WORLD ECONOMIC FORUM

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Industry Agenda

The Future of Electricity
Attracting investment to build tomorrow's electricity sector

In collaboration with Bain & Company

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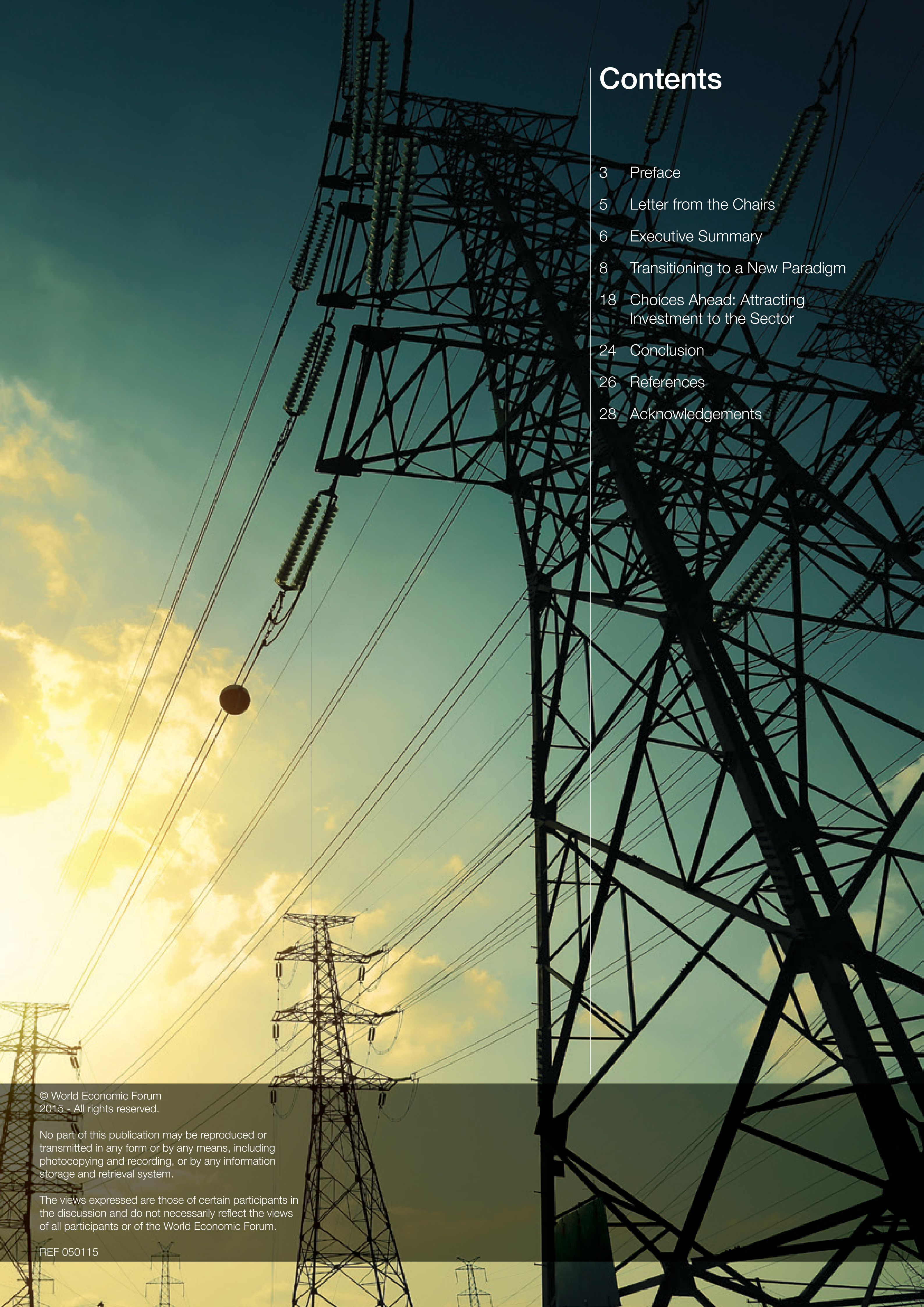

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Jim Hagemann Snabe,
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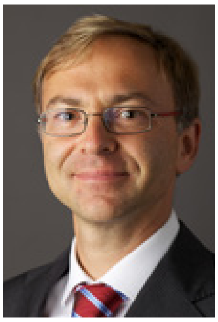

Roberto Bocca,
Senior Director,
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The World Economic Forum is pleased to present the Future of Electricity report – a set of recommendations for policy-makers, regulators and businesses to attract investment to the electricity sector in OECD markets.

The electricity landscape is undergoing a significant transformation, becoming more complex than ever before. The transition towards a lower-carbon electricity system initiated by OECD countries is proving to be a challenging exercise, balancing trade-offs between environmental sustainability, energy security and economic competitiveness.

The World Economic Forum has established the Future of Electricity platform to help countries, companies and societies learn and reflect as they undergo this transformation: a space for fact-based, yet informal dialogue on the transition to a new electricity landscape among the key stakeholders involved.

The initiative was launched at the World Economic Forum Annual Meeting 2014 in Davos-Klosters, Switzerland; subsequent discussions involved stakeholders from industry – incumbent utilities, renewable developers, supply and demand equipment manufacturers – and beyond, including policy-makers, regulators, academics and investors. The spirit of multistakeholder collaboration is underscored throughout this report, seeking to develop a holistic understanding of the electricity landscape with recommendations focused on achieving the most efficient transition to a lower-carbon electricity system.

The report comprises two key chapters, and proposes the dimensions of policy, market design and business models as key investment enablers in the electricity sector. The first, "Transition to a new paradigm" offers a rich description of the context in which we operate and the key issues before the landscape, while the second, "Choices ahead: attracting investment to the sector", offers specific recommendations for policy-makers, regulators and businesses alike.

This report is part of the Forum's work to understand and shape industry transformation across all sectors through Global Challenge initiatives. This initiative is conducted under auspices of the World Economic Forum Energy Utilities and Energy Technologies communities, in collaboration with Bain & Company. We would like to thank the Steering Committee for its direction and leadership, the Working Group, for its support of the dialogue and research behind this report, and the external contributors.

Letter from the Chairs

Ignacio Galán, Chairman and Chief Executive Officer, Iberdrola, Spain

Steve Bolze, President and Chief Executive Officer, GE Power & Water, USA

The electricity industry is transforming, with a number of structural and disruptive changes challenging the traditional utility model. A mix of technological, economic, regulatory, environmental and societal factors is resulting in a lower carbon, digitized electricity system with new players emerging. This new landscape will be more complex and interrelated than ever before.

At the same time, the International Energy Agency (IEA) estimates that an investment of $7.6 trillion through 2040 will be required from countries in the Organization for Economic Cooperation and Development (OECD). In a sector accustomed to long-term investment cycles and stable policy frameworks, this transformation introduces policy uncertainties and market design complexities.

During the World Economic Forum Annual Meeting 2014 in Davos, chief executives from leading utilities and energy technology companies discussed the challenges ahead for the transformation, and identified the risk that some parts of the industry value chain may not attract the necessary investment. CEOs recognized that the changes needed to deliver affordable, reliable, accessible and sustainable power to the world will require better coordination of political, regulatory and technological developments.

In this context, the Forum's Energy Utilities & Energy Technologies communities launched the Future of Electricity initiative, which aims to engage relevant stakeholders in defining options for making the electricity sector more sustainable for society.

This report summarizes the deliberations and findings of those communities on increasing the viability of investments in mature markets, with existing power infrastructure and flattening of declining demand. We hope it will help guide further discussion and decisions on these critical issues.

Executive Summary

The electricity sector is undergoing an unprecedented transition. In the past, the sector provided affordable, secure and reliable electricity by attracting investors with low risk, stable returns. In the last decade, significant declines in the cost of renewable technologies, combined with new sources of natural gas, have offered the opportunity to simultaneously decarbonize the sector while also increasing energy security and reducing dependence on imported fuels.

OECD countries have invested heavily to achieve this, spending $3 trillion on new renewable and conventional power plants, transmission and distribution (T&D) infrastructure, and energy efficiency measures. This investment has helped reduce carbon intensity per unit generated by about 1% per annum and increase energy security by reducing imports of fuels by about 4%.

Yet more has to be done, especially as the industry is less than 30% through the process, with a further $8 trillion needed from now until 2040 to meet policy objectives.

The experience of the EU – an early mover – raises concerns over the ability to attract this additional investment. As renewable capacity has been deployed in the EU, returns on capital have fallen across the board and risks for investors and technology providers have risen due to policy instability. This crisis of "investability" has highlighted lessons for policy-makers, regulators, business and investors, whether in the developed or developing markets.

To attract the necessary investment, all key stakeholders need to take action.

Policy-makers need to create policy frameworks that are efficient, stable and flexible, recognizing the inherently uncertain technological and economic environment we live in.

– **Plot the most efficient pathways to policy objectives**. Incentivize "no regrets" investments such as energy efficiency technologies, demand response services, and the upgrading of network and generation plant efficiencies. Exploit the most efficient renewable resources within and across borders.

– **Stabilize policy by building in flexibility and working to increase societal support.** Recognize inherent uncertainties by investing incrementally. Communicate the value to society of the investments. Reduce investor risk by prohibiting retroactive policy changes.

Regulators need to provide clear direction to markets, while minimizing interventions.

– **Ensure clear, effective signals:** Provide a clear, stable market signal on carbon pricing to incentivize decarbonization. Reward efficiency, reliability and flexibility, encouraging predictable, dispatchable, fast-responding supply to complement growth in demand response solutions in balancing increasingly volatile supply and demand. Recognize in network tariffs and regulatory frameworks the value of reliable grid capacity.

– **Create "level playing fields" across geographies, businesses and technologies:** Harmonize incentives, encourage appropriate physical interconnection and remove unnecessary regulatory barriers to competition between incumbent utilities and new entrants.

Business and investors need to drive innovation in business and investor models to secure the necessary investment.

– For businesses, continue to engage with policy-makers and regulators to identify the most efficient pathways. Evolve strategies and business models that exploit the opportunities in the evolution of centralized generation while also supporting the rise of customer-centric offerings and propositions.

– For investors, engage with policy-makers and regulators on how best to balance risk and return to attract the required investment. Continue to innovate in investment structures to finance the evolving risk profile in different parts of the electricity value chain.

While there are many ongoing debates in global energy policy and regulation, these areas of general consensus offer a clear path forward for the transition in OECD markets, a journey that will be watched carefully by developing nations.

Finally, as no single cross-stakeholder body exists, developing a joint, cross-geography, multistakeholder task force is recommended to increase communication and share lessons and best practices across borders and throughout the industry. This would help address the currently "atomized" nature of supervisory and regulatory decision-making bodies. Only by ensuring the viability of investment can policy-makers successfully transition to a more sustainable and efficient energy future.

Transitioning to a New Paradigm

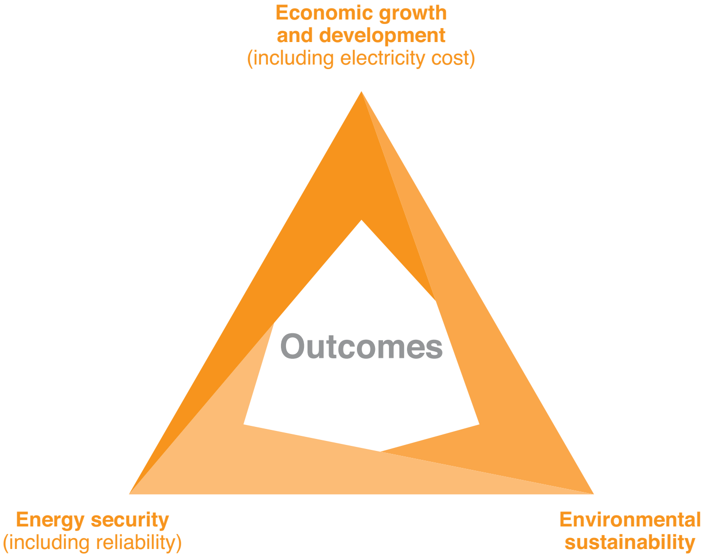
Success in the electricity sector has long been defined by ensuring a secure and reliable supply of electricity at a low cost, enabled by investment attracted to low risk, stable returns. But in the last decade, the global consensus on the importance of reducing human-made carbon emissions has highlighted the need to also decarbonize the electricity sector, the second largest contributor to carbon emissions after transportation.

Energy policy today must balance affordability, security of supply and environmental sustainability.

Technology is playing a critical role in the sector's efforts to become more environmentally sustainable, providing new methods for generating power from renewable sources and new ways to use energy more efficiently. Renewable sources offer the potential to reduce emissions and, for some countries, improve security of supply by reducing dependence on imported fuel.

However, these new technologies also bring new challenges. In the early stages, they cost more than the fossil fuels that they replace and require back-up, but costs decline as the technologies are deployed at scale and manufacturers gain experience. Just as significantly, the broad roll-out of renewables, with their mostly upfront capital costs and low operating costs, is changing the way that wholesale electricity markets operate. In particular, this process creates challenges in drawing investment into the conventional thermal generation sector, which for the foreseeable future will be required to provide back-up for intermittent generation sources.

Figure 1: Energy policy objectives, as applied to electricity



Investments have led to declining carbon intensity

Investment in power generation has grown sharply over the past decade in markets across the OECD, rising from $60 billion in 2000 to $220 billion in 2012 – an annual growth rate of 11% in real terms.

Most of the investment in generation (54%) has been in non-hydro renewables – wind, solar, biomass and geothermal – although it still accounts for only a small percentage (7-8%) of OECD energy generation.

Eight out of the nine countries leading the transformation are in Europe – with more than 10% of their power capacity coming from non-hydro renewables. Even nuclear-dominated France has plans to significantly increase renewable generation over the next 15 years. In the US, the pace of change is also accelerating – 37 states have policies to encourage utilities to generate part of their capacity from renewables and 14 states already generate more than 10% of their power from non-hydro renewables.

Alongside the transformation in central power sources, there has also been significant investment in decentralized generation, such as solar photo voltaic (PV) and biomass combined heat and power (CHP). These sources have taken off rapidly, particularly in some areas – for example, providing about 40% of capacity in Germany.

The final set of investments has been in energy efficiency where OECD nations are becoming steadily less energy intensive, with a decline of almost 40% in energy use per unit of GDP between 1980 and 2010.

All these investments have made a major contribution to a decline in carbon intensity of about 1% a year across OECD markets, and more in those countries that have installed a significant amount of non-hydro renewables. They have also contributed to increased security of supply by reducing the imports of fossil fuels and exposure to volatile prices and geopolitical access risks. Imports of fossil fuels to OECD have declined by about 4% over the last 7 years.

Germany is a notable exception. Despite its very significant investment in renewables, its emissions have increased since 2011 due to a switch in thermal power generation from gas to low-cost coal and the phasing out of nuclear power in the wake of Fukushima. This is in stark contrast to the US where abundant shale gas has caused the opposite shift – from coal to gas generation – contributing significantly to reduced carbon emissions.

Electricity prices are rising

This scale of investment has a cost for society. The inflation adjusted price of electricity across OECD markets increased at 2.8% for households and 5.3% for industrial users between 2006 and 2013. Germany and Spain have seen the steepest rises: more than 8% annually since 2006 for households and industry. Between now and 2040, wholesale electricity rates are expected to continue to rise by 57% in the EU and 50% in the US, due to higher operations and maintenance and investments costs. Retail prices are also expected to rise in real terms by 15% and 9% in the EU and US, respectively, for industrial use.

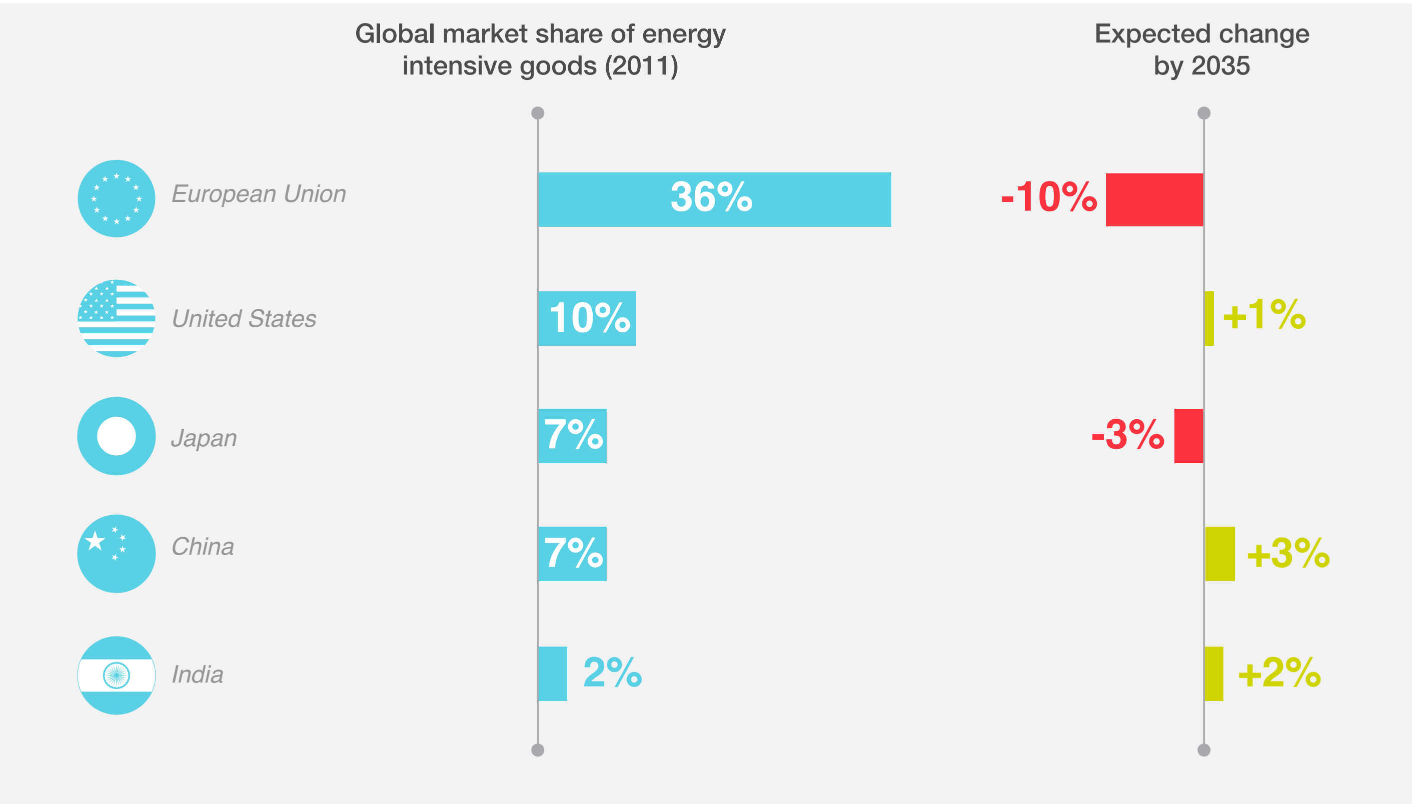
Residential electricity prices are expected to increase by 12% in real terms in the US. In the EU, prices are expected to continue to increase until 2020 and then drop to levels similar to today's prices by 2040.

Subsidies for renewables have increased by about 20% per annum for the last 6 years in the EU, and are expected to rise about another 20% over the next 6 years. Many factors have contributed to the increase of electricity prices, including renewables' support, network costs, taxes (VAT, industrial and excise taxes) and other levies (policy support for nuclear decommissioning, energy efficiency or CHP).

In addition to underlying costs rising, governments in many markets still use the regulated electricity price to raise tax revenues for activities outside of the sector such as social costs or debt repayment. These trends exacerbate already significant differences in industrial power prices across developed countries, with implications for global economic competitiveness.

Industrial power prices in Europe, for example, are about twice those in the US. More importantly, the differential in gas prices between Europe and USA increased to 65% in 2013. This difference in energy prices (partly driven by low natural gas costs in US) is expected to contribute to a significant decline in the market share of energy intensive goods within high cost regions. The EU, for example, is forecast to decrease its share from 36% to 26% over the next 20 years. Globally, energy intensive goods account for 25% of industrial employment and 70% of industrial energy use.

Figure 2: Europe, with high energy prices, is forecast to lose market share in energy intensive goods

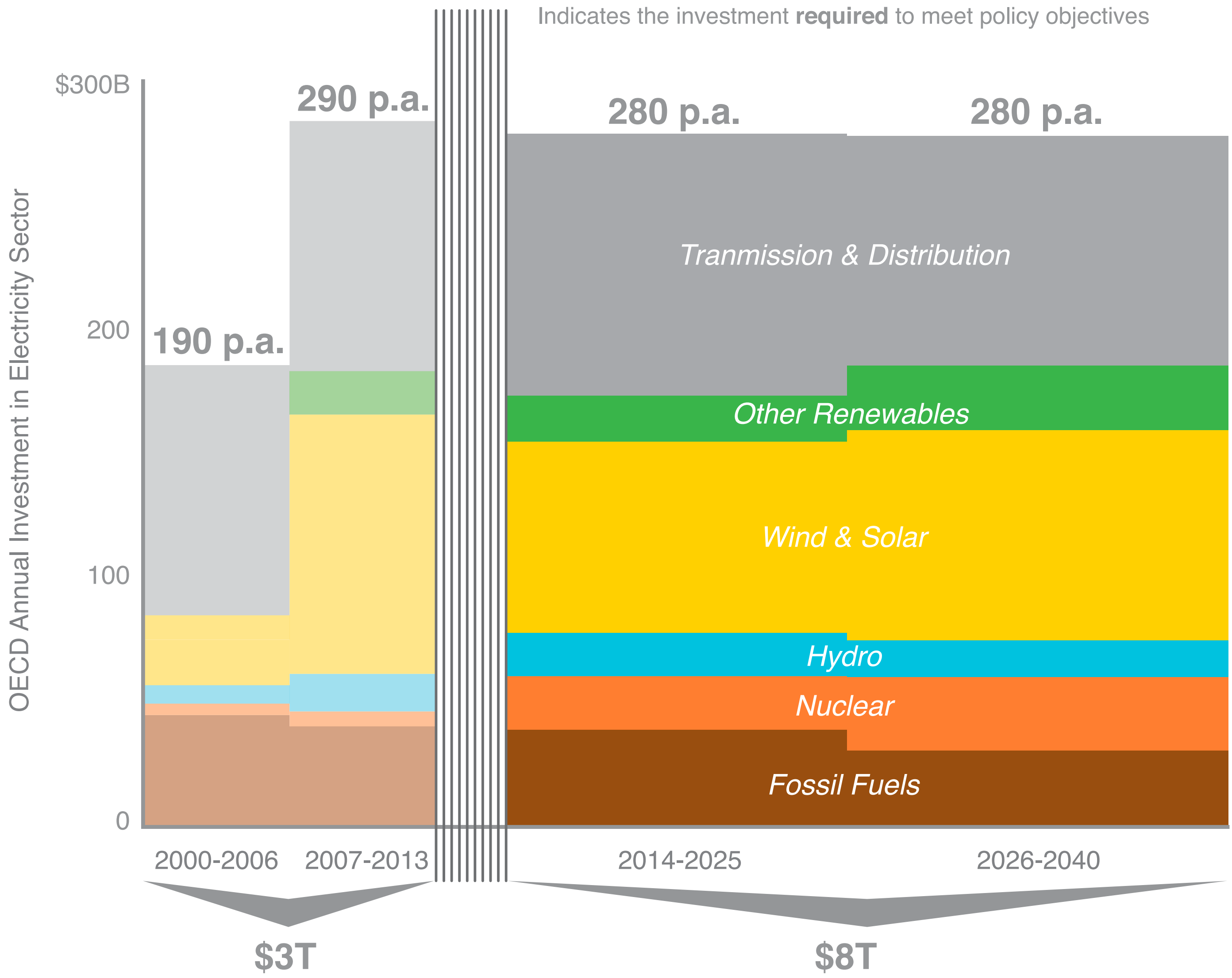


Further investment is needed

While the sector has come a long way in its transition towards a more sustainable approach for generating and delivering electricity, it still has a long way to go. Despite investing $3 trillion between 2000 and 2012, the sector is less than 30% of the way through – with a further $7.6 trillion required by 2040. The high level of investment seen over the last five years will need to continue if energy policy objectives are to be met.

Investment will be required across the board, in conventional and renewable, centralized and decentralized capacity ($180 billion annually), and the expansion and modernization of transmission and distribution grids ($100 billion per year). Smarter technologies will be required to allow customers a wider range of choices, from a more active management of demand to the greater use of distributed generation sources.

Figure 3: High levels of investment will need to be maintained to 2040



This level of investment would produce a system that generates about 24% of electricity from non-hydro renewables across OECD countries by 2040.

Although renewable generation will expand rapidly, thermal generation plants will continue to be the key source of back-up capacity for intermittent renewables during the next decade until energy storage solutions become competitive with a peaking thermal plant.

Many of the conventional thermal plants in OECD countries are old and will need to be replaced over the next decade; sooner in some countries like the UK. Over the next 11 years, the EU will need 138 GW of new thermal capacity to maintain system adequacy.

Similarly, networks will also need investment both to connect the new renewable generation and to provide reliable, flexible back-up capacity for the intermittent sources.

Most developed countries are incentivizing significant investments in networks to modernize their asset base, increase flexibility and accommodate a more complex and smarter system.

However, investment is threatened by low returns

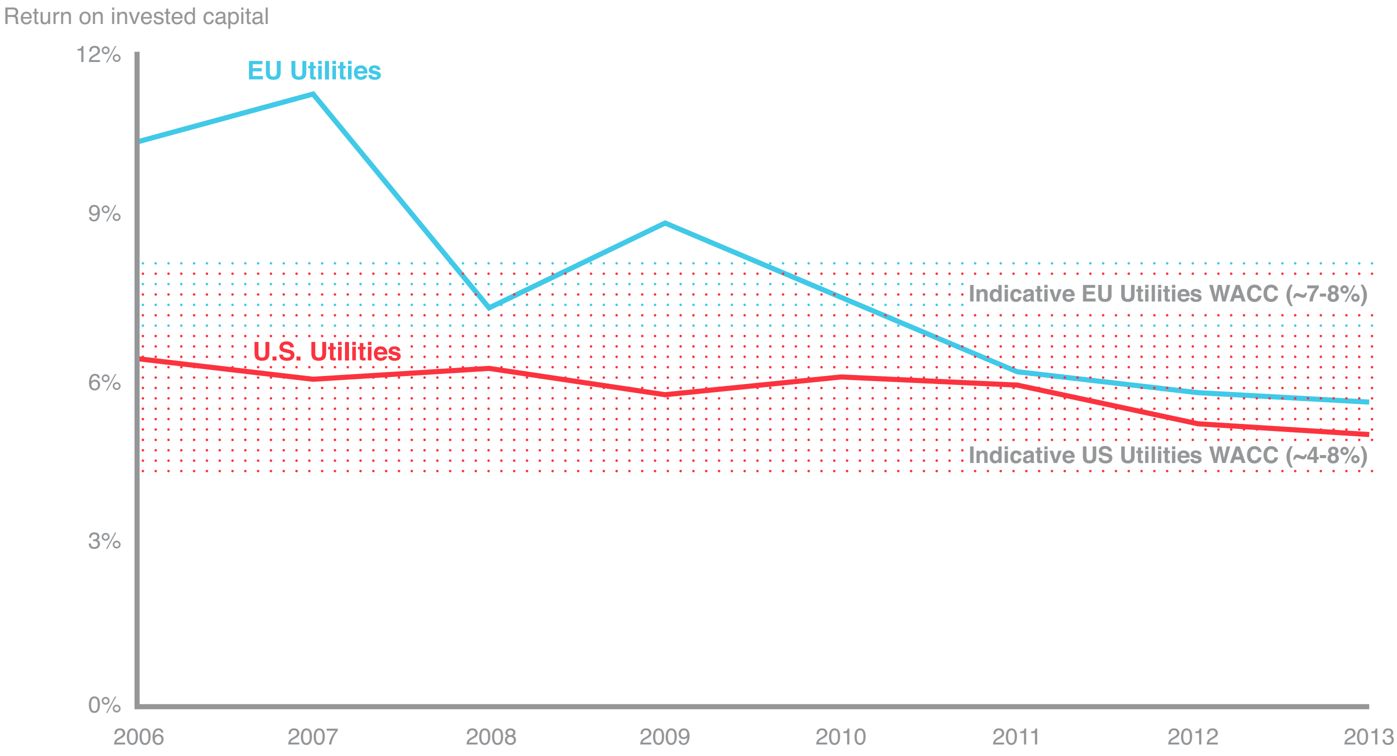
But challenges to the viability of investments in traditional and renewable power generation, as well as transmission and distribution (T&D), have begun to emerge.

Average returns on invested capital in renewable generation in Europe have declined by four percentage points from 2001 to 2013, in part because subsidies have been rolled back in many places due to pressures on public finances. Returns for some renewable players in North America have also declined, but to a lesser extent.

At the same time, returns are falling for incumbent utilities – the traditional investors in thermal and other conventional generation. In the US, returns have also fallen about 1.3 percentage points from 2006 to 2013 due to flattening demand and decreased load factors, despite improvements in dark and spark spreads and lower gas prices. In the EU, returns have fallen 4.8 percentage points from 2006 to 2013 as a result of falling demand, significant overcapacity, reduced load factors and wholesale price declines.

For example, in Europe, demand has flattened to 0% in 2007-2012, compared to a growth rate of 2.7% annually since the 1970s. In the US, demand has declined at 0.5% in 2007-2012 compared to a growth rate of 2.8% annually over the previous 30 years.

Figure 4: Returns have declined for EU and US utilities



Overcapacity, caused by a lack of coordination among energy plans designed by governments and private businesses, also contributed to declining returns of conventional generators. Over the past five years in the EU, 130 gigawatts (GW) of renewable capacity and 78 GW of conventional generation have been added to the system while only 44 GW of conventional generation has been retired.

The shift from thermal to renewable generation – combined with flattening demand and general overcapacity – has led to decreased load factors by as much as 30% in Italy and Spain since 2006. Competition for the remaining load increased, with spark spreads falling to as little as 5% of their 2009 values in Italy. In contrast, power generators in the US have preserved their profit margins as capacity has remained more balanced, with retirement of old plants more closely matching new build of renewables and dropping fuel prices.

In many European markets, returns on conventional thermal plants are no longer high enough to justify the capital expenditure to replace them.

T&D is marginally more immune to the factors that are driving down returns because networks are a longer term, regulated asset business. However, decentralized generation raises questions about the traditional economic model for T&D businesses. As customers substitute locally generated electrons for those from centralized power plants, load on the grid falls and grid operators are forced to raise prices on the remaining units to recover their fixed costs. Rising T&D charges create a greater incentive for local generation, creating a downward spiral. If investment is to be maintained, new remuneration systems will be required that better value reliable grid capacity and the evolving role of network operators.

Lessons from first movers on the root causes of investment challenges

The EU has moved towards renewables ahead of other OECD nations, offering valuable lessons in three areas: policy design, market design and business models.

Policy design. Society recognizes the need for an electricity system that produces less carbon, but has not yet fully bought into the full value of decarbonization. This creates a gap between society's desire for renewables and its willingness to pay for them. Although the falling cost of renewable technologies is helping to reduce this gap, additional efforts are required to promote the value to society from reductions in emissions. For example, a 2013 survey conducted by Swiss Re found that across 19 nations, individuals were unwilling to pay more than 2% extra on their energy bills for renewable energy on average, despite a desire for increased decarbonization. This gap leads to policy instability, which drives up those same costs by increasing investor uncertainty and cost of capital

It is important, therefore, for policy-makers to incentivize investments that help minimize or avoid unnecessary costs. The EU's experience as a "first mover" provides valuable lessons.

For example, it is obvious to most European citizens that southern Europe has the lion's share of the solar irradiation while northern Europe has the wind.

But the EU's investment in renewables does not reflect this: where Spain has about 65% more solar irradiation than Germany (1750 vs 1050 kWh/m^2), Germany installed about

600% more solar PV capacity (33 GW vs 5 GW). In contrast, whereas Spain has less wind than countries in the north, it has still installed 23 GW of wind capacity.

Such suboptimal deployment of resources is estimated to have cost the EU approximately $100 billion more than if each country in the EU had invested in the most efficient capacity given its renewable resources. And by looking across borders for the optimum deployment of renewable resources (with associated physical interconnections), the EU could have saved a further $40 billion.

Figure 5: Non-hydro renewables are an increasing component of the OECD energy mix; Europe is leading the roll-out

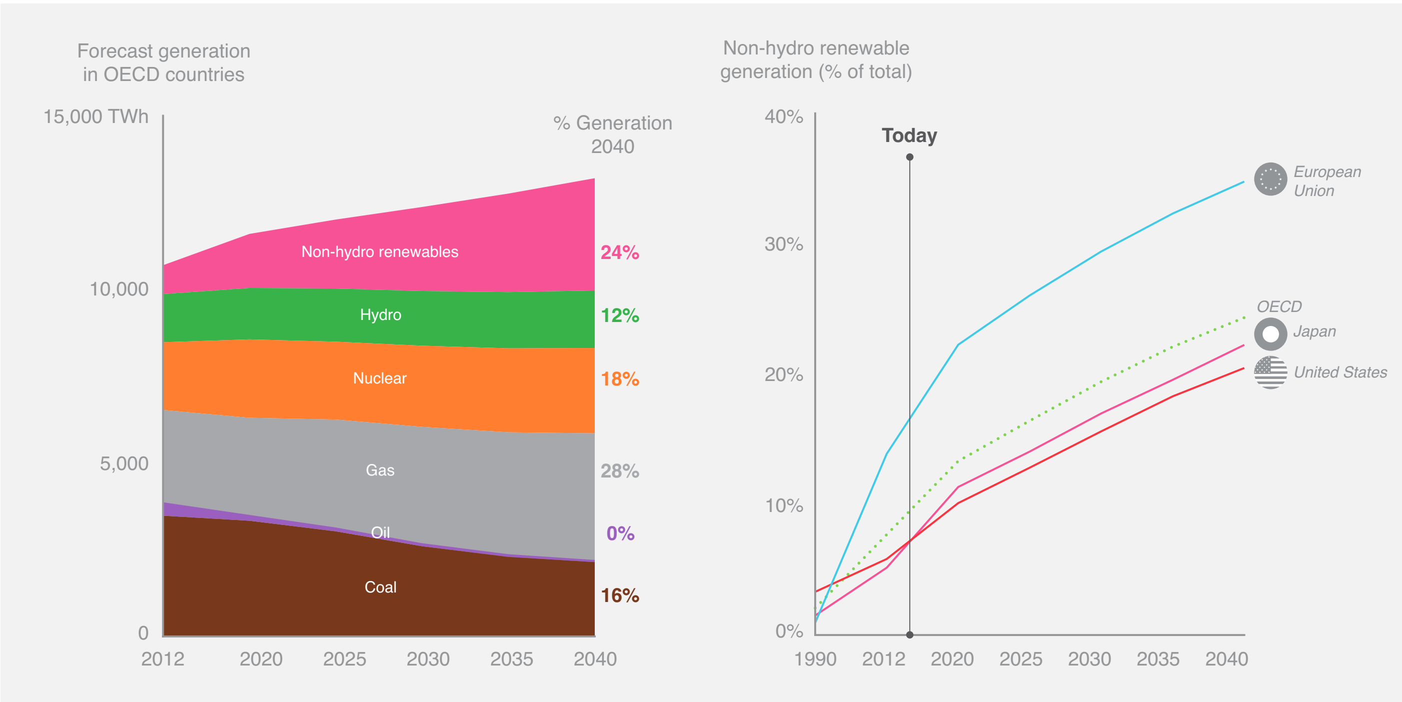
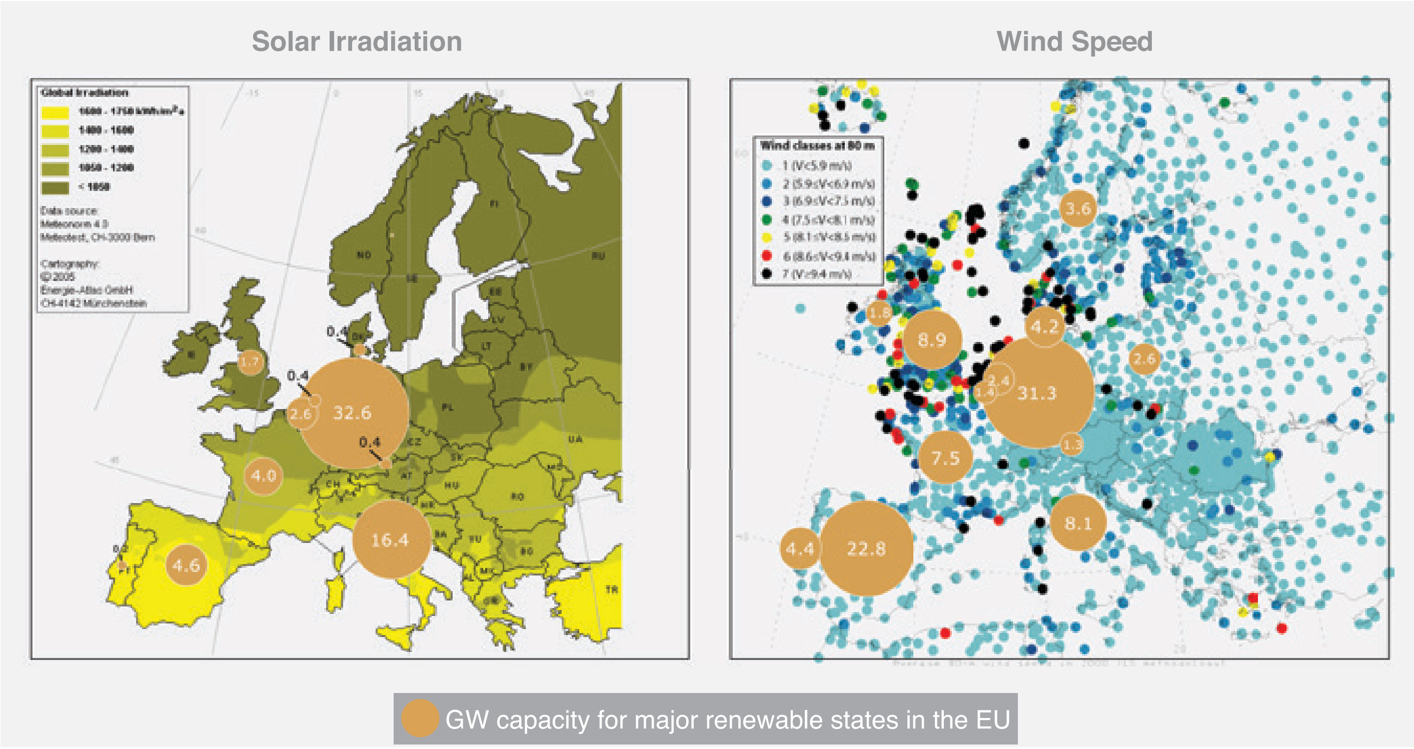


Figure 6: EU renewable capacity has not been deployed in optimal locations



Policy design issues contributed to this costly outcome, including the desire within EU states to maintain national sovereignty over energy policy, a lack of integrated planning and interconnection between EU markets, and particular market design issues such as uncapped solar incentives in Germany.

Given the misalignment between society's desire for decarbonization and its willingness to pay for the perceived benefits, policy instability has been seen across many countries, particularly in support for renewable incentives.

Renewable incentives will continue to be important over the next decade, particularly for those technologies that are still at an early stage of development and require support to deploy at scale and drive down costs with increased experience. Combined subsidies for renewables in the EU, US and Japan are forecast to rise from $99 billion per annum to a peak of $136 billion per annum by 2025.

In some countries, however, the financial crisis and other economic concerns have caused policy-makers to re-evaluate their subsidy regimes. This kind of policy instability deters investors and further raises the cost of capital of investment. In some cases, this has caused forward looking subsidy budgets to be scaled back. For example, in the US, there are uncertainties in the renewal of tax credits for renewables, and for carbon taxation in Australia.

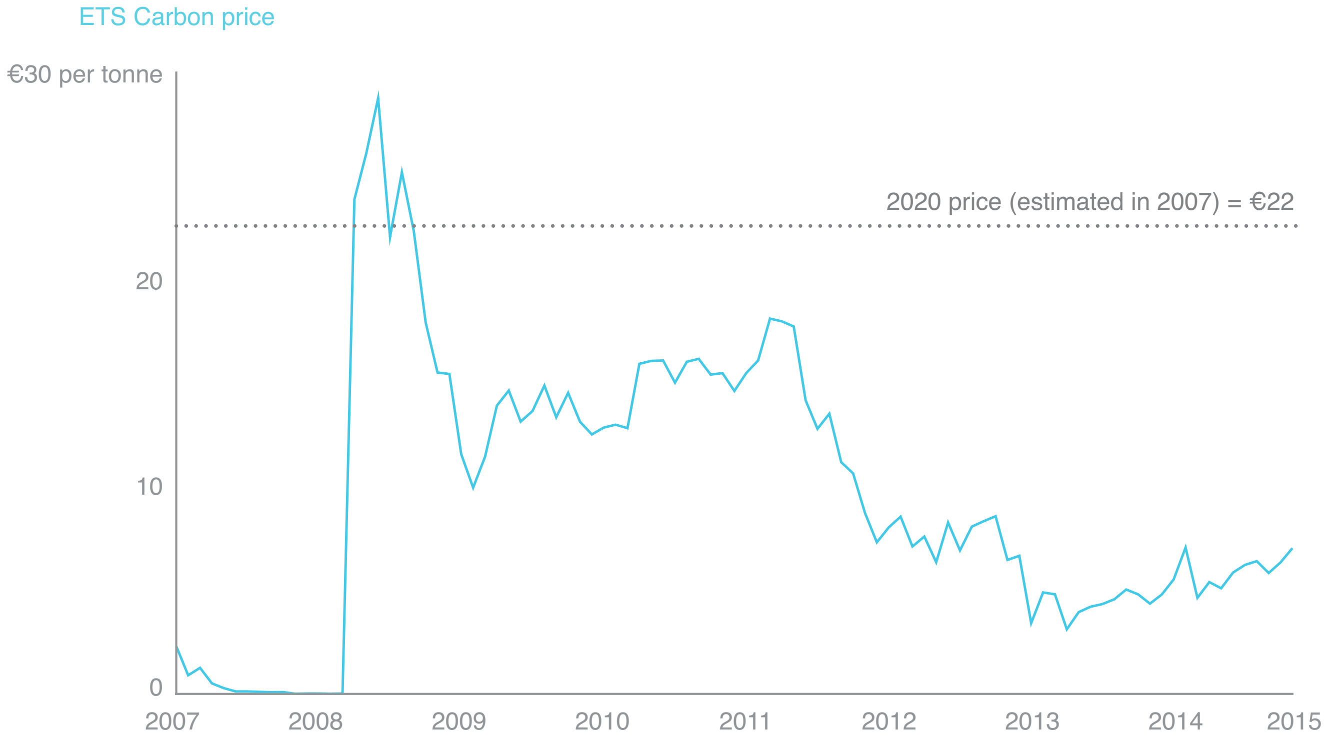
In other cases, governments have made retroactive changes to subsidy policies. For example, in 2013, Spain effectively removed subsidies on wind capacity installed before 2005 and scaled it back on wind farms installed between 2005 and in 2008. Portugal, Greece and other European countries have also made retroactive changes to renewable subsidies.

Market design. Electricity markets across developed economies have deployed nearly every flavour of market design, from the liberalized markets that prevail in the UK, Australia and New Zealand, to the more highly regulated models found on the West coast of the US and in Japan. No single type of market presents the right answer for every economy. Liberalized markets can succeed as long as policy-makers ensure very clear signals through market mechanisms to encourage industry participants to invest behind society's policy goals. In more regulated markets, policy-makers have more direct control, but efficiency depends on making the right policy and technology choices, providing stability in policy and being vigilant in agreeing investments.

Regardless of the regulatory positioning, all regulators must recognize that balancing environmental stability and affordability against security of supply requires that they ensure clear, effective signals on carbon pricing, reliability and flexibility, networks and other market mechanisms.

The experience of recent years suggests that current electricity markets suffer from a lack of effective market mechanisms, particularly in regard to carbon pricing. The existing carbon pricing mechanisms are conceptually simple, but politically and practically complicated to implement. The EU Emissions Trading System (ETS) failed to deliver a cost of carbon sufficient to drive adoption of renewables – the price of carbon falling from about €30 per tonne in 2008 to €5 per tonne in 2014, well below the 2020 target price of €25 per tonne, and a Market Stability Reserve is to be introduced. Overlapping renewable targets and the economic downturn likely further exacerbated this outcome.
In the generation part of the value chain, the increasing penetration of low marginal cost and intermittent renewables in Europe has lowered wholesale prices and raised the debate over whether "energy only" markets can ensure reliability without interventions. Policy-makers and regulators need to find a way to signal the need for new investments by appropriately valuing reliability and flexibility.

Figure 7: The EU ETS has failed to deliver a carbon price that will materially reduce emissions



Without these clear signals, policy-makers risk shortfalls in electricity supply. For example, in the UK, low returns led to a predicted short-term shortage of capacity as older plants were retired. This has forced the regulator and system operator to step in and introduce a competitive capacity market (paying generators to maintain available reserves of electricity capacity) to improve the reserve margin in 2018-2019.

The uncapped renewable incentives and the lack of an integrated plan across renewable and conventional technologies have also resulted in capacity overbuild in some countries. And this overcapacity can be exacerbated when state or national governments intervene to support particular technologies for the purposes of local industrial activity — where costs may be too high without either the right competitive advantage in the renewable resources or R&D and manufacturing expertise.

In Spain, renewable generators installed 26,000 MW of capacity between 2005 and 2010. Over the same period, nearly 11,000 MW of traditional combined-cycle gas turbine (CCGT) capacity was installed by businesses that overestimated demand and underestimated the ability of renewable technology to meet the energy plan's objectives. Consequently, the CCGT plants must now reduce capacity, for which the government plans to provide compensation which, in turn, raises the price of electricity.

In transmission and distribution, decentralized generation has reduced the load on the grid and net metering tariffs have disrupted traditional economics. Although net metering can provide effective incentives for investment in decentralized generation, it does not appropriately reflect the value and cost of the required grid connection. At the same time, traditional regulation of distribution networks can prevent the deployment of innovative technologies and business models such as smart grid solutions and demand-side management. Thus, effective market design must also include appropriate signalling and pricing for decentralised generation.

Overall, market harmonization of generation and T&D across countries also remains a challenge for regulators, creating inefficiency and resulting in an uneven playing field for energy-intensive industries and a slow pace of grid interconnections between countries. The opportunity in increasing harmonization, encouraging appropriate physical interconnection and removing unnecessary regulatory barriers to competition is large.

In the UK, National Grid estimates that each gigawatt of new interconnector capacity could reduce Britain's wholesale power prices by as much as 2%. In total, 4 –5 GW of new links built to mainland Europe could unlock up to £1 billion of benefits to energy consumers per year, equating to nearly £3 million per day by 2020.

Business and investor models. Significant transitions in other industries offer many lessons about the opportunities and risks to existing business models in the power sector. During the shift from fixed-line to wireless mobile in the telecom industry, for example, many incumbent telecommunications companies moved slowly because they feared cannibalization of their core business, were prevented by regulations from participating or simply lacked the capabilities to take full advantage of new opportunities in mobile. Some of the firms that successfully adapted spun off new businesses which were able to move at a faster pace and often under different regulations. In that transition, incumbents were able to capture some of the gains from new products and services, but much went to new and more nimble players who had the capabilities required to succeed in mobile communications.

If anything, the energy transition driven by both decarbonization and technology innovation promises an even more startling shift. Customers – once merely consumers at the receiving end of long lines of transmission and distribution wires – are, in some cases, now generators themselves. And even if they are not generating or storing their own energy, they will certainly participate more actively in choosing their supply sources and controlling their demand. This will encourage the development of more customer-centric business models and technologies.

New business and investment opportunities are therefore arising, particularly at the customer end of the energy value chain, for example, in distributed generation, demand-side management, energy efficiency measures and electrification. Policy-makers can encourage these new, higher risk ventures with the right kinds of incentives.

For example, solar has spurred a whole set of new businesses in which companies work with individual consumers to create an end-to-end proposition: providing low cost solar energy and coordinating all the investment flows on behalf of the customer.

Energy service businesses also have emerged to support customers in installing and maintaining their own heat and power networks. Technology companies are showing much innovation in energy efficiency and support for demand-side response in businesses and consumers, respectively. Innovation is happening on the supply side too, with financing for plant upgrades that can improve efficiency in existing plants. And network equipment companies have created "virtual networks" of decentralized generation and consumption to optimize system efficiency, increasingly employing big data technology to manage the complexity.

As in the transformation of the telecom sector, much of this innovation comes from new companies entering the electricity sector, excited by the opportunities offered by new technologies. Incumbent utilities, like their landline telecom counterparts, have often been inhibited by regulatory constraints or lack of relevant capabilities. But there are signs that some incumbents are developing the necessary capabilities, either through separate subsidiaries or by acquiring and growing businesses.

Contrary to some other countries where the development of renewables has been led by utilities, in Germany incentives on renewables attracted an entirely new set of investors. The majority of the investment (more than 80%) was from non-traditional investors – individuals, new developers, sovereign wealth funds – rather than incumbent utilities. Much of the investment was targeted at decentralized energy, closer to the customer, which is indicative of the types of business models required to be successful in this customer-centric environment.

Choices Ahead: Attracting Investment to the Sector

While there are many ongoing debates in global energy policy and regulation, experience to date highlights a range of actions where there is broad consensus.

Governments, regulators and industry participants each have a role to play in attracting the required investment to complete the transition.

Create efficient, stable and flexible policy

The recent economic downturn and declining returns in the sector highlight the importance of policy stability. To encourage such stability, the gap between society's commitment to environmental sustainability and the value it attributes to decarbonization needs to be closed.

Residential electricity prices are predicted to increase over the next two decades, so policy-makers must minimize the burden on businesses and consumers by containing costs and avoiding policy inefficiencies. At the same time, they must work to build societal acceptance of energy policy goals, the broad value of decarbonization and the investments required.

The lower the costs of the energy transition, the less likely policies will shift when the economy dips or political winds change.

Plot the most efficient pathways to policy objectives. Policy-makers should begin by investing in "no regrets" areas that have a positive business case, and so will be palatable in almost any economic climate. These include investments in energy efficiency technologies, demand response services, and upgrading of network and generation plant efficiencies. The IEA projects potential for $4 trillion of additional investment in energy efficiency measures with positive business cases through 2035. These investments could generate fuel cost savings of about $7 trillion and reduce the need for generation investment by $3 trillion.

Other "no regrets" investments include those renewable sources that have a strong business case even without subsidies – for example, onshore wind in northern Europe, solar power in the southern regions of North America, or low-cost district heating in colder and more densely populated environments.

Where incentives are required to deliver energy policy objectives, policy-makers must focus them on the lowest cost routes. They should concentrate their support on fewer renewable technologies so that deployment builds scale rapidly and drives costs down through experience. For example, onshore wind is approaching cost parity with thermal generation in many locations and offers a lower cost route than other renewables.

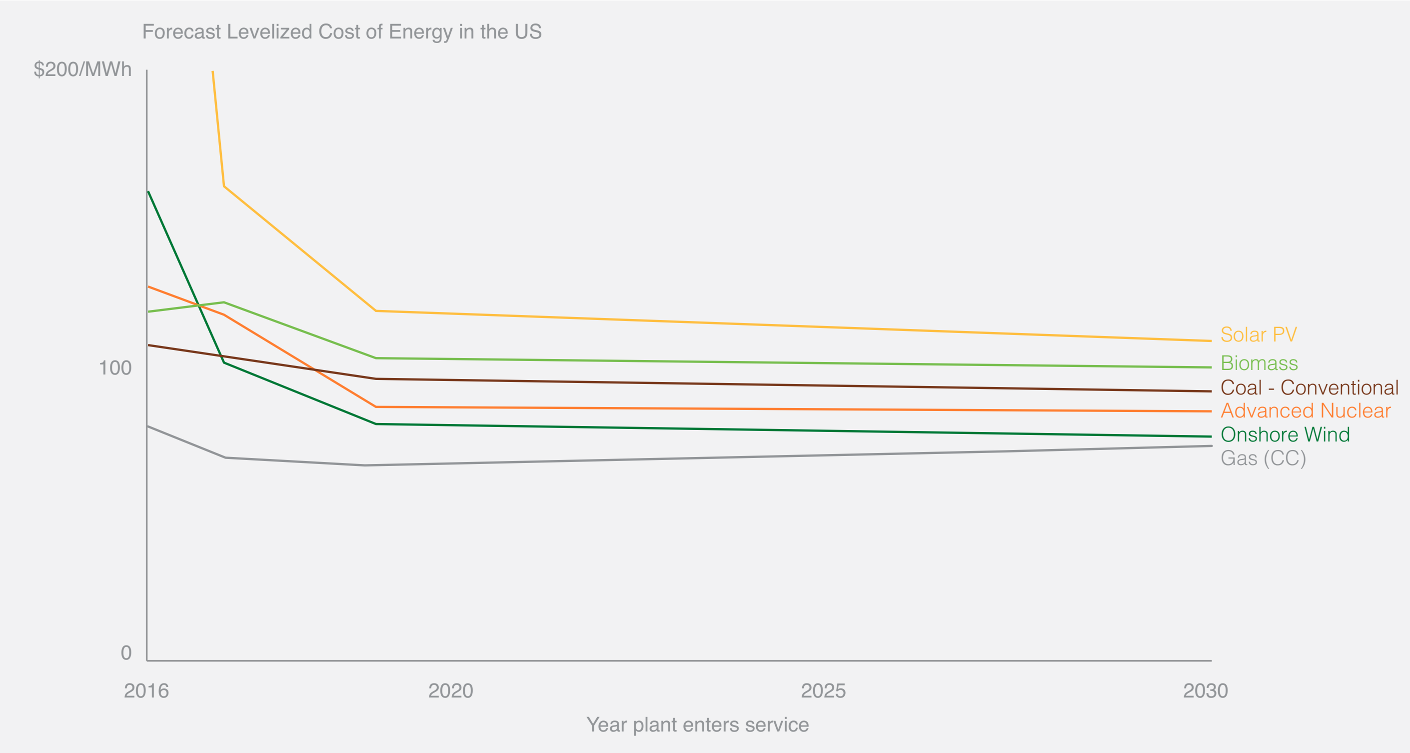
Additionally, national and state authorities should look to exploit the best renewable resources within and across borders. This is not a new insight. For more than a century, utilities and industries have imported their energy, whether it is a New York power plant getting coal from Pennsylvania or a power plant in Asia sourcing LNG from Qatar. By cooperating across borders, policy-makers can decarbonize at lower cost and with greater diversity of supply.

Similarly, policy-makers should also look beyond the boundaries of the electricity sector for lower cost opportunities to decarbonize – converting the transport sector to electricity or other low carbon, clean fuels, offers substantial opportunities.

Finally, conventional thermal generation will remain a vital component of the energy mix for decades to come. Robust carbon pricing would encourage investment in the right mix of fossil fuels and carbon abatement technologies.

Stabilize policy by building in flexibility and work to increase societal support. Despite the rapid development of renewable technologies, there is still significant unavoidable uncertainty in the future. The optimal policy pathway depends on a broad range of factors: developments in individual technologies; the rate of deployment in different regions and the reduction in cost as they scale; and societal appetite for and ability to fund investment. One way to address this inherent uncertainty is to invest incrementally, building in flexibility in the system, without overcommitting to a particular technology.

Figure 8: Generation costs decline as technologies mature, but exact endpoint is uncertain



Policy-makers, businesses and other stakeholders must also present a stronger case to society for the value of decarbonization and the investment in renewables – and thereby avoid the risk of a public backlash causing policy instability. The case must emphasize the full benefits beyond reducing carbon emissions and climate change, including international security of electricity supply, national employment and broader health effects. Different elements of these benefits will be important to different stakeholders so it will be important to tailor messages.

In these efforts, all industry stakeholders will have a role: new entrants with innovative technologies and NGOs can often be more persuasive than incumbent utilities or governments. A 2006 review of climate policy influences in Australia found that NGOs had more influence on public awareness of climate change than the scientific institutions at the forefront of climate research.

Policy-makers will also need to address the question of who in society pays for the evolution of the energy sector. The US and Europe have charted different paths, with the US funding systems based on broader taxation across society while Europe putting the cost burden more directly on consumers through electricity tariffs. Some have criticized Europe's policy for being regressive, placing a disproportionate burden on poorer regions and consumers. Rising public resistance to environmental taxes and subsidies has resulted in some being rolled back in southern Europe and even in some northern European countries like the UK.

Providing better transparency of the underlying costs may help garner support for investment in the electricity sector, but it will also question the role of unrelated taxes in raising the price of electricity. In other industries such as petroleum, retailers have split out the different element of the costs "at the pump" to provide this transparency.

Provide clear direction to markets with minimal intervention

Across developed economies, governments have put in place a range of electricity market designs, from highly regulated to more liberalized ones. No single type is right for every economy, and all can deliver the necessary capacity while moving a society towards its energy policy goals.

In all cases, however, regulators must think carefully about the signals they send and market mechanisms they employ. Among the key elements of good market design will be clear, effective signals for carbon pricing, predictable, dispatchable, fast-responding supply and demand response and reliable grid capacity. Regulators must also ensure that they create a level playing field by harmonizing incentives across borders, encouraging appropriate physical interconnection and removing barriers to competition.

Ensure clear, effective signals. As more power derives from intermittent sources like wind and solar, regulators and industry participants will need to take steps to send clear and consistent market signals to ensure investment continues to flow into the right policy priorities.

The most comprehensive signal that regulators can send is to provide a clear, stable price for carbon. This enables investors to internalize the value of decarbonization alongside the economics of different generation sources and creates a level playing field across technologies. The price needs to be adequate to incentivize the right level of investment and ubiquitously applied to avoid market distortions.

As the power system becomes increasingly volatile – with intermittent generation sources and variable end user demand – increasing value is placed by the electricity system on reliability and flexibility. Optimal solutions will differ across countries and regions, depending on the climate, topography and amount of power generated by renewables. But it is critical that regulators look to reward all forms of generation and demand side response based on their flexibility, reliability and technical characteristics.

In particular, given the current overcapacity in thermal generation and the associated write-offs for many incumbents, it is critical to signal early how new capacity built will be remunerated when the ageing plant comes to the end of its life – whether it will be left to the wholesale markets or if a "flexibility/reliability" payment will be implemented.

Uncertainty over the future regime inhibits investment and threatens both decarbonization and security of supply. For instance, the ambiguity in the UK regime resulted in only two centralized power stations being built in the past three years, further contributing to the projected capacity shortage in 2016. Recent regulatory action has been required to address this risk to security of supply.

A strong consensus has yet to emerge on the optimum mechanisms for ensuring reliability and flexibility. If wholesale markets prices are left to signal through peak prices, there is significant risk that these prices will not be politically acceptable and potential interventions may inhibit investors.

Alternative options include capacity payments such as those used in Portugal, strategic reserves as favoured by Sweden, or the market-wide, volume-based mechanisms that have been adopted in the US and drafted in the UK.

An important extension of the mechanism is required to reward sources with different operating and response characteristics differentially to ensure technical stability and quality in electricity supply.

Another way to increase flexibility and reliability is through manual or automated demand response programmes incentivized, either by allowing prices to rise in real time as demand spikes or via flexibility payments. Others sources of reliability and flexibility include increased grid interconnection and, in the future as economics improve, energy storage.

For the foreseeable future, a reliable and flexible grid connection will remain, for many, the best source of capacity. As decentralized generation replaces load from the grid, it will be important that it continues to be appropriately remunerated – similar to the way consumers purchase broadband connectivity as mobile telecommunications moved voice calls from the fixed telecommunications networks.

Grids will also need to invest in smarter management of the diverse sources of supply and demand that they connect. In New York, a distributed system platform provider (DSPP) has been proposed to more effectively manage the interface between distributed assets and the wholesale grid. This new model aims to better balance supply and demand variations at the distribution level and link wholesale and retail markets, while maintaining the New York Independent System Operation's traditional role of the operator as a custodian for transmission system reliability.

Create a level playing field. Integrating electricity grids and markets across state and national boundaries can reduce costs, increase the stability of supply and create new investment opportunities. But to achieve these goals, national decision-makers will need to balance their desire for control over their energy resources with the benefits available from broader integration of electricity grids and markets. This will require regulators to harmonize incentives, encourage appropriate physical interconnection and remove unnecessary regulatory barriers to competition between existing and new participants.

Interconnection can reduce overall electricity costs (net of investment costs) and raise the reliability of electricity across large systems. For example, today customers in Netherlands are benefitting from Germany's oversupply, importing 23 TWh in 2012 – and greater interconnection may be part of the solution for the UK shortfall in coming years. With more interconnection, northern Europe could benefit from the solar resources in southern Europe and vice versa on wind resources.

But there are policy challenges to be worked out as grids reach beyond regulatory borders, including how countries and states agree on the benefits and costs of cross-border projects, and how they mitigate negative consequences, which can include loss of control over generation assets and local resistance to high voltage transmission lines. New regulations or even regulatory or administrative organizations will be required to harmonize policy, coordinate efforts for both public and private enterprises across technologies and work out details such as network codes. For example, in regulated markets, an independent system operator may be required.

Regulators must also work to encourage competition among the various industry participants, enabling utilities and other entities to provide new, innovative customer services. For policy-makers, the numerous players and potential models offer a wealth of opportunity that is best encouraged by lowering artificial barriers to entry, including regulations that prevent incumbent utilities from offering many services.

An increasingly important issue in the new, smarter electricity system is access to data. Regulators have a core role to play in creating robust, understandable privacy protection for consumers while establishing data standards that remove barriers to competition and open up access to new innovative business models.

New business and investment models are required

To attract the investment on the scale required, businesses and investors will need to evolve and innovate. This will be accelerated by increased competition among incumbent utilities and new entities, as well as new financing channels and models for asset valuation.

For businesses, this means engaging with policy-makers and regulators to help identify the most efficient pathways through the transition. Both incumbent utilities and new entrants must evolve their strategies and business models to exploit new opportunities. They will have to transition their centralized generation portfolio, while also adapting to the rise of more customer-centric models.

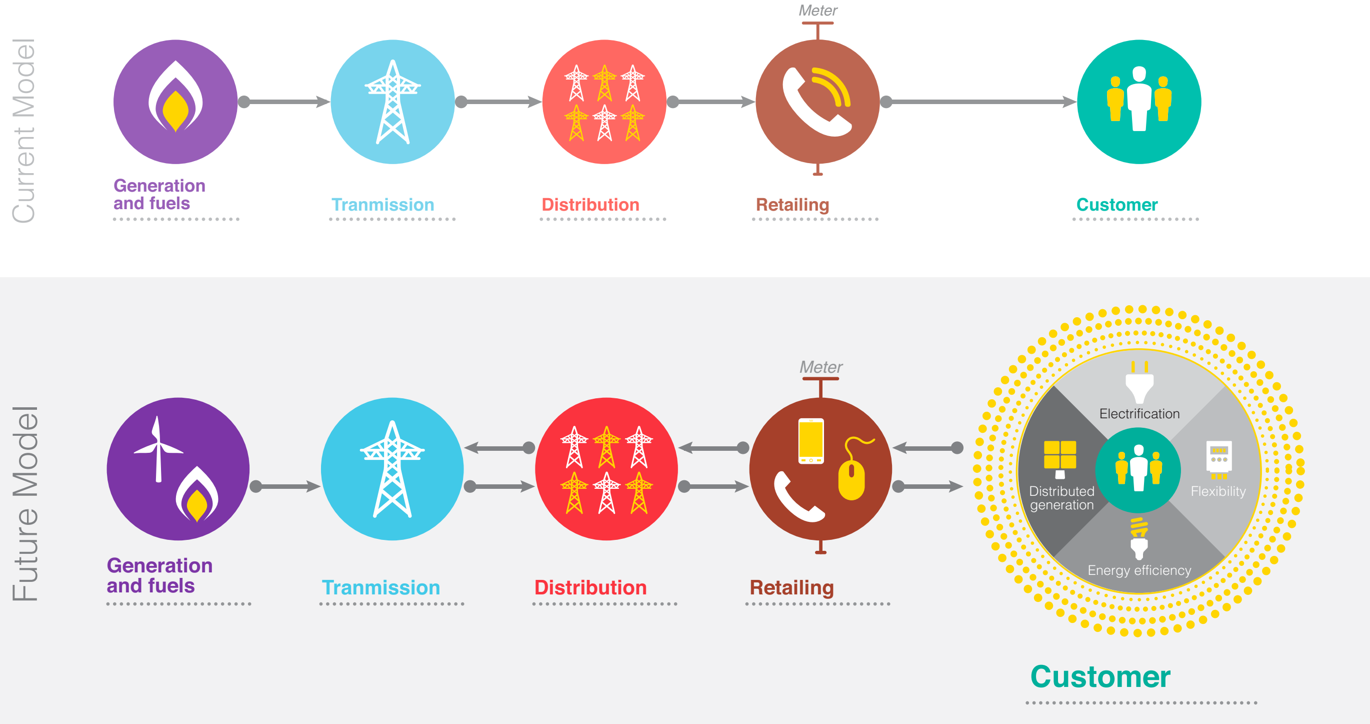
Investors must also engage with policy-makers and regulators to determine how best to balance risk and return to attract the required investment, while continuing to innovate investment structures to address the evolving risk profile in different parts of the electricity value chain.

Businesses: Adopt new paradigms before the meter. As the electricity system transitions, the mix of power generation sources is diversifying and the direction of travel is much less certain than it used to be. This raises the level of risk and complexity for the traditional incumbent operating models.

As they form long-term strategies, utilities must consider how to adapt their traditional model to the new environment. For example, they will have to decide what their optimal mix of generation is, balancing current market conditions (for example, cheap coal in Europe), with long-term policy objectives that encourage renewables and conventional generation from lower carbon sources. In deregulated markets, they must also take a view on the risk of cyclical overbuild given uncertainty about deployment of new renewable, thermal and distributed generation and declining demand due to energy efficiency.

Transmission and distribution companies should also discuss with regulators about how to provide the right incentives to ensure a smarter, more flexible and reliable grid continues to provide appropriate support for the roll-out of both centralized and distributed renewables technologies.

Figure 9: New business and investment opportunities are emerging close to the customer



Businesses: Get closer to the customer. As investment is increasingly made by "prosumers" (producer-consumers), incumbent utilities and new entrants are in the early stages of a revolution in new products and services beyond the meter and consumer-centric.

Across the industry, these companies are learning what packages of services they should offer and what capabilities are required to successfully deliver them. Offers in electrification of heat, distributed generation, demand side management and energy efficiency are just some of the innovations that are taking place "closer to the customer".

While new entrants start with a clean slate on which to build a trusted brand and customer relationship, incumbent utilities have long-term relationships with and knowledge of their customers' needs that they can leverage. Incumbent utilities are experimenting with different models for entering these new businesses, including: organic expansion through separate, innovative brands – like, for example, in France; moving to acquire and scale up early innovative companies; or partnering with technology companies.

The vast amounts of data produced by smart meters, connected devices and other consumer data offer potentially interesting business opportunities, including analysis of big data, providing opportunities to produce or consume electricity more efficiently. To enable this, data communication standards and clear guidelines for data privacy and protection will be needed.

Other new opportunities will arise as more services (such as heating) and sectors (transportation) are increasingly electrified.

This increasingly sophisticated range of business models offers significant opportunities for innovation, but also provides new challenges for the system operator in taking a holistic, strategic view of the development of the electricity system to ensure that the optimal investments are made.

Investors: Promote the right investment environment. Given the huge amount of capital still required, policy-makers, industry executives and investors will need to have a detailed discussion about the trade-offs required to ensure the environment is attractive to potential investors.

Governing bodies and regulators have a role to play in keeping down the cost of capital by reducing unnecessary risks, including technology, regulatory and market risks. The experiences of recent years may have alienated some groups of investors who will have to be reassured to encourage their continued participation in the sector.

Innovative choices for financing can help encourage further investment. Some new entrants are successfully using asset-backed securities to raise capital. Incumbent utilities are also employing new investment instruments and methods including green bonds, capital recycling and co-investment in new facilities. Investors should be clear on the metrics they will use to evaluate utilities and new entrants to reduce information asymmetry and improve investability.

Increasingly, commercial, industrial and residential consumers also have opportunities to invest in the sector through their ownership of assets (for example, rooftop solar panels) at the individual and community levels.

Investors need to engage policy-makers to determine what type of risks they are willing to undertake (regulatory, financial or technological). Financial intermediaries need to be explicit about the nature of risks of electricity investment financing so investors can make informed decisions. Investors also have to understand from the industry the evolving risk profile of assets across the value chain. Traditional investors with lower risk appetite (such as pension funds) will need to seek lower risk profile assets (like regulated transmission assets).

Conclusion

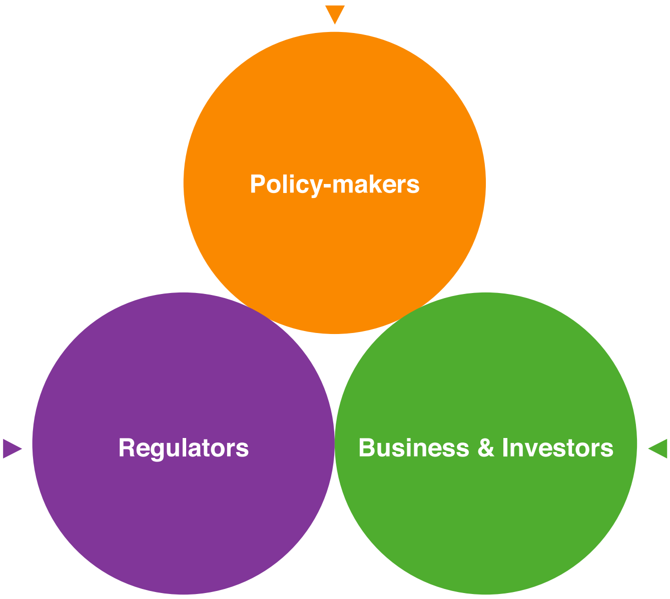
While there are many current debates on global energy policy and regulation, these areas of general consensus offer a clear path forward for the transition in OECD markets, a journey that will be watched carefully by developing nations as they begin to navigate their own, similar transitions.

Finally, as no single cross-stakeholder body exists, developing a joint, cross-geography, multistakeholder task force is recommended to increase communication and share lessons and best practices across borders and throughout the industry. Only by ensuring the viability of investment can policy-makers successfully evolve toward a more sustainable and efficient energy future.

Figure 10: Key recommendations

Plot the most efficient pathways to policy objectives. Incentivize "no regrets" investments and exploit the most efficient renewable resources within and across borders.

Stabilize policy by building in flexibility and increasing societal support. Recognize inherent uncertainties by investing incrementally. Communicate the value to society. Prohibit retroactive policy changes.



Ensure clear, effective signals. Provide a clear, stable market signal on carbon pricing. Reward efficiency, reliability and flexibility, encouraging predictable, dispatchable, fast-responding supply. Recognize in network tariffs and regulation the value of reliable back-up grid capacity.

Create "level playing fields". Harmonize incentives, encourage appropriate interconnection and remove unnecessary regulatory barriers to competition.

Businesses: Engage policy-makers and regulators to identify the most efficient pathways. Evolve strategies that exploit opportunities in the evolution of centralized generation and the rise of customer-centric offerings.

Investors: Engage with policy-makers and regulators on how best to balance risk and return to attract investment. Continue to innovate investment structures to finance the evolving risk profile of the electricity value chain.

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