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Performing while transforming:

The role of transmission companies in the energy transition

Innovation Insights Brief | 2020

In collaboration with PwC

FOREWORD

Transmission of electricity plays a crucial role in meeting growing demand for clean, affordable, reliable, and equitable power. The role and position of transmission companies is changing in fast and fundamental ways in this time of energy transition. The importance of electricity transmission is not in question, but the who, operating and business models involved are expected to transform in the decades to come.

Demand for renewable and net zero carbon power is expected to triple by 2050. Electricity will need to be transported across longer distances, via increasing cross-border connections and regional grids. Transmission companies are working to provide the physical and operational backbone of a new global energy system that can meet growing and shifting demand for heat and cooling, ‘on demand’ energy-plus services, and, short and seasonal storage needs. Meanwhile, the short and medium term ‘how to’ practicalities of designing, building and operating large scale, multi-directional and hybrid grid systems are characterised by ambiguity, uncertainty and new kinds of systemic and emerging risk, including global pandemics, cyber security and extreme weather events .

Transmission companies and system operators around the world also face new kinds of ‘off-grid’ community opposition and competition from non-traditional energy providers. They are challenged to find ways to balance the trade-off between arriving too early with the wrong technology solution (e.g. battery and/or alternative to battery storage solutions) or hindering the speed of global energy transition by waiting until the fog of societal ambiguity and new technology risk becomes clear.

This study by the World Energy Council, in collaboration with PwC, provides timely insights on the challenges ahead and solutions emerging, based in interviews with 37 transmission companies, covering all regions of the world. Three strategic implications are clear: (1) the future of the grid involves investment in people and skills, as well as in the tools and infrastructure required to anticipate and meet more mobile and dynamic demand; (2) transmission companies will need to play an increasingly active role in designing the new power ecosystem and securing their social licence to operate; and, (3) cross-border and regional connected grid systems offer multiple benefits, including enhanced resilience but these systems may incur political risks.

As the COVID-19 crisis continues to have an impact across the world, the lights have stayed on in many countries even as national economies and social mobility have come to a virtual standstill. It is too early to say when there will be a return to pre-covid business-as-usual. Based on the Council’s wider global energy community surveys, expectation is growing of a slow recovery to a ‘new/next’ normal, rather than a return to normal. The shape of the ‘new normal’ varies, however, depending on the duration of global economic recession or depth of contraction, priority to climate neutrality and the ambition for transformational outcomes and societal behaviour change.

Dr Angela Wilkinson
Secretary General & CEO
of the World Energy Council

Jeroen van Hoof
PwC Global Power & Utilities
Leader

ABOUT THE WORLD ENERGY COUNCIL

The World Energy Council has been at the heart of global, regional and national energy debates for nearly a century, developing new thinking and driving effective action around the world to achieve the benefits of sustainable energy for all.

Comprised of over 3,000 member organisations in nearly 90 countries, drawn from governments, private and state corporations, academia and new and wider system shapers stakeholders, the Council is the world’s first and only truly global member-based energy network.

The Council works dynamically across the whole energy sector as a global energy transition platform, pulling together intelligent leadership to catalyse and inform the world’s energy policy dialogue, create impact and drive practical action. Learn more visit www.worldenergy.org

Published by the World Energy Council 2020

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World Energy Council
Registered in England and Wales
No. 4184478

VAT Reg. No. GB 123 3802 48

Registered Office
62-64 Cornhill
London
EC3V 3NH
United Kingdom

ABOUT THIS BRIEF

This Innovation Insights brief on electricity transmission is part of a series of publications by the World Energy Council focused on Innovation. This was developed in collaboration with PwC. In a fast-paced era of disruptive changes, this brief aims at facilitating strategic sharing of knowledge between the Council’s members and other energy stakeholders and policy shapers.

The World Energy Council and PwC would like to thank 37 interviewees who contributed to developing this brief.

| | |
|--------------------------------|--|
| Stefan Kapferer | 50Hertz Transmission GmbH, Germany |
| Steve Berberich | The California Independent System Operator (CAISO), USA |
| Alfonso Morcos | El Centro Nacional de Control de Energía (CENACE), Mexico |
| TK Chiang | CLP Holdings (CLP), Hong Kong |
| Mohamed Zakaria Kamh | Egyptian Electricity Transmission (EETC), Egypt |
| Marcio Szechtman | Elektrobras, Brazil |
| Kalle Kilk | Elering, Estonia |
| Uroš Salobir | Elektro-Slovenija (ELES), Slovenia |
| Chris Peeters | Elia Group, Belgium |
| Laurent Schmitt | European Network of Transmission System Operators for Electricity (ENTSO-E), Europe |
| Bill Magness | Electric Reliability Council of Texas (ERCOT), USA |
| Segomoco Scheppers | Eskom, South Africa |
| Jukka Ruusunen | Fingrid, Finland |
| Ahmed Ali Al-Ebrahim | Gulf Cooperation Council Interconnection Authority (GCCIA) |
| Haibin Wan | Global Energy Interconnection Development and Cooperation Organization (GEIDCO) & China Electricity Council, China |
| Tomislav Plavsic | Croatian Transmission System Operator (HOPS), Croatia |
| Bernardo Vargas Gibsone | ISA, Colombia |
| Angelo Ferrante | Mediterranean Transmission System Operators, (MED-TSO) |
| David Wright | National Grid Electricity Transmission, England and Wales' |
| Ibrahim Al Jarbou | National Grid SA, Saudi Arabia |
| Abderrahim El Hafidi | Office National de l'Électricité et de l'Eau Potable (ONEE), Morocco |
| Mike Bryson | PJM Interconnection (PJM), USA |
| Leszek Jesień | Operator Polskie Sieci Elektroenergetyczne (PSE), Poland |
| Mauricio Remacha Moro | Red Electrica de España (REE), Spain |
| João Conceição | Redes Energéticas Nacionais (REN), Portugal |
| Pavel Livinsky | Rosseti Group, Russia |
| Olivier Grabette | Réseau de Transport d'Électricité (RTE), France |
| Safiétou Diallo | Senelec, Senegal |
| Rais Abdelhamid | Sonelgaz / GRTE, Algeria |
| Harsh Shah | Indigrd, India |
| Bo Krantz | Svenska K., Sweden |
| Usman Gur Mohamed | TCN (Transmission Company of Nigeria), Nigeria |
| Manon van Beek | Tennet, Netherlands |
| Nobuyuki Ryu | TEPCO, Japan |
| Giacomo Donnini | Terna, Italy |
| Andres Kuhlmann | Transelec, Chile |
| Alison Andrew | Transpower, New Zealand |

“IT IS A VERY EXCITING FUTURE ALTHOUGH WE CAN'T POSSIBLY TELL YOU WHAT IT'S GOING TO BE LIKE. WHAT I CAN SAY IS THAT WE NEED TO BE OPEN TO THE FACT THAT THERE ARE SOLUTIONS WE HAVEN'T THOUGHT ABOUT YET.”

ALISON ANDREW
CHIEF EXECUTIVE OFFICER, TRANSPOWER

“I SEE TENNET, AND MAYBE TSOS IN GENERAL, NOT JUST AS A FACILITATOR. WE ARE NOT JUST TRANSPORTING ELECTRICITY OR OPERATING THE GRID. WE WANT TO DRIVE THE TRANSITION.”

MANON VAN BEEK
CHIEF EXECUTIVE OFFICER, TENNET

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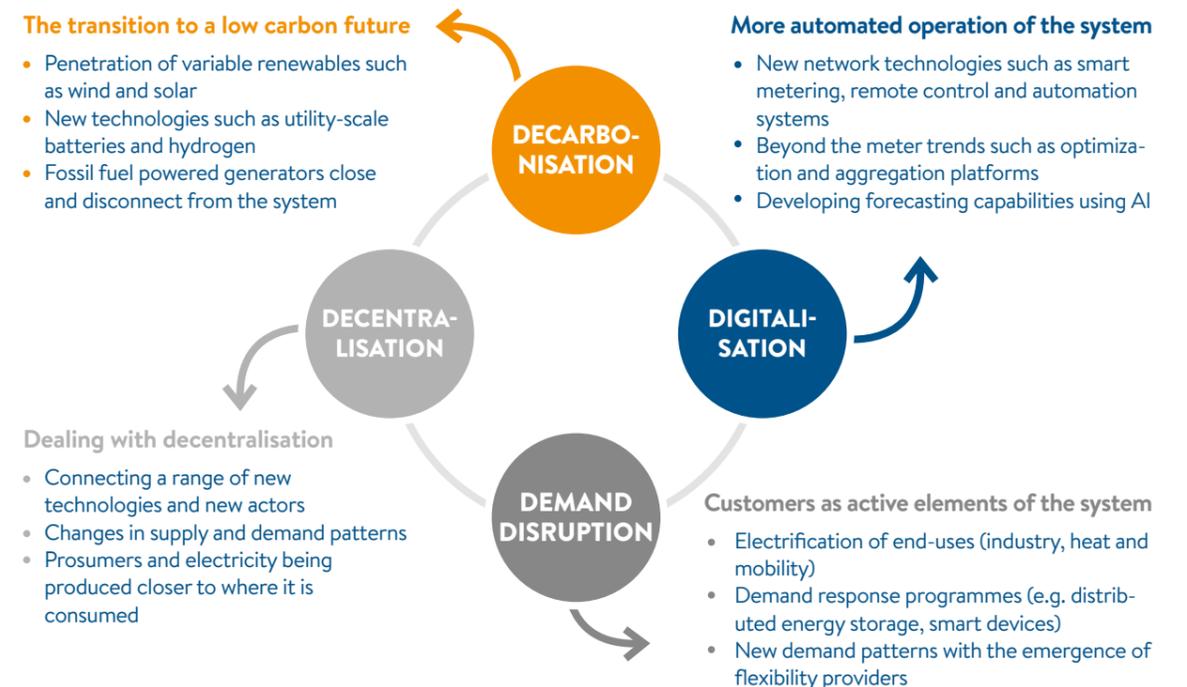
PREFACE

The need to deliver reliable and affordable electricity whilst addressing climate change is driving dramatic transformations of power systems globally. This brief is the first stage of a working series aimed at understanding how these transformations are shaping **the future of electricity grids around the world**. This first brief focuses exclusively on electricity transmission and will be followed by workshops and a deep dive on electricity distribution and other actors of today's and future grids.

The insights reflected here are the result of in-depth interviews with CEOs and senior leaders from 37 Transmission System Operators (TSOs), Independent System Operators (ISOs), Transmission Owners (TO) and associations representing 35 countries¹. We refer to these companies as “transmission companies” in the brief. The interviews which inform this brief were conducted between January and February 2020. At the time, and with the exception of a few, the COVID-19 pandemic had not yet impacted the organisations interviewed. To understand how transmission companies were managing to keep electricity flowing while also safeguarding their staff and operations, we conducted a survey as well as a series of webinars with interviewees². The findings are available in Annex 3.

The energy landscape in which the organisations interviewed operate is undergoing a period of significant and rapid change as we move away from a historical reliance on large, centralised thermal power generation and price insensitive consumption towards a greater diversity of supply and flexibility of demand. This is driven by four global drivers: decarbonisation, decentralisation, digitalisation and demand disruption.

Figure 1: Key trends and uncertainties affecting electricity transmission companies



¹ Additional information on how transmission companies operate is available in Annex 1

² The webinars were conducted on the 2nd of April and 23rd of April 2020. The findings can be found in Annex 3

The challenge for grid owners and operators is to know where these trends will lead:

- What critical new infrastructure do you need?
- How do you operate a grid with a high proportion of distributed and renewable resources?
- What level of electrification of end-uses will we reach?
- Which technologies may disrupt your system?

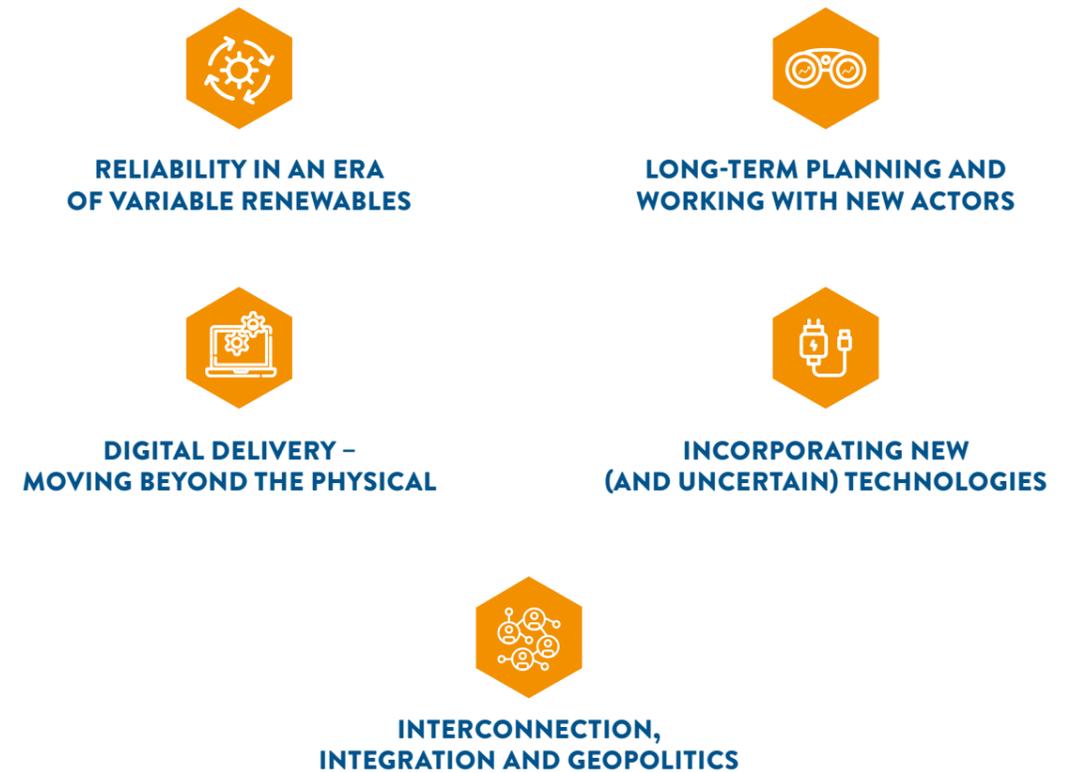
Transmission companies are initiating dialogue, sharing visions and playing a central role in debates as they look ahead to the coming decades. This brief gives a flavour of some of those conversations and those visions and seeks to raise questions rather than to provide final answers. It is part of an ongoing conversation with network owners and operators as well as the broader energy system on the topics and recommendations raised. It is a starting point for an international and cross-sector conversation, building on the dialogues that many transmission companies are having at a national level.



EXECUTIVE SUMMARY

Transmission companies are key players in electricity systems. With safety and reliability in the foreground, their main responsibility is to ensure that the grid remains stable at all times so as to safeguard consumers' security of supply³. Spanning all continents and a range of regulatory and national contexts, this brief reviews the common themes, the differences in how transmission companies are planning for the energy transition and the dilemmas they are facing in the process.

Despite the great diversity in terms of structure, geography, resources, GDP of the country of operation of the transmission companies that we interviewed, their CEOs and other top executives are in no doubt about the importance of transmission in the future. They see a future where **transmission companies are at the heart of change, enabling innovation in their energy systems and, in many cases, helping to lead its visionary development.** Whilst the end-goal for these organisations is clear, several trends are affecting how they prepare and re-think their operations and business models:



³ Security of supply entails meeting the demand for transmission while keeping generation/consumption levels balanced as to avoid any fluctuations in frequency, interruptions in supply and even grid failure.

Arising from these five trends and uncertainties, we found that the overarching challenge of transmission companies is to **perform and transform simultaneously**. On the one hand, they need to **perform**: security of supply is to be ensured at all times whilst complying with fast changing regulation (e.g. integrating new technologies, working with new actors or increasing the overall flexibility of the system). On the other hand, they must **transform** to integrate, manage and influence the changes affecting them as a result of energy transitions.

Leveraging the insights from our interviewees, we developed four recommendations to accompany transmission companies in this perform and transform journey:



FOCUS ON THE FUTURE

The variability of renewables as well as the key uncertainties discussed in this brief shed new light on the critical role of both forecasting and scenarios. Building capacity in these two areas is key to deliver clean energy futures.



SAFEGUARD THE LICENCE TO OPERATE

Transmission companies find themselves increasingly needing to have a social conversation, not just with stakeholders but also the wider public, on the choices that are available. Maintaining and building their social licence to operate with their community is key.



SHAPE THE ECOSYSTEM

The interviews which inform this brief have highlighted the opportunity for transmission companies to define themselves as drivers of the energy transition by moving beyond being physical infrastructure providers to being shapers of a community of energy system actors.



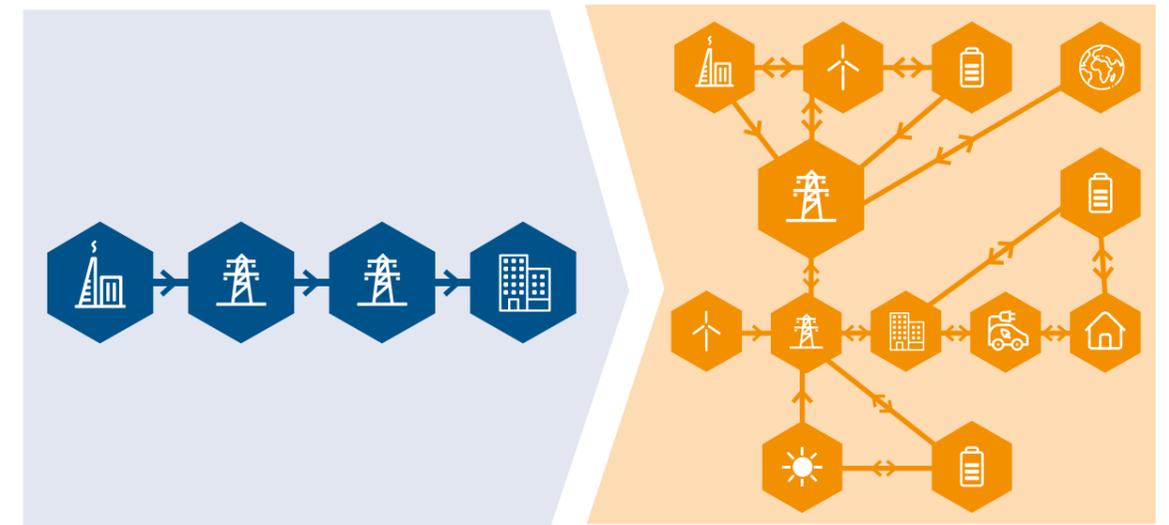
TRANSFORM THE ORGANISATION

The many challenges of energy transition are shifting the skillset and mindset the transmission companies need inside their organisations. To become more integrated energy ecosystems, there will be stronger emphasis on softer, collaborative aptitudes as well as digital skills.

BUILDING TOMORROW'S VISION WITH TODAY'S UNCERTAINTIES

The vision for transmission companies everywhere is simple: a reliable clean electricity grid to fit future needs. But that simple goal masks considerable uncertainty, complexity and new coordination challenges with other system operators. Understanding and defining future needs with precision is a challenging task which requires intensive collaboration with other actors, especially DSOs. The requirements of overall demand, decarbonisation, technology change and increasingly diverse energy sources all interact with significant consequences for transmission operators.

Old top-down energy systems are being eclipsed by more complex ecosystems with a blend of centralised and decentralised generation sources. The intermittency of renewables can create considerable system volatility with consequences for grid stability. A mix of one-way and two-way flows adds to the technical challenges faced by grid operators. And, on top of all this, many of the driving forces affecting decision frameworks are subject to political uncertainty.



PAST

Historically, electricity flowed from large transmission-connected generation, through passive distribution networks to the end consumer.

FUTURE

The future power system may be much more flexible, sophisticated and intelligent, connecting a range of new technologies and more active consumers, while maintaining overall resilience and reliability.

This section delves into the five key trends and uncertainties that emerged from the interviews and are shaping the future of electricity transmission.



RELIABILITY IN AN ERA OF VARIABLE RENEWABLES

Reliability and security of supply is a crucial goal for transmission companies. As Tomislav Plavsic, CEO of HOPS, put it to us: **“One key word is security. We need to ensure the future security of the system is, at least, at the level that it is today.”** As variable renewables penetrate the market, generation becomes increasingly dependent on weather conditions. The intermittent nature of wind and solar results in an irregular supply profile leading to a more volatile supply which becomes more difficult to balance with demand.

When asked about the main challenges they were facing, the majority of interviewees mentioned the integration of renewables and the requirement for visibility. Mike Bryson, Senior Vice President – Operations at PJM puts it very clearly **“The first challenge that comes to mind is what we call, what I call the visibility issue. So, it’s the forecasting and behaviour of the renewables with solar and wind; I’ll include in that, the behaviour of distributed energy, resources, non-conforming, load, all those kinds of things.”**

Angelo Ferrante, Secretary General of Med-TSO, the Association of the Mediterranean TSOs for electricity, observed: **“TSOs are required to operate the grid with much more flexibility than in the past. Flexibility means the capability of reacting to the different risks coming from a system that is becoming more and more complex while also guaranteeing the system security.”** In addition to flexibility, Bill Magness, CEO of ERCOT noted the requirement for transmission and distribution to better coordinate: **“Given the additional amount of energy generation resources that are sitting out there on the distribution system, there is no question that better coordination is needed.”**

In some contexts, governmental pressure to develop renewables is leading to unintended consequences which will require incentives and regulations to be reviewed. For example, in Senegal, all renewable independent producers are Take or Pay: **“As a result, we [Senelec] must pay the cost for a capacity that we are not using, and thermal power plants are struggling to sell enough energy to have a sufficient return on investment.”** This highlights the importance of knowledge exchange on a global level. Those with higher penetration of variable renewables can share best practices, as noted by Bernardo Vargas Gibsone, CEO of ISA: **“[...] the biggest challenge we face is this learning curve that’s starting to happen. We are making a jump from less than 1% of our footprint in renewable sources to close to 10 or 12%.”**

The volatility challenge is apparent in an area like California where renewables already account for a big share of generation. The amount of solar generation on the system creates very steep ramp-up rates. In just three hours 15,000MW comes on to the system and that is expected to grow to 25,000MW as more renewable generation comes online. California ISO (CAISO) CEO Steve Berberich says: **“The challenge is to decarbonise 24/7 as opposed to just during the sunny parts of the day. We’ve been pretty good about managing the intermittency, but you also have to look at the whole capacity picture as you get multiple cloudy days. It’s going to be a little bumpy as we move to higher and higher levels of penetration of renewables.”**

For Berberich one of the most important aspect of managing the intermittency that comes with renewables is good forecasting. The ISO uses a neural network load forecasting model with seven day-, two day- and day-ahead forecasting. **“We have a very sophisticated optimisation in our software and technology that takes the forecast into account as we do unit commitment and unit commitment look-forward. What’s unique is we do a forward unit commitment looking-ahead. Many others don’t or can’t do that. They’re more reactionary.”**

The value of transmission is becoming relatively more important in the electricity system according to interviewees. As pointed out by Harsh Shah, CEO of Indigrid: **“By nature, solar and wind are**

intermittent and sometimes unreliable and therefore, the role of transmission and distribution utility will increase significantly in terms of providing the end service - a reliable service.” Following a similar train of thought, Chris Peeters, CEO of Elia Group noted that: **“The original grid was built for a situation where thermal plants were relatively close to demand centres. There was no need for long-distance bulk power transmission. Today, the electricity grid is the focus of the energy transition. For the next five years, our Group will be investing €6.5 billion in Belgium (Elia) and north-east Germany (50Hertz) for the integration of renewable energy, the development of an offshore high-voltage grid and the construction of interconnectors to facilitate the integration of a European energy market.”**

EMERGING INSIGHTS



Due to its balancing role and further development requirements to connect remote renewables projects to demand centres, the role of the grid is being characterised by the penetration of variable renewables as well as the general increase in electrical demand, mainly due to the electrification of heat and transportation.



As variable renewables grow, transmission companies need to focus on developing forecasting capabilities tailored to their context.



Sharing of lessons learned and capacity building by organisations dealing with a high percentage of variable renewables in their electricity system would avoid repeating mistakes and accelerate the energy transition.



LONG-TERM PLANNING AND WORKING WITH NEW MARKET ACTORS

Two trends are expected to affect long-term planning for transmission asset owners and operators. On the one hand, the development of variable renewables is accelerating infrastructure development expectations. On the other hand, Transmission companies need to plan how they will work and integrate new market actors led by new dynamics on the demand side.

Traditionally, grid networks were designed around the locations of conventional generation plants. But a large share of current and future renewables production does not correspond to this grid architecture. **“The resources are only available in certain geographic locations,”** observes Bill Magness, President and Chief Executive Officer of ERCOT. **“We have very rich wind resources, for example, in Texas but the best wind resources are not where the people live which means you have to build more and longer transmission lines.”**

Renewable generation cannot always be located in the vicinity or large demand centre as they depend on weather conditions. As a result, electricity sometimes has to be transported over longer distances from supply to demand, which can lead to the increased need of transmissions lines. As the CEO of Transelec explained, in Chile, the rapid deployment of variable renewables is placing transmission at the forefront of the transition. Whilst for countries where hydro power is predominant, planning used to be driven by generation and transmission would follow, the penetration of renewables, especially

solar in the case of Chile, is reversing this trend. **“For large hydro or coal projects, their development always took longer than the time you need to develop the transmission grid. This has changed. Permitting and development times for renewables are much faster than the development of transmission lines. We now have to make sure that the transmissions assets are there, when the renewables are starting to be developed.”** Timeframes are accelerating and transmission companies are calling for visibility as Manon Van Beek highlighted: **“We can do a lot, but we need to know it a little bit more in advance, we are not magicians. If you ever want to build a network, it is typically a 10- year time horizon. Out of those 10 years, typically seven to eight years are licencing, and two years typically are the actual construction.”**

Yet, national and geographical contexts vary and for some transmission companies, the future will not be about “building more”. For Bo Krantz, Deputy CEO of Svenska **“When it comes to network capacity, there will be strong alternatives to building more transmission infrastructure in the near future. These can be flexibility solutions, smart grids, storage, smart transmission tariffs and so on.”** Demand-side dynamics are set to have a growing impact on the grid with the wider adoption of electric vehicles, battery storage and innovations such as virtual power plants (VPPs), demand-side response (DSR), coordinating with the local management of these by the DSO and sector coupling. Some transmission companies such as Svenska are actively encouraging this: **“We are challenging new actors to come into the market: aggregators and new players. We need more and new resources to support us for the balancing on the system. In the future, because there will be a lot of new players, some very small, we really need everything running more or less automatically.”**

Transmission companies have long been experts in balancing supply and demand but this new dynamism presents a complexity that requires major investment in digital platforms and processes. Grids that were built for large central generation resources and one-way flows are having to be transformed to accommodate a multimodal and interactive system. Chris Peeters, CEO of Elia Group, says: **“Over the coming years there will be a complete shift in how the system will be operated. The original system has been based on a limited number of large entities but we are moving to a consumer-centric system with more and more flexible assets like electric cars, boilers, home batteries and heat pumps and a multiplicity of data and access points. It is quite a revolution. But we are convinced that the evolution towards a consumer-centric energy system will bring value to all market parties and our economy.”**

Increasingly sophisticated and smart digital processes, and coordination with more localised platforms are vital for both DSR and sector coupling. DSR offers a way to strengthen power grid flexibility by shaving and shifting peak demand to better match supply. End users – commercial and residential – are incentivised to alter their demand patterns through various financial incentives. Sector coupling involves the increased integration of energy end-use and supply sectors with one another to create energy system optimisation. California ISO (CAISO) CEO Steve Berberich says: **“Sector coupling is key. For example how you are going to use and integrate electric vehicles to facilitate renewables and prevent system problems.”**

Sector coupling is also often used to describe specific strategies to decarbonise sectors by enabling links between energy carriers and sectors, for example the use of renewable electricity to decarbonise the gas supply through the production of carbon-neutral gas using power-to-gas technologies. A further coupling in this instance could see a future in which this (renewable) gas is used to both to generate back-up power and to meet demand in specific end-use sectors like transport. Again, sector coupling has huge implications for transmission companies and their role at the heart of a wider, more complex and interconnected energy system.



Proactively including new market actors to provide balancing services provides Transmission companies with the opportunity to learn and provide revenue opportunities for technology developers (e.g. aggregators, energy storage providers, etc.) They could also provide flexible solutions to offset the need for infrastructure in certain circumstances.



Sector coupling should be an inherent part of transmission companies’ thinking when planning for the future.



DIGITAL DELIVERY – MOVING BEYOND THE PHYSICAL

The role of transmission companies is focused more and more on optimising the utilisation of assets, managing interfaces to other players and balancing an ever-increasingly complex supply and demand profile. In this world, data is as important a commodity as physical infrastructure. Digitalisation of the grid infrastructure is already a key priority for many transmission companies and many are reaching further by accelerating digital transformation of their whole organisations and adjusting their business models accordingly.

Russia’s Rosseti say they are planning to invest up to 1,3 billion RUB (18,5 billion USD) in digitalisation in the period to 2030. Pavel Livinsky, Chairman of the Management Board, Director General of Rosseti said: **“Digital transformation is a shift in the very logic of technological and business processes. It has been primarily fostered by changing patterns of both production and consumption of electric power. However, COVID-19 pandemic turned it into a tool that can be used to ensure reliable energy supply during crises of various origin. I can assume post-COVID world will see significant acceleration of digitalization”.**

David Wright, National Grid Group Chief Engineer – Electricity and Director of National Grid Electricity Transmission in England and Wales, expects **“the digitisation of industry and business is going to be a huge driver of change over the course of the next decade.”** Marcio Szechtman, Chief Transmission Officer of Brazil’s Eletrobras, says: **“Over the coming years, there will be a complete shift in the way the system will be operated through digitalisation. It will be quite a revolution.”**

Digital transformation of transmission companies is happening at two levels. First, they are using digital technologies to streamline their organisations and operations, unlocking new data sources and improving data analytics to gain new insights. For example, Chris Peeters, CEO of Elia Group commented that Elia and 50Hertz are evolving from a traditional into a digital system operators. **“This transformation is the biggest our Group has ever faced. There are benefits in various areas. As a digital operator, we can provide the interface needed to implement a true digital architecture where market parties and consumers can participate and contribute to balancing the system. Digital tools will help us to manage a more complex system closer to real-time. By using smart sensors and automation, we will also extend the lifespan of our existing assets and it will make the power system more resilient.”**

Second, digitalisation is preparing the way for transmission companies to play their part in a much more connected, dynamic and interactive energy system in which digital relationships will be as important as physical infrastructure is in balancing the grid. In turn, this will have implications that go to the heart of the business and operating model of transmission companies. Olivier Grabette, Deputy Chief Executive Officer of French TSO RTE, observes: **“It is not a matter of patching a digital solution on the existing business but, instead, it is transforming the existing business through digitalisation. It goes right to the heart of understanding what our business at the TSO is.”**

EMERGING INSIGHTS



The pace of building new generation from renewables such as wind and solar is outpacing the development of transmission infrastructure. Visibility and inclusion of transmission developers at early stages is key.

Andres Kuhlmann, CEO of Transelec in Chile, observes: **“Digitalisation is something that is not only a must for us but for the entire electrical system, including the digital smart grid.”** Giacomo Donnini, Head of Strategy, Development and System Operation of Terna in Italy, told us: **“We plan to invest around €900 million in digitalisation and innovation, which will be crucial both in terms of connectivity and computational power, giving us new stochastic artificial intelligence and machine learning-based algorithms to operate the grid.”**

Grid digitalization opens up many possibilities and enables numerous innovative solutions, however, it leaves system potentially vulnerable not only to external threats, but also to routine systemic malfunctions. As noted by David Wright from National Grid Electricity Transmission in England and Wales, as systems become more digitalised, **“with that comes the whole issue of cyber security and how we keep our system safe.”** Interviewees often referred to cyber security as a big challenge for the next decade.

The directive defines ‘energy storage’ widely, encompassing both reconversion to electricity or conversion into another energy carrier. It is recognised as a distinct asset class, separate from generation, and the presumption is that transmission companies and DSOs cannot own storage, except in strictly limited circumstances as for example it is the case in some contexts when installed battery capacities are used for frequency regulation. It will be up to individual EU member states to translate the directive into national law.

Elsewhere in the world, regulatory regimes are also adjusting to accommodate a new world of storage, with a considerable degree of national variation. But in many places, the issue of ownership of storage is unresolved. In the US, for example, Bill Magness, President and Chief Executive Officer of ERCOT, observes: **“The question of who can own storage is something our regulators or our legislature will need to resolve.”** Similarly, Dr. Mohamed Zakaria Kahm, Technical Advisor to the Egyptian Ministry of Electricity and Renewable Energy, conjectures: **“Can storage be a regulated asset with transmission system operators owning storage devices to stabilise and operationalise the grid? This is actually the biggest obstacle the TSOs will see.”**

Hydrogen itself is a clean fuel with no direct emissions of harmful pollutants or greenhouse gases. There is already a major industrial demand for hydrogen, but it is currently almost entirely supplied from fossil fuels and so is a major contributor to CO₂ emissions. The vision of a hydrogen future is based on producing hydrogen from low-carbon energy sources such as renewable generation (green hydrogen) or from natural gas with CCUS (blue hydrogen). If produced in this way, hydrogen offers a solution to decarbonising a range of sectors, including transportation, heating, chemicals, and iron and steel.

Because hydrogen can be produced by drawing off excess output from solar and wind generation, it is also a leading contender for providing a long duration ‘storage’ solution for renewable power output. In addition, there is the prospect of economic use cases for the development of solar or wind locations specifically for hydrogen production. Marcio Szechtman, Chief Transmission Officer of Brazil’s Eletrobras, refers to hydrogen as potentially a **“big revolution”** for a **“new world.”**

But commercial, regulatory and technological uncertainties remain in the path of developing a hydrogen economy. As Laurent Schmitt, Secretary-General of ENTSO-E, the European Network of Transmission System Operators for Electricity, observes: **“There is currently a big question mark around these ‘green molecules’ and power fuels as we call them in Europe, or new fuels being powered from renewable electricity.”**

A key issue is whether, for an efficient market that delivers the most equitable, reliable and secure electricity, regulation needs to allow transmission companies to be able to experiment more and investigate non-wire alternatives to grid capacity expansion, such as battery storage. And is there a way to provide incentives to develop IT, data, behavioural solutions and 3rd party flexibility solutions that can take the pressure off CAPEX budgets? Current regulation typically provides revenue recognition for CAPEX rather than actually avoiding it.

EMERGING INSIGHTS



Digitalisation should be thought of holistically, collaboratively working with the entire electrical system in order to identify opportunities to improve operations and gain in efficiencies.



Automation and forecasting capabilities are key to integrating variable renewables and new market actors.



Digitalising means large investments both in developing digital capabilities as well as cyber security. Several organisations interviewed mentioned numbers in the hundreds of millions of US dollars.



INCORPORATING NEW (AND UNCERTAIN) TECHNOLOGIES

As well as managing a much more complex and uncertain grid on a day to day basis, transmission companies must plan for a range of potentially disruptive technological developments that could have major implications for grid investments. These include the development of energy storage and moves towards a hydrogen economy.

If a hydrogen economy remains in the future, battery technology is developing strongly as a current storage solution. **“Battery storage is starting to play an important role,”** observes Andres Kuhlmann, CEO of Transelec in Chile **“and that presents a big challenge operationally, for the TSOs and mainly for the ISO, to assure the coordination and the safety of cooperation in the network.”**

Russia’s Rosseti, among some other companies, has made energy storage systems an important part of its development program. Pavel Livinsky, the company’s General Director, noted: **“In the future, 2.5 million km of wires [of the Rosseti Group] may become irrelevant as energy storage devices develop.”**

The growth of battery storage has raised a number of questions about the role energy storage plays on the system, how it can be incentivised and regulated, and who can own it. In the EU, for example, the Electricity Market Design Directive 2019/944 aims to reduce barriers to energy storage, and mandates non-discriminatory and competitive procurement of balancing services and fair rules in relation to network access and charging.

EMERGING INSIGHTS



Remaining flexible enough in your planning to integrate new disruptive technologies is key for grid owners and operators. Hydrogen and energy storage are considered as the main two potential disruptors.



Energy storage is critical to integrating renewables and new demands such as EVs, and hence the regulatory regime must be developed to optimise its integration.

INTERCONNECTIVITY AND INTEGRATION

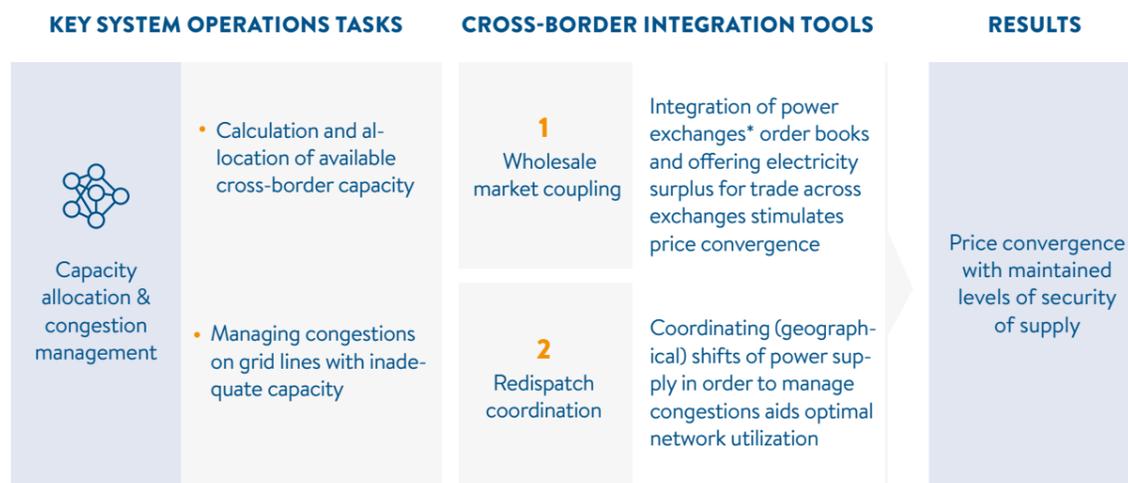
The impact of renewables, distributed energy resources, demand growth as well as the increasing number of extreme weather events has major implications for future grid capacity and flexibility. Moves towards a hydrogen economy will have even greater implications. Storage is likely to form one part of the solution. In addition, interviewees noted that interconnectivity of grids with each other and smart integration will be key for transmission companies in delivering the capacity and flexibility that is needed to facilitate the energy transition.

Originally, cross-border interconnection had the principal goal of allowing for mutual support in case of supply disruptions. Today, international grid interconnection is increasingly important in managing the day to day or even intra-day variability of wind and solar sources, as well as requiring transmission to shift the energy from renewables-rich areas to demand centres.

Grid expansion and interconnections across borders, regions and continents is becoming a main focus of transmission companies. In Europe, the EU has increased its interconnection target with neighbouring regions from 10% of import capacity over installed generation capacity to 15% by 2030⁴. It is a substantial increase, but it is against a backdrop of a very significant need for extra capacity. David Wright, Chief Electricity Engineer and Director of Transmission at National Grid in England and Wales, notes: **“A couple of years ago, we had four gigawatts of interconnection and the forecast has just been increasing and increasing. Now, the forecasts indicate more than 20 gigawatts of interconnection is going to be needed, driven by the growth in that intermittent generation.”**

Across the world, a number of cross-border power system interconnectivity projects are well-established, albeit at different stages of development. They include the South Asian Association for Regional Cooperation Energy Ring (SAARC), the ambition of the Association of Southeast Asian Nations (ASEAN) to establish an ASEAN Power Grid, power pools in eastern, southern and western Africa, and the Central American Electrical Interconnection System SIEPAC).

Figure 2: Increased cross-border coordination across several system operations tasks can bring benefits for public interest



⁴ PwC's Strategy& (2020)

FROM REGIONAL TO GLOBAL INTERCONNECTIONS

The decarbonisation challenge and the potential for interconnectivity to deliver flexible and efficient use of new energy sources has also raised the profile of the vision of increased cross-continental interconnection. The Beijing-based Global Energy Interconnection Development and Cooperation Organisation (GEIDCO) is developing the idea through a series of international initiatives. Wan Haibin, High Commissioner of GEIDCO, says: **“Global energy interconnection is a grand vision and requires assiduous and long-term efforts. So we need to do it phase by phase. Currently, we are conducting studies for interconnection projects between China, Korea and Japan and, in southeast Asia, between China, Burma and Bangladesh. We are also promoting the comprehensive development of electricity-mining-metallurgy-industry-trade in Africa based on grid interconnectivity. Eventually we are looking at global interconnections.”**

⁵ China rolls out proposal for worldwide grid, www.powermag.com 25 February 2016.

Elements of Haibin's vision find echoes elsewhere. Harsh Shah, CEO, Indigrid, says that, while it will be geopolitics that will dictate the potential and the limitations of a global grid ambition, the energy vision case for connections between India and Africa is strong: **“India can serve Africa demand when India is not at peak and Africa is at the peak. And Africa can serve Indian demand when India is the peak.”** Dr. Mohamed Zakaria Kahm, Technical Advisor to the Egyptian Ministry of Electricity and Renewable Energy, says they are currently studying the possibility of having **“an intercontinental transmission system that connects all the regions in Africa for the objective - on the transmission level - of minimising the expenditure of each country and improving the stability of the grid. As one country might have lots of renewables and another country lots of thermal, if they are connected together both will be stable.”**

In the Middle East, the Gulf Cooperation Council Interconnection Authority (GCCIA) also echoes the global theme. It sets itself the ambition of becoming **“a global hub in grid interconnections emphasising innovation, resiliency, and sustainability; and creating a dynamic electricity market for the region and beyond.”** The GCCIA is the owner and responsible body for interconnection linking the power systems of all six GCC states. CEO Ahmed Al-Ebrahim says: **“I think we need to clearly make the case for a grid that can be, or rather should be, physically integrated, but the operation of it will remain independent and as it is for various reasons – politics, security and efficiency.”**

This vision was highly contested by other interviewees. Our interviewees from Morocco's ONEE commented that electricity will stay regional because of technical constraints: **“As distances grow, losses grow as well. Even with new technologies, interconnections will remain regional in scale.”**

INTERPLAY WITH GEOPOLITICS AND REGULATION

Mr Al-Ebrahim's point highlights the interplay of geopolitics and electricity system design when it comes to interconnection. The momentum for such projects requires political goodwill but, even in a highly cooperative context, interconnection is not necessarily accompanied by common codes, market rules and commercial practices. For example, cooperation frameworks between the EU and interconnected neighbouring systems differ greatly in terms of technical, political regulatory and market rules.

Even within the EU, where market integration is advanced, the implementation of EU-wide directives is subject to national government interpretation, resulting in differences between states. Laurent Schmitt, Secretary-General of ENTSO-E, the European Network of Transmission System Operators for Electricity, highlights the considerable progress towards a single unified market but says: **“It is about having one coordinated system working together, not merging all market designs together. We have to recognise each system has its own set of operational requirements. So that means that we see different systems and different regulatory regimes being aligned together but not into a single aligned system.”**

While more physical integration & coordination may be inevitable, political and economic realities of the world make it very complicated for further integration of transmission companies themselves. Bernardo Vargas Gibsone, CEO of ISA, which operates in several Latin American countries noted how transmission companies in the region are actively discussing with governments the opportunities of connecting different countries. He commented that the biggest challenge was political: **“Unfortunately, the discussion on electric integration through interconnection between countries sometimes bring political elements to the table which cloud a much more sensible discussion about the future of the region as it tries to shift to cleaner sources of energy.”**

While there are political limits to regulatory integration in a cross-border context, transmission companies have a very important role in developing platforms for all system and market participants ensuring full transparency regarding usage of data. Increasingly that requires moving towards open data on all system occurrences, events and flows, both nationally and internationally.

EMERGING INSIGHTS



From resource adequacy, congestion management to balancing and frequency services, cross border interconnection and integration presents many advantages.



The international shape of the electricity transmission grid remains very unclear. While some are pushing for cross-continental transmission, others perceive this as unrealistic and emphasize the need to focus on regions and sub-regions.



Integration and interconnection are highly political topics. Although the benefits may be clear, politics can get in the way of interconnection projects being developed.

LESSONS LEARNED AND RECOMMENDATIONS

The discussions with interviewees highlighted different and contrasting pathways that could be followed by energy systems in the decades ahead, each with profound implications for transmission companies. What is certain is that no one pathway will be followed by all and that the practical dictates of geography, resources, technological development and socio-political considerations will be the most overriding influences.

Whatever the course of each pathway, our conversations with CEOs and other top executives across the globe lead us to identify four recommendations for transmission companies:



FOCUS ON THE FUTURE

Looking ahead through scenarios, planning and forecasting are familiar tools in the transmission companies skillset. Nonetheless, the variability of renewables as well as the key uncertainties discussed earlier in this brief shed new light on the critical role of both forecasting and scenarios.

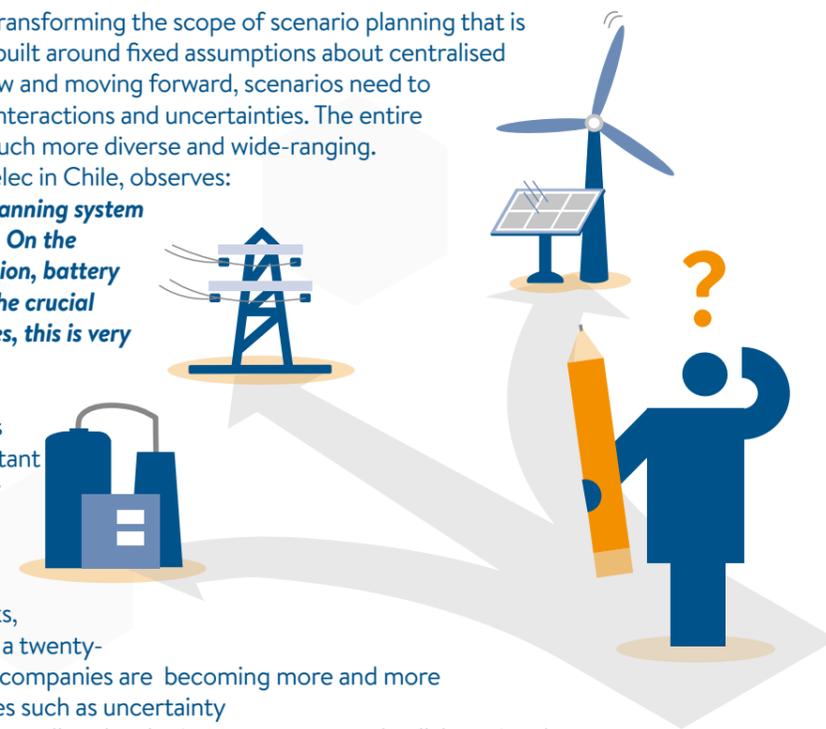
As highlighted by most interviewees already dealing with significant variable renewable penetration, forecasting and understanding the specific behaviour of wind and solar farms in the region of operation of Transmission companies is paramount. Looking beyond the supply side, system operators will increasingly have to develop their forecasting capabilities on the demand side – e.g. the behaviour of distributed energy resources such as battery storage systems, non-conforming load, demand response programmes, etc. As noted by several interviewees, the future is likely to require much greater collaboration with DSOs.

In addition, the energy transition is transforming the scope of scenario planning that is needed. In the past, scenarios were built around fixed assumptions about centralised generation and a top-down grid. Now and moving forward, scenarios need to encompass a multiplicity of actors, interactions and uncertainties. The entire landscape for scenario planning is much more diverse and wide-ranging.

As Andres Kuhlmann, CEO of Transelec in Chile, observes:

“We are transitioning from a static planning system to a scenario-based planning system. On the technical side, variability of the injection, battery storage and digital grid are among the crucial factors. And here, as in other countries, this is very dynamic as all players play a role.”

Many of the transmission companies we interviewed stressed how important scenario planning is to their strategy work. But they also commented on the immense uncertainty that needs to be accommodated within future scenario planning frameworks, even on a ten-year horizon let alone a twenty- or thirty-year timeline. Transmission companies are becoming more and more sophisticated in the use of techniques such as uncertainty analysis and visualisation platforms, as well as developing transparent and collaborative datasets.



Access scenarios from organisations interviewed:

- [Transpower, Te Mauri Hiko – Energy Futures](#)
- [Tennet, Infrastructure Outlook 2050](#)
- [ENTSO-E Scenarios](#)



SHAPE THE ECOSYSTEM

Grids are changing in different, perhaps fundamental ways, becoming more dynamic with a growing number of participants and stakeholders. The interviews which inform this brief have highlighted the opportunity for transmission companies to define themselves as drivers of the energy transition by moving beyond being physical infrastructure providers to being one of the shapers of a community of energy system actors.

Shaping the ecosystem can happen at different levels:

- Working with regulators to develop the rules for a system aimed at making the most out of emerging flexibility options, whether they are behind or in front of the meter
- Collaborating with DSOs to improve forecasting capabilities and understand the impact smart grids, demand response programmes, etc. may have on the system
- Encourage R&D as well as open innovation to test and adopt new technologies
- Working with other transmission companies on integration and interconnection

The growth of DERs, for example, has necessitated interconnection rules, communications technologies and standards, advanced distribution systems implemented by DSOs and reliability technologies, integration with grid planning, and enabling policy and regulation. Transmission companies are at the forefront of the dialogue needed for these developments. And again, like the physical move from top-down centralised grids to integrated and interactive infrastructure, the dialogue needs to move from being centralised to being collaborative and inclusive. Such initiatives are important. With technology cycles shrinking and the pace of technology change greater than ever, transmission companies are part of a fast-evolving, more dynamic and flexible operating environment. In sum, as ecosystem shapers, transmission companies can spur innovation, new ways of working together, and encourage and stimulate new solutions.

A key challenge is how this new ecosystem can spur and incentivise innovation and ensure timely evolution of regulation to enable this. Some of the transmission companies we interviewed spoke of the need to move forward and act while regulation catches up. Decreased time-to-market of new regulation and policies will be needed to react to the ever-changing market environment, and transmission companies will have an important role in ensuring that regulation can facilitate and not put a brake on innovation.





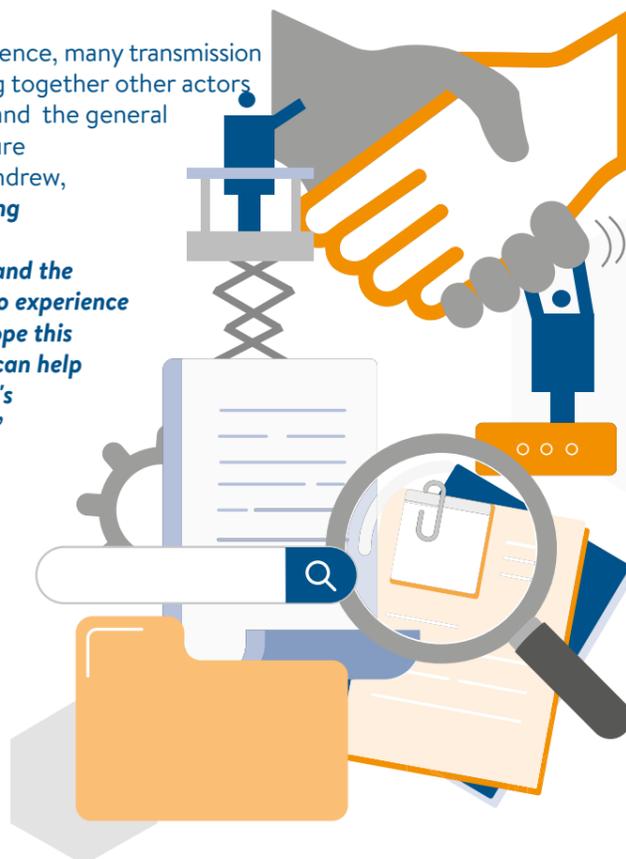
SAFEGUARD THE LICENCE TO OPERATE

The interface between transmission companies and the general public is likely to become more important than ever in the energy transition. Transmission companies find themselves increasingly needing to have a social conversation, not just with stakeholders but also the wider public, on the choices that lie before them. Maintaining and building their social licence to operate with their community is important. Cost benefit analyses to show the extent to which a project is worthwhile from a social perspective will be increasingly necessary and, as more consumers become prosumers, dialogue about their relationship with the grid will assume greater prominence.

In recent years, grid expansion and new power lines have sparked public protests. In Germany, for example, major projects to connect offshore wind generation in the North Sea with the major consumption areas further south have encountered considerable public opposition. Such protests are not confined to western economies. In Afghanistan, for example, thousands of demonstrators from Afghanistan's Hazara minority marched through Kabul in 2016 demanding changes to the route of a transmission line bringing electricity from Turkmenistan⁶.

Aware of the importance of their social licence, many transmission companies told us about initiatives to bring together other actors in the energy system, wider stakeholders and the general public to determine a shared vision of future energy systems. In New Zealand, Alison Andrew, CEO of Transpower, told us: ***“We are sharing information in an attempt to help industry, government, and consumers better understand the challenges and opportunities we are likely to experience in the years and decades ahead. It is our hope this information can spark a conversation that can help enable the decarbonisation of New Zealand’s economy in the most efficient way possible.”***

As transmission becomes more visible, both literally and financially, there is an increasing need to work with different actors of society to demonstrate the social benefits of transmission infrastructure. To drive the transition, transmission companies will increasingly need to be transparent and accountable on their impacts and benefits.



⁶ <https://www.reuters.com/article/us-afghanistan-protests/thousands-of-afghan-hazaras-join-power-line-protest-in-kabul-idUSKCN0Y70BW>



TRANSFORM THE ORGANISATION

The many challenges of energy transition are shifting the skillset and mindset the transmission companies need inside their organisations. The importance of their social licence, for example, will heighten the need for skillsets that can engage with wider audiences outside of their immediate industry community. As energy networks expand to become a wider, more integrated energy ecosystems, there will be stronger emphasis on softer, collaborative aptitudes.

The move to softer skills will also be reflected in a changing balance of technical skills. Software will be as important as hardware with innovative software and data capabilities playing a role alongside engineering and logistics capabilities. Many of the transmission companies leaders we interviewed spoke of the difficulties of attracting that kind of talent, but many also saw energy transition as an opportunity to reposition how their organisations are seen by young job hunters.

Bill Magness, President and Chief Executive Officer of Texas-based ERCOT, told us: ***“We’re finding for the first time in our memory that we’re kind of a cool place to be. We’re attracting some fantastic people because they are interested in the integration of renewable and other new resources, and working to take advantage of data analytics.*** Andres Kuhlmann, CEO of Transelec, says: ***“We are telling people you are not going to belong to an organisation that is full of people like you. But you are going to have the power to change things. And that is attractive to people.”***



NEXT STEPS

As noted at earlier in this brief, the insights gathered here are meant to start dialogues across regions, countries and segments of the energy system.

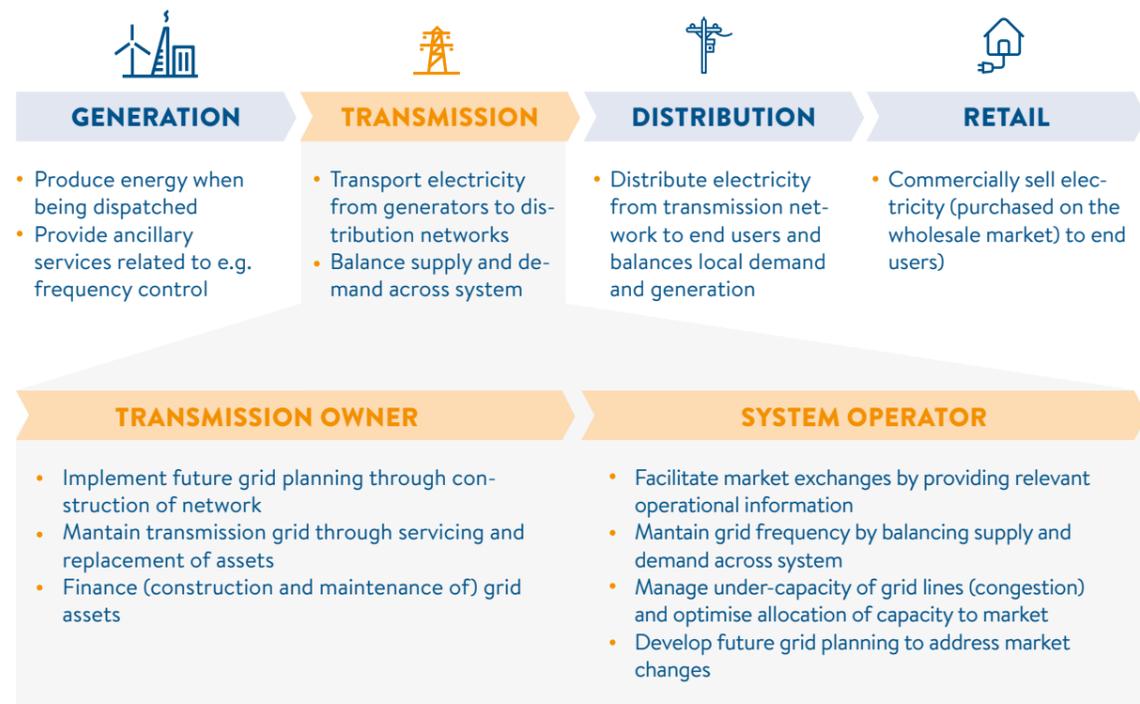
This brief is the stepping stone in developing an international community of impact which will focus on developing and implementing the set of recommendations outlined earlier in this brief. This community is to include all actors relevant to the future of the grid.

If you would like to get involved, please contact insights@worldenergy.org.

ANNEX 1:

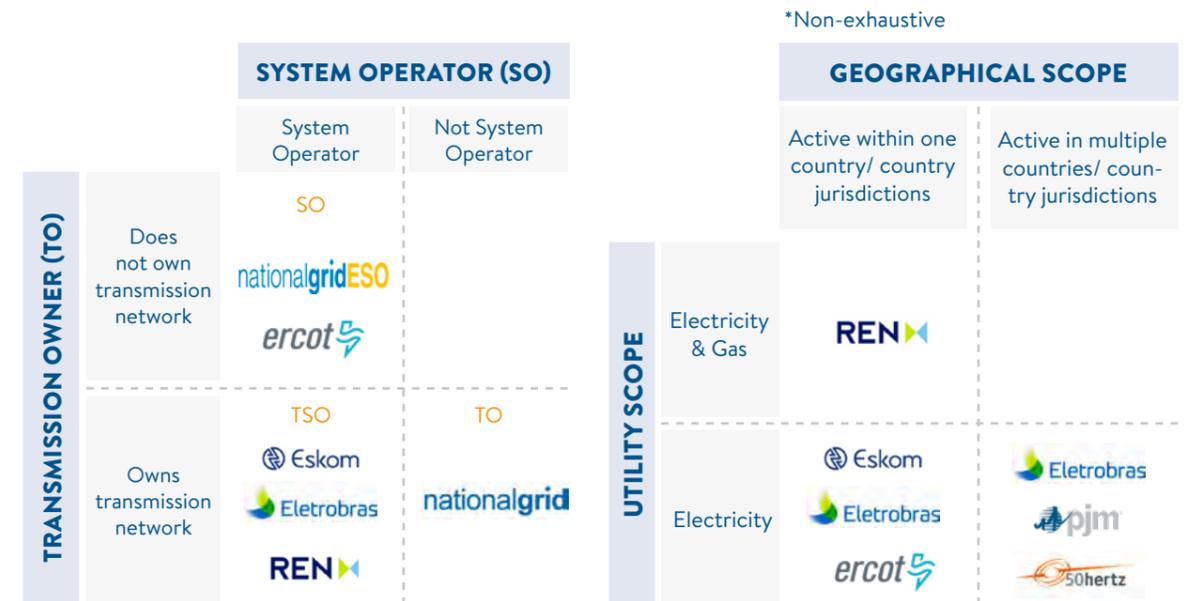
WHAT YOU NEED TO KNOW ABOUT ELECTRICITY TRANSMISSION

1. A transmission system operator typically owns and operates the infrastructure necessary to transport electricity from the generators to the distribution networks

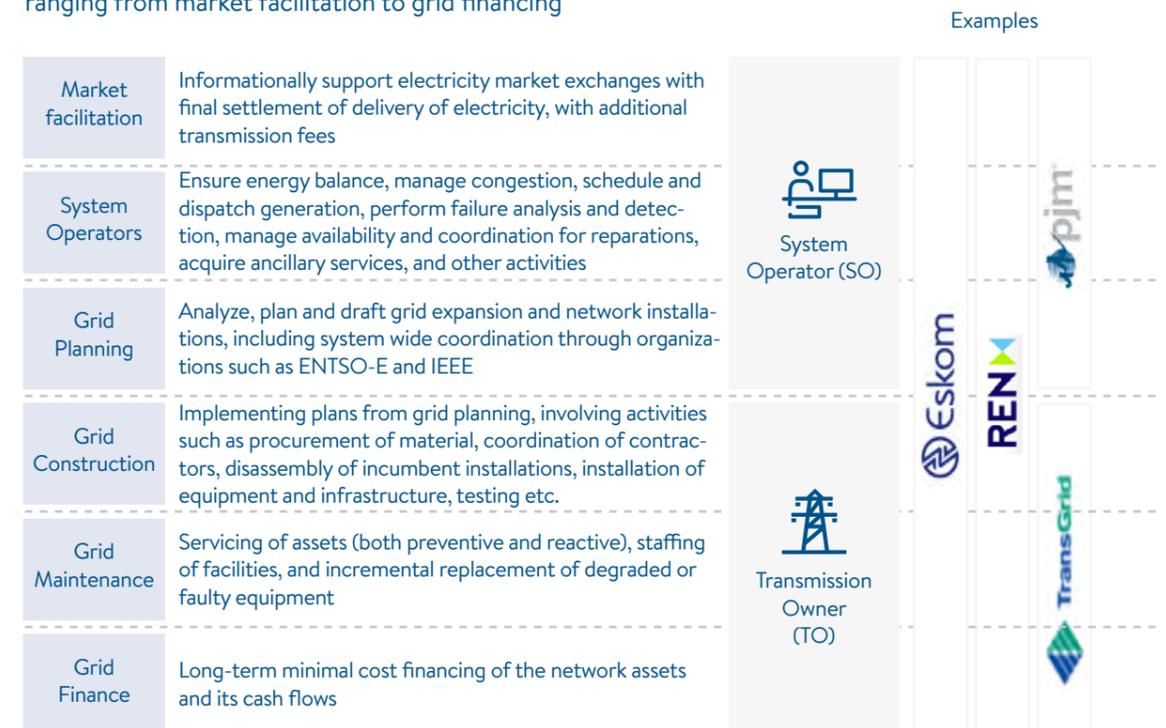


Source: PwC's Strategy& (2020)

2. Across the globe, many different organizational models exist – single utility, single jurisdiction, with a form of State involvement is most common transmission companies set-up



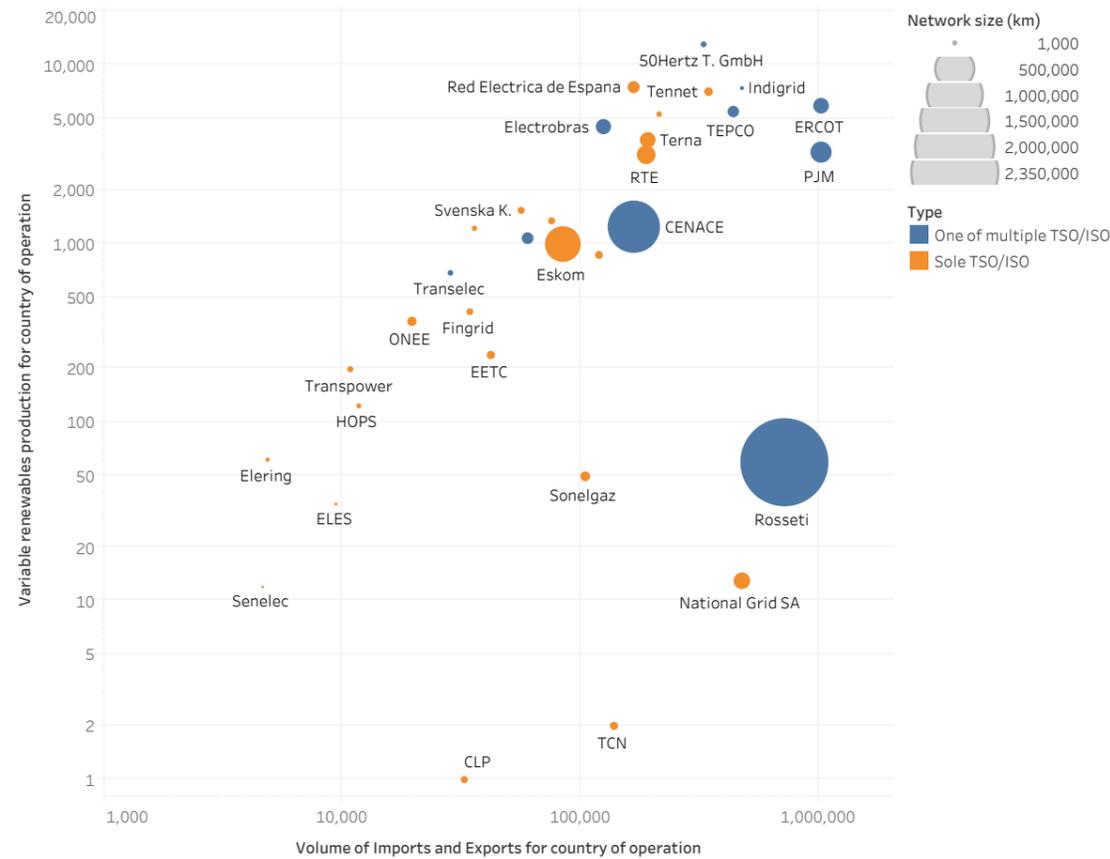
3. The activity spectrum of transmission companies around the world differs, with responsibilities ranging from market facilitation to grid financing



Source: PwC's Strategy& (2020) and World Energy Council

ANNEX 2: DIFFERENT PROFILES OF ORGANISATIONS INTERVIEWED

Organisations interviewed: How much renewables are they dealing with and how interconnected are they?



X axis: Volume of Imports and Exports combined (log scale).
Y axis: Variable renewables: Solar, Wind, Tidal combined (log scale).
Year:2017 | Unit: ktoe | Source IEA / Companies website

Each axis shows values for country of operation, if a company operates in more countries, an average is shown. Size shows the network size in kilometers.

ANNEX 3: DEEP DIVE THROUGH A COVID-19 LENS

The interviews which inform this brief were conducted before lockdowns or restrictions were implemented due to the COVID-19 pandemic. In order to understand how the crisis was affecting transmission companies, we conducted two webinars, on the 2nd of April and 22nd of April 2020 as well as a short survey with interviewees in late March. In addition, taking a broader approach, the World Energy Council has been working on a set of global surveys aimed at informing post-crisis scenarios. The findings of these different exercises and their implications are detailed here. Please note that as this is a fast-moving situation some more up to date insights may be available on [our website](#).

INSIGHT #1:

The sharp decline in electricity demand due to the closure of many businesses and industrial sites is affecting many transmission companies. To try to control high-frequency problems due to potential oversupply, system operators are using various techniques, such as paying certain power plants to switch off or by exporting power. In addition, in the UK as in other European countries, record-breaking weather patterns⁷ ideal for renewable energy generation such as solar and wind led renewables consistently supplying the vast majority of demand. In the UK, when renewable generation surges above 50 per cent, National Grid ESO has to intervene by paying wind farms to switch off or exporting more power abroad to ensure gas plants and other technologies needed to keep the system stable can continue to generate.⁸

Implication for transmission companies: On the one hand, the COVID-19 pandemic is highlighting the importance of visibility and understanding of what is happening on the demand side. This means greater cooperation with DSOs. On the other hand, record breaking amounts of renewables on the system such as in the UK emphasises the need to prepare for a situation they will face more often in the future as the share of renewables grows.

INSIGHT #2:

Overall, transmission companies indicated⁹ that challenges related to social distancing requirements and working from home were manageable. Webinar panellists mentioned that this was due to prior and on-going investments in digitalising their businesses' operations, reactive and adaptable leadership and staff driven by the duty to "keep the lights on". Both webinars as well as the Council's survey highlighted that digitalisation spillover effects and resilience capabilities are emerging with potential long-term implications for energy organisations. Nevertheless, almost all respondents noted that their supply chains were being disrupted and that travel restrictions were causing disruptions to field projects.

Implication for transmission companies: For many transmission companies as well as for energy companies in general, the pandemic has accelerated digital transformation. This was motivated by the requirement to enable staff to work from home. This is not only an opportunity for organisations to

⁷ In late April and May

⁸ <https://www.ft.com/content/54cc33d2-82ab-43c7-8ff8-235278d3858a>

⁹ In the transmission specific survey and webinars

become more digital but also to consider their organisation’s culture. This is also an opportunity to look back, establish lessons learned, asses how others responded and build resilience for the future.

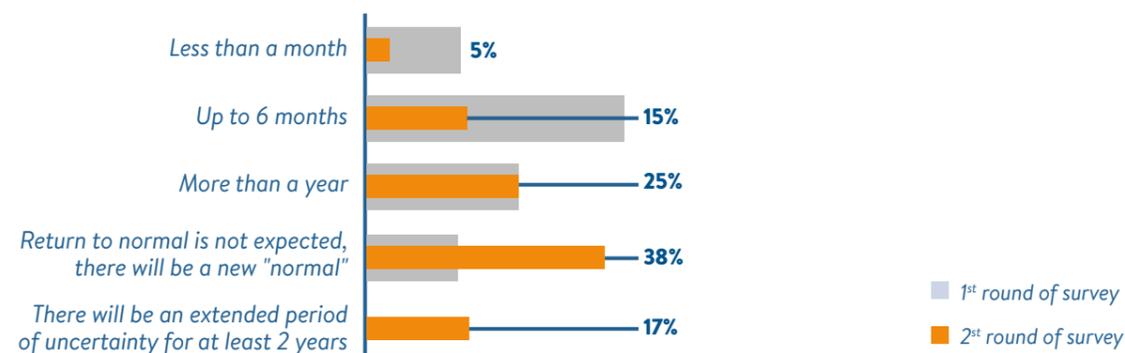
According to the wider Council survey, at least 85% of organisations are expecting to reallocate their investments in response to COVID, with main focus on digitalisation and transformational new businesses.

How is your organisation **reallocating investment** to prioritise key functions in the business?



INSIGHT #3:

According to the wider Council survey, as the COVID situation unfolds, from April to May, twice as many respondents expect a ‘new normal’ for energy systems – 15% vs 38%.

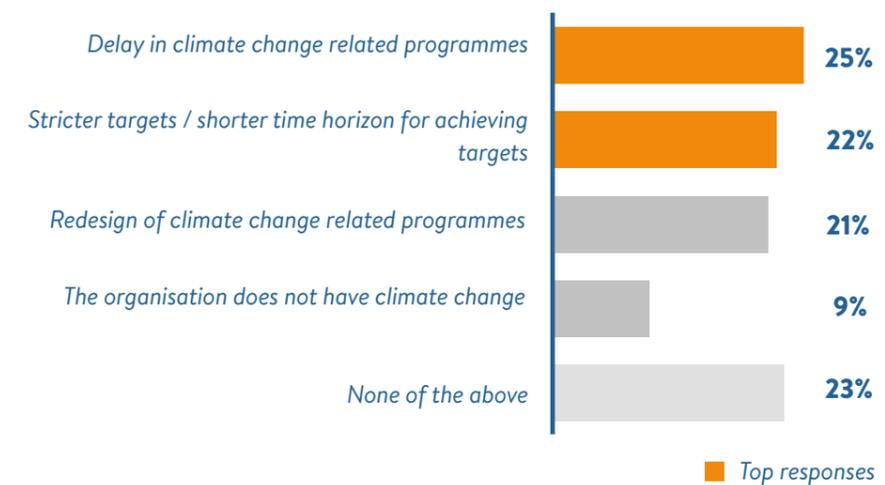


Implication for transmission companies: This chart shows how quickly the situation and people’s views are evolving. What a “new normal” means is still unclear but using scenarios, transmission companies can start thinking about what may change and how it may affect them. For example, will governments emphasise a green recovery? Will the energy transition accelerate or decelerate? Will there be a second wave in a few months’ time?

INSIGHT #4:

The transmission specific survey asked interviewees about the long-term effects of the pandemic on their strategies. Over ¾ of respondents considered that the crisis will delay their strategies to enable the energy transition. The wider Council survey found that there are split views on the outlook for decarbonisation of energy systems – some respondents anticipate potential delay as governments respond to pressures to restart growth by rolling back action on climate goals. Others anticipate, however, that crisis will accelerate decarbonisation as governments increase direct investment to energy systems. Same diverge perspectives on mass transit and migration.

What are the new **global energy system shocks** your organisation and sector are least prepared for?



Implication for transmission companies: Implication for transmission companies: Responses suggest that the impacts of and responses to the COVID-19 crisis might be a game changer in energy transition – emphasising the need for resilience, re-localisation and dealing with the social issues of energy transition. It is therefore key for transmission companies to ensure to safeguard their licence to operate while also shaping the ecosystem, working with all actors to build the energy system of tomorrow.

For any questions related to the Council’s COVID-19 work, please contact us at insights@worldenergy.org

PROJECT MANAGEMENT

Dr. Angela Wilkinson (Secretary General & CEO), Dr. Paul Nillesen (Partner, PwC Strategy & Netherlands), Martin Young (Senior Director, Insights), Gina Domanig (Innovation Executive Co-chair), Richard Lancaster (Innovation Executive Co-chair); Jeroen van Hoof (Global Power & Utilities Leader, Partner, PwC Netherlands)

PROJECT TEAM

Pauline Blanc, David Deboudt, Maelle Gomez, Katharina Poirier, Thibault Reynier, Neon Steinecke, Marzia Zafar

WORLD ENERGY COUNCIL STUDIES COMMITTEE

Leonhard Birnbaum, Chair (Germany); Martin Young, Secretary (UK); Andrea Heins (Argentina); Herwig Klima (Austria); William D'haeseleer (Belgium); Claudio Huepe Minoletti (Chile); Miguel Pérez de Arce Jeria (Chile); Kang Yanbing (China); Edouard Sauvage (France); Francois Dassa (France); Burkhard von Kietz (Germany); Hans-Wilhelm Schiffer (Germany); Jeanne Ng (Hong Kong); Atul Sobti (India); Nalin Shinghal (India); Mehdi Sadeghi (Iran); Nastaran Rahimi (Iran); Andrea Maria Quaggia (Italy); Berardo Guzzi (Italy); Yuji Matsuo (Japan); Joseph Al Assad (Lebanon); Tina Schirr (New Zealand); Mamadou Diarra (Niger); Lawrence Ezemonye (Nigeria); Krystian Kowalewski (Poland); Stefan Gheorghe (Romania); Andrey Logatkin (Russia); Dave Wright (South Africa); Klaus Hammes (Sweden); Tom Kober (Switzerland); Barış Sanlı (Turkey); Fatima AlFoora AlShamsi (UAE); Alejandro Perroni (Uruguay); Jeff Spivak (USA)

WORKING GROUP MEMBERS

Olga Bogdanova (Latvia); Pedro Ernesto Ferreira (Portugal); Randolph Brazier (United Kingdom); Leo Jansons (Latvia); Andrea Bonzanni (United Kingdom); Jose Maria Valenzuela (Mexico)

We would also like to thank Anastasia Belostotskaya, Dominic Byrne, Chris Gentle, Natalie Vinters, Dajana Czaja and Lucila Galtieri for their precious help.

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62–64 Cornhill
 London EC3V 3NH
 United Kingdom
 T (+44) 20 7734 5996
 F (+44) 20 7734 5926
 E info@worldenergy.org

www.worldenergy.org | [@WECouncil](https://twitter.com/WECouncil)