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Energy 4.0: Energy & Policy environment 2030

Transformation in the energy sector

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1. Sector overview

Energy is a critical enabler and economies require reliable energy sources to underpin their development and prosperity. Provision of reliable, affordable and sustainable energy services to industry, commercial and retail consumers paves the way for an enhanced lifestyle, improved health, increased productivity and economic growth. The World Energy Outlook estimated that in 2016, 1.2 billion people (or 16% of the world's population) had no access to electricity and 2.7 billion (or 38% of the world's population) still relied on solid biomass for cooking.

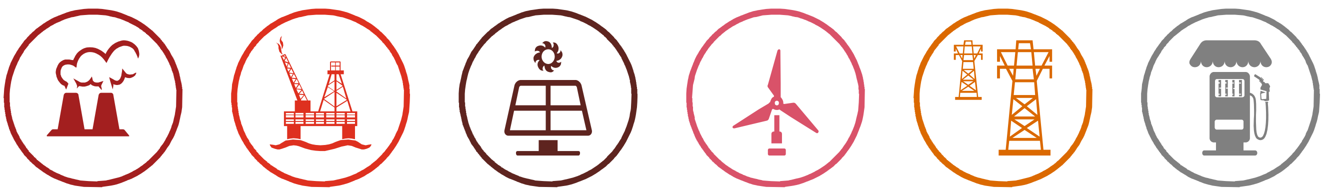
1.1. Global energy scenario

The global economy is expected to witness a shift and over the next 10–20 years, global economies are estimated to account for almost 75% of the global GDP. With these changes in the global economy and shifting consumption patterns across regions, the following key trends are anticipated for transitioning to the envisioned global energy future.[1]

- **Carbon emission reduction and energy efficiency** are expected to be focal points in the future, driven by policy and technological interventions.
- **Energy sector's evolution in the future would be heavily dependent upon technology –** development of renewable energy (RE), replacement of ICE with electric vehicles, etc., would have a significant impact on the global energy future.
- **Maximum demand is expected to be from the two largest economies** in the world – India and China.
- To meet local demand, **Asia-Pacific and the Middle East are expected to add the majority of new refining capacities.**
- Despite a growing trend towards electric mobility, **transportation will continue to be the largest demand driver of the oil and gas sector.**
- Demand in the medium term is also anticipated to be impacted by **regulations by the International Maritime Organization (IMO).**
- **The role of natural gas is expected to increase over the next ten years.** Most of the incremental supply requirement is expected to be from natural gas in the future.

1.2. India's energy scenario

With nearly 304 million Indians lacking access to electricity and around 500 million people dependent on solid biomass for cooking, India clearly has a long way to go in terms of securing its energy future. With the expected growth rate of the economy, experts estimate that the country should be able to cover these gaps and achieve its goals of providing basic access to energy to its populace over the next 2–3 years. From there, it has the potential to leapfrog into an energy-rich economy with security over the next 10–12 years.



[1] OPEC. (2017). World Oil Outlook 2017. Retrieved from http://www.opec.org/opec_web/en/publications/340.htm (last accessed on 18 January 2018)

Outlook of the energy sector	2017	2030
National population (million)	1,324	1,527
Electricity demand (MW)[2]	1,61,834	3,34,618
Installed generation capacity (MW)[3]	3,02,088	6,40,189
Per capita electricity consumption (kWh/year)	1,075[4]	1,904[5]
Share of renewable-based power generation capacity[6]	17%	40%
Per capita energy demand (Kgoe/year)	573	808

The above table briefly captures some key energy transition milestones envisaged to be achieved over the next 12–13 years. This period is crucial since it is anticipated that India, with its GDP growth trajectory, can transition into an advanced developing or developed economy.

While India paves the way towards rapid economic and industrial growth, its commitments to reduce carbon emissions relative to its GDP by 33% to 35% from 2005 levels by 2030 is a major development that is likely to shape the country's energy future. With the signing of Paris Climate Change Agreement, the country is expected to move to an over 40% share in total electricity generation capacity. Further, with key policy and governance interventions, it is expected that all the villages will be electrified by the end of 2018, along with universal electricity availability by the end of 2022, which will stimulate electricity demand. With the increase in disposable income and the quest for an enhanced quality of life, the per capita consumption is consequently expected to reach around 1,900 kWh per year by 2030, increasing at a compound annual growth rate (CAGR) of around 4.3% per annum.

1.2.1. Oil and gas sector

With the objective of reducing crude imports by 10% and making energy available to all by the year 2022, the Government of India (GoI) has an intense focus on increasing domestic production by 10%, attracting foreign direct investment (FDI) in the oil and gas sector, building greenfield and brownfield refineries, developing pipelines and LNG terminals, etc. This commitment by GoI is manifested in the form of several initiatives in the oil and gas space. A few of these initiative which can potentially transform the sector are described below.

Global energy trends

- Change in energy mix and a rapid shift towards RE sources
- Maturity of renewable technologies, making them more affordable
- 50% fall in global oil prices % since 2014, triggering energy policy reforms across the world, especially in oil-importing countries like India

[2] Ministry of Power, Government of India. (2016-17). 19th Electric Power Survey of India. Retrieved from www.cea.nic.cin (last accessed on 18 January 2018)
[3] CEA. (December 2016). Draft National Electricity Plan. Retrieved from http://www.cea.nic.in/reports/committee/nep/nep_dec.pdf (last accessed on 18 January 2018)
[4] CEA. (January 2017). Power sector report. Retrieved from http://www.cea.nic.in/reports/monthly/executivesummary/2017/exe_summary-01.pdf (last accessed on 18 January 2018)
[5] Niti Aayog. (June 2017). Draft National Electricity Policy. Retrieved from http://niti.gov.in/writereaddata/files/new_initiatives/NEP-ID_27.06.2017.pdf (last accessed on 18 January 2018)
[6] CEA. (January 2017). Power sector report. Retrieved from http://www.cea.nic.in/reports/monthly/executivesummary/2017/exe_summary-01.pdf (last accessed on 18 January 2018)
Note: Figures exclude hydro numbers.

several initiatives in the oil and gas space. A few of these initiative which can potentially transform the sector are described below.

1. *Upstream initiatives being undertaken in the oil and gas segments*

- Hydrocarbon Exploration & Licensing Policy (HELP) for formulation of an attractive investment regime, fiscal terms and regulatory environment and promoting Ease of Doing Business;
- Open Acreage Licensing Policy (OALP), as part of HELP, will enable exploration and production (E&P) companies to choose the blocks of their interest for exploration and development;
- Marketing and pricing freedom for new gas production;
- Reassessment of Indian basins by Oil and Natural Gas Corporation (ONGC), Oil India Limited (OIL) and the Directorate General of Hydrocarbons (DGH).

2. *Midstream initiatives being undertaken in the oil and gas segments*

- Laying of 15,000 km of pipeline infrastructure for the National Gas Grid;
- Urja Ganga Scheme for providing gas access to eastern India.

3. *Downstream initiatives being undertaken in the oil and gas segments*

- Pradhan Mantri Ujjwala Yojana to promote use of clean fuel by giving free LPG connections to poor women;
- 'Every-day' pricing for petrol and diesel

4. *Moving towards a methanol-based economy (boosting cleaner and cheaper fossil fuels)*

- The Ministry of Petroleum has committed to cut the oil import bill by 10% by 2022, which has enabled Niti Aayog to adumbrate a roadmap for substituting 10% of crude oil imports with methanol by 2030, a cheap fuel (which costs 30% less than any other available fuel) with near zero emissions. With a boost from the Make in India initiative, increased methanol production has the potential to reduce 20% diesel consumption in the next 5–7 years, with a saving of nearly 26,000 crore INR annually.
- Backed by these initiatives, India is expected to drive oil demand growth. Demand for crude oil is expected to increase from 4.5 mb/d in 2016 to 7.5 mb/d in 2030 at a CAGR of 4%. Demand for petrol is expected to reach 1.1 mb/d and that for diesel, 2.6 mb/d by 2030. Historically, the growth in demand for diesel and petrol has been at a CAGR of 6.3% and 5.2% respectively. However, demand for diesel and petrol is expected to increase at a CAGR of 4% in view of the increasing penetration of electric vehicles (EVs), energy efficiency, etc. Also, the government is taking various steps to encourage the use of blended fuels by mixing ethanol and methanol with petrol and diesel. Demand for LPG is expected to increase from 0.6 mb/d in 2016 to 1.1 mb/d in 2030 at a CAGR of 5%.

5. *Cooking with clean fuels (stimulating electricity demand)*

- GoI is planning to launch the National Mission on Clean Cooking (NMCC) which will coordinate efforts on cooking fuels, efficient cook-stoves and related R&D with the aim of achieving full clean cooking fuel coverage by 2022. To enable this mission, the use of electricity for cooking cannot be overlooked.

6. *Increased production of domestic fossil fuel (energy security)*

- GoI is undertaking multiple measures to augment domestic fuel production, including thermal coal, oil and gas. In addition, research and development efforts are also being made to enhance the production of newer technologies such as shale oil and gas, underground coal gasification (UCG) and coal bed methane (CBM).

1.2.1. Power and utilities sector

The year 2022 is expected to be an inflection point in India's energy and electricity sector with policies aligned to provide citizens 24x7 power. Enablers and policy trends, both on the demand and supply side, which are in implementation mode for the transition towards this energy future are:

1. *'Saubhagya' scheme and 'Power for All'* *(stimulating electricity demand)*

- With the electrification of villages nearly achieved (the slated date of completion being December 2017), the focus has now shifted to driving household electrification. Despite being electrified, many households in several villages still do not have electricity connections owing to lack of awareness, limited capacity to pay the initial service connection charges, etc. In order to tackle these issues, GoI has recently introduced the 'Saubhagya' scheme to ensure universal household electrification by December 2018. This scheme would support distribution companies (DISCOMs) across the country financially, to enable them in connecting every last consumer with electricity. The subsequent logical step is to provide 24x7 electricity to all consumers, excluding agriculture, by 2022.

2. *Leapfrog towards electric and shared mobility* *(stimulating electricity demand)*

- India has the potential to save up to 64% of anticipated passenger road-based mobility-related energy demand with a reduction in petrol and diesel consumption of 156 Mtoe by 2030 through shared, electric and connection mobility. Some key enablers envisaged by the Ministry of Road Transport and Highways and Niti Aayog are systems integration enabling wide-scale adoption of mobility, scaled manufacturing of EVs and a shared infrastructure development. Niti Aayog also predicts that transit-oriented development, a shift towards rail-based mass transport systems, coupled with the development of systems, and increasing investments to fuel the same, concentrated economic activity in the form of logistical parks, industrial clusters, etc., would reduce the demand for freight transport, increasing electric traction in railways, which would also have a huge impact.

3. *Perform, Achieve, Trade (PAT) for industries* *(potentially stimulating electricity demand)*

- With Phase II of PAT now underway, increasing energy-efficiency penetration in energy-intensive industries and the move towards more disruptive technologies (such as switching to electric furnaces, utilising more electricity from the grid, increasing waste heat recovery) are expected to help stimulate electricity demand in industries as well. Moreover, with the impetus provided by the Make in India campaign and the competition in the global market with other developing economies, there is a huge incentive for industries to optimise their input energy costs and move towards sustainable energy alternatives.

4. *Enhancing electricity consumption in other segments* *(stimulating electricity demand)*

- In several parts of the country, sectors like agriculture and telecom are still dependent on diesel-based generators to power pump sets or telecom towers respectively. With the enhanced reach of the electricity network, a transition to electricity-based solutions will soon follow, which will be not only significantly more efficient but also more economical.

5. *Penetration of RE* *(sustainability of electricity supply)*

- Further to the 175 GW target of RE capacity addition targeted in the country by 2022, India plans to increase its RE mix in power generation to 40% by 2030. Newer technologies, including concentrated solar power (CSP) and offshore wind capacities, are also being explored and expected to contribute significantly in the future. The focus is currently on making storage capacities economically viable, which can be the game changer for making RE-based power affordable as well as reliable.

6. *Reducing electricity network losses* *(energy supply optimisation)*

- At present, approximately 22% of the total generated power in the country is lost throughout our transmission and distribution networks before it reaches the consumer. The reasons for this high loss range from the condition of the network to inefficient network nodes and theft of electricity. The central and the state governments are taking concerted steps through multiple schemes such as the Integrated Power Development Scheme (IDPS) and Deen Dayal Upadhyaya Gram Jyoti Yojana (DDUGJY) to upgrade the distribution network (where majority of the losses occur) and control any pilferage. GoI aims to achieve 15% aggregate technical and commercial (AT&C) losses across the country by 2020, and potentially bring it down by another 3–4% over the next decade.

1.3. Context of this background paper

This paper provides a quick snapshot of how the energy future is likely to shape up by 2030.

- To begin with, the current global megatrends have been captured, along with the manner in which they are likely to impact the energy sector.
- Discusses key findings of the 'Delphi Energy Future 2040' report which is a catalogue of 56 theses on how energy systems might evolve in the future, developed by the BDEW German Association of Energy and Water Industries, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH and PricewaterhouseCoopers (PwC).
- PwC carries out a 'Global Power & Utilities Survey' and its 14th edition captures insights on the kind of anticipated disruptions, change in business models across the value chain, new operational strategies and necessary capabilities.
- The fourth chapter discusses the understanding key disruptions anticipated in the run-up till 2030 around technologies, information, customers and talent.

A case study of the transformation of the power sector is evaluated along with the possible scenarios and role of each stakeholder in ushering in this transformation.

2. Megatrends

Energy transformation is being driven by five global megatrends interacting with and amplified by a set of shifts taking place within the energy sector. The five megatrends—technological breakthroughs; climate change and resource scarcity; demographic and social change; a shift in global economic power; and rapid urbanisation—are challenges for all businesses.

While it is not uncommon for megatrends and disruptors to impact markets and businesses, they are increasingly testing the sector's ability to plan for the future.

Demographic and social change

- From 7 to 8 billion people in the next 10 years
- Half of the girls born today have a life expectancy of at least 100 years.

Shift in global economic power

- Welfare growth – by 2030 the E7 will overtake the G7
- How to secure sufficient capital for investments?

Rapid urbanisation

- In 1800, only 2% of the world's population lived in cities – now it is 50%.
- Two-thirds of the world's population will live in cities by 2050.

Climate change and resource scarcity

- A challenge is Supply of resources keeping up with demand growth while reserves are finite
- The carbon target to keep temperature rises to 2°C is will be missed by 2034.

Technological breakthroughs

- Costs of new technologies fall dramatically and adaptation speed rises.
- Achieving a 50% penetration rate for telephones took decades, while mobile phones took <5 years.

"Energy is at the heart of these trends, both as an essential resource for feeding and fuelling the world population and economy, and also as a sector strongly influenced by renewable technologies and business model innovation"

2.1. Technological breakthroughs

Technological innovation is at the heart of the shifts that are occurring in the sector. Advances are happening in many parts of the sector—for example, in large-scale technologies such as offshore wind and high-voltage DC transmission, in distributed and smaller-scale customer-based energy systems and on the load side. Power is being transformed from a top-down centralised system to one that is much more interactive and also decentralised and fragmented. Elements of the old centralised system are becoming rigid and there's a need to find an alternative investment model that recognises technological advances.

In many jurisdictions, renewable power is replacing or has the potential to replace fossil fuel generation. Smart grids are delivering the potential for greater interactivity with customers. The scope for even more transformative technological breakthroughs is now being taken more and more seriously. A breakthrough in the cost and practicality of battery storage technology could be a quantum leap enabler, opening up the possibility of off-grid customer self-sufficiency when used in combination with 'own generation'. 'Power–to-gas' is also a potential transformative technology. While all these technologies create opportunities for incumbent power companies, many also eat away at a utility company's traditional revenues and undermine the traditional utility business model.

Other technologies, notably the combination of the Internet, mobile devices, data analytics and cloud computing with smart grids and smart metering, present opportunities for utility companies to get closer to the customer, play an enhanced 'energy partner' role and exploit data opportunities. Analytics capabilities, which today are generally of a low to moderate standard within utilities, will need to be a core strength in the future if companies are to fend off competition from new entrants who already have these capabilities at the heart of their business.

2.2. Climate change and resource scarcity

The energy sector is on the frontline of concerns about climate change. The sector as a whole accounts for more than two-thirds of global greenhouse-gas emissions, with just over 40% of this stemming from power generation. Resource scarcity or availability, and the associated geopolitics and economics of gas, oil and coal supply, are key factors shaping the power market policy.

A growing emphasis on renewables is a response to both climate change and concerns around security of supply. In the US alone, over 30% of new electricity generation capacity added in 2010–2013 involved solar and wind power, up from less than 2% in 2000–2003. Solar photovoltaic (PV) is now present on more than 1.2 million Australian homes and producing over 3.3GW per annum. In Germany, renewables accounted for 24% of gross electricity consumption in 2013, placing the country slightly above the growth trajectory needed to reach its 2025 target of 40 to 45%.[7]

Transformation is also very relevant to developing countries, many of which face the triple challenge of being unable to meet existing demand for electricity while also facing huge demand growth and the need to extend access to those who don’t have electricity. The need for good demand management is already very familiar in countries such as South Africa where managed outages and demand restrictions are commonplace. Technological advances will enhance this response as well as present the opportunity for expansion of power in ways that may leapfrog the traditional grid evolution route.

2.3. Demographic changes

Within the next minute, the global population will rise by 145. By 2025, we’ll have added another billion people to reach about eight billion. Explosive population growth in some areas set against declines in others makes for very different power market growth potential in different parts of the world. Africa’s population is projected to double by 2050, while Europe’s is expected to shrink.

The growth prize of serving expanding populations for power companies is a big one. For example, Nigeria’s population is expected to exceed America’s by 2045. But the infrastructure challenge in many countries is immense and not all growth markets are readily open to international expansion. Companies seeking to reposition their geographic footprints towards fast-growth countries will also need to have a clear view on the impact of energy transformation on these countries.

The prospect of bypassing the grid and leapfrogging to new local distributed technologies and market models is not unrealistic if the pace of technological advances and cost reductions continues.

2.4. Shift in economic power

The focus of global growth has shifted. Taking a historical point of view, we come to realise that Western economic strength is a relatively recent phenomenon and the current developments we see are essentially a rebalancing of the global economies.

As fast-growth economies become exporters of capital, talent and innovation, the direction of capital flows is being adjusted in a way that is quite different from the traditional routes from developed-to-emerging and developed-to-developed countries.

We are already seeing significant east-west and east-south investment flows in power markets, involving both financial investors and power sector corporate investors. For example, Chinese state-owned power and utilities companies have been active in their search for suitable international power utility and grid investment opportunities. Europe, South America, Australia and other parts of Asia have all been targets for expansion. Sovereign wealth funds and pension fund investments in the sector have also become multidirectional. The challenge for many power companies is access to scarce capital from this global flow of capital, minimising the risk of stranded investments and seeking innovative ways of securing investment in replacement assets.

[7] PwC. (2014). The road ahead: Gaining momentum from energy transformation. Retrieved from https://www.pwc.com/gx/en/utilities/publications/assets/pwc-the-road-ahead.pdf (last accessed on 19 January 2018)

2.5. Accelerating urbanisation

Over the next two decades, nearly all of the world's net population growth is expected to occur in urban areas, with about 1.4 million people—close to the population of Stockholm—added each week.

By 2050, the urban population will increase by at least 2.5 billion, reaching two-thirds of the global population. Fast urban expansion presents a major challenge and an opportunity for power utility companies. The speed of urban growth puts a big strain on infrastructure development. In Africa, large cities such as Lagos, Kinshasa and Cairo are already set to become megacities, with more than 15 million people. The population in Nairobi is set to more than double between now and 2025.

Power companies can play a pivotal role in ensuring future cities become 'urban smart' rather than 'urban sprawl'. They have the potential to be lead players at the heart of future city infrastructure, but it will require a new mindset and the development of new partnerships. And, of course, the pace and nature of urbanisation in fast-growth and developing economies take a different form than in the West. In the former, the challenge is very fast growth on top of already stretched or absent infrastructure. In the West, rural urbanisation is a trend alongside big city growth.

3. Delphi Energy Future 2040

Delphi Energy Future 2040 is a catalogue of 56 theses on how energy systems might evolve in the future. These theses were developed out of interviews with more than 80 experts from different disciplines and were then evaluated by more than 350 international energy experts.

We have shared findings that reflect a considerable consensus in terms of outlook across various heads.

Energy systems

- An ‘all electric society’ will have become a reality. Electricity, especially power generated from renewable sources, will also provide mobility and heating, and will have displaced petroleum and natural gas in many industrial processes.
- The energy supply system will be structured in a cellular way – interconnected cells and ‘islands’ of cities/regions will generate power from solar/wind /storage and a minor share of conventional plants.
- Highly efficient ‘sustainable cities’ will have emerged, with populations that have sharply reduced their individual mobility needs and that satisfy their energy demand by acting as prosumers in smart microgrid systems (‘neighbourhood generation’).
- Economic profitability, investors’ interests and independence from imports will be the key considerations driving the trend to build sustainable energy systems.
- Distributed generation with renewable energies using battery storage will have led to the emergence of new democratic self-governance structures at the local level. Municipalities and social bottom-up movements will have gained momentum.
- Chances of cyber security breaches will increase and pose grave threats to the reliability of power systems.

Policies

- Governments and consumers will be more concerned about carbon emissions and, therefore, will be more interested in sustainable energy systems.
- The influence of the middle classes in the emerging economies, especially in countries like China and India, will be a significant factor that will lead to more climate and environment-friendly policies.
- States will be involved in energy supply activities given that energy security and sovereignty will be the key goals underlying national energy policies.
- New multilateral governance structures will have been created to facilitate the cross-border integration of energy systems and joint infrastructure investments.

Demand

- It was found to be certain or at least likely that global energy demand will double by 2040.
- The vast share of energy demand growth will take place in developing countries and emerging economies, which might thus increasingly turn to cost-effective renewable solutions that are tailored to their demand.
- Energy consumption will have risen significantly as private households will have stepped up their use of convenience solutions (mobility, increased automation of homes, heating, etc.)
- The Internet of things will come close to coordinating power generation and consumption with a majority of electrical appliances reporting their energy demand online and responding to supply and price movements.
- EVs capable of travelling up to 3,000 km on single charge will be available.

Sources of energy

- By 2040, the falling demand for fossil energy sources in industrialised and emerging countries will have destabilised producing countries. There is no clear picture on long-term development of the prices of fossil energy sources. It is very likely that many other producing countries will follow the example of the US and commit themselves to the exploration of shale gas, which will, in turn, increase the likelihood of the prices of fossil energy sources remaining at a low level.
- Thin-film and organic photovoltaic (PV) technologies will drive decentralised energy generation; and distributed generation with renewable energies using battery storage will proliferate.
- Battery storage facilities providing frequency control services will have taken over the role of conventional power stations.
- Power generated from renewable sources will also provide mobility and heating and will displace petroleum and natural gas from many industrial processes.
- High-performance customer generation facilities will be sold in retail stores and can be installed in a matter of minutes.

Power markets

- The power market will be characterised by a high level of disintegration, load-profiled customers and real-time pricing; smart meters and appliances will enable users to optimise their consumption.
- Energy will be traded in fully automated trading systems based on complex algorithms.
- Generation and supply of energy will have been decentralised and made more flexible, which will have led to the emergence of structures that are more resilient to crises and acts of terrorism.

Financing

- Decentralised energy systems will lead to a majority of energy projects being funded by small crowd- and community-based funds or microfinancing initiatives.

Pricing

- Effective regional systems for pricing to be in place.
- Unit price of electricity will become of secondary importance in view of the low marginal costs of renewable generation.
- Consumers will pay a flat rate of fees for electricity which will depend upon their average consumption.

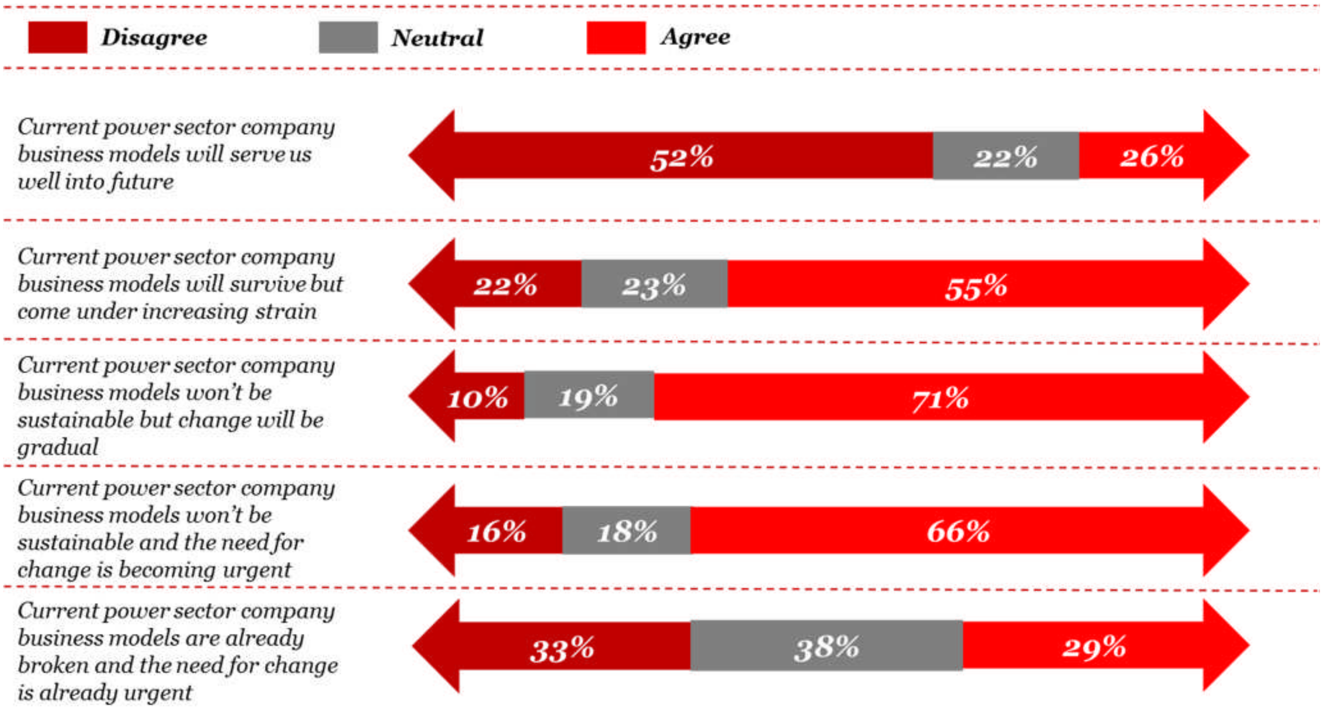
4. 14th PwC Global Power & Utilities Survey

A PwC survey conducted across 70 power and utilities companies across 52 countries provided unique insights into the anticipated disruptions, changes in business models across the value chain, and new operational strategies and capabilities necessary.

It is clear that the new operational models will be heavily determined by the future direction of each country's market and regulatory situation. And it's unlikely that there will be a single winning business model but rather a range of business models that will deliver success in the new, different and evolving market environments. This location-specific shaping of business models is reflected in the wide variety of answers we got from different regions of the world on the outlook for the existing power sector business models.

As per a global survey conducted by PwC in North America, only 7% of survey participants feel that current business models will 'serve us well into the future' but nearly half (47%) of those in the Asia-Pacific region think that the current business models will remain durable. However, globally, only a quarter (26%) agreed with this optimistic outlook, with just over half (52%) disagreeing. [8] In part, these different regional outlooks reflect the different patterns of state ownership and opening of market sectors across the world, with developing countries, in particular, having a higher number of state-owned utilities and less necessity to consider a business model change.

A majority (71%) of the respondents were in agreement with the view that current business models 'won't be sustainable but change will be gradual'. However, many (66%) were also inclined towards the view that 'change is becoming urgent'. These responses were broadly similar across all regions.



Source: PwC's report on 'A different energy future: Where energy transformation is leading us"

[8] PwC. (2015). A different energy future: Where energy transformation is leading us. 14th PwC Global Power & Utilities Survey. Retrieved from https://www.pwc.com/ca/en/power-utilities/publications/pwc-global-power-and-utilities-survey-2015-05-en.pdf (last accessed on 19 January 2018)

The area where there were significant regional differences was whether current business models might survive or, at the opposite extreme, whether they were already broken. None of the respondents in South America, for example, agreed with this pessimistic view of current business models, whereas it did win support from 43% of North American and 35% of European survey participants. These results indicate that, while there is a significant global consensus that current power sector business models are not sustainable, there is less agreement about the urgency of change and, indeed, there remains significant support in some parts for the view that the current business models may still remain viable. Whether this is the case or not will depend on the regulatory and market models in place to support the continuing viability of the current business models. Perhaps it is only the delay in reaction and reform by some market frameworks that is extending the sustainability of the current business models.

4.1. Impact on the energy value chain

A global survey by PwC[9] indicates which parts of the value chain business model transformation would impact most and on what timescale. The near-term impact, between now and 2020, is expected to be confined to specific parts of the value chain and is most intense in North America and Europe. But all regions anticipate that business model transformation will have a high impact across all parts of the value chain, with the exception of transmission, by 2030.

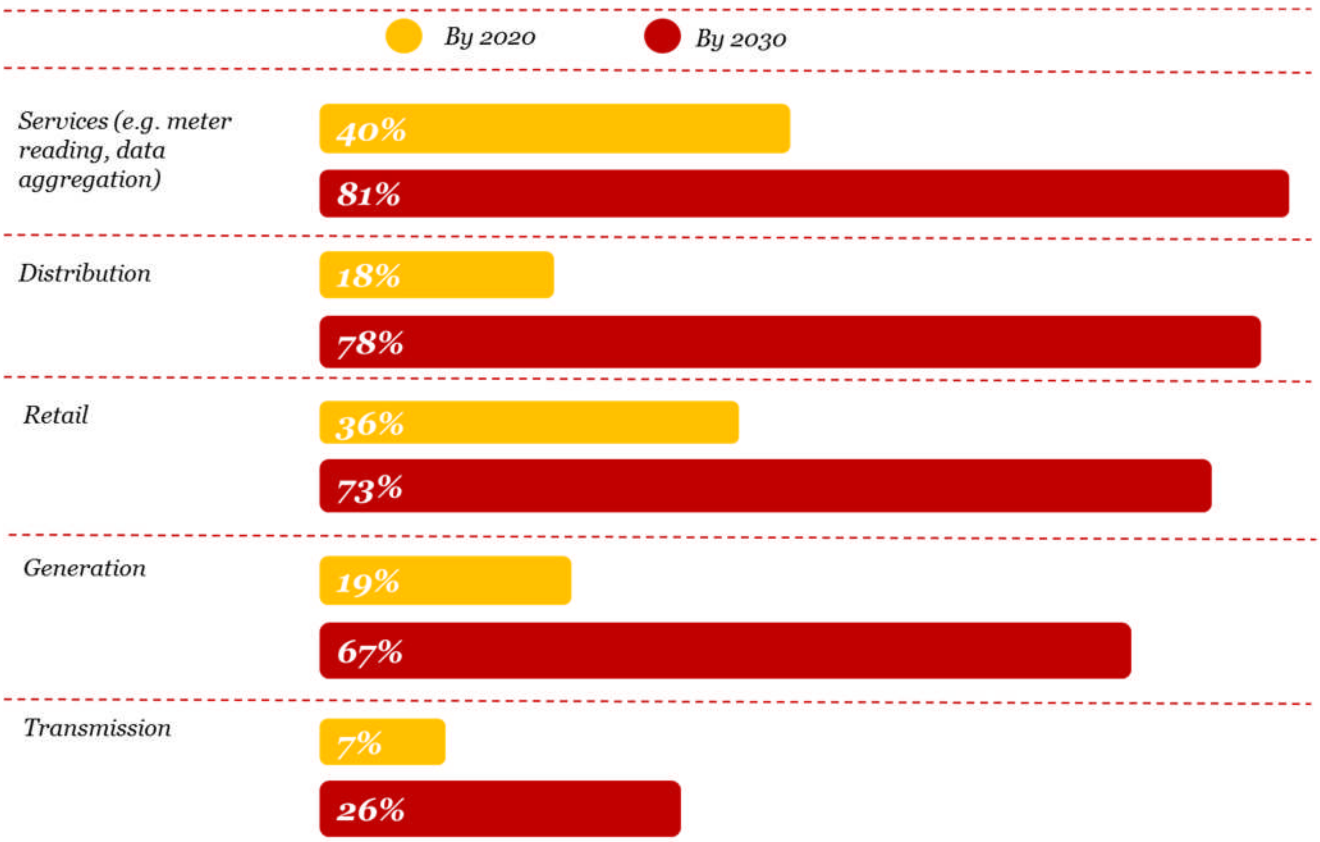
Half of the respondents in North America (50%) said that they expect business model transformation to have a major impact on energy retailing by 2020 (compared to 36% in the global sample), and nearly a third (29%) expect a similar big impact on distribution (compared to 18% of the global sample). The near-term view of many European survey participants was also generally ahead of that in other regions. Nearly a third (30%) expect a high impact on generation (global: 19%), 35% on retail (global: 36%) and 43% on services such as meter reading and data aggregation (global: 40%).

It is not surprising that the impact is felt earliest and is most widespread in North America and Europe, as these are relatively open markets where competition and customer choice can have a greater impact. They are also places where policy directives have provided a significant impetus for energy transformation. But all regions expect business model transformation to have a high and far-reaching impact by 2030.

[9] PwC. (2015). A different energy future: Where energy transformation is leading us. 14th PwC Global Power & Utilities Survey. Retrieved from https://www.pwc.com/ca/en/power-utilities/publications/pwc-global-power-and-utilities-survey-2015-05-en.pdf (last accessed on 19 January 2018)

One of the biggest impacts is expected in the 'services' area, where a wave of energy control and management, data handling and 'behind the meter' services to customers are expected to take hold. Four-fifths of the respondents (81%) foresee a big business model transformation impact on services and high impacts are also expected in distribution (78%), retail (73%) and generation (67%).

Only a quarter (26%) anticipate that transmission will be heavily impacted. If local energy systems take hold, the role of the transmission network might be greatly reduced, with the potential for significant overcapacity in transmission. On the other hand, markets that develop along regional super grid lines, taking a regional approach to RE sources and other large-scale power generation, will require significant new levels of transmission capacity.



Impact of business model transformation on different parts of the power and utilities value chain by 2030

Source: PwC's report on 'A different energy future-Where energy transformation is leading us'

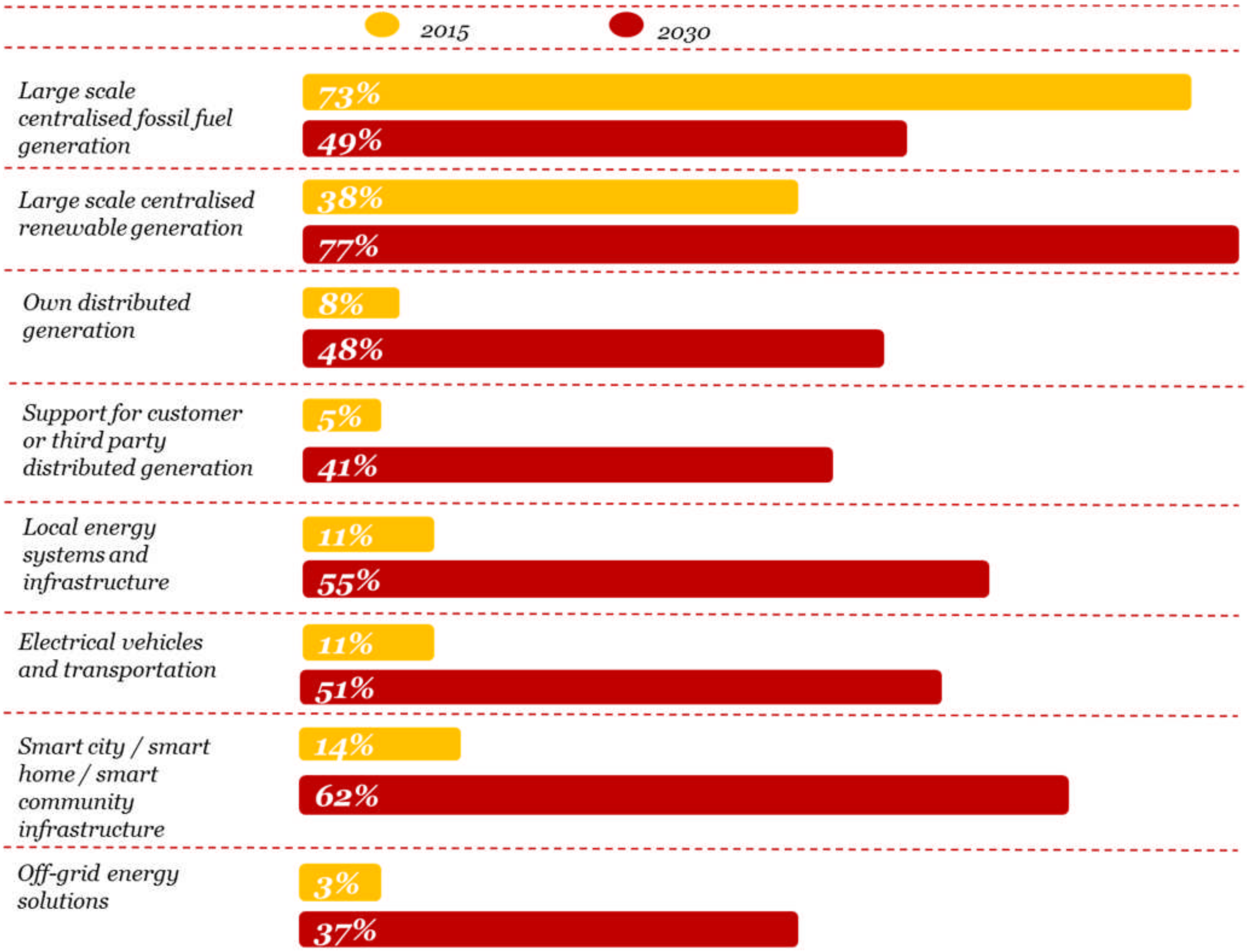
4.2. Operational strategies

On the question of operational strategies most important to energy utilities now and in 2030, a clear preference for renewable generation emerged. The proportion expecting renewable generation to be of high importance jumps from 38% now to 77% in 2030 while fossil fuel generation drops from 73% to 49%.

The number of respondents who say involvement in smart city, smart home and smart community infrastructure will be of major importance rises from 14% now to 62% in 2030.

Similar big increases are evident across a range of areas:

- Local energy systems and infrastructure – up from 11% now versus 55% in 2030;
- Electric vehicles and transportation – 11% now versus 51% in 2030;
- Own distributed generation – 8% now versus 48% in 2030;
- Support for customer or third-party distributed generation – 5% now versus 41% in 2030;
- Off-grid energy solutions – 3% now versus 37% in 2030.



Operational strategies – now and in the future

Source: PwC's report on 'A different energy future-Where energy transformation is leading us'

4.3. Envisaged capabilities

Moving successfully into these areas will require the power utility of the future to develop a wider set of capabilities. Traditionally, utility companies have focused on energy generation, trading and retailing. While these will continue to be a major driver of value in the future, data services and a broader services portfolio will become part of the mainstream for utility companies and energy service companies.

To survive and prosper, the 'utility of the future' will have to provide much more than reliable energy supply—it must respond to a diverse range of customer, business and community demands and do so in a rapidly changing regulatory and technological environment. The utility of the future is unlikely to control the value chain but will need to enable or facilitate customer energy solutions—they will become 'energy enablers'.

It is one thing to recognise the new data, innovation and customer capabilities that will be required, but another to make sure they are in place. Many incumbents are likely to find it difficult to develop a complete portfolio of capabilities to meet customer needs. In such circumstances, they may determine that market opportunities (and market position preservation) are best enhanced through an extension of relationships with outside companies. These may be companies that they already have a supply chain relationship with or they might be entirely new relationships. In such cases, a 'partner of partners' business model approach may be attractive. Becoming a partner of partners involves recognising that the energy ecosystem is broad but interconnected and complicated to navigate. Customer positioning can be improved by integrating 'high-grade' internal capabilities with external skills and offers.

Company strategies/capabilities	Average Score
Pricing and margin enhancement	4.3
Asset management and optimised supply chain / field service	4.2
Behind the meter innovation (e.g. user-friendly smart control and price optimisation systems for homes and businesses	4.0
Managing partnerships and alliances	4.0
Digital customer management	4.0
System operation data analytics	4.0
Customer data analytics	3.9
Innovation of grid, generation or other 'core' operational technologies	3.9
Energy trading and hedging	3.8
Data security and confidentiality	3.6
Product innovation	3.6
Managing 'big data' platforms	3.4

Future capabilities

Source: PwC's report on 'A different energy future-Where energy transformation is leading us'

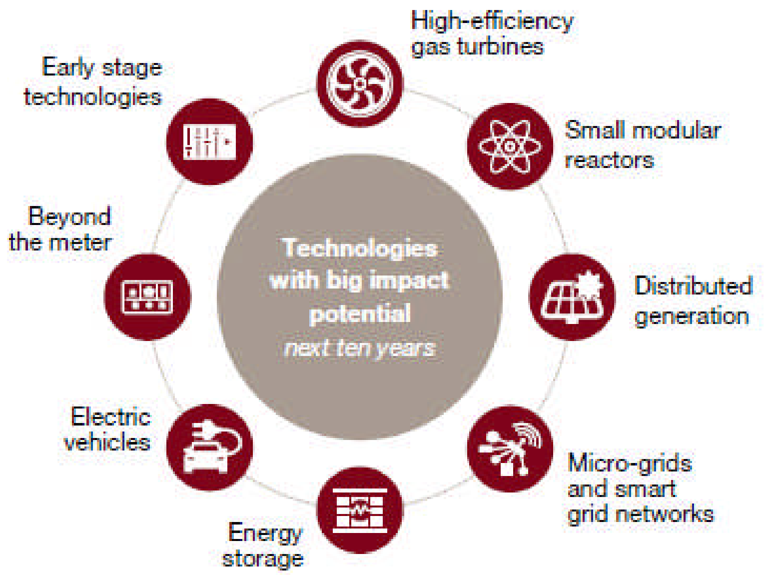
5. Looking ahead

5.1. Technologies with a big impact

Research laboratories, universities, trade associations, vendors, governments and utilities have been continually working on new technologies of all types for application to the utilities sector. Many of these newly deployed technologies, such as renewables and smart meters, have proven to be valued additions to the structure of the electric grid. But even more robust and disruptive technologies are being tested and developed that can further change the way in which utilities and their customers think about their energy future.

Numerous technologies are emerging that could dramatically affect the future of the utilities industry and current costs. We focus on those that appear more likely to be commercialised within the next 10 years and could have a widespread impact on traditional elements of power infrastructure. These technologies are discussed in brief in this report, with a look at both their economics and likely proliferation. The choice of these technologies is also supported by many of the findings of a study on the future of energy systems in Germany, Europe and the world by the year 2040,[10] which included in-depth consultation with 80 recognised international experts from the energy sector and related industries.

Figure 1: Technologies with big impact potential – next ten years



Source: PwC's report on 'Capturing value from disruption: Technology and innovation in an era of energy transformation' (http://www.pwc.com/gx/en/industries/energy-utilities-mining/power-utilities/)

[10] Delphi Energy Future 2040, Delphi-study on the Future of Energy Systems in Germany, Europe and the World by the Year 2040, German Association of Energy and Water Industries (BDEW), Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, PricewaterhouseCoopers AG WPG (PwC), 2016. Retrieved from http://www.delphi-energy-future.com (last accessed on 19 January 2018)

5.1.1. High-efficiency gas turbines

The development of natural gas combined cycle (NGCC) technology in the 1990s was a significant efficiency breakthrough in the evolution of natural gas generation. In the US, for example, NGCCs became the predominant new-build baseload option in the early 2000s—well before the emergence of unconventional gas. Rising gas prices in the mid-2000s, followed by the downward shift in overall electricity demand in 2008, put a near halt to NGCC expansion. But the slowdown was short-lived.

NGCCs have benefited from both the steady retirement or merit order displacement of ageing coal plants with a long-term fuel cost disadvantage and environmental policy pressures, as well as most developed countries' nuclear new-build prospects effectively being placed on hold. With fracking-enabled supply shifts spreading beyond the US and global LNG flows picking up, the position of natural gas as the primary baseload capacity fuel source has been enhanced. Additionally, natural gas has solidified its position as the 'bridge' fuel to a future emissions-reduced environment.

5.1.2. Small modular reactor

Although the falling cost of gas generation and low emissions relative to coal are driving a medium-term upward shift for natural gas generation plants, nuclear power retains its value as a source of non-intermittent emission-free power. Less certain, however, is the preference of utilities in traditional 'big box' (e.g. 1,000 MW unit capacity) nuclear versus small modular reactors (SMRs) as alternatives to gas generation.

Modern nuclear technology emerged in the early 2000s when established nuclear OEMs such as Westinghouse, Areva and Rosatom invested in 'Gen III' reactor designs with enhanced safety features, longer operating lifecycles and improved thermal efficiency. In the US, for example, high natural gas prices and the prospects for imminent carbon pricing supported talk of a 'nuclear renaissance' in the utility industry planning circles as recently as 2010. Almost a decade later, the results have been mixed as the market for 'big box' nuclear diverged with 85% of 2006–15 capacity adds coming from non-OECD countries, most of which are countries with relatively undeveloped nuclear regulatory regimes and supply chains.

While traditional nuclear OEMs struggled to make scale economies of 'big box' nuclear attractive to plant owners, several companies sought to build off the compact features of nuclear submarine reactors to commercialise SMRs—a subset of 'Gen III+' technologies. While scale economics drove up capacity footprints for 'big box' designs, modular unit offers potentially comparable levels of cost savings.

5.1.3. Distributed generation

While natural gas and nuclear alternatives battle for their share of future utilities' baseload generation portfolios, a more fundamental disruptive trend is gaining popularity as distributed energy generation technologies increasingly become economical for utility customers. After years of being limited to just a back-up power option during grid outages, in the form of inefficient, high-emission and noisy diesel turbines for customers who place high value on uninterruptible power, distributed generation (DG) is rapidly evolving.

Rooftop solar has rapidly become the 'flagship' DG technology, most notably in Hawaii, California, Spain, Germany and China through a mix of policy support, favourable solar insolation and high retail power costs. While solar photovoltaics (PV) has further cost reduction potential and thus scope for improved commercial positioning, other DG technologies are also rapidly maturing and opening up an array of generation sources (including community solar and wind, and micro-turbines) and size alternatives (from small, premises-based to 20 MW systems). For example, technology advancements, combined with incentives and mandate support, have enabled fuel cells and combined heat and power (CHP) technologies to be deployed in commercial and industrial applications.

DG growth

The key theme for DG solutions of all sizes is that technology improvements, combined with various government incentives to encourage adoption, have driven rapid DG deployment growth at a pace that was not forecast ten years ago. As customers become more comfortable with DG technologies as a whole and R&D investment, scale manufacturing and government incentives reduce costs, the competitiveness of DGs with centralised power generation will expand in some regions.

Disruptive potential

While the long-term opportunity for industry disruption is substantial, the electricity value chain is unlikely to completely shift to DG. Traditional central generation supply sources will continue to provide baseload diversity and be complemented by local sources that provide load-sourced capacity. Customers using premises-based or beyond-the-meter solutions are likely to continue to depend on the central grid for emergency or peak energy use for many years.

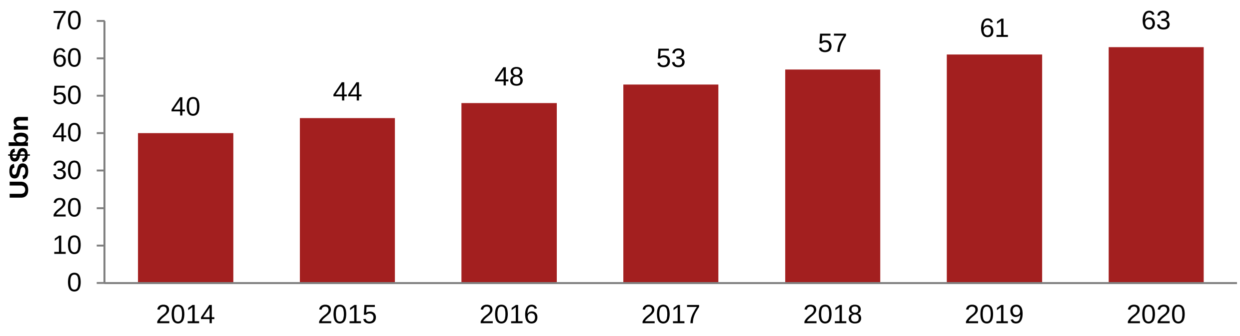
More importantly, the ways that DG sources interact with the central grid are expected to change dramatically as the number of DG uses and configurations continue to expand. For example, DG assets can operate in isolation to provide low-cost baseload electricity or for back-up power. In addition, DG may be tied to the grid and provide extra capacity and help utilities better manage peak load or provide resilience, particularly in localised applications such as campuses or military installations. Wider disruption will nonetheless be constrained by cost and operating factors. For example, capacity factors for DG (e.g. rooftop solar) are much lower than traditional central generation due to less favourable siting, scale economies and intermittency.

5.1.4. Micro and smart grid networks

After decades of limited grid technology evolution and investment focused on expanding access, the emergence of 'smart meters' in the 2000s helped utilities establish a foundation for an intelligent and resilient grid to manage energy flows. More than 600 million smart meters have been deployed to date worldwide, and an additional 180 million are expected to be deployed in the next five years, mostly in the Asia-Pacific region.[11] *However, this is far from global saturation.*

New grid investments focus on distribution automation, transmission modernisation, network operations software and grid analytics, and around 400 billion USD is expected to be invested in grid modernisation by 2020. While the US had been the investment leader in the last decade, China is now a smart grid infrastructure spending leader, with the State Grid Corporation of China set to spend around 31 billion USD to upgrade its provincial grid by 2020. This is indicative of the fact that the total global smart grid investment is on a steady and significant upward trajectory.

Global Smart Grid Market (USD Billion Spend)



Source: Technavio; strategy & analysis

[11] ABI Research. (2015). Smart electricity meters to total 780 million in 2020, driven by China's roll-out. Retrieved from https://www.abiresearch.com/press/smart-electricity-meters-to-total-780-million-in-2/ (last accessed on 19 January 2018)

5.1.5. Energy storage

After decades of limited application, a 'next generation' of energy storage with new technology options and new demand drivers is fast developing. Historically, bulk energy storage in the form of pumped hydro was used to store excess energy from off-peak coal generation and expended to replace costlier natural gas for on-peak generation. From the 1920s to mid-1980s, more than 22 GW of pumped hydro was installed in the US. Currently, around 127 GW has been installed around the world, with Japan, China, the US and several European countries leading in capacity development.[12]

In recent years, the rapid growth in intermittent renewables on the grid has rejuvenated utility demand for energy storage not only to complement renewables but also defer transmission and distribution investment in congested parts of the grid and to improve local frequency regulation. In addition, direct user demand has emerged, partly due to the expansion of high-volume and energy-intensity data centres and other customer segments, thus placing high value on uninterruptible power.

While most historical activity has been in pumped hydro storage, there is a new interest in advanced storage technologies. Billions have been invested in lithium-ion batteries, other chemical batteries, thermal batteries and physical storage technologies such as compressed air and flywheels, resulting in accelerated performance and cost reductions. Lithium-ion battery technology costs, for example, are projected by the US Department of Energy to fall by over 10% per year over the next seven years.

5.1.6. Electrical vehicles

Since the release of the EV1 by a motor giant in the 1990s, alternative vehicle propulsion advocates have touted a robust market opportunity for electric vehicles (EVs). However, market realities have repeatedly failed to meet robust forecasts due to customer 'range anxiety', periodic spells of low fuel prices, lack of charging infrastructure and unattractive model options. For a number of years after some big name launches in 2010, there was a lull in new EV launches from major automobile manufacturers.

However, the entry of new players has helped spur interest from car buyers to consider EVs over more conventional options. However, expected new launches from most major automobile manufacturers, which believes hydrogen power vehicles will win over EVs in the long term) offer renewed hope for the EV marketplace. Major global automobile players are expected to launch more than 20 different EV models in the next 24–36 months. EVs currently make up less than 0.1% of total global vehicle stock but sales are expected to increase tenfold from 164,000 in 2014 to 1,695,000 units by 2019. This increased focus on EVs is driven by both supply and demand side factors that are changing the equation on price, performance and value.

On the demand side, policy has been a major driver in countries such as the US (especially California), China, Japan, the Netherlands and other European countries which have created EV-specific mandates that provide national and regional tax credits, incentives related to charging stations, dedicated highway lanes and other subsidies or supporting measures. More aggressive charging station build-outs help overcome a key barrier to EV success—charging infrastructure density, leading to customer willingness to go electric.

In addition to these mandates and subsidies, countries are increasingly setting more challenging fuel economy and greenhouse gas emission targets at fleet and vehicle levels. Automobile manufacturers are forced to increase the percentage of zero and low-emission vehicles in their portfolios to meet these targets. The fallout from one of the major manufacturing company's vehicle software scandal in 2015 and the apparent demise of 'clean diesel' further strengthens EV prospects. Still, the 2014 and 2015 oil price decline reversed much of the progress on the total cost of EV ownership relative to traditional internal combustion (IC) vehicles. Growth in the numbers of sustainability-conscious and more affluent consumers partially offsets these economic factors. On the supply side, the costs of batteries have also declined significantly. For example, the average costs for lithium-ion batteries declined from around 1,000 USD/kWh in 2010 to 600 USD/kWh in 2014 and is expected to reach 100 USD/kWh by 2020. In fact, some analysts believe that a few market leaders may break the 100 USD/kWh barrier a few years earlier.

[12] Carnegie, R., Gotham, D., Nderitu, D., & Preckel, P. V. (2013). Utility scale energy storage systems: Benefits, applications and technologies. State Utility Forecasting Group.

5.1.7. Beyond the meter

During the late 2000s, many energy management start-ups failed to live up to the hype that accompanied venture investment and the millions of smart meter deployments. However, although cost management alone has not been sufficient to drive high demand for these services, current residential, commercial and industrial customers are increasingly interested in choice, control, comfort, convenience and collaboration. In particular, customers are expanding their interests to include the vision of 'connected homes' and 'smart facilities' that integrate energy controls with other premise or site functions.

To address these needs, several technologies that support energy monitoring, measurement, visualisation and control have emerged to enable the functionality long envisioned by the industry. Advance metering infrastructure (AMI) deployment and national-level reporting standards such as the US 'green button' initiative have helped customers view and understand energy consumption in real time.

Load disaggregation technologies provided by companies are helping customers understand their base load and appliance load to optimise energy consumption. Expensive and dedicated in-home displays for energy monitoring are being replaced by software applications on smartphones. Further, 'big data' processing and data visualisation technologies have become much more affordable and accessible. Better networking has allowed sensors to proliferate in more wireless devices, enabling more functionality and a 'pathway' to connected home functions envisioned by smart home providers.

5.2. Customer expectations

New expectations and possibilities are leading to a shift in the wider strategic and customer context in which energy companies operate. These expectations and possibilities are opening up in a number of different directions. Regulatory expectations across the world are changing, with far-reaching energy transformation policies expected in some countries and significant momentum about such policies gathering in others. Business models are changing and becoming more customer-centric and reliant on customer interactivity. Further, customer expectations are also changing as the immediacy, ease and control of wider online digital retailing becomes the norm. All these changes are being underpinned by technological innovation that is transforming the power choices of people and the way the energy system can be managed.

In the industrialised world, the utilities sector will always find itself trying to economise and innovate—two goals that might seem to conflicting but actually work in harmony. The rise in demand and, consequently, revenues would be consistently lower than general economic growth while the customer expectations from utilities would be to innovate.

An array of changes are expected:

- Older equipment being replaced with newer, and more efficient stock
- Efficiency standards getting implemented
- Technology change occurring, particularly in mobility, lighting and other appliances

Demographic and economic factors driving this trends will include slowing population growth and shifting the economy towards less energy-intensive industries.

Offsetting these trends will lead to a surge in demand in the offerings of new utilities. Innovations in technology such as new storage battery options and smartphone-based thermostat apps are advancing at a pace that has surprised developers and adopters alike. Further, customers have also begun asking for these products. To meet that demand, industry leaders will need to integrate those innovations into their operations and infrastructure as rapidly as they can.

Digital technologies are evolving and customers are quick to adopt them. Both business and consumer energy users are clear about their expectations. They want to reduce their consumption and they know that technological controls and data analytics can help them do it.

For example, customers are increasingly interested in managing their energy use patterns. Manufacturers and industrial firms are monitoring heating and cooling equipment performance with intelligent sensors that can indicate malfunctions, anticipate and prevent disturbances, or signal when major maintenance is needed. Owners of commercial buildings are installing energy monitors to help gauge variations in consumption and predict future fuel requirements.

Companies pursuing energy efficiency have two long-standing goals—gaining a competitive advantage and boosting bottom lines, and one relatively new one: environmental sustainability.

New energy-related technologies are also beginning to trickle down to the residential sector. To be sure, the initial response to such technology was weak. In a May 2016 PwC survey of energy consumers in the UK, 72% of respondents said that they were unlikely to use fully smart home technology before 2020. 13 They also said they were unwilling to pay for it. However, the rapid proliferation of smart home devices such as Amazon's Alexa and Google Home could change consumer attitudes quicker than expected. The same survey, for example, found that 81% of people with smart heating devices noticed a positive effect in the daily running of their home.

Another recent study in which PwC surveyed industrial, commercial and public sector energy users in the UK found an even higher level of interest. Respondents indicated that they trusted utilities to deploy smart building solutions in their business over and above all other vendors, including engineering and technology firms. Utilities have a limited window of opportunity to engage with this trust and establish their new business models because rivals from other industries are rapidly building their capability and credibility with customers.

A solution might lie in 'retailisation', which is the development of more direct consumer-to-utility relationships, along the lines of consumer banking or online shopping. Early steps might include real-time mobile and digital experiences, energy efficiency audits, home energy management solutions and real-time billing and mobile payments. However, there is still a long way to go. In 2015, only 40% of customers in the US received outage information directly from their electric utilities.

Over time, a broader array of new technologies such as battery storage, micro grids, analytics software, and intelligent substations will find their way into the retailised power grid as utility offerings. New home and office electric power installations are coming to be known as 'gateway hubs' because they do not only provide energy but security, telecommunications links and infotainment. These changes are happening, in part, because a group of manufacturers, start-ups, non-traditional entrants and venture capital funds are focused on bringing technology to the utility sector. Utilities across the sector recognise that their customers expect them to innovate, just as other service providers do, and that old industry boundaries seem much less relevant today.

5.3. Reset on data

Utilities have entered an era of digital connectivity and massive data flows. After more than a decade of deployment of advanced metering infrastructure, the industry is well into the second wave of 'instrumentalising' their operations with the help of data-gathering devices by expanding their data analytics capabilities. This is underway on both sides of the meter, from installing sensors along transmission and distribution networks to measuring energy use and patterns of end users on a real-time and granular level, yielding gains in asset management and performance. These digital advancements will also enable utilities to meet regulatory requirements to provide indications on the quality of their monitoring and analysis of data and notification of 'monitoring alarm failures'.

We expect this digital transformation to persist and yield new operational and customer benefits, along with new revenue-generation opportunities. Looking ahead, we expect utilities to take stock of how they are managing the deluge of data they are collecting. We expect a particular push to improve data quality by 're-architecting' and standardising the numerous and varied grid technologies and software systems across networks. We expect more utilities to take a fresh look at their operational analytics systems and build out formalised programmes to deliver clean, usable data and compatible systems. Such formalised data and analytics programmes can better enable utilities to seamlessly roll out new technology in the years ahead. For

[13] Flaherty, T., Schwieters, N., & Jennings, S. (2017). Managing a revenue downturn while meeting the demands of consumers. 2017 Power and Utilities Industry Trends. PwC and Strategy&. Retrieved from https://www.strategyand.pwc.com/media/file/2017-Power-and-Utilities-Industry-Trends.pdf (last accessed on 1 January 2018)

some utilities, the data-gathering and analysing systems installed over the years are becoming sprawling and cumbersome—a balkanised, non-standardised patchwork. Underlying data is the DNA of utilities, and if that data is not standardised or clean, then it is hard to get value from it.

For utility companies considering a data overhaul, the key questions to ask include:

- Do we have enough manpower for the build-out?
- Are we getting the right data from our assets?
- Are our assets consolidated on compatible systems?

We expect the continued investment and refinement of data and analytics to be a pressing issue in 2017 as utilities 'press the reset button' and craft a unified, formal and sustainable strategy around data collection and analytics, while taking stock of long-term needs from the technology they need to the talent that should be in place to exploit that technology.

Utilities, naturally, are not alone on this path. Traditional suppliers are aggressively leveraging data and the Internet of things (IoT) by layering software-based analytical services upon hardware they supply to utility companies. It's likely that utility companies will increasingly partner with traditional vendors, as well as look to new start-ups to help create data solutions. Most utilities have no shortage of data; however, exploiting the full benefits of that data will be one the biggest and most pressing mandates for the industry. So far, this has been a challenge. Utilities are racing to monitor energy flows and performance data across the entire network. They are also aiming to use the vast amount of collected data to power predictive insights for faster, better decision making and a look around the corner to anticipate change and position the power business of the future.

5.4. New breed of talent—workforce of 2030

A team from PwC UK and the James Martin Institute for Science and Civilisation at the Saïd Business School of the University of Oxford conducted research that begun in 2007, which comprised a specially commissioned survey of 10,000 people from China, India, Germany, the UK and the US. This report provided insights into how people think the workplace will evolve and how this evolution will affect their employment prospects and future working lives.

The shape that the workforce of the future takes will be the result of complex, changing and competing forces. Some of these forces are certain; however, the speed at which they unfold can be hard to predict. Regulations and laws, the governments that impose them, broad trends in consumer, citizen and worker sentiment will all influence the transition toward an automated workplace. The outcome of this battle will determine the future of work in 2030.

The megatrends are the forces reshaping society and the world of work—economic shifts that are redistributing power, wealth, competition and opportunity around the globe; disruptive innovations, radical thinking, new business models and resource scarcity that are impacting every sector. Businesses need a clear and meaningful purpose and mandate to attract and retain employees, customers and partners in the decade ahead. How humans respond to the challenges and opportunities which the megatrends bring will determine the world in which the future of work plays out.

Technological breakthroughs like automation, robotics and AI are advancing quickly, dramatically changing the nature and number of jobs available. Technology has the power to improve our lives, raising productivity, living standards and the average life span of people. It is also giving people free time to focus on personal goals. However, it is also causing social unrest and political upheaval if economic advantages are not shared equitably.

Demographic shifts across the world, with a few regional exceptions, indicate that the global population is ageing, thus putting pressure on business, social institutions and economies. Our longer life span will affect business models, talent ambitions and pension costs. Older workers will need to learn new skills and work for longer. 'Re-tooling' will become the norm. The shortage of human workforce in a number of rapidly-ageing economies will drive the need for automation and productivity enhancements.

Rapid urbanisation, according to the United Nations, will contribute to 4.9 billion people becoming urban dwellers by 2030, which is expected to increase by 72% by 2050.[14] Many of the largest cities around the world already have GDPs larger than mid-size countries. In this new world, cities will become important agents for job creation.

Shifts in global economic power will result in rapid developments in nations, particularly those with large working-age population that is embracing business ethos, attracting investment and improving their education system. These nations are expected to gain the most. Emerging nations face the biggest challenge as technology increases the gulf with the developed world; unemployment and migration will continue to be rampant without significant, sustained investment. The erosion of the middle class, wealth disparity and job losses due to large-scale automation will increase the risk of social unrest in developed countries.

Resource scarcity and climate change will increase the demand for energy and water by 50% and 40% respectively by 2030.[15] New types of jobs in alternative energy, new engineering processes, product design, and waste management and re-use will need to be created to deal with these needs. Traditional energy industries, and the millions of people employed by them will see rapid restructuring.

Together, the megatrends and their impact on the workforce indicate the following:

Pressures on industries facing higher than average employee retirement such as utilities will intensify. This is happening at a time when disruptive technologies require an expanding array of skills more than ever before. Clearly, investing in a workforce that can harness and exploit technologies as they evolve has become a strategic imperative.

First, utilities' existing workforces can benefit from the wider use of mobile and digital technology for greater efficiencies, real-time situational awareness and improved safety. Going forward, field workers can benefit through the use of emerging technologies such as augmented reality (smart glasses or smart helmets), which can aid maintenance and repair and improve the safety of workers by accessing data instantly. Virtual reality can also be adopted for trainings and worker-safety applications; currently, it is being adopted for training workers in dangerous workplace situations such as chemicals plants and oil rigs.

Beyond empowering their existing workforce with digital and mobile tools, utilities are in a race to lure new talent—not only traditional roles such as engineers and technicians but also more important, altogether new talent such as data scientists, app developers, virtual and augmented reality experts, social media specialists, and home automation and IoT specialists. Going forward, utilities will need to adjust to the mindset of millennials.

As power and utility business models expand into to other areas such as energy efficiency products and services, energy storage and distributed power, they will need talent to drive their new business endeavours. Hiring this new breed of workforce is not the only avenue to capture new skill sets. Joint ventures, acquisitions and alliances too are paths utilities could pursue to narrow the talent gap. Others are forging relationships with colleges and technical schools to develop curricula; some are also tapping ex-military talent.

Power and utility companies are finding new ways to tackle knowledge transfer of their aging employees—a perennial and urgent issue for the industry. Companies should view knowledge transfer efforts not as a cost but as an investment. The leadership, particularly in operations, may find the need to double efforts around workforce planning as the waves of retirements continue. However, it is not just about scrambling for new hires; they can get more out of their existing workforce by efficiently allocating talent to the right places in the organisation. Importantly, better workforce management means quick and accurate monitoring of talent shortfalls and finding ways, including turning to third parties, to fill those talent deficits.

[14] United Nations Department of Economic and Social Affairs. (2012). World urbanisation prospects: The 2011 revision. Retrieved from http://www.un.org/en/development/desa/population/publications/pdf/urbanization/WUP2011_Report.pdf (last accessed on XXX)

[15] National Intelligence Council. Global trends 2030: Alternative worlds. (2012). Retrieved from https://www.dni.gov/files/documents/GlobalTrends_2030.pdf (last accessed on XXX)

6. Case study: Transformation in power and utilities

6.1. Disruption dynamics

Disruption in the power sector is just the start of an energy transformation. It's not a question of whether the business models pursued in the sector will change but rather what new forms they will take and how rapidly companies will have to alter course. Companies need to be sure they have fully factored in the megatrends and changes discussed in the previous chapter into their strategic planning.

The pace of change will be different in each market and each situation. The important thing for companies is that they assess their strategy and implement the changes they need to make in time or, even better, ahead of time. Many of them have already reset their compasses and have changed their priorities and roles. However, will this be enough and what more needs to be done?

We see five areas in which disruption is having an impact and where it will be important for companies to assess their strategies:

- Customer behaviour
- Competition
- Production service model
- Distribution channels
- Government and regulations

Together, these areas set the context around which future markets and business models will be framed. It is possible to identify developments for each area that are currently happening and which, if accelerated, could intensify disruption dynamics.

6.1.1. Customer behaviour

We're already seeing a gradual erosion in the revenues of power utility companies as distributed energy is gaining a strong a foothold. Some commentators go so far as to predict that customers will be saying 'goodbye to the grid' in the future. In some places, it is already happening. Significant changes in the economics and practicalities of self-generation and storage are needed for such a scenario to occur on any kind of scale.

However, even if customers stop using the grid, power utility companies face the prospect of playing the role of providers of secondary or back-up power to customers. Instead, they could become part of the change by being more active participants in the self-generation market, providing advice on equipment, metering and using the opportunity to secure more of the home and business services space.

The growth in self-generation can create a reinforcing dynamic. Along with the decline in revenues to decentralised sources, there is also the impact of cost pressures on the centralised system which, in turn, reinforces the movement to decentralisation. Some players in the industry have been pressing for new regulatory policies to allow cost recovery in the recognition of utilities being left as the fixed cost of the grid shrinking the revenue base. However, as one academic study points out, 'in the short run, these steps very well could insulate the utility from solar PV competition but at the same time create substantial medium- and long-term risks, including those of customer backlash, deferral of adaption, and stimulation of enhanced competition".

In terms of both regulatory and customer relations, utility companies need to align their ambitions with those of their customers towards the future of new energy, ensuring their services are relevant to and cost effective for as many customer situations as possible.

6.1.2. Competition

Energy transformation is shifting the opportunity for good margins into new parts of the value chain. However, lower barriers to entry in these areas of the value chain and the need for new capabilities mean that there is the prospect of existing companies being outflanked and outpaced as more nimble and able competitors seize key revenue segments.

New roles for companies have come into view. In a distributed energy community with its own micro grid, players other than power utilities can play an energy management role. This could be for local systems such as transport networks, residential communities or industrial communities.

For example, distributed energy is a key focus both for incumbent power utility companies and for new entrants. It's a big market space that is worth tens of billions of dollars and one that covers a wide spectrum of opportunities, from energy controls and demand management activities that save energy, to local generation, both small scale and larger-scale, embedded in own use or local networks, through to distributed storage that can shift loads or, ultimately, ends grid dependency.

Engineering and technology companies such as GE, Siemens and Schneider Electric have long been important players as equipment providers in larger-scale segments of the distributed energy market. The growth and extension of distributed energy is likely to blur the boundaries between such companies and the power utility sector, both at the customer and community levels.

Demand management services are another key area and we already see some companies in the UK providing services to industrial and commercial clients, offering demand reduction strategies that they claim might typically see larger businesses reduce their electricity bills by around 100,000 GBP.

In addition, companies seeking to explore opportunities in home and online services, as well as future smart grid and distributed energy provision. 'The battleground over the next five years in electricity will be at the house', David Crane, CEO of NRG Energy, told Bloomberg Businessweek. He further added, 'when we think of who our competitors or partners will be, it will be the Googles, Comcasts, AT&Ts who are already inside the meter. We aren't worried about the utilities because they have no clue how to get beyond the meter, to be inside the house.'

6.1.3. Production service model

The production service model of centralised generation and grids is being joined by a much more disintermediated and distributed model. New supply sources requiring centralised infrastructure, such as offshore wind, are becoming on-stream. However, the danger for utilities is that other assets and infrastructure are left stranded. The centralised infrastructure that has long been a source of strength for the industry can be a source of weakness vulnerable to market, policy or disaster risk. Further, we're seeing all three of these risks currently play out in Europe, the US and Japan.

In Europe, the changing economics of generation brought about by a combination of the rise of renewables, the collapse in the carbon market and cheaper international coal prices has left gas generation out of the market. Even modern plants, completed as recently as 2013, have had to be temporarily mothballed and many others have been taken out of the market more permanently. In total, from 2012–13, 10 major electric utilities (EUs) announced the mothballing or closure of over 22 GW of combined cycle gas turbine (CCGT) capacity in response to persistently low or negative clean spark spreads, of which 8.8 GW was either built or acquired within the last 10 years.

Disaster risk led to all of Japan's nuclear reactors being gradually taken offline after the 2011 Fukushima disaster, which remained offline till 2014. In Germany, the reaction to Fukushima was to begin to phase out nuclear power altogether. Official policy in Japan is to bring plants back into operation, with the first restart expected to be announced in late 2014 as and when the atomic regulator deems new stricter safety standards are being complied with. However, opinion polls have consistently shown that a majority of Japanese are opposed to restarting reactors and nuclear assets are unlikely to regain the same role in Japan's energy system as they had before Fukushima.

In the US, one can draw a direct line from environmental policy to the stranded asset risk faced by many of the country's coal generation plants. Coal-fired power plants are subject to the Mercury and Air Toxics Standards (MATS), which require significant reductions in emissions of mercury, acid gases and toxic metals. The standards are scheduled to become effective in 2015 and 2016, with generators needing to install costly pollution-control equipment if they want to keep their coal plants running. The US Energy Information Administration expects about 60 GW of coal generation to shut down between 2012 and 2018—a reduction of about a fifth to previous coal generation. A further threat to coal comes in the form of the proposed Clean Power Plan, which will require carbon emission from the power sector to be cut by 30% nationwide below 2005 levels by 2030.

These developments highlight the risk of over-reliance on a concentrated centralised power generation asset mix. The wrong type of asset mix can leave companies vulnerable to rapid transformation, arising from market or policy forces or the forces of events, in the case of nuclear. Such forces provide a wake-up call, which is likely to accelerate the move to alternative power systems.

6.1.4. Distribution channels

In a digital-based smart energy era, the expectation is that the main distribution channel will be online and the energy retailing prize will hinge on innovative digital platforms to secure the energy automation, own generation and energy efficiency customer space.

Many companies are already shifting their positioning to cluster energy management offerings around a central energy efficiency and energy saving proposition and are using new channels such as social media to engage with customers. However, do power utility companies risk losing out to new entrants from the world of online data and digital technology?

A risk for energy companies is that their distribution channel to end customers becomes disintermediated in ways that are not dissimilar to what has happened to incumbent publishers and booksellers with the advent of Amazon. Not only is the channel to market for incumbents dominated by the new platform but the actual demand for product is eroded as the platform acts as an aggregator for self-publishing and second-hand sales. Further, the offering is now much wider than just books, with the combination of a trusted brand and sheer presence that provides a marketplace and introduces consumers to a wide range of product providers.

Smart grids, micro grids, local generation and local storage all create opportunities to engage customers in new ways. Increasingly, we are seeing interest in the power sector from companies in the online, digital and data management world who are looking at media and entertainment, home automation, energy saving and data aggregation opportunities. In a grid-connected but distributed power system there are roles for intermediaries who can match supply and demand rather than meet demand itself.

A key consideration for incumbent power utilities is if their brands are perceived as being part of the past that is being broken away from rather than the future for customers. An energy saving or demand management proposition may be perceived as more credible coming from a new entrant rather than an incumbent; therefore, the use of the brand needs to be carefully considered.

Another important challenge for companies arises from the need to be experts at managing data in a smart home, smart city and smart company environment. Along with data from smart devices and the grid, additional layers of information about demographics, behaviour, customer characteristics and other factors will often be required to best exploit data opportunities. Many power utility companies already use sophisticated data analytics for customer segmentation purposes, which can be built on and supplemented by enhanced analytics, big data from social media and learnings from other industries.

6.1.5. Government and regulation

Energy is, by its nature, a key economic and political issue. More than in many other sectors, firms in the power sector depend on the political context for their licence to operate and public trust in their activities is a big factor.

The cost of power is an important element in household budgets as well as business and industrial competitiveness. The availability of power is a 'make or break' matter for everyone, and its infrastructure is at the centre of often controversial planning debates.

So, it's inevitable that the activities of power utility companies are never far from the centre of the public and political spotlight. Recent and current events in different countries discussed in the earlier section on the production service model highlight the potential of the public and political will to alter the nature of the business.

The political context shapes the utility business model. Therefore, changes in this context can dramatically impact utilities. This has always been the case but in a more dynamic energy transformation context, political and regulatory decisions become even more significant. The different political approaches to energy transformation in different countries are key to explaining why the impact on fossil and nuclear generation has been faster and more dramatic in Europe compared to elsewhere.

A more dynamic environment also elevates the importance of public trust and perception. Energy transformation is extending the scope for the public to vote with their feet, not just by switching suppliers but by reducing dependence on utility companies altogether.

6.2. Business models

6.2.1. Emergence of a service-based model

Much of this change will start in the business-to-business domain. As enterprise customers focus on reducing their energy consumption and expanding their mix of options, they are creating new opportunities for power utilities. Energy management is a new competency for many of these businesses, and it requires sophisticated help — of just the sort that an electric power or oil and gas utility can provide. Thus, with an eye on future value, customers are proactively turning to utilities and contracting with them for sophisticated energy management services.

Advances in power-sector technology will ultimately extend to all customers. But at first, utilities will direct their emerging technology offerings toward large commercial and industrial customers. In operational settings—infrastructure, large-scale equipment, industrial platforms, and complex assets—advances in energy management can have the greatest impact on reliability and costs.

Many power utilities already maintain active, expertise-driven energy management programs for customers in these key categories. Unfortunately, however, the utilities may lack the skill sets and resources needed to extend them to a broader customer base. Data analytics capabilities, for example, often receive limited funding owing to overall cost constraints. That's likely to change as analytics' value to utilities becomes more obvious.

To capitalize on this emerging market opportunity, utilities need to move beyond the old commodity-based model in which the primary goals were cost-effective supply acquisition, modernisation of industrial process equipment, and total bill reduction. Cost management and basic service will still be important, but they will no longer be central. Power utilities will now need to provide alternative generation sources, energy storage, equipment replacement, sensor-based energy monitoring systems, software-based data analytics, facilities management services, and the infrastructure to back it all up. On this basis, they will expand their customer relationships.

6.2.2. Redefining the portfolio

Utilities are used to providing knowledge and services through a single model: the regulated business. And this tradition may not need to change. Many electric power companies can simply expand out from their regulated business model, increasing their portfolio of offerings to include some that are regulated and some not. But even utilities that operate almost entirely in regulated businesses will have to embrace a new, digitally enabled portfolio of offerings. This is the simplest and most direct path to a service capability that will have increasingly high value in the marketplace.

Numerous utilities will find it difficult to stand up this new business, especially if they try to build all the requisite capabilities to scale on their own. For example, many utilities will need to build a sophisticated capability in real-time business model development, incorporating data analytics and pricing strategies to tailor energy-related services to each major customer's interests, and adapting automatically to changing circumstances; others will require a capability in making good use of innovations such as sensors and storage technology. These may be difficult for utilities to develop on their own. An alternative is to adopt a broad partnering approach that leverages the existing market expertise of others — either other power utilities or key suppliers. This partnering approach can be a first step in a new go-to-market model that positions the utility as part of a broader energy platform.

Several large utilities have already employed an inorganic, M&A-based strategy, identifying and acquiring companies that have an existing brand and market position in energy service management. By buying other companies, these utilities intend to leverage established market presence, existing technology expertise, and broader distribution channels to evolve the customer-facing model that they presently employ.

Whether through M&A, partnerships, or both, choosing energy services management as a growth path means evolving from a basic regulated-utility model to one with more flexibility in market participation, offerings of products and services, risk taking, and other factors.

6.3. Future market models

We foresee a number of market models emerging. Unlike markets for many other products and services, the role of governments is significant given the importance of power to everyday life and economic activity. So the exact market shape for individual countries will depend on policy direction as well as on other local factors such as the extent of competition and customer choice, access to fuel, the nature of existing infrastructure, the degree of electrification and degrees of interconnectedness or isolation from neighbouring territories. And, of course, a crucial factor will be the pace of global technological change.

'Business as usual' with the maintenance of a classic centralised 'command and control' energy system may continue to be an option for some countries, although we expect to see an increased focus on technology and innovation as this model develops. But already over the last two decades or so, many countries have moved away from this 'classic model' and, through a combination of regulator-led and market-led innovation, have created markets characterised by different ownership structures with varying degrees of market liberalisation, customer choice and technology adoption.

Current change has so far, on the whole, been incremental and stopped short of 'transformative change', although many would see aspects of current developments in Europe as transformative. But we believe that, if the pace of innovation leads to widespread adoption of renewable and smart energy technologies, we are likely to see the emergence of a number of new market models. Each market scenario can be described by a unique set of characteristics and illustrates different points along a series of transformation curves. We have considered a wide range of characteristics in developing the scenarios, including ownership structures, the level of adoption of renewable technology, level of deregulation, level of engagement in the wholesale market by customers, regulatory and policy involvement in market structure and operations, use of digital media and the mix of large-scale and small-scale generation.

We outline below four new market scenarios which represent transformative change—a significant shift from where we are today. Power utility companies are unlikely to be in only one of these scenarios but, instead, experience a blend of them with perhaps one being dominant. The most appropriate path for any given company will depend on local, as well as global, factors.

6.3.1. Green command and control

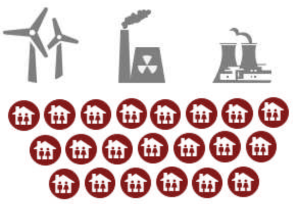
The Green Command and Control market scenario represents a market in which government owns and operates the energy sector and mandates the adoption of renewable generation and digital technology.

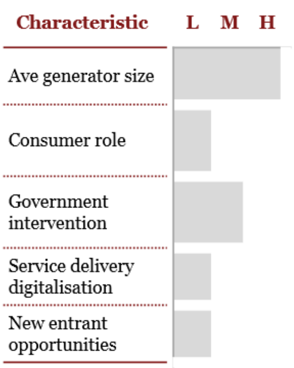
In this scenario, we see vertical integration as the norm (particularly between generation and retail), and investment decisions made as a response to regulatory direction. It is a market in which renewables may be cost-competitive or supported under renewable policy initiatives, whilst stranded thermal assets may remain operational even when private sector owners would have taken closure decisions. Ongoing capital investment would be subject to policy approval and would feed into regulated tariffs.

The market may combine a central grid with distributed networks where the latter support social policy initiatives such as rural electrification or reducing the level of capital investment in major transmission infrastructure. There is likely to be an increased level of investment in distribution networks to support back-up capacity in localised areas of the grid. Consumer tariffs will reflect policy decisions and recovery of stranded costs, and may be smeared across central and distributed networks.

Green command and control has a high degree of Government intervention

Characteristics ...





Drivers ...

Drivers for adoption

- Political focus leading to retention or extension of state ownership and control
- Collapse in investor confidence leading to projected capacity shortfalls and transmission issues leaving Government no choice but to step in and take control
- Complexities of subsidies, wholesale pricing and tariff setting to meet the political agenda lead to independent players exiting the market and concern about viability from larger players

Opportunities for new entrants

- Compliance analysis (for regulator or Government)
- Outsource partners for utilities following green agenda

Impacts ...

What are the biggest impacts of this model on

Generation	• Focus on meeting Government targets rather than own strategic objectives • Operator of stranded thermal assets will support renewable focus • Centrally Managed combined with Transmission
Transmission	• Refocus investment and O&M plans to match Government direction • Regulatory negotiations on tariffs may need to take account of stranded assets • Centrally Managed combined with Generation
Distribution	• Refocus investment and O&M plans to match Government direction • Regulatory negotiations on tariffs may need to take account of stranded assets • Increased investment to support backup capacity
Retail	• Need to design new tariffs to reflect impact of technology and renewables on demand profiles and energy efficiency • Potential for consolidation
Customers	• Reduced choice of retailer • Incentives to reduce energy usage and to improve energy efficiency • Experience positive social wellbeing
Regulators	• Role diminished to focus on customer service metrics and policy implementation under Government direction • More oversight to prevent corruption, drive efficiency and discourage outside investments

Strictly private and confidential

6.3.2. Ultra distributed generation

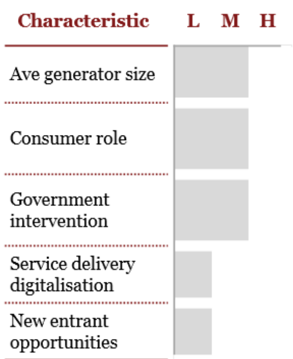
The ultra distributed generation (DG) market scenario represents a market in which generators have invested in distributed renewable generation, with investment decisions based on policy incentives and/or economic business cases. It is a market with full unbundling and strong customer engagement, both in retail and as micro-generators.

Market operation becomes more complex for both transmission and distribution operators, given the increased volume of distributed and renewable generation and the continued operation of large-scale thermal generation, but remains centrally operated and does not fragment. Regulatory oversight and revenue price controls are likely to address efficiency of system operation and equitable treatment of generation in dispatch and system support. In particular, determining which market participants pay for the central transmission grid becomes a critical regulatory question.

We expect to see stranded thermal assets as distributed resources become cost-competitive and, in part, due to the lower flexibility of some distributed generation and the ensuing volatility of wholesale prices. Risks to security of supply increase and we are likely to see continued policy and regulatory intervention to maintain an appropriate level of thermal capacity on the system. Generators with distributed capacity will have increased volumes of operational data to manage as they match their physical and trading positions. Retailers will need to continually review their trading and hedging strategies to manage price volatility and to determine the tariffs that can be offered to different categories of consumers – particularly prosumers who offset their demand through micro-generation.

Ultra distributed generation balances centralised and decentralised generation

Characteristics ... → *Drivers ...* → *Impacts ...*



Drivers for adoption

- Policy support and regulatory obligations for distributed generation and micro-generation
- Increasing tariffs cause more customer to self generate to reduce cost
- Regulatory imposed changes to market mechanisms to enable small scale generation to compete

Opportunities for new entrants

- Aggregators to purchase demand for a large number of customers
- Bundlers – renewables and storage and electro mobility
- Data services – analytics, insights
- Offshore Transmission Operators
- VPP/Independent traders to balance portfolios of small scale generators

What are the biggest impacts of this model on

Generation
- Difficulty in taking large-scale investment risk without regulatory price guarantee.
- Stranded assets due to regulatory price-based merit order, therefore, support required for flexible thermal plant
- Fuel – access/pricing/security in context of the changed demand profile.

Transmission
- More challenging operations due to location of large-scale and distributed generation
- Becomes more complex with aggregation from diverse sources and planning for rest of system
- Higher ancillary service payments to provide back-up for intermittent renewables
- Who pays for grid?

Distribution
- More challenging operations due to increasing proportion of distributed renewables
- Move to local balancing activities using load-management and incentivising local users
- Data management/security due to assets under control that are not their own.

Retail
- Development of new tariffs for active customers with micro-generation
- Increased trading & hedging challenges to manage price volatility
- New types of customers – aggregators

Customers
- DG Owners: Ability to reduce bills through investment in micro-generation
- Non-DG Owners: Increased bills due to subsidies and socialised Tx and Dx charges.
- All: Incentives to improve energy efficiency due to rising bills

Regulators
- Continued policy & regulatory interventions to manage pricing volatility, market power and security of supply.
- New licence regimes/requirements

Strictly private and confidential

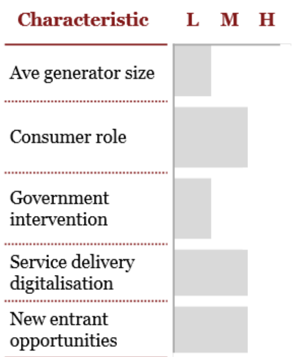
6.3.3. *Local energy systems*

The Local Energy Systems market scenario represents a market in which we see significant fragmentation of the existing transmission and distribution grids and local communities demand greater control over their energy supply, or a market in which a local approach is adopted for serving remote communities.

The market is likely to have undergone full unbundling and experienced strong customer engagement, both as consumers and micro-generators, but recognises the benefits of vertical integration for off-grid solutions. Financial viability of distributed generation and distributed grids is a prerequisite. Strong policy support for fragmentation is required, either to allow local initiatives or to encourage and incentivise local communities and businesses to take control and build and operate their own local energy systems.

Local Energy Systems could lead to stranded assets as generation becomes decentralised

Characteristics ... → ***Drivers ...*** → ***Impacts ...***



Drivers for adoption

- Energy security and lack of control over prices
- Communities demanding that they take benefit of local energy sources
- Electrification of remote communities

Opportunities for new entrants

- Micro grid operations and services companies
- New Local Energy Operator Service Providers
- VPP Operators
- Power to Gas Operator
- CHP Providers
- Integrated Local Systems

What are the biggest impacts of this model on

Generation	• Small and decentralised - Reluctance to invest in large-scale generation due to challenging economics • Stranded assets as role of bulk generation is marginalised.
Transmission	• Lack of investment - Declining revenues as transmission networks become increasingly less used • Potential for new role as interconnector between local energy systems to provide back-up security of supply
Distribution	• New business model. Change in role from distributor of electricity to maintenance of interconnections between micro-grids for security of supply
Retail	• Retailers potentially locked out of markets as communities and businesses elect to self-supply • Restricted to supporting industrial customers with a large, secure, long-term load • Local Retailing. Loss of customers if a community defects (e. g. UK) vs. Gain of customers if new electrification (e. g. Africa)
Customers	• Customers able to execute complete choice of who they buy and who distributes their energy. • Reduction in ability to compare tariffs as these are dependent on the local energy sources – potential for large discrepancies in customer tariffs within a market
Regulators	• Complex environment with many more parties. Critical decision on how to regulate numerous disparate local systems in order to provide customer protection • New role in managing stranded assets which may be mothballed and retained for security of supply • (Africa) Rural Electrification Authorities

6.3.4. Regional supergrid

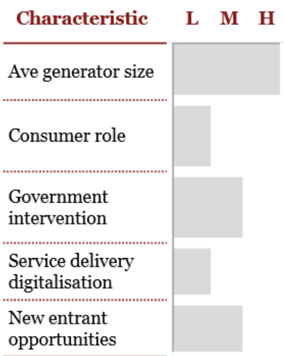
The regional supergrid market scenario represents a market which is pan-national and designed to transmit renewable energy over long distances. It is likely to embrace some degree of unbundling and customer choice. It requires large-scale renewable generation, interconnectors, large-scale storage and significant levels of transmission capacity.

The main challenge that will need to be overcome is regional regulation that applies across borders. National regulators will have limited responsibilities and will be required to oversee national markets within the regional context. In some situations, geopolitical risk will also be a major factor, for example if supply relies on generation located in neighbouring but politically sensitive regions.

We will see a new approach to generation investment decisions, where generators or governments will consider a regional merit order and interconnector access requirements as part of their business case assessment (for example, South Africa and the Democratic Republic of the Congo in the case of the Inga hydro dam project). The emphasis on large-scale renewable generation means that we are likely to see stranded thermal assets, which would require regulatory support to remain available for national or local grid support for security of supply reasons.

Regional Super-grid draws upon renewables across a wider region

Characteristics ... → *Drivers ...* → *Impacts ...*



Drivers for adoption

- Greater government commitment to renewables leading to a focus on policy and incentives
- Benefitting from renewables in a wider region and managing community opposition to siting of renewable plant
- Suppress future security of supply issues

Opportunities for new entrants

- Pan-regional merchant transmission operators
- Pan-regional energy brokerage
- Aggregators
- Regional system operators

What are the biggest impacts of this model on

Generation	• Stranded carbon intensive assets as bulk renewables brought online at unprecedented scale. • High generation cost, high carbon cost suffered. Lowest cost renewable sources will predominate. Low carbon base load (in a capacity market) within territory.
Transmission	• Increasingly interconnected requiring regional control. • Connection of large amounts of grid scale storage. • Significant reinforcement of national transmission infrastructure. • Big winner "new supergrid" • Some legacy assets could be stranded
Distribution	• In the main are shielded from impacts as focus is on local transport of power
Retail	• Power markets become pan-national requiring new trading and hedging strategies. • Increased challenge for retailers to know their customers as regional market • Commodity driven retailers harmed in the long run • Energy Trading and Risk Management more challenging to manage
Customers	• Requirement to fund significant transmission projects through tariffs • More challenging interfaces with retailers on billing issues • Customers who invested in DG could suffer due to later investments in Transmission or Generation.
Regulators	• Cross border regulation and cost recovery/cost allocation issues • Geo-political uncertainty

Strictly private and confidential

7. How utilities need to transform

Utilities may choose from a range of paths to move forward from where they are today. But frankly, business model clarity may be difficult to achieve as a lot of uncertainty exists on how future markets may develop and mature. And multiple models may need to be deployed to meet diverse market needs or specific regulatory structures in various countries, or even jurisdictions. Companies will need to be agile in designing their future business model and recognise that an imperfect view of the future will likely lead to an unfinished product that evolves through time.

Regardless of the business model chosen, utilities need to understand how they can leverage their current business position and the external market to enhance their future competitive positioning. While not always obvious, companies have several levers that can be used to advance their readiness for the future and position themselves for success.

Incumbent companies may not be as nimble or focused as some new entrants. But they have a number of potential advantages with regard to data, policy, relationships, pricing, partnering and regulatory decisions. These can help leverage the successful development of their future business models. At the same time, it's important for companies to recognise that future markets are likely to create networks of participants in new partnerships and collaborations that become a norm of the go-to-market models.

Companies can take advantage of these levers to strengthen their starting point for defining their future roles and for subsequent market participation. For example, utilities already hold large quantities of data that have not been effectively utilised, giving them the opportunity to add value through better utilisation and communication of this data.

Similarly, utilities are a natural collaborator with regulators in the shaping of responsive policies to accomplish public interest objectives, including how to enable customers to achieve greater control and choice. Utilities are also attractive partners to new entrants that wish to offer high-value products but do not wish to support them in the manner customers are used to from their utility.

Utilities will need to determine 'where' it makes sense for them to participate in the future energy market and 'how' they can best position themselves for success. No single business model will be the panacea for utilities. Rather, they will have to be adaptive to the development of the marketplace and the evolution of the connected customer. Just as utilities are unsure of market direction, customers are equally uncertain of what really matters to them in energy decision making.

These gaps between foresight and expectations provide the 'open seas' where utilities can forge new business models that fundamentally reshape the historical relationship with customers and position incumbents for a broader and more value-creating future.

8. Discussion points

8.1. Theme 1: How are you preparing for disruptions in energy market?

a. How do you see the disruptions impacting India and various stakeholders in energy sector?

b. What will be the shifts in energy consumption patterns and the resultant demand for energy resources look like by 2030?

c. What actions are being taken to ensure that our production and supply models are compatible to the emerging energy demand?

8.2. Theme 2: Are you embracing change, new ideas and a bias for action?

a. What innovative paths to growth are you taking to capture and enhance value for your stakeholders in your business plan while building future scenarios?

b. How are you looking at emerging market design, business models and competition?

c. Are investments in people, digital technologies, innovation and data science being made?

d. Are you making your customers 'energy literate' and 'empowered' – sometimes at the expense of short term profitability?

e. Are you making new services offerings to raise customer satisfaction and loyalty while generating revenues (from new sources)?

8.3. Theme 3: How do you see role of governments and regulators?

a. How robust are the existing policies and regulatory framework to usher India into this transformation and providing its citizen with reliable, sustainable and affordable energy?

b. In a federal set up, with some of the energy elements in concurrent list and regulatory set ups at state level, is aligning to one policy vision and local execution a challenge?

c. Large elements of energy sector value chain are owned and controlled by the Government. Does this impact ushering in innovation, competition and choice for customers?

d. How should the regulatory institution evolve to facilitate comprehensive reforms?

Notes:

WEC India (World Energy Council India) is the country member of World Energy Council, a global and inclusive body (estd.1923 with over 90 country members) for thought leadership and tangible engagement in the pursuit of sustainable energy. WEC India functions under the patronage of Ministry of Power and with the support of all energy ministries and leading organisations in energy sector of the country.

India Energy Congress, an apex congregation of energy professionals from across the sector, is the flagship event of WEC India. Now into its 7th edition, the Congress is a joint event of **Ministries of Power, Coal, New & Renewable Energy, Petroleum & Natural Gas, External Affairs and Department of Atomic Energy**. The theme of the 7thedition ,"ENERGY 4.0: ENERGY TRANSITION TOWARDS 2030", will centre around transition led by disruptions that are fundamentally changing the way we live, work and relate to one another. Energy sector is going through a **grand transition** and as sector boundaries get blurred in this transition, the Congress seeks to have insights from Industry leaders on the challenges and response of subsectors.

PricewaterhouseCoopers have been our Knowledge Partner in this endeavour. We thank PricewaterhouseCoopers Team led by Shri Sambitosh Mohapatra, who anchored the process of writing this background paper. We are also grateful for the valuable advice and support from various organisations and individuals for making this paper possible.

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