreb Countries Interconnection Project, between Algeria, Libya, Morocco and Tunisia.

Meanwhile, in October 2021, the Saudi Electricity Company and the Egyptian Electricity Transmission Company awarded a tender for the development of the first-ever, large-scale high voltage direct current (HVDC) power line connecting the Middle East and North Africa. The project involves a 1,350 km network, from Medina in Saudi Arabia to Badr in Egypt, with up to 3 gigawatts (GW) of power, mostly renewable energy traded.¹⁴

The Moroccan and Spanish networks are also linked. In addition, Jordan also aims to begin exporting 150 MW to Iraq in 2023, marking the next phase in the transformation of Jordan's power sector. This transformation has seen Amman slash its reliance on oil and pivot towards natural gas and renewables, over the past decade.¹⁵

Overall, only 2 per cent of the electricity produced in the Arab region is traded, however, leaving much room for growth.¹⁶ For a variety of reasons, governments in the region would benefit greatly from optimizing their clean energy resources and diversity of demand patterns, while integrating their national grids and committing to the commercial cross-border electricity trade. These reasons include imbalanced energy resources across the Arab region, the energy transition agenda and the unique position of regional countries to exploit solar power. They also include the rapid cost decline and exponential growth in usage of renewable energy technologies.

Recognizing these benefits, under the League of Arab States (LAS) umbrella, the Arab Ministerial Council for Electricity (AMCE) has prioritized the establishment of a Pan-Arab Electricity Market (PAEM), in collaboration with the World Bank. The PAEM aims to boost cross-border electricity trade in the region from the current 2 per cent to between 37 and 41 per cent by 2035, creating one of the world's largest multi-country integrated systems, with a generation capacity of over 600 GW. Furthermore, the extensive size and geographical reach of the PAEM present potential trade opportunities with electricity grids in the European Union (EU), sub-Saharan Africa and Asia.¹⁷

CHALLENGES TO INTERCONNECTION

The benefits of power system connectivity are widely recognized, yet several factors have limited their progress in many parts of the world. These include energy security concerns, which may lead to a lack of political support for connectivity initiatives. In addition, the financial implications for the power system may also raise political concerns. Importing low-cost power, for example, may be good for consumers, but could also reduce the revenues of nationally-owned power utilities. Allowing for the export of low-cost power, on the other hand, may lead to higher domestic prices. The presence of energy subsidies at the national level could also impede connectivity efforts by undermining the potential economic benefits of integration. Left unchecked, connectivity initiatives could also give a new lease of life to otherwise uneconomic fossil fuel-based generation, making connectivity a potential obstacle to the development of new clean energy resources.

Insufficient regulatory frameworks and a lack of technical and legal harmonization at the subregional and regional levels are also critical obstacles in many parts of the world.

For power system connectivity initiatives to succeed, there must be general alignment on power system planning practices. This includes, for example, agreement on the underlying assumptions, such as fuel price forecasts and resource potential. There must also be arrangements for cost sharing and cost recovery and a harmonization of protocols to ensure efficient and secure system operations.

Integrated power systems are also more complex. In particular, if they include high shares of renewable energy generation, they will require both technically sophisticated control centres and a highly trained workforce.

Power system connectivity allows countries to take advantage of resource and demand diversity. A mismatch between locations with high potential for renewable energy generation and areas with high levels of demand, is therefore ultimately an opportunity.

One example of this is in Europe. The potential for offshore wind is greatest in the North Sea, while for solar, it is around the Mediterranean basin. However, most of these renewable energy sources are located far from the centres of highest demand in Western and Central Europe. These centres need vast low- and zero-carbon sources to decarbonize their carbon intensive energy systems. The main issue, therefore, is transmitting that power from where it can be cost effectively generated to where it can be consumed.

A large-scale transmission network, or 'super grid', could make it possible to trade high volumes of electricity across great distances. It could also allow renewable energy in the EU to reach a 45 per cent share of energy supply by 2030, as proposed in the EU's REPowerEU plan.¹⁸ The EU estimates that, to meet this goal, the share of renewable energy in the electricity sector would need to reach 69%.¹⁹

Yet, the infrastructure development required to connect these diverse regions would be significant. Longer power development corridors also imply an increased need to consider land rights and the corridors' impact on local communities and the environment. Infrastructure financing requirements could also be substantial, which may limit the potential investment opportunities for capital-constrained countries with high debt costs. To increase the share of renewable energy in the electricity sector in line with REPowerEU plan targets, for example, the EU estimates that an additional EUR 29 billion in investments in power grids would be required between 2022 and 2030.²⁰

POLICY RECOMMENDATIONS

In consideration of all the above, this policy brief makes the following recommendations:

- Countries should develop clear visions for the role of power system connectivity, rooted in evidence-based modelling of socio-economic benefits and supported by domestic policies, clear mandates, and intergovernmental agreements. Political will is a fundamental enabler of power system connectivity.
- Institutions to support multilateral collaboration on power system connectivity at the subregional and regional levels should be further developed.
- The capacity of relevant stakeholders and institutions should be increased, with the sharing of best practices and experiences across subregions and globally part of this process.
- Regulatory frameworks at the subregional or regional level should be harmonized in the form of common or aligned standards and codes. This ensures grids are interoperable and can be connected at the technical level to enable cross-border electricity trade and infrastructure cost sharing and cost recovery.
- Market integration at the sub-regional and regional levels should be encouraged to enable countries to trade electricity more freely.
- Energy pricing should be reformed at the national level to reflect the true cost of energy, including its environmental and social costs.
- There is an urgent need to increase investment in transmission infrastructure. Countries should consider all available sources of financing, including private finance, in order to speed up transmission development.
- Public-private partnerships should be developed to finance, build and operate interconnection projects.
- Connectivity initiatives should be fully aligned with sustainable development. Sustainability criteria should therefore be developed and integrated into connectivity initiatives to ensure that projects that increase sustainability are prioritized.
- Energy, climate, and environmental goals should be integrated more closely with socioeconomic development targets.
- The generation of renewable energy should be promoted to fully capitalize on the ability of interconnection to increase grid flexibility and manage intermittent generation.
- Develop and reinforce technology dissemination & research and innovation in order to leverage emerging digital technologies like artificial intelligence and blockchain to improve grid management, increase efficiency and more effectively manage transactions.

ENDNOTES

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- ⁹ See IEA (2021), "Net Zero by 2050: A Roadmap for the Global Energy Sector", IEA, Paris, https://iea.blob.core.windows.net/assets/7ebafc81-74ed-412b-9c60-5cc32c8396e4/NetZeroBy2050-ARoadmapfortheGlobalEnergySector-SummaryforPolicyMakers_CORR.pdf, accessed 15 June 2023.
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