Capturing value from disruption

Technology and innovation in an era of energy transformation

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Contents

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This report has been written by a team from Strategy& in conjunction with PwC's global power and utilities centre of excellence to assist companies in the fast-changing power utilities environment. It is part of a series of PwC reports examining the various market and business models that could emerge in the power sector, the implications of the new energy ecosystem for customer strategies, and the increasing importance of innovation for success in the sector.[1]

1 http://www.pwc.com/gx/en/industries/energy-utilities-mining/power-utilities/publications.html

Cover image courtesy of Coffice Architecture & Urban Planning (Arch. Francesco Colarossi, Ing. Paolo Colarossi, Arch. Luisa Saracino)

Introduction

In the next 20 years, more innovation will occur in the utilities sector than has occurred to date since the time of Thomas Edison. Whether companies enjoy the promise of this innovation depends on how they embrace the potential of new technology as the vanguard for industry evolution.

The pace of technology-driven change is accelerating well beyond the speed the power sector believed possible. No aspect of the value chain – from upstream generation, through grid and network operations to beyond the meter – is unaffected. The utilities sector will develop very different performance roles, technology landscapes, customer platforms and business models than those that served it over its first 100 years. From a scale-driven, centralised and standardised model, the sector is set to evolve to one that is digital, distributed and personalised.

Technology economics will drive part of this shift and be complemented by changes in customer behaviours that reshape the provider–consumer relationship. Those companies that recognise and embrace this shift will find success as a valued, innovative solutions provider to their customers and partners. Those that fail to recognise this new technology-driven market model will find themselves forfeiting their natural rights to grid enhancement and to the customer relationship.

As today's utility CEOs think about how to reposition their company for success in this rapidly changing industry landscape, they need to work closely with their leadership teams to discuss the following questions:

- How might disruptive technologies impact our business over the next five to ten years?
- What should we do to capture value from these disruptive technologies?
- How do we leverage disruptive technologies to create competitive advantage?
- What can we do to build a sustainable innovation capability that supports new business models?

Identifying strategies to manage these challenges should add significant value, but evaluating the questions at just one point in time is not sufficient. Key assumptions and the market conditions that will affect the discussion will change, so utility executives must figure out ways to conduct an ongoing dialogue. Also, leaders may want to think about potential scenarios for some questions if there is a high level of uncertainty around key elements that greatly influence the future. We will revisit these questions later in this report and share perspectives for utility executives to consider as they think about the impact of disruptive technologies on the future of their business.

In this report we look at the technologies that are likely to drive disruption and change in the utilities sector over the next 20 years and what they mean for incumbents and new players in the market. Much of our focus and examples come from the United States but the trends and changes described are applicable to many other parts of the world as well.

The report is part of a series of PwC initiatives looking at the impact of energy transformation. In an earlier report, *The Road Ahead: gaining momentum from energy transformation,* we discussed the various market and business models that could emerge. This was followed by *Customer engagement in an era of energy transformation* in which we examined how the energy ecosystem is evolving and the implications for customer strategy. In this latest report we look at the scenarios that could arise from the fast pace of technological evolution. We paint a picture of how five possible future scenarios (among many possibilities) could unfold and affect utilities as technology evolution pushes forward. And we conclude with a look at what it will take to win in tomorrow's market and, in particular, the need for utilities to think very differently about how to embrace innovation as a market enabler.

Executive summary

The last 100 years have witnessed an explosion of technology as the industrial revolution progressed into the era of the consumer. Technology development windows continued to shrink while markets grew at increasingly faster rates than occurred in the past. But the power sector has not kept pace with other industries and has been neither a leader nor a fast follower of technology adoption.

The sector has maintained a natural reluctance to 'jump' into new technology without extended periods of testing and evaluation – sometimes lasting decades. But in the immediate period ahead, utility companies will need to completely change their approach to innovation and technology adoption or face becoming increasingly sidelined as a series of transformative waves hits the sector.

The accelerating pace of change

A look back on various technologies that have appeared since the 1960s illustrates the slow pace of technology deployment among utilities. Whether automated generation control in the 1960s or advanced gas turbines in the 1980s, it took 15-20 years for utilities to widely adopt what was available in the market. Similarly, control and digital relays were available for system operations in the 1980s but again it took 15-20 years for this technology to widely take hold in the grid and network. And advanced metering rollout is still a long way off high penetration, even after more than ten years of technology availability.

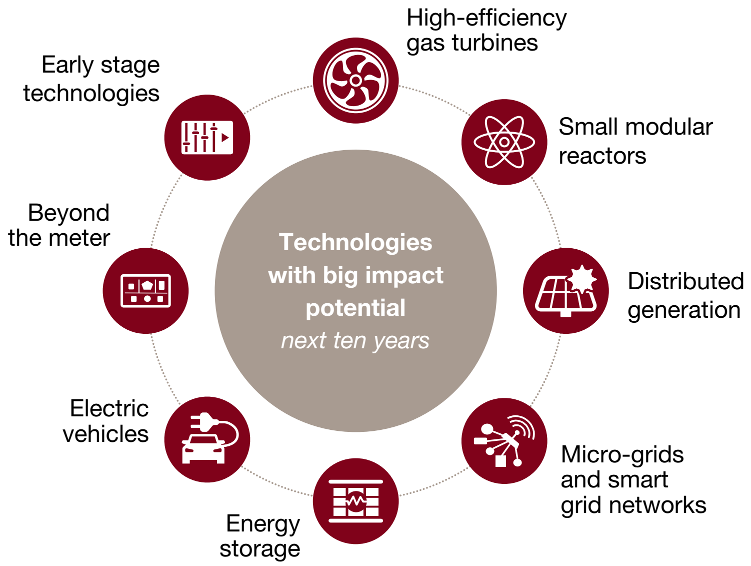
Contrast this pace of adoption to what has happened in new industries over the last several decades. While it took more than 55 years for telephony to achieve 50 million customers, it only took 18 years for personal computers, 15 years for mobile phones and ten years for the internet to achieve the same level of customer adoption. And consider the short time frames for various applications, games and novelty devices to reach similar levels. This now happens in single-digit years as technology-based product and application value is made available to consumers at internet speed.

Disruptive technologies

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 ten years and could have a widespread impact on traditional elements of power infrastructure (see panel). These technologies are discussed in the first half of 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, which included in-depth consultation with 80 recognised international experts from the energy sector and related industries.[2]

2 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.

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



For utilities, this accelerated pace of change that comes with technological change is both an opportunity and a threat. As customers become more aware of technology possibilities that can provide useful applications in their lives, they are quick to seek out these offerings. Customers are not receiving their product and technology knowledge from their utilities; rather, they are obtaining information from non-utility sources on the internet, other customers and non-traditional entrants to the utility grid and customer businesses.

Five future scenarios

What could these technology breakthroughs mean for incumbents and new players in the market? Whether companies are providers of power generation, managers of an electric grid or retailers of power and energy solutions, many of the technology evolutions we discuss could have a significant impact on their businesses. In the second half of the report, we look at how five possible future scenarios could unfold and affect utilities as technology evolution pushes forward.

'Losing touch' – a future where utility companies lose touch with their customers as other players take control of the customer energy hub. Incumbent utilities provide simple delivery of wholesale energy at the cheapest price with an energy 'hub' performing all routine and value-added functions for the consumer.

'Off grid' – the centre of gravity shifts away from the main grid to on-site generation and storage as well as distributed generation attached to micro-grids. The grid becomes more akin to a source of back-up power and utilities face a number of dilemmas on what role to play in a more diversified power system and how to maintain underused and costly power infrastructure.

'Mobile and virtual' – electric vehicles become the norm, creating the need for substantial infrastructure investment and the opportunity to use vehicles as a mass storage source. Local utility networks and circuits face tremendous strain. Utilities have the potential to capture several sources of value from this scenario but face considerable competition from a range of other players.

'Data rich' – ubiquitous, intelligent sensors collect energy flow and performance data across all levels of the network, and regulators require utilities to allow data access to third parties. Value shifts away from traditional utilities toward those who can collect, process, interpret, and convert these data to offer knowledge-based, value-added energy management services to customers.

'Scaled down' – large business customers start to install their own decentralised and scalable generation for their own usage. As technology continues to progress, smaller and smaller commercial and industrial customers migrate toward a new era of 'site-based' generation. Traditional utilities see a diminished role with their larger customers and are not able to avoid disintermediation for their largest load entities.

For each of these scenarios we look at the implications for utility companies and their possible responses. Many of the technological developments add to the real threat of separation between utility companies and their customers. And when customers determine they are willing to consider or outright adopt emerging technology alternatives, they will seek out these products and services from wherever they can. If the sources of this information are those offering the technology or products themselves, rather than the utility, then disintermediation between the utility and its network and its customer is not long to follow.

A new 'technology push – customer pull' era

The utility industry has entered an era of 'technology push – customer pull'. The rate of technology improvement and performance enhancement grows shorter and interest from customers in incorporating technology to improve their lives accelerates faster. When this technology push' and 'customer pull' collide, transformation of an industry ensues, which is precisely where the utilities sector finds itself today.

The ability of the utilities industry to weather the sea change evolution that comes from 'technology push' and 'customer pull' depends on how it responds in the next several years to the challenges that it has begun to face. At a minimum, utilities will need to shorten the time between technology availability and adoption.

The industry will also need to 'raise its game' in communication with its customers so that it becomes the trusted source for technology-enabled products and services. It would also be wise to shift from a defensive posture on technology to an offensive attitude that sees technology evolution as a natural progression of its role and value to customers. How fast the industry is able to do this depends on its view of the pace of technology economics and customer adoption itself, and its willingness to move from being a protector of the status quo to an advocate of market change.

The need to be better at innovation

Utilities will need to think very differently about how to leverage innovation as a market enabler. Innovation hasn't been a major focal point for executive management in utilities companies. Technology advancement has largely come from the OEMs serving the industry. And the innovation that has taken place has generally been directed at selected R&D activities related to generation. Utilities haven't felt a strong need for wider innovation, not seeing it as a capability that the utility industry believed would be required as a table stake for market success. But that's changing fast and companies need to find ways of embedding a culture of innovation into their core thinking.

In the emerging future marketplace, innovation will be a differentiator between those companies that will be recognised as market leaders and those that will simply be 'part of the pack'. Innovators will be acknowledged for their unique insights into their customers, creative approaches to the market, tailored product and service portfolios and distinctive market channels that access traditional and non-traditional customers.

Innovative utilities will be capable of 'trendspotting' within the market and responding with offerings that anticipate and fulfil personal and business commercial needs. They will also be agile enough to rapidly shift their market focus when customer buying patterns and technology evolution cause a change in course. Ultimately, innovation will become a fundamental ingredient of a company's 'go-to-market' strategy. And it will become a means by which to take market space from other competitors and increase opportunities for commercialisation of technologies and market solutions.

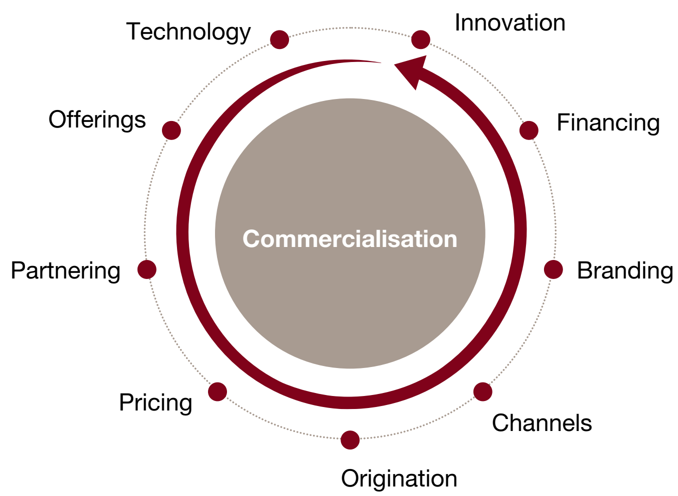
Winning in tomorrow's market

As the pace of technology evolution and customer behaviours changes, incumbent utility roles will need to transform in tandem. From a legacy of gradual acceptance of new technologies to one of rapid adoption of emerging technology and continuous optimisation of business models, the future utilities industry will need to accelerate its own pace of change.

Creating competitive advantage will come from utilities seeking to utilise emerging technologies as a lever to extend existing relationships, foresee future customer needs or create markets for products and services that did not previously exist. This means that executive managements will need to abandon their desire for high degrees of predictability and learn to take and manage greater market entry, business execution and technology deployment risks than they have been used to.

Utilities will need to become adept at growing the portfolio of market-directed ideas. Moving from conceiving ideas to creating commercial value will be one key to success. Commercialisation will depend on blending the right mix of offerings, pricing, channels and partners. Each of these in its own right – and particularly when bundled together – positions a utility to compete effectively in the market.

Figure 2: Strengthening commercialisation – the capabilities that utilities will need



Raising utility innovation performance

Breakthrough innovation: *break-through strategic moves* that create or unlock markets and build the utility of the future, e.g. customer energy management

Advanced innovation: *advanced thinking* that moves the business forward to enhanced market positioning, e.g. asset deployment

Incremental innovation: *incremental gains* within the business driven by an operational focus, e.g. performance execution

A golden opportunity could lie ahead for utility companies that embrace innovation and commercialisation of ideas. Foreseeable technology deployment in just the next ten years will unlock greater value discovery and technology development targeted at energy production, storage, delivery, management and optimisation. Utility companies have the opportunity to transform how countries, economies, producers and consumers alike think about energy, its use and its value. But companies that cannot see through the haze of emerging technology development and applications, or think it is too far away for them or customers to consider today, may find they don't get a second chance to stake out a future for themselves.

Viewpoint

Innovation that is shaping energy's future

Larry Monroe

Chief Environmental Officer and Senior Vice President, Research and Environmental Affairs, Southern Company

The US utility industry has long been involved with research and development in the power and gas sectors. While the historical focus of most companies has largely been on supporting the activities of other research organisations through funding, some companies have led the sector in applied research, creating value for both themselves and the industry as a whole. As a leader in the research, development and deployment of new, innovative energy technologies, Southern Company has committed billions to the pursuit of applicable research and development, particularly in the area of coal generation and carbon capture.

Partnering with the US Department of Energy (DOE) and numerous other organisations, Southern Company manages and operates the National Carbon Capture Centre (NCCC) in Wilsonville, Alabama, which focuses on developing advanced technologies to reduce greenhouse gas emissions from coal- and natural gas-based power generation. Southern Company is also at the forefront of advanced nuclear research and was recently awarded up to US$40 million in grants from DOE to explore, develop and demonstrate "Generation IV" non-light water reactor technologies.

Larry Monroe, chief environmental officer and senior vice president of research and environmental affairs, oversees Southern Company's research and development efforts. With deep insights into the operating challenges facing the industry – whether related to generation or other areas – he is leading Southern Company's broad innovation for the advancement of its enterprise, generating fleet, operating infrastructure and customer base.

Southern Company is leading the way in developing real, innovative solutions that will shape America's energy future. Headquartered in Atlanta, Georgia, and with more than 4.5 million customers and approximately 44,000 megawatts of generating capacity, we are one of the largest utilities in the United States. Since the 1960s, we have actively engaged in and supported research and development across our generation, power delivery and end-use enterprise, with the longstanding emphasis on protecting the environment leading to a current focus on carbon capture and sequestration. We have been fortunate to be involved with the DOE and others in our industry to champion these efforts and to accelerate technology innovation for the customers and communities we are privileged to serve.

A broad innovation scope

While we have been actively engaged with the DOE and our industry in the development of 21st-century coal generation, our focus has been much broader and is growing in scope every day to include battery energy storage deployment, smart grid infrastructure and advanced nuclear. In 2015, Southern Company established the Energy Innovation Centre (EIC) to complement the work within the NCCC and focus on emerging technology becoming available throughout the downstream value chain - for example, electric vehicle charging in the network and smart behind-the meter devices. The stand-up of the EIC further signals our commitment to leading the power industry in providing innovative solutions for customers and in positioning Southern Company at the forefront of technology development and deployment.

The specific focus of Southern Company's research and development and EIC functions is to advance our business capabilities in technology understanding and deployment and engage the broader employee base in technology evolution and customer value creation. We recognise that our customers – whether residential, commercial or industrial – are aware of the technology revolution that is happening around them and are seeking to both understand what it means to them and how they can take advantage of it.

In both areas, we are educating our employee base so they are aware of how our industry is changing and how their roles and interfaces with customers will also evolve. Beyond the obvious value in being at the forefront of the power sector revolution, we believe that enabling our most valuable assets – our employees – is just smart business and will pay dividends to us and our customers in the future.

Extending innovation to customers

As Southern Company continues to explore emerging technologies and further advance their deployment, we will be in position to make these technologies more relevant and valuable to customers. We will also be able to offer a wider range of products and services to our customers that leverage this technology knowledge. On this point, we recently completed the acquisition of PowerSecure International Inc., a leading provider of distributed infrastructure, which broadened our ability to deliver customer-focused energy solutions on a national level.

Southern Company has been committed to fundamental research and development and innovation for decades. Our recent activities illustrate that our long legacy of advanced technology evaluation and deployment will continue and drive our commitment to our industry and to our customers. As we begin a new cycle of technology development and deployment, we look forward to even greater promise in the next 10 years than we have witnessed in many decades.

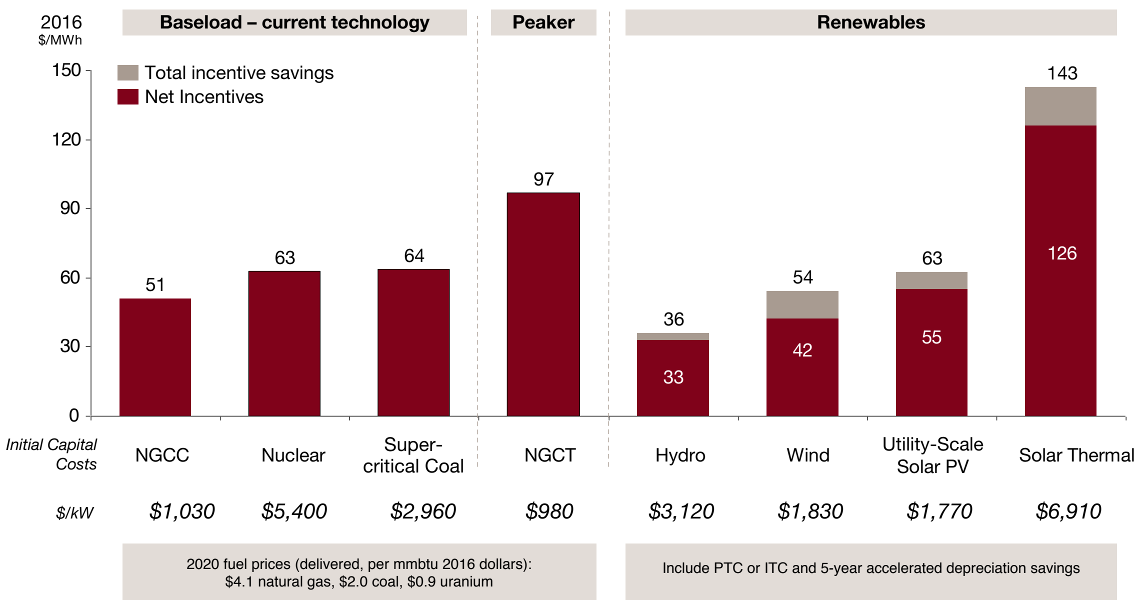
Technologies and disruption

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.

A look at the current technology landscape shows that many non-traditional supply options already exist. But more will develop and costs will continue to decline. *Figure 3* compares the levelised cost (the real per kilowatt hour cost normalised over the assumed operating lifecycle) of selected current generation technologies in the US. This comparison offers a current view into relative performance and cost based on currently available technologies operating in perceived future market conditions.

However, relative economics can vary by region based on local policy incentives, renewables capacity factors, fuel prices, and other factors. Moreover, this view provides only a static look into comparative technology economics, while future decision-making needs to consider how these current costs could be dynamically affected.

Figure 3: Indicative levelised costs of generation technologies



Note: Note: 6% nominal (4% real) after-tax WACC, 2% inflation rate; taxes excluded; $25/ton CO2 starting in 2025; renewables exclude backup power; nuclear includes fuel disposal, site decommissioning, and maintenance capex spend

Source: Multiple industry reports including EIA, SNL, NREL, LBNL, and OpenEnergy; power plant project database; Strategy& analysis

A similar view across technologies a decade ago would have indicated significantly different relative economics than those existing today. Higher natural gas price expectations, solar PV module costs almost ten times higher than current costs, and optimism for Gen III nuclear reactors and potential carbon pricing would have favoured baseload nuclear power and given only niche opportunities for solar and wind across most regions. In contrast, current conditions favour natural gas, wind, and solar, but new technologies, including storage and next-generation nuclear reactors, could reconfigure the playing field again.

Numerous technologies are emerging that could dramatically affect the future of the utilities industry and current costs as illustrated. We focus on those that appear more likely to be broadly commercialised within the next ten years and that could have a widespread impact on traditional elements of the power infrastructure. Several of these technologies are discussed in the remainder of this chapter with a look at their economics and their likely proliferation.

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 aging 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.

Efficiency gains

The increased certainty for gas turbine sales has, in turn, provided business case support for original equipment manufacturers (OEMs) to invest in efficiency improvement innovation. While NGCC turbines from the 2000s build-out reached about 48% thermal efficiency (around 7,200 Btu/MWh), current GE and Siemens products exceed 60% thermal efficiency (around 5,500 Btu/MWh).[3]

Moreover, OEMs are investing in next-generation 'high-efficiency turbines' which promise further efficiency improvements comparable in relative magnitude to the introduction of combined cycle technology. Innovation in temperature tolerances through advanced ceramic coatings, advanced metallurgy and improved blade cooling systems could bring efficiencies up to 65% or 5,250 Btu/MWh.[4] The result would be further improvements in dispatch costs and, in turn, a further reinforcement of gas' advantage relative to coal and nuclear alternatives.

A more complex business case

The gradual evolution of turbine efficiencies, combined with falling fuel prices, has so far made the business case for utilities investing in currently available turbines a relatively easy sell – especially when compared to coal and nuclear alternatives. The introduction of high-efficiency turbines (65+% efficiency), on the other hand, is likely to bring correspondingly higher capital costs (and perhaps maintenance costs) and complicate buying decisions. When comparing newhigh-efficiency turbines with currently available turbines, upward capital cost pressure will need to be lower on a levelised cost basis than corresponding efficiency improvements.

OEMs are keenly aware of this trade-off, and when the technology becomes commercially available, are likely to price their products accordingly. Traditional NGCCs in low gas price markets are well positioned as a preferred generation option relative to coal and, in most cases, nuclear. The exception is when large subsidies are available, fuel diversity outcomes are more highly valued or 80-year lifecycles are considered. High-efficiency turbines, on the other hand, will more likely be competing with their less efficient predecessors and utilities are poised to benefit from resulting technology design innovation and OEM pricing competition.

OEMs are investing in next generation high-efficiency turbines which promise further efficiency improvements.

3 US DOE FE Advanced Turbine Programme: Suggested Next Steps for UTSR, DOE National Energy Technology Laboratory, 21-23 October 2014. www.netl.doe.gov/File%20Library/Events/2014/utsr-workshop/wed/Dennis-Final.pdf

4 A Look at GE's New State-of-the-Art Gas Turbines, Greentech Media, 7 April 2015. https://www.greentechmedia.com/articles/read/ges-new-gas-turbines-are-state-of-the-art-but-are-we-getting-too-cozy-with

Small modular reactors

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 long-term 'option' value as a source of non-intermittent, emission-free power. Less certain, however, is utilities' preference for 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, spiking natural gas prices and prospects for imminent carbon pricing supported talk of a 'nuclear renaissance' in utility industry planning circles as recently as 2010.

Dampened demand for big nuclear

A decade later, 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[5]. Moreover, a significant share of China and eastern Europe reactor deliveries has come from Chinese and Russian suppliers.

Western and Japanese suppliers are left struggling to pay back sunk investments with 'slivers' of demand – initial 'first of a kind' (FOAK) units in China and a handful of units in the US, Europe and elsewhere. Sluggish 'big box' nuclear take-up not only directly slows investment payback but also prevents vendors from moving beyond FOAK deployment challenges. Significant cost and schedule deviations in initial deployments – from Finland, France and the US – are further dampening nuclear new-build prospects in a low gas price environment.

The potential of small reactors

While the 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, the potential for modular unit addition offers potentially comparable levels of cost savings.

Moreover, three specific SMR differentiators may enable 'incremental' customer adoption relative to 'big box' nuclear:

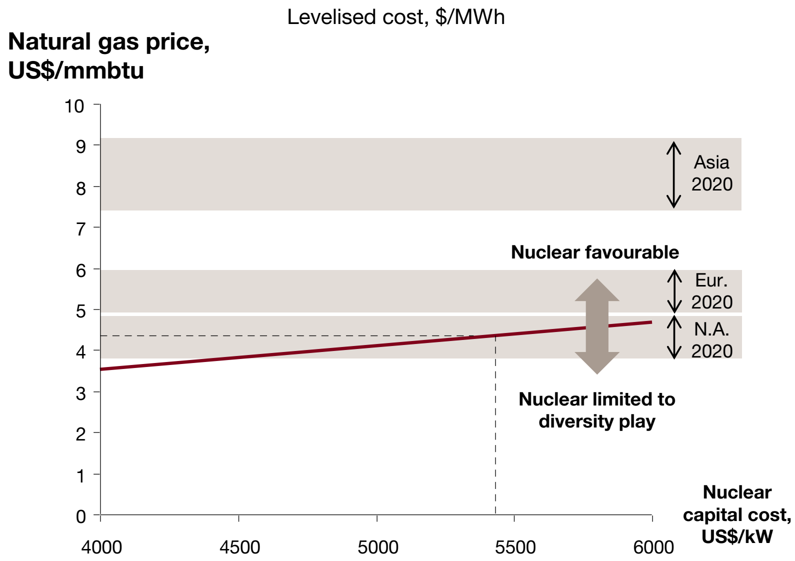
(1) reduced capital needs widen the number of utility companies (or governments) able to finance nuclear;

(2) lower capacity sizes (50MW to 330 MW) more easily allow for scale-up flexibility to match load growth, and;

(3) the 'load-following' attributes of some designs ease pairing with intermittent renewables.

A mix of new commercial nuclear participants are pursuing SMR designs – from public entity offshoots such as NuScale and the Korean Atomic Energy Research Institute (KAERI), to diversified industrial players like Babcock & Wilcox (B&W) and Holtec. No designs have been licensed and commercial prospects are mixed, but NuScale, with the support of over US$200M in US government funding, is targeting a 2020 licence and 2023 first unit completion[6].

Figure 4: Nuclear vs. natural gas combined cycle (NGCC)



Note: Gas prices and capital costs in real 2016 dollar terms; future natural gas price ranges are estimates based on multiple industry perspectives with Asia low end based on US futures plus liquefaction / gasification and transport costs; capital costs indicate overnight cost basis

Source: Multiple industry reports including EIA, CME Group, Cheniere / Wood Mackenzie, Platts, Bloomberg, Strategy& analysis

5 World Nuclear Association, operating plant database.

6 World Nuclear Association. Small Nuclear Power Reactors summary.

Establishing the business case

However, unlike the declining renewables and storage cost curves, SMRs share some of the upward cost estimate trends that characterise the 'big box' options. Even moderately rising n^{th}-of-a-kind (NOAK) capital costs would challenge project economics in low natural gas price economies (especially if carbon pricing settles at or below around US$25 – 30 per ton CO_2). A range of factors may point to stronger SMR demand prospects in emerging countries. Specifically, utilities with moderate load growth potential, mid-scale capacity replacement needs, demands for lower emission alternatives to coal, and/or higher-cost natural gas import reliance would be more inclined towards SMR take-up.

Utilities seeking a zero emission baseload alternative to natural gas should keep a sharp eye on current SMR pilot projects. For example, the eventual outcome of the UK's recently announced SMR competition and KAERI's potential Saudi Arabia deployment will provide a yardstick for future technology adoption. Even these few data points, however, will not be fully reliable indicators. The challenge will be projecting from the FOAK capital costs what the next and then the NOAK costs will be. If a nuclear vendor (SMR or big box) can provide capital cost certainty of US$5,000 - US$5,500/kW[7], then they would be within the levelised cost parity range with even US natural gas plants. The operational and financing benefits afforded by modular capacity addition widen utility value-risk trade-offs and, in turn, make SMRs a viable part of more utility portfolios. The business case is even stronger in growing, higher natural gas price markets such as East Asia and Europe.

Distributed generation

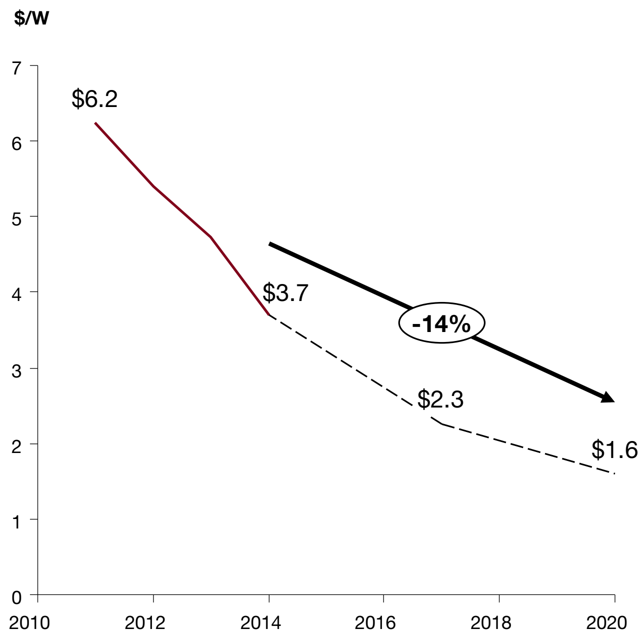
While natural gas and nuclear alternatives battle for their share of future utilities' baseload generation portfolios, a more fundamental disruptive trend is accelerating as distributed energy generation technologies increasingly become economical for utility customers. After years of being limited to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

Advantages of DG

Although scale economies have typically constrained DG take-up, these are partly offset by several inherent configuration and operational advantages. Firstly, the typical smaller project size demands less up-front capital, which benefits areas of the world where capital for large infrastructure projects is scarce. Secondly, DG solutions can be more easily sized to match demand with supply and installed quickly (in days or weeks) compared to years for larger utility-scale power stations. Both of these benefits are useful when supply must be ramped up quickly. Finally, since DG technologies are installed in close proximity to demand, they offer a better level of control and operational advantages to the grid. Several DG technologies are poised for stronger commercial viability due to declining technology component costs and improving operations performance. For example, despite already benefiting from five years of 16% year-on-year cost reductions, rooftop solar economics are projected to improve further through balancing of system cost reduction.[8] In addition to technology improvements,

Figure 5: Residential solar PV system costs in the US



Source: Source: Credit Suisse, DOE, SEIA, Strategy& analysis

7 Strategy& analysis – proprietary levelised cost of electricity modelling.

8 Credit Suisse, NREL, Lazard, DOE, SEIA, Strategy& analysis.

'soft costs' for acquiring customers, permits, installation, and financing are subject to further decline.

Critically, the emergence of rooftop solar as a viable complement to grid-supplied power for users in certain markets is helping open the door to DG more widely. Firstly, the availability of rooftop solar has helped stimulate customer interest in mitigating dependence on grid-sourced power. Secondly, the availability of excess residential rooftop solar power is creating an opportunity for customers to move from being just energy consumers to energy 'prosumers', selling excess power produced back to the grid under often favourable net metering rules. Thirdly, as solar developers such as SolarCity create business models, e.g. leasing, that help overcome financing constraints, DG becomes more accessible to a broader set of customers.

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 lower costs, DG's competitiveness with centralised power generation will expand in some regions.

Looking ahead, global DG deployment is projected to grow at above 10% CAGR in the next few years – growing from a US$76bn business in 2014 to US$126bn by 2019. By 2019, solar is expected to dominate with a 65% market share, followed by CHP at 22% and fuel cells at 6.7%.[9] GE estimates that distributed power capacity additions, including gas turbines, reciprocating engines and solar PV in electric, power, mechanical drive and propulsion applications, will grow from 142 GW in 2012 to 200 GW in 2020, increasing from US$150bn to US$206bn in annual investment.[10]

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 continues to expand. For example, DG assets can operate in isolation to provide lower-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, like campuses or military installations. Wider disruption will nonetheless be constrained by cost and operating factors. For example, capacity factors for some distributed generation (e.g. rooftop solar) are much lower than traditional central generation due to less favourable siting, scale economies and intermittency.

Even if not poised to replace grid-based power, these smaller-scale supply sources are putting pressure on incumbent market positions and portfolio competitiveness. For example, even small amounts of DG penetration in the US could wipe out the majority of expected commercial and residential load growth, a key historical driver for utility earnings[11]. Analysis based on overall demand growth and PV installations indicates that distributed PV reduced 2013 expected load growth in California and New Jersey by 47% and 42% respectively[12].

Utility responses

It is clear that relying on the traditional model where up to 80 – 90% of bills are variable would be detrimental to many utilities. High levels of renewable penetration in Germany have driven power prices negative when renewable energy generation accounts for a large percentage of power generation. This trend, combined with over-investment in fossil generation capacity, has significantly affected the financial performance of several European utilities, forcing them to shutter or sell underperforming assets and rethink their business proposition for customers.

Going forward, utilities will need to closely monitor both the technology cost trajectories and policy dynamics to assess the timing and magnitude of disruptive threats and prepare their strategic response. In many regions, rooftop solar can be expected to reach parity with retail rates in the next decade. Clearly, utilities will continue to play an active role in the marketplace, whether directly through offering on-premises DG options to their customers or indirectly by providing alternatives such as community solar. Given the challenges of defining new regulatory, customer and innovation strategies to help mitigate customer loss to DG, it is not too early for utilities to start planning proactive responses now.

The long-term opportunity for industry disruption is substantial.

9 Global Distributed Energy Generation Technologies Market, 2015-2019, Technavio. 31 December 2014.

10 Rise of Distributed Power, GE. 2014

11 GTM How to Really Disrupt the Retail Energy Market With Solar, April 2014 - http://www.greentechmedia.com/articles/read/Slide-Show-How-to-Really-Disrupt-the-Retail-Energy-Market-with-Solar

12 Ibid.

Micro-grids 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 in the next five years, mostly in Asia-Pacific.[13] Yet this is far from global saturation.

New grid investments focus on distribution automation, transmission modernisation, network operations software and grid analytics, and around US$400bn is expected to be invested in grid modernisation by 2020.[14] While the US had been the investment leader in last decade, China is now a smart grid infrastructure spending leader – with the State Grid Corporation of China itself set to spend around US$31bn to upgrade the provincial grid by 2020. Total global smart grid investment is on a steady and significant upward trajectory *(figure 6)*.

As the technology for smarter, more resilient grid management improves, it will also enable the development of more self-contained micro-grids *(Figure 7)*. We use the term micro-grids in this context to describe small, self-balancing networks that have the ability to break apart from the larger grid for autonomous operation and then seamlessly re-combine to function as part of the whole on demand. These micro-grids have their own generation, e.g. community solar, and/or storage capacity that can complement the traditional supply of energy. The technology deployed in micro-grids is not too dissimilar from that discussed elsewhere in this section.

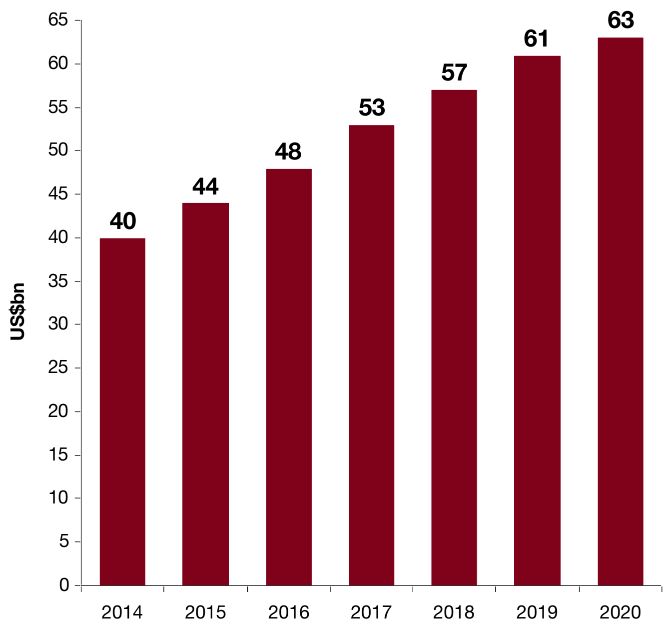
The customer appeal of micro-grids

Customer interest in micro-grids has risen due to handful of high-profile extended outages, such as occurred in New York and New Jersey following Hurricane Sandy.

Micro-grids appeal to customers with large, concentrated load or critical infrastructure that have specific needs not fully met by the current grid, whether they be enhanced reliability, service in remote locations or increased usage of renewable energy. With this combined source of supply and protected delivery network infrastructure, customers may avoid or minimise the impact on power availability of all but the most severe disasters.

Globally, the micro-grid market is expected to represent an industry of US$8.4bn by 2020 and US$12bn by 2030, with about 40% of capacity in campuses and commercial or industrial locations and 40% in military or remote area applications.[15] In the US, the Department of Energy recently announced dedicated funding to advance the design of community-scale micro-grids. But growth potential will depend on costs. It is far from certain as system costs, and in turn the share of customers willing to pay some premium for reliability, remain uncertain. Moreover, even high-end forecasts for growth do not represent a near-term disruptive threat to utility business models.

Figure 6: Global smart grid market (USD billion spend)



Source: Technavio; Strategy& analysis.

13 Smart Electricity Meters to Total 780 Million in 2020, Driven by China's Roll-out. ABI Research. 02 June 2015.
14 Global Smart Grid Technologies and Growth Markets 2013-2020. GTM Research. July 2013
15 Remote Microgrids Will Surpass US$8.4 Billion in Annual Revenue by 2020, Navigant Research, 25 September 2013.

Implications for utilities

Micro-grids can be beneficial to utilities, as they can reduce the need for capacity investment for peak demand. However, self-contained micro-grids are a long-term threat to utilities, particularly if they can become broadly cost-competitive with utility rates, as customers will rely less on traditional energy sources delivered through existing transmission and distribution networks. Continued micro-grid adoption could open multiple pathways for utilities, from taking on a role of micro-grid developer for customers inside (or outside) the service territory, to playing a marketplace role. In the latter, integration and coordination of supply and demand of electricity across dozens or hundreds of micro-grids would become the key function, while physical operation and maintenance activities are minimised.

A lack of common standards across the hardware and software required for integration is a barrier to the development of a common 'plug and play' platform by suppliers and thus the customer adoption of micro-grids. The OpenADR Alliance has standardised many elements for demand response, but there are other controls that operate under different data standards. Also, as most utilities have added new systems and platforms on top of their existing infrastructure, the system architecture has become a patchwork of hundreds of systems that lack a clear structure. These complexities make it difficult to implement analytical systems for coordination and control of a multi-faceted micro-grid.

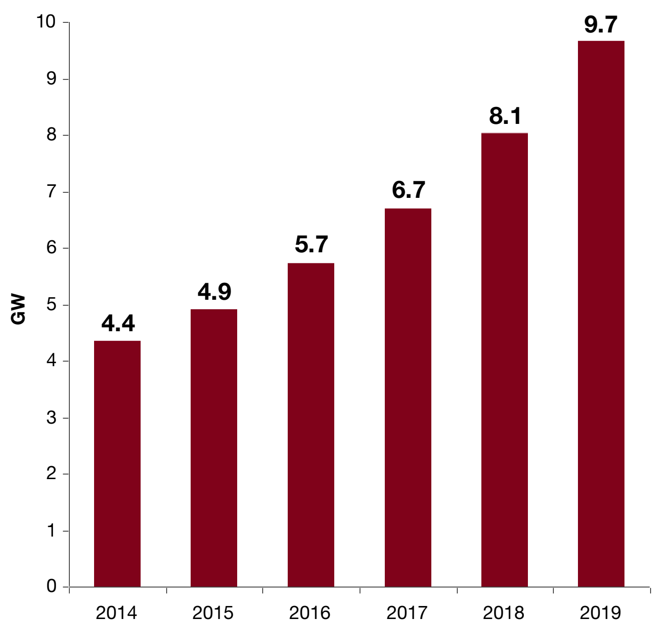
Most importantly, utilities need to monitor the potential timing and scale of micro-grid expansion. A severe event, a government-driven mandate, and/or system economics proving to be on a par with other reliability solutions could jump start deployments. In the meantime, it is likely to be a niche market – well suited for utility participation but less likely to be a strong disintermediating threat to the current network.

Future developments

Looking forward, the energy grid of the future will be digital and 'intelligent', perhaps with neural network capabilities that enable 'human brain-like' processing of large amounts of information simultaneously and able to focus on the most important sensory inputs. There remain challenges in standardisation, managing and linking massive amounts of data from different systems and implementing the data layer on top of the physical layer. Nonetheless, 'big data' analytical capabilities are enabling the grid to be digital and intelligent.

Traditional OEMs such as GE, Siemens, and Schneider Electric are developing and acquiring software technologies that bring analytical capabilities to their hardware. Global solution companies, like Toshiba and Honeywell, are also expanding from their traditional hardware-only solutions to more holistic, software-based, end-to-end data management solutions for their utility customers. Other 'big data' startups, such as C3 Energy, Space-Time Insight, Bit Stew Systems and Focus Energy, are further leveraging analytical software to drive intelligent decision-making from data gathered across utility operations.

Figure 7: Global micro-grid market (GW capacity)



Source: Technavio; Strategy& analysis.

Continued micro-grid adoption could open multiple pathways for utilities.

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 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.[16]

In recent years, the rapid growth in intermittent renewables on the grid has rejuvenated utility demand for energy storage – both to complement renewables, but also to defer transmission and distribution investment in congested parts of the grid and to improve local frequency regulation. In addition, direct user demand has emerged, due in part to the expansion of high-volume and energy-intensity data centres and other customer segments placing a high value on uninterruptible power.

The changing economics of storage technologies

While most historical activity has been in pumped hydro storage, new interest is 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.[17] In Germany, costs have fallen by 80% since 2010.[18]

These lower costs, in turn, help open up new opportunities for energy storage. For the moment, North America leads the deployment of advanced, non-hydro energy storage, with around 860 MW of installation capacity at the end of 2015. Japan, China, India, Germany and Australia have also begun to see significant installations, and by 2020, the US share of installations is expected to fall to 40%[19],with the German manufacturer Sonnen already having deployed more than 10,000 systems.[20]

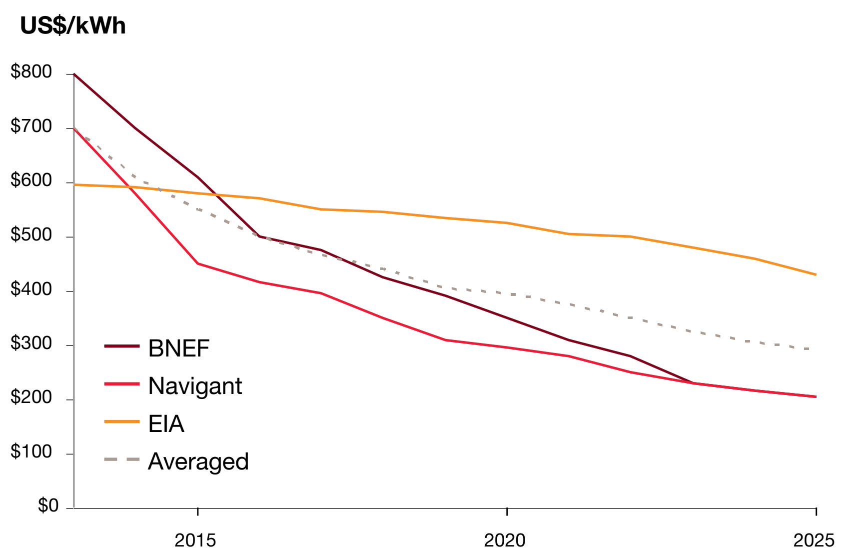
Given the uncertainties of technology and scale economics , energy storage cost curves vary widely. Optimists point to the last decade's silicon solar cost evolution as potentially analogous but the high proportion of rare earth materials in batteries (versus commodity silicon and labour that could be automated in solar modules) is a cost-reduction constraint. At the same time, commercial viability varies by application (frequency regulation vs. price arbitrage vs. capacity market participation).

Significant investment

However, one recent report estimated that 5,000 MW (1,5000MWh) of grid-integrated distribution storage will be cost effective in the US at installed costs of US$350/kWh.[21] This indicates broad adoption is not imminent but it is not discouraging significant investments in additional manufacturing capacity. Players such as Sonnen, Tesla, Panasonic, LG Chem and contract manufacturers such as Flextronics and others could bring these costs down even more rapidly than expected.

In addition, energy storage has received sustained US venture capital investments of over US$250m annually since 2012, even though investments in other clean technologies have declined.[22] Innovation is occurring, including the identification of new battery chemistries as well as further optimisation of existing lithium ion and flow battery technologies.

Figure 8: Battery storage costs



Source: RMI "Economics of Grid Defection", 2014

16 Utility Scale Energy Storage Systems – Benefits, Applications and Technologies, Purdue University – State Utility Forecasting Group, June 2013.
17 US Department of Energy Strategic Plan 2014-2018, US Department of Energy, April 2014.
18 Sonnen Ships Its 10,000th Battery, Putting Pressure on Tesla and Utilities, Greentech Media, 17 February 2016
19 Global Advanced Energy Storage Systems Market 2016-2020, Technavio, 9 December 2015.
20 Op. cit. 17.
21 Deploying Up to 5,000 MW of Grid-Integrated Electricity Storage in Texas Could Provide Substantial Net Benefits According to Brattle Economists, The Brattle Group, 10 November 2014.
22 US Cleantech Investments and Insights: Q4 2015, PwC, 2015.

Viewpoint

Perspective: M5BAT, our contribution to energy's future

Dr. Stefanie Kesting
Director of Innovation,
Uniper

Uniper is a new name in the energy market. The company's business is founded on a balanced portfolio of assets—from power stations, storage facilities, and pipelines to state-of-the-art trading systems—that ensures a secure flow of energy. Uniper's portfolio in a changed energy landscape is to combine large-scale power generation and the effective management of global and regional energy supply chains.

With the continuous growth of renewables and further decreasing conventional capacity, energy systems are becoming more and more difficult to balance. To ensure security of supply also in the long run, flexibility will be key.

Batteries can and will play an increasingly important role in the energy system, as an efficient new way of providing this flexibility in both directions by charging and discharging. In parallel, the costs for such storage systems are decreasing significantly. This opens up new business opportunities. Building on our operational, trading and storage capabilities, Uniper is developing new and flexible business models around energy storage.

We are currently building an innovative hybrid battery storage system together with our project consortium in Aachen. M5BAT is a worldwide unique combination of five different battery technologies, able to cover a total capacity of around 5 megawatt hours (MWh). This highly efficient and modular system offers a range of applications and therefore facilitates the integration of renewable energies in a new way.

http://m5bat.de/en-gb/

The complexity of energy storage systems presents a natural entry point for utility involvement.

An expanding company universe

The expected growth in the energy storage market has triggered the entry of small storage-focused startups as well as large players from adjacent industries. Initial deployment of large storage systems, for grid operators and utilities, was handled by large developers such as AES Energy Storage, Invenergy and RES Americas. Gradually, existing utility suppliers, such as S&C, ABB, NEC and, GE, expanded into energy storage products to address utility needs at feeders and substations. Several startups such as Greencharge Networks and STEM unlocked opportunities in commercial and industrial markets via new business models to address demand changes.

This trend drove other companies in electronics (e.g. Sharp, Bosch), automobile manufacturers (e.g. Tesla, Daimler, BYD), solar developers (e.g. Solar City, SunPower) and energy services companies (e.g. Johnson Controls) into the fray. The residential 'solar plus' storage market has also seen traction but has mostly been limited to specific regions, such as Germany (to address high energy prices) or Australia (to address reliability for remote regions). While large-scale energy storage developers have been operating globally for some time, players in commercial and industrial (C&I) and residential markets are also increasingly becoming global.

Utility involvement

The complexity of energy storage systems presents a natural entry point for utility involvement. Grid-tied storage systems are natural assets for the centralised, direct ownership model that utilities are accustomed to. And site-based installations, particularly those at commercial or industrial customers, will still require a high degree of integration with the local utility to optimise operations potential and thus justify their costs. Moreover, advanced energy storage systems enable ancillary services, such as frequency regulation and black-start, that help stabilise the grid, thereby providing a natural basis for utilities to work with their regulators to encourage adoption.

In the near term, this will require utilities to collaborate with regulators on new rate mechanisms, tariffs, and policies. In the US, storage growth is being driven by two distinct policy strategies – a command and control-based system with a 1.3 GW procurement target in California[23], and a wholesale rate and tariff revision in New York, dubbed Reforming the Energy Vision (REV), intended to create market and rate signals that pay for new storage installations and other technologies.[24] It remains to be seen which one will provide the best opportunity for utility participation in energy storage, but both are currently driving large-scale utility pilot programmes and being eagerly copied by other states.

23 California Sets Energy Storage Target of 1.3 GW by 2020, Greentech Media, 11 June 2013.
24 Reforming the Energy Vision – About the Initiative, New York State, 28 January 2016.

Electric vehicles

Since GM's release of the EV1 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 the Chevrolet Volt and Nissan Leaf launches in 2010, there was a lull in new electric vehicle launches from major automobile manufacturers. The entry of smaller players such as Tesla, though, helped spur interest from car buyers to consider electric vehicles over more conventional options.

However, expected new launches from most major automobile manufacturers (except for Toyota, which believes hydrogen power vehicles will win over electric vehicles long term) offer renewed hope for an EV marketplace. Major global automobile players are expected to launch more than twenty 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.[25] This increased focus on EVs is driven by both supply and demand side factors that are changing the equation on price, performance and value.

Growth drivers

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

In addition to these mandates and subsidies, countries are increasingly setting more challenging fuel economy and greenhouse gas emissions 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 Volkswagen'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 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 US$1,000/kWh in 2010 to US$600/kWh in 2014 and is expected to reach US$100/kWh by 2020. Indeed, some analysts believe that a few market leaders may break the US$100/kWh barrier a few years earlier.[26]

Infrastructure and grid considerations

These demand and supply factors have dramatically increased the types of electric vehicles available to consumers. Range (40 to 300 miles), type of drivetrain (pure battery vs. hybrid vs. extended range), level of hybridisation (simple start-stop vs. plug-in hybrid), performance (common saloon vs. high performance cars), charging time (multiple hours vs. partial-hour) and price (mass market vs. luxury) are major emerging variables. Proliferation in model differentiation and increased availability of charging stations are expected to substantially increase EV sales, with North America and Europe set to have the major share (around 35% each in 2019) of the global EV market followed by Asia Pacific at around 20%.[27]

Increased EV charging, at rates of 3.3 kW (Volt) to 10 kW (Tesla Model S) and 122 kW (Tesla supercharger), is expected to significantly affect the operations of local electric grids. Because EV buyers tend to be concentrated in specific affluent regions, as seen in California, the impact on the part of the distribution grid closest to the consumers – at transformer and substation levels – is greatly increased. A recent study estimated that at 35% plug-in hybrid electric vehicle (PHEV) penetration, the utility system peak demand will increase by 27%.[28]

In addition to this increased demand, the energy consumed by EVs is equivalent to that for a small home, requiring more generation resources, which will further increase as EVs become more technology-enabled for consumers. EV chargers could also create harmonics, which when injected into the grid can create problems for motors, interfere with communication lines and cause false operation of grid protection systems. Voltage regulation could also be a concern with increased EV penetration.

Implications for utilities

Automobile manufacturers are working with utilities to define stringent requirements for charging stations to reduce detrimental impacts on the grid. They are also developing innovative technologies to make it easier for consumers to charge in an economical (using time of use (TOU) rates to incentivise use during off-peak hours to reduce peak demand), sustainable (charge when the availability of renewable energy on the grid is high), and convenient (navigation provides directions for nearby charging stations such as Tesla superchargers) ways. -> in ways that are economical (using time-of-use (TOU) rates to incentivise use during off-peak hours to reduce peak demand), sustainable (charge when the availability of renewable energy on the grid is high), and convenient (navigation provides directions for nearby charging stations such as Tesla superchargers). For example, General Motors has been working with utilities and their vendors across the electric system to enable these solutions using their onboard OnStar telematics platform. In the future, automobile manufacturers are also expected to provide two-way charging capabilities for vehicles, enabling vehicle-to-grid applications, in effect converting EVs into multi-use energy platforms.

Utilities need to invest in new technologies to increase real-time awareness of distributed generation and loads on their local grids. They also need to automate demand and supply balancing at substation and even transformer levels by adjusting local

25 Global Battery Electric Vehicles Market 2015-2019, Technavio, 4 February 2015.
26 Global Li ion Battery Market for All Electric Vehicles 2015-2019, Technavio, 10 June 2015.
27 Global Battery Electric Vehicles Market 2015-2019. Technavio. 4 February 2015.
28 The Impact of Electric Vehicles on Utilities. International Journal of Power and Renewable Energy Systems. 2015

distributed generation (solar, etc.) and by implementing more real-time demand-side management programmes (control electric vehicles, air conditioning, lighting, and other major loads as aggregated groups). As consumers drive their EVs across state and utility boundaries, new services such as mobile subscriptions for accessing power grids may be required. Additionally, standards-based software and communications platforms that work across various charging stations, electric vehicles and utilities will help balance the needs of the various stakeholders.

Beyond the meter

Many energy management startups during the late 2000s never lived up to the hype that accompanied much of the venture investment and the millions of smart meter deployments. But 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 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 closer to real time.

Readily available technology

Load disaggregation technologies provided by companies like Bidgely, Opower and PlotWatt are helping customers understand their base load and appliance load to optimise energy consumption. Expensive, dedicated in-home displays for energy monitoring are being replaced by software applications on smartphones, and '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 still more functionality and a 'pathway' to connected home functions envisioned by smart home providers.

Demand for better energy management needs at the residential level has started to be fulfilled by multiple low-cost technology options available to consumers. As of 2015, there were over 240 products in the home energy management space in the US across 12 different categories, ranging from smart lighting, plugs and appliances to energy portals, analytics platforms and displays. Among them, online energy dashboards and in-home displays accounted for 34% of the products in the market.[29]

More and more functionality

Many products in the market today go beyond the display of energy consumption information, and provide analytical, intelligent information based on history, preference, and integration with other statistical data. Individual devices, like intelligent energy monitors, are starting to proliferate within the premises or building and greatly affect consumption patterns and customer engagement. These devices are also integrating increasingly greater computing and communication capabilities while building repositories with valuable data to create 'energy hubs'.

These simple but powerful platforms that integrate on-premises energy uses and customer behaviours with the network will eventually evolve to support the fully connected home. But in the big picture, the battle for the 'energy hub' space is less about individual energy devices and the analytics behind them than about conquering the operating system of all internet of things (IoT) devices inside the home.

Google's acquisitions of Nest and Dropcam show this renewed interest after shutting down its original PowerMeter programme. Amazon's Echo wants to become the hub that connects people, devices and the network through a voice interface. Currently, Echo connects with a multitude of energy devices including smart plugs, Philips Hue light bulbs, and even its competitor, Google's Nest smart thermostat. Startups like Silk Labs (founded by the ex-Mozilla team) are also entering the home operating system space with their video surveillance technology.

Energy services for businesses

On the commercial side, similar market trends are pushing a variety of providers to develop holistic energy services for commercial and industrial customers. These services seek to integrate on-site power, including renewables and storage, active supply and demand management and energy efficiency retrofits, such as networked LED lighting, with an array of monitoring, predictive and control features.

The success of these services will require sophisticated software that goes well beyond existing offerings that are mostly limited to energy-reporting dashboards and passive improvement suggestions or less scalable consulting models. This software will have to seamlessly integrate multiple technologies, each with its own software layer, and enable decision-making as well as automation that is flexible enough for a wide variety of environments.

More entrants to this space will emerge as new businesses are announced and others are formed via partnerships.

29 Opportunities for Home Energy Management Systems (HEMS) in Advancing Residential Energy Efficiency Programmes. Northeast Energy Efficiency Partnerships (NEEP). August 2015.

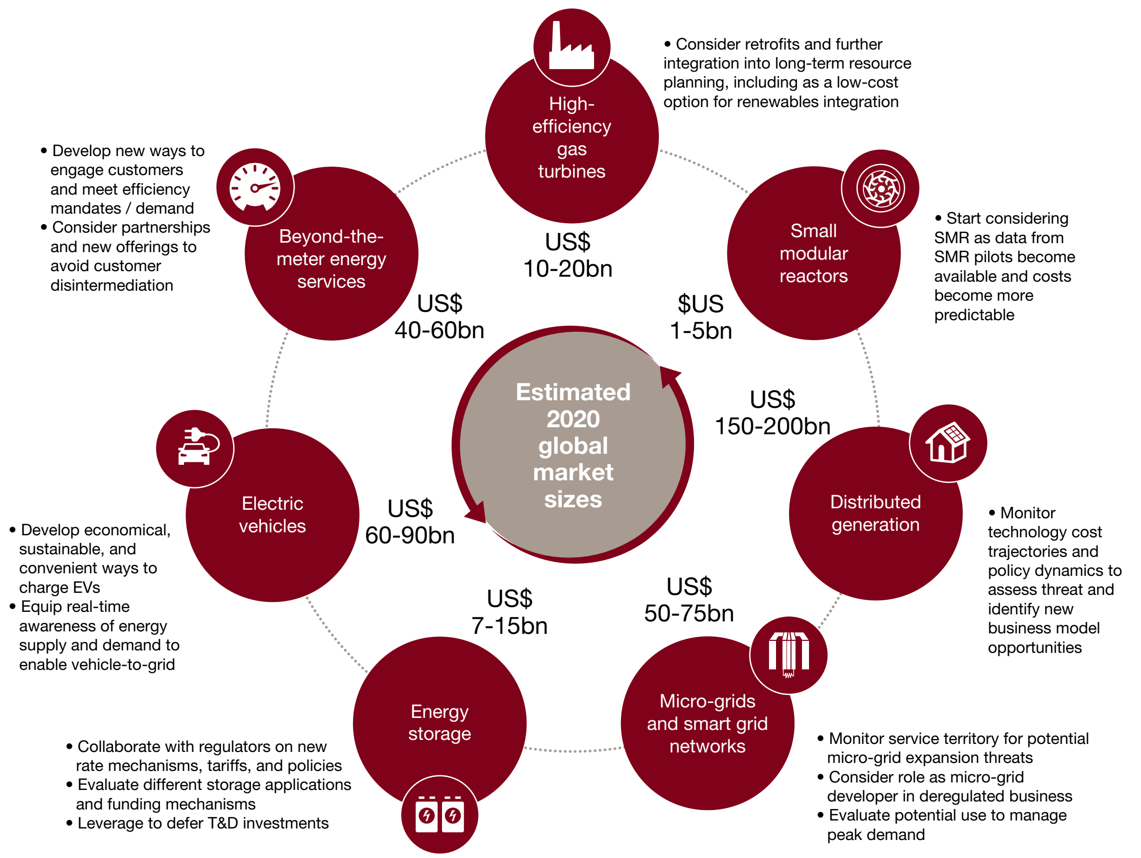
Diverse companies such as GE (Current) and Edison (Edison Energy) have launched offerings in the past six months, while others such as Southern Company and EnerNOC are building their offerings through acquisitions or partnerships. More entrants to this space will emerge as new businesses are announced and others are formed via partnerships. In this case, the utilities will be only one type of entrant, with others coming from the solar, storage, software as a service, energy management, lighting, retail, and diversified industrials sectors. As entrants into this crowded space, utilities will need to tread carefully and consider partnerships as well as licensing to avoid becoming over-extended with acquisitions and staffing.

The value of partnerships with utility companies

From the beyond-the-meter equipment and service provider perspective, collaboration with utilities is critical. Lowering the customer acquisition cost has always been crucial for startups, especially in the utility industry. Even leading US rooftop solar companies are spending several thousand dollars to have a customer sign a solar contract. Energy management service companies also face adoption challenges, as lead generation and installation costs have often proven higher than customer lifetime values. Gaining access to customers through utilities may sound easy, but it requires multi-year commitment and persistence, due to the slow nature of the funding process and low uptake motivations.

However, there have been success stories of service providers that have approached utility customers with some creativity. Powerley, a home energy management service startup, is a good example. Their joint venture with DTE Energy, the local utility in Detroit, Michigan, not only provided the initial capital to develop innovative hardware and software-based solutions but also gave quick access to a large customer base. In less than two years, Powerley installed its products in 65,000 homes and drove demand for 140,000 application downloads. DTE Energy supported this joint venture and its DTE Insights solution through promotions and support centres, ultimately lowering customer acquisition and service costs. With the success from DTE Energy, Powerley is now expanding to other utilities by white-labelling their service to other utilities. Such arrangements also demonstrate the value of partnerships to utilities which gain access to new services demanded by their customers without having to build them internally.

Figure 9: Estimated 2020 global market sizes by technology



Source: Allied market research, GTM Research, IEA, Markets and Markets, National Nuclear Laboratories, Navigant, Technavio, Strategy& analysis

Early-stage technologies

While the technologies outlined above hold the potential to sharply reshape the electricity industry in the next five to seven years, the longer pipeline of technologies under development shows that the industry is entering a period of continued change. This will not be a one-time shift, but an ongoing transformation as new technologies are commercialised in ways that continuously test long-held assumptions. There are a number of significant technologies, currently in an early stage of development. We look at three key areas: generation, the grid, and beyond the meter, and just a few of the over-the-horizon technology offerings that could emerge.

Generation

The introduction of new solar technologies, including ***perovskite-based solar cells*** hold the potential to surpass silicon PV efficiency while finally achieving the vision of thin-film solar, namely low cost with potential to print on flexible substrates that could enable building-integrated photovoltaics (BIPV).

Although nuclear power prospects are challenging in the near term, ***'Gen IV' nuclear plant innovation*** includes focusing on closing the nuclear fuel cycle and thereby minimising fuel waste. Continued progress, for example from TerraPower's travelling wave reactor, could bring a true nuclear renaissance to fruition.

Carbon capture and sequestration (CCS) has spent a long time on the cusp of commercial viability, but an increasing global focus on carbon emissions reduction could generate legislation and innovation that may ultimately favour the technology. CCS could find a niche in specific markets like China and the US where power needs are great, coal is available and emissions are no longer tolerated.

The grid

An increased focus on improving the resilience and reliability of the electric grid will drive development of new power system models. ***Open-access power system models*** will, in the short term, use advanced algorithms to optimise and control distribution and transmission. ARPA-E, the US Advanced Research Projects Agency-Energy (ARPA-E), recently announced an initial funding plan for seven transformational projects that optimise efficiency of the grid.

Industrial-scale 'flow batteries', which can store energy in liquid form and quickly recharge and retain charges for long periods of time, are expected to capture a significant share of the energy storage market in the near future. These cheap, large sources of storage may be a welcome solution for large-scale applications at the grid level where lithium ion technology is still cost-prohibitive.

Also related to energy storage, ***aggregated control of EV batteries*** will in the nearer term be exploited to enable charging coincident with periods of decreased load, and ultimately, if warranty issues can be resolved, serve as a battery that the grid will rely on for the same centralised storage functions that are being commercialised today.

Beyond the meter

Wireless power charging has the potential to increase the adoption rate of battery-powered devices, including vehicles, which will be critical to reversing electricity demand deterioration across much of the developed world.

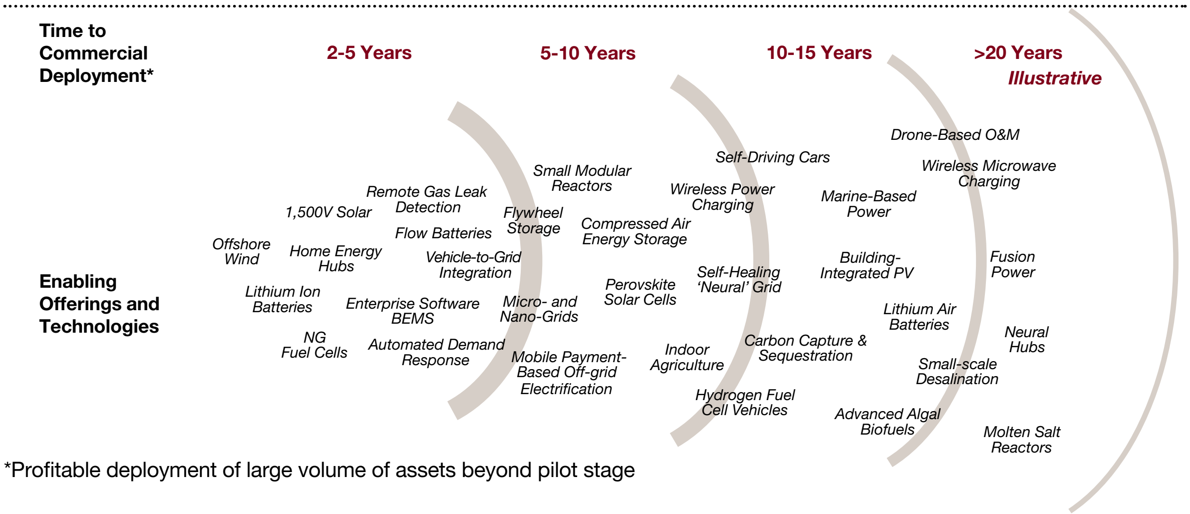
'Energy hubs', which are intelligent and thinking systems that optimise energy device performance, consumption and prosumer actions, will also emerge as real-time, active and integrated knowledge tools for premises and facilities.

Improved power consumption profiles will also drive a ***proliferation of connected devices*** that will finally enable applications that have been discussed for years, including ***fully automated demand response and energy management.*** These devices will continually push the boundaries of what is possible behind the meter and create new communication layers for utilities to utilise.

Impact on utilities

While it remains uncertain whether these early-stage innovative technologies will achieve commercial scale, utility executives must consider that a few of them might. Several Fortune 500 companies, universities and governments are making significant investments in many of these areas, and the wave of momentum behind clean energy technologies is unlikely to slow. Since there is no 'crystal ball' to help us figure out which technologies might make an impact in the future, it's important for utilities to think through different ways and scenarios that these technologies, their customers and the overall market might develop.

Figure 10: Early stage technology deployment funnel



*Profitable deployment of large volume of assets beyond pilot stage

Possible futures

What could these technology breakthroughs mean for incumbents and new players in the market? Whether companies are providers of power generation, managers of an electric grid or retailers of power and energy solutions, many of the technology evolutions discussed could have a significant impact on their businesses. In this chapter, we paint a picture of how five possible future scenarios could unfold and affect utilities as technology evolution pushes forward.

Our five scenarios

'Losing touch' – a future where utility companies lose touch with their customers as other players take control of the customer energy hub. Incumbent utilities provide simple delivery of wholesale energy at the cheapest price, with the energy 'hub' performing all routine and value-added functions for the consumer.

'Off grid' – the centre of gravity shifts away from the main grid to on-site generation and storage as well as distributed generation attached to micro-grids. The grid becomes more akin to a source of back-up power and utilities face a number of dilemmas on what role to play in a more diversified power system and how to maintain underused and costly power infrastructure.

'Mobile and virtual' – electric vehicles become the norm, creating the need for substantial infrastructure investment and the opportunity to use vehicles as a mass storage source. Local utility networks and circuits face tremendous strain. Utilities have the potential to capture several sources of value from this scenario but face considerable competition from a range of other players.

'Data rich' – ubiquitous, intelligent sensors collect energy flow and performance data across all levels of the network and regulators require utilities to allow data access to third parties. Value shifts away from traditional utilities toward those which can collect, process, interpret and convert these data to offer knowledge-based, value-added energy management services to customers.

'Scaled down' – large business customers start to explore installing their own decentralised and scalable generation for their own usage. As technology continues to progress, smaller and smaller commercial and industrial customers migrate toward a new era of 'site-based' generation. Traditional utilities see a diminished role with their larger customers and are not able to avoid disintermediation for their largest load entities.

These scenarios are not mutually exclusive nor collectively exhaustive, and we've simplified and embellished them for the purposes of illustration. None of them will occur exactly as described, but each one contains some elements of what the future could hold if appropriate actions are not taken by utilities. The future that may result will more likely reflect a combination of some of these scenarios, in whole or in part, or in different time frames. There may also be different scenarios that emerge that take the industry in other directions as unforeseen events occur.

We will also see differences across global geographies based on the landscape of existing infrastructures, the ecosystem of players in different territories and local regulations. For example, in developing countries where grid infrastructure is absent or unreliable, business models based on fully off-grid and sustainable technology systems are already playing a significant role.[2] Similarly, in such situations, small-scale generation, as in 'scaled-down', may also not apply in the same way, since any generation may already be at the local level and not from a traditional centralised fuel source.

While any number of scenarios could be imagined, the scenarios we have selected are each triggered by the evolution of technology disruptions and customer behaviour discussed earlier, and summarised in *Figure 9*. These scenarios can and do depend on the extent to which multiple technologies advance and develop within their conceptual performance boundaries. They also are dependent on how the costs of emerging technologies ultimately compare to conventional alternatives and to customer expectations of functionality and value.

Scenario time frames

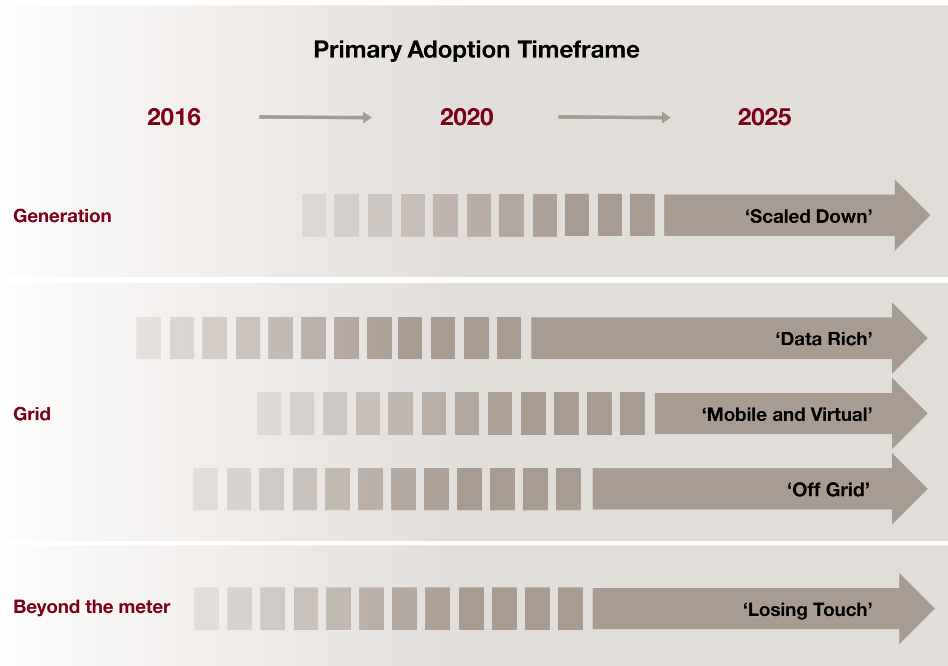
The time frames over which the various scenarios could unfold vary according to technology development, regulatory incentives and /or customer attitudes. Some are closer to actualisation or more likely to occur than others. We expect that the full impact of most of these scenarios are slightly "over the horizon', but most have a grounding in what is actually transpiring today. The view of when these scenarios might develop in this imperfect future, illustrated in *Figure 10,* is not meant to be deterministic, but is rather a view on when the underlying technologies might develop and allow them to happen.

The 'home hub' performs all value-added functions for the consumer.

Figure 11: Mapping of technologies to scenarios

	'Losing Touch'	'Off Grid'	'Mobile and Virtual'	'Data Rich'	'Scaled Down'
Small Modular Reactors					■
High-Efficiency Gas Turbines					■
Distributed Generation		■			■
Intelligent and Modular Grids		■		■	
Electric Vehicles			■		
Energy Storage		■			■
Beyond the Meter	■		■	■	

Figure 12: Varied future deployment timeline



30 PwC, Electricity beyond the grid: accelerating access to sustainable power for all, 2016.

Energy optimisation and management shifts away from the provider to the customer.

Scenario 1:

'Losing touch'

With the availability of connected objects and sensors inside homes and premises, non-traditional market entrants can play a more direct and active role with customers and supplant the incumbent utility. In this scenario, Google Nest and other connected home players, such as telecom operators, manage the customer interface, offering a wide variety of connected home services. These players employ a 'home hub' that controls all digital services in the homes and buildings of their customers: security, home automation, connected devices in the home and, of course, power and heating services.

This 'hub' is an intelligent and continuously learning system that manages device connection and utilisation, monitors and directs total site and individual device consumption, makes energy-use decisions for the consumer, links to the overall delivery network and utilises the total energy available from all micro-generation sources, including storage, for the benefit of the customer and the grid. Under this scenario, this 'home hub' operates as a real-time intermediary between the premises and the network to enable bilateral engagement, particularly in times of premises need or system stress. Energy optimisation and management has now shifted away from the provider to the customer through the 'home hub' operator's intelligent system.

Value from technology deployment in this scenario goes to the owner of the customer interface, i.e. the 'home hub' platform that controls energy consumption in the homes and businesses. This entity is able to leverage the system's inherent knowledge and analytics and shift energy insights and bargaining power from the traditional utility to customers in the form of managed consumption, lower energy costs, sale of excess energy to the grid and smarter energy decisions.

Implications for utility companies

Incumbent utilities provide simple delivery of wholesale energy at the cheapest price, with the 'home hub' performing all routine and value-added functions for the consumer. Connected home players buy wholesale energy from these providers, decide on retail pricing and adapt to the usage and behaviours of their customers (e.g. offering energy discounts for reducing consumption during peak load times).

Providers of electricity and gas compete on price, giving an advantage to those who have either the scale to provide this energy at a lower cost, or who are capable of exploiting energy exchange markets to their advantage. Those operating the electricity grids and gas distribution infrastructure are pushed to lower their costs and competition between energy providers becomes a game of cost-efficient production, smart sourcing of energy and attractive pricing options.

Possible responses of utility companies

Utilities could try to preserve competitive advantage in this scenario by offering their own platform to control energy consumption in homes and businesses or by striking alliances with 'home hub' providers. But they will be competing in a technology-dependent area that has not been at the centre of their core capabilities. Incumbent utilities could also seek to provide data from the grid to the provider of the 'home hub' so that the platform operator can leverage these data with the consumption data of customers to extend and optimise the range of value-added services. In any case, in this scenario, utilities are likely to need to find ways to lower the costs of energy production and to optimise their sourcing, provision and management of energy to become low-cost energy providers and the most valued knowledge partner with customers.

Scenario 2:

'Off grid'

Leveraging the widespread availability of economic and high performance micro-generation technologies, a significant proportion of individual consumers invest in premises-based generation equipment plus storage, allowing them to be almost entirely autonomous in their power sourcing and consumption. They maintain back-up connections to their traditional power supplier only for use in emergency situations.

In some regions or cities, consumers organise as discrete communities and jointly invest in decentralised micro-generation and storage technologies to create a micro-grid. Their scale and micro-grid infrastructure allow them to be largely independent, although they maintain a grid connection as back-up.

Taking this scenario to its ultimate level, communities invest in sufficient and diverse decentralised energy solutions and in high-performing energy storage technologies, such that they can move almost completely off the grid, obviating dependency on utilities and traditional power suppliers. In some cases, the traditional utility may manage the micro-grid of the community, and in others a third party may perform this function.

Implications for utility companies

In this scenario, utilities and traditional alternative power suppliers maintain under-used power-generation capacity to meet regulatory grid connection requirements and for maintaining grid voltage regulation. However, the maintenance of under-used power generation infrastructure equipment is costly and these costs may not be entirely recovered from consumers, who would then have even more incentive to move entirely off the grid.

Consequently, utilities and traditional power suppliers become financially stressed with high stranded investment. As a result, they are reconstituted as publicly-owned entities and/or are highly subsidised. They subsequently face enormous pressure to reduce costs, both in capital investment and in operating expenses, which stretches their ability to maintain minimum reliability and service levels.

In this scenario, a large portion of the value from distributed generation and the micro-grid infrastructure goes to the providers of distributed energy resources and to those who maintain and operate this equipment infrastructure. These entities could include OEMs, specific technology owners, monitoring and control software providers, and newly-established micro-grid managers (virtual utilities).

Possible responses of utility companies

Utilities can still capture value and play at the interface between the distributed energy sources and the grid edge, providing an ability to capture excess capacity or energy from the micro-grid, store this excess on the grid and then provide it back to the customers or the market when needed.

Utilities can also maintain a role in micro-grid interconnection and integration, as well as micro-grid operations, management and optimisation. They can seek to mitigate the risks of this scenario and influence regulators to allow utility participation in micro-grid development and operation and/or modify the rate structure, and move towards a higher fee for connection to the grid in only a back-up capacity or recover stranded costs through a system disconnection tariff.

Utilities can capture value and play at the interface between the distributed energy sources and the grid edge.

Scenario 3:

'Mobile and virtual'

With continuing vehicle model expansion and technology breakthroughs in battery costs and over-the-road charging, electric vehicles become widespread. These vehicles are crammed with portable energy-using devices that make the automobile both a steady consumer of electricity as well as a mobile energy platform for the grid. This proliferation in attractive models that consumers want to buy, coupled with the minimisation of 'range anxiety' from batteries that are safer, perform better, and charge faster, allows the on-road electric vehicle to become a viable and vital source of power consumption on utility grids.

Customers use vehicles loaded with built-in consumer-focused technology for both mobility, entertainment and business, and expect to consume power wherever and whenever they want. These vehicles also act as sources of power when in the garage, particularly when the grid has an interruption or the selling price of electricity is high enough to warrant exchange. Rapid charging technologies allow customers to charge their vehicles very quickly, e.g. 80% capacity within 15 minutes, although this places tremendous pressure on utility networks and localised circuits.

Implications for utility companies

In this scenario, utilities will need to target new infrastructure investment for circuit support and build new technical capabilities to be able to manage the strain on the network from daily variability in mobile energy consumption across the grid. They will also need to develop new marketing capabilities and channels to focus directly on the mobile customer and pricing schemes for the consumption of energy 'on the go'.

Particular attention will need to be directed at fashioning dynamic tariffs that provide a mix of fixed, per-charge and time-based options that are viewed by consumers as providing charging security and mobile value, are viewed by utilities as providing and pricing stability and asset recovery. To support these pricing options, utilities will also invest in advanced data analytics capabilities to determine where and how customers are likely to recharge and discharge their vehicles.

Possible responses of utility companies

Utilities could encourage the development of this scenario by influencing the adoption of electric vehicles, for example by encouraging countries, states or provinces or cities to offer incentives for adoption and operation. But they will need to do this in parallel with improving the reliability and adaptability of their grids. The roles that utilities could play across the electric vehicle value chain will depend on how and where the industry identifies value can be added to the grid and charging infrastructure, and whether incentive provision is directly or indirectly supported.

Utilities can capture several sources of value from electric vehicle market participation, i.e. front-end incentivisation, infrastructure strengthening, charging infrastructure, grid interconnection, energy exchange, etc. However, these value sources will also be subject to competition from OEMs, charging station operators and energy aggregators. Utilities will need to determine how this value chain is apportioned across other providers, given the relative risk among these players. Utilities could gain a competitive advantage by managing the customer in a uniform way, including all mobile channels, leveraging customer knowledge and behaviours to offer competitive pricing and services.

Utilities will need to manage the strain on the network from daily variability in mobile energy consumption across the grid.

Scenario 4:

'Data rich'

It won't just be evolving technology that will affect the future utilities industry. An equal influence will be the manner in which the industry exploits the data flows from this technology, e.g. turning data into insight and foresight for the benefit of the network and/or the customer. In the 'data rich' scenario, ubiquitous, intelligent sensors collect energy-flow and performance data across all levels of the network. All energy consumption devices (electric and gas) in the premises are connected through the 'internet of everything' and are continually sending data on their status, consumption and performance.

Regulators decide to require utilities to allow network and premises data access to third parties. Similarly, customers choose to allow access to data coming from their premises-based electronic devices in exchange for value-added services, such as diagnostics, predictive analytics and high-touch communication and notification. Smart analytics companies emerge and start to offer equipment monitoring, data analytics and consumption optimisation solutions, disintermediating the utilities from their customers.

Implications for utility companies

The industry can expect an explosion of technology startups to rush in to exploit this data trove, offering a range of network and premises optimisation services. Utilities are challenged by this explosion of innovation and struggle to maintain their relevance with their customers, perhaps even becoming more and more disintermediated.

Value shifts away from traditional utilities in this scenario toward those which can collect, process, interpret and convert these data to offer knowledge-based, value-added energy management services to customers.

Possible responses of utility companies

Utilities could try to reshape how the scenario unfolds by seeking to preserve their ability to participate in this data analytics role by sharing their grid and certain customer data with third parties. But given the nature of their business, market position, network standards protocols and government open data policies, utilities are unlikely to be favoured at the expense of the market and customers.

Nonetheless, utilities can still capture value in other ways by enabling the sharing of network data to achieve enhanced maintenance insights, forestall system failures and target future equipment component replacement, all of which improve capital and operating expense management. In addition, utilities can leverage the broader customer relationship – along with third parties - to provide energy management and optimisation services based on their knowledge of customer patterns, on-premises equipment and changing behaviour.

The industry can expect an explosion of technology startups to rush in to exploit this data trove.

Scenario 5:

'Scaled down'

With traditional generation sources shrinking in scale and becoming more modular, efficient and portable, large business customers start to install their own decentralised and scalable generation for their own usage. As technology continues to progress, smaller and smaller commercial and industrial customers migrate toward a new era of 'site-based' generation, i.e. newly engineered or configured reciprocating internal combustion engines (RICE), combined heat and power (CHP) etc., scaled to meet needs that grow unevenly over time.

Deployment of these technologies creates a gap between the efficiency of more traditional generation and the increasing needs for more local generation control at the site, plant or facility. Some commercial and industrial sites may also discover that their power consumption needs are asymmetric with those of neighbouring residential communities and start to connect themselves to community grids and to sell their extra capacity or energy to these communities directly.

Implications for utility companies

This scenario disrupts traditional supply relationships, strands existing assets and erodes supply margins at both the wholesale and retail levels. Much of the historical value of centralised, large-scale generation evaporates from the industry, with some residual value moving to suppliers of the small-scale power generation equipment and to industrial customers themselves. Traditional utilities see a diminished role with their larger customers and are not able to avoid disintermediation of their largest load entities.

Possible responses of utility companies

Utilities could try to mitigate the impacts of this scenario by ensuring mechanisms for recovering stranded costs are in place, developing alternative micro-generation offerings with third parties, and embedding interconnection charges that reflect the value of the grid and disruption to grid generation balance. The industry can also fulfill the position of the intermediary between these on-site and small-scale power generators and the industrial customers that have needs beyond simple generation.

Utilities could further respond to this displacement of generation by moving away from selling energy as a commodity and towards providing energy management solutions as a service, such as local regulation, ancillary services and excess capacity and energy marketing alone or in tandem with specialised partners.

Much of the historical value of centralised, large-scale generation could evaporate.

Viewpoint

Innovation and digital, catalysts of Engie's transformation

Stéphane Quéré

Senior Vice President Innovation
Group Commercial Innovation & New Business
ENGIE Group

In order to improve its growth potential ENGIE is investing in emerging technologies and in digital. In the context of its transformation plan, 1.5 billion euros will be dedicated to these investments until 2018.

ENGIE's vision is that of a decentralised, decarbonised and digital energy world.

Innovative Ecosystem

Focused on the rapid development of new businesses, the entity "Innovation, Marketing & New Business" stimulates innovation in the Group and in its ecosystem.

Internally, a social network "innov@ENGIE" was launched in 2014 in order to foster collaborative innovation. Today this network has 10,000 members throughout the organisation. This network has generated over 550 ideas in its 18 months of existence, which is equivalent to one new idea every single day. The Group has also put in place a process to incubate projects from employees in order to enable the emergence of new businesses. There are 20 teams of employees that are currently developing their ideas in external incubators in France, Belgium, the Netherlands, Brazil and soon also in the UK. Seven of the ideas pursued by these teams have already been launched on the market. These new business ideas cover five main domains: decentralised energy and storage, city and mobility, domestic comfort, IoT and hydrogen.

This has been added to the Group's existing Innovation Trophies, an internal competition that rewards innovative projects from employees throughout ENGIE.

In addition, in order to reinforce the links with the innovation ecosystems where ENGIE is present, the Group has launched 40 calls for projects from startups. It has received over 750 proposals and has selected 26 with whom it has launched collaborations. The Group has also launched many innovation events, such as a "Hackathon", "Mornings of Innovation" and "Innovation Days" in cities such as Lille, Marseilles and Bordeaux.

Innovation Fund

The innovation fund, ENGIE New Ventures, with 115 million euros, is geared to take minority stakes in innovative startups in the area of energy transition. It provides the selected startups with funds to fuel their growth and with operational support through collaborations with its business units. To date, 8 investments have been made, using about one third of the fund. These investments are in companies such as Advanced Microgrid Solutions and Green Charge on power storage, Powerdale on intelligent charging stations for electric vehicles, Sigfox on low-power networks for connected objects, Tendrill on energy management solutions, Kiwi Power on demand-side management solutions, StreetLight Data on smart city solutions, and Apix Analytics on gas chromatography solutions.

Technologies for Tomorrow

Medium- and long-term innovation is driven by the R&D team whose mission is to bring to maturity the technologies of tomorrow. With this mandate, the R&D team investigates prospective technologies in renewables, in smart energy and the environment, in the transportation and storage of CO2. The R&D team has pursued its internationalisation with the creation of labs in Singapore and in the UAE. It has also developed new capabilities in 3D printing and in drones.

Going forward

ENGIE is preparing for the growth beyond 2018 through the recent launch of ENGIE Tech, the new business factory for the Group. ENGIE Tech is open to the external world and brings together four pillars: venture capital, incubation, a lab, and a digital environment. It will host a data platform and another one dedicated to the development of applications linked to the energy businesses of the Group in partnership with large players in the industry.

Scenario round-up

Although it is unlikely that each of these scenarios will unfold exactly as described, it is unavoidable that the utilities industry is set to undergo substantial change to its historical business and delivery models. This change will result in the industry progressing down a more competitive path, driven by the combination of 'technology push' and 'customer pull'. Figure 13 summarises several of the more relevant elements of each scenario across several key attributes.

Different regions around the world will move at different paces. Some countries, like Germany, are already well into several scenarios that are built around distributed energy resources. Others, like the United States, are just at the cusp of the potential for these scenarios to occur in some form. And others, like countries in Asia or South America, have yet to see the advent of the combination of regulatory, technology or economic conditions that could give rise to these potential disruptive challenges. And in some scenarios, such as that related to electric vehicles, the market has yet to emerge and less emphasis has been placed on it by policymakers.

The key for utilities, regardless of where globally they may serve, is to recognise that an uncertain, but more disrupted, future will occur – it is just a question of timing and degree. All utilities have a planning window that they can use to prepare for the occurrence of these or other similar scenarios. The timing of these disruptive shifts – particularly as they relate to ubiquitous, robust occurrence – will differ by market. Consequently, incumbent utility companies can target their strategic responses to achieve specific market positioning objectives across their existing business segments and within a range of potential scenario outcomes.

An uncertain and more disrupted, future will occur – it is just a question of timing and degree.

Figure 13: Playing out the scenarios

	'Losing Touch'	'Off Grid'	'Mobile and Virtual'	'Data Rich'	'Scaled Down'
Relevant Time-Frame	2022 →	2018 →	2022 →	2020 →	2023 →
Regulatory Impetus	• Customer choice	• Customer choice • Open standards	Open standards	• Open access • Data priority	• Open access
Technologies					
Competitor Types	• Telcos • OEMs • Technologists	• OEMs • Specialist contractors • Municipalities	• OEMs • Municipalities	• Data managers • Software analysts	• OEMs
Competitor Enhancers	• Technology • Solutions as a service • Partnering • Applications	• Technology • Partnering	• Applications • Selections as a service	• Software • Partnering	• Partnering • Technology

A whole new emphasis on innovation

The various disruptive shifts that are taking place require utilities to think very differently about how to leverage innovation as a market enabler. Innovation has never been a capability that the utility industry believed would be required as a table stake for market success. But in the emerging future marketplace, innovation will be a differentiator between those companies that will be recognised as market leaders and those that will simply be 'part of the pack'. Innovators will be acknowledged for their unique insights into their customers, creative approaches to the market, tailored product and service portfolios and distinctive market channels that access traditional and non-traditional customers.

Innovative utilities will be capable of 'trendspotting' within the market and responding with offerings that anticipate and fulfil personal and business commercial needs. They will also be agile enough to rapidly shift their market focus when customer buying patterns and technology evolution cause a change in course. Ultimately, innovation will become a fundamental ingredient of a company's 'go-to-market' strategy. And it will become a means by which to take market space from other competitors and increase opportunities for commercialisation of technologies and market solutions.

Breaking with past approaches

Innovation hasn't been a major focal point for executive management in utilities companies. Technology advancement has largely come from the OEMs serving the industry. And the innovation that has taken place has generally been directed at selected R&D activities related to generation. Utilities haven't felt a strong need for wider innovation. But that's changing fast and companies need to find ways of embedding a culture of innovation into their core thinking.

For decades, the industry focused its activities on generating plant performance improvement, particularly in nuclear and coal, and generally on either life extensions or environmental challenges. Initiatives have often been prompted by policy direction, for example treatment technologies for coal fleet carbon emissions and remediation. Innovation in electricity transmission and distribution businesses has been even more limited. Only in the last decade or so has momentum gathered pace, with the advent of the intelligent network.

There are bright spots in the utility sector, particularly in Europe, where EDF and E.ON among others have evolved their companies to embrace a focus on innovation within their broader R&D activities. These utilities have created formal campus environments with a focus extending beyond traditional fuels-based research and into the grid, network and beyond-the-meter areas. Similarly in the US, Southern Company has operated the National Carbon Capture Centre on behalf of the government and industry for decades and recently created an Energy Innovation Centre to organise, galvanise and align its efforts beyond generation.

While other isolated pockets of innovation activity have also occurred, there has been a general lack of industry emphasis in this area. Utilities have relied on suppliers to the industry, trade groups and universities to be the engines of innovation. This has partly been the result of inadequate internal capabilities and funding, as well as a recognition that OEMs and non-profit labs were better positioned to perform this role. However, the main reason innovation has never received real attention is that the utility industry has not believed it needed to 'explore and embrace' innovation as a fundamental element of its future.

But that misperception has now been debunked. Utilities are not just exposed to technology disruption, they are also presented with unprecedented opportunities across the value chain from this technology evolution. Whether upstream in generation, midstream in the wires or downstream with the customer, utilities can now see that innovation needs to be an everyday and ubiquitous focus, not just topical and transitory.

From incremental to breakthrough innovation

The need for innovation in the sector is extending beyond the traditional limited focus that incrementally improves operational execution, e.g. processes, into more advanced thinking and ingenuity that centres on moving the business forward, such as shifts in technology deployment priorities and sustained 'free-thinking'. Companies that are most advanced in their approach to innovation have a breakthrough-oriented intent to strategically open or unlock markets, like the adoption of a new business model to drive 'beyond the meter' revenue growth (figure 14).

Innovation for utility companies is changing from a 'table stakes' focus on operational enhancement to a targeted focus on commercialisation of innovation for the benefit of the enterprise and customer, i.e. new products and services and delivery models that enhance the customer's value proposition and the utility.

A utility's 'go-to-market' strategy will extend well beyond reliance on innovative technology development and deployment to grow the portfolio of market-directed ideas. Moving from conceiving ideas to creating commercial value will be one key to success. Commercialisation will depend on blending the right mix of offerings, pricing, channels and partners. Each of these in its own right – and particularly when bundled together – position a utility to effectively compete in the market.

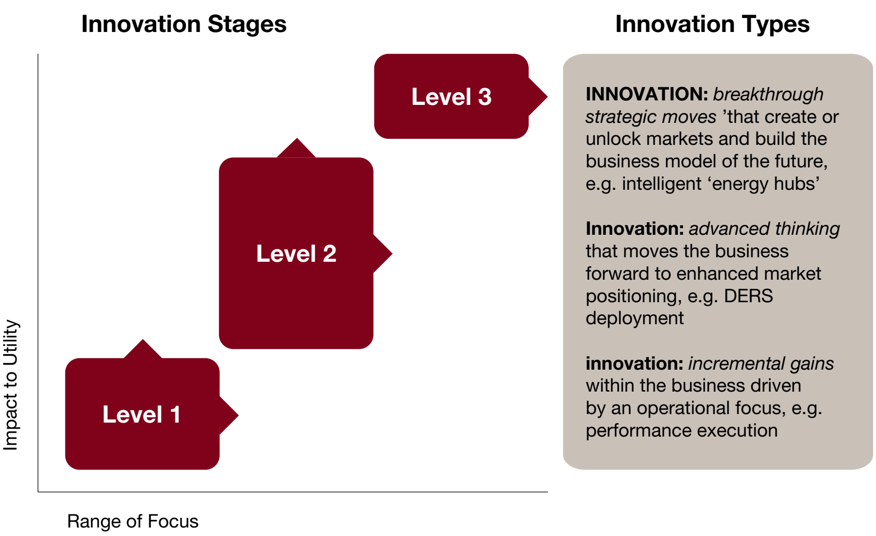
Organising for innovation

While executives tend to rightly think that innovation is everyone's responsibility, a utility typically needs a specified role identified to conceive, evaluate and drive innovation execution. This role – potentially an organisational unit or a high-level executive – needs to be visible to the employee base and viewed as the catalyst for innovation advancement, but does not need to be the entity responsible for all innovative thinking and commercial execution. Too often, companies forget that the purpose of innovation is around ideation and assessment of ideas and building readiness for commercialisation within the business, not market execution itself, which is the business unit role.

Utilities also need to find the right approach to maintaining continuous awareness and connectivity to 'idea flow' from the outside. Technology trends move at a rapid pace and can quickly exhaust the ability of a utility to keep up with external evolution if internal capabilities are not properly created, structured and aligned. Since utilities do not have infinite resources to devote to market scanning and evaluation, options exist to outsource parts of these roles to a third-party partner that can canvas new business startups and funding sources to stay abreast of promising technologies and companies that could benefit the utility. Alternatively, utilities can create externally-focused events like 'innovation fairs' to broadly engage multiple entities on a regular basis and shorten the time to technology or supplier identification and assessment. The goal for the utility is to accelerate its market presence and minimise its learning curve.

Preaching innovation is very different from actually being innovative. While most companies are willing to adopt new technologies at some point in their maturity curve, they are far less open to being at the frontier of ideation and innovation, particularly with respect to products and business models. Innovation needs to be embraced and embedded throughout the business, not just used as an occasional theme.

Figure 14: Incremental to breakthrough innovation



Management needs to be visible about its objectives for innovation and ensure alignment across the business. While innovation is frequently discussed on the executive floor, the incentives to encourage the right kinds of behaviour are often missing. Instead of a culture where risk taking is encouraged (within established bounds), it is replaced by a culture where failure is to be avoided at all costs.

Embedding a culture of innovation

It will be valuable for the organisation to collaborate and cooperate on a recurring basis beyond the formal silos that exist. This collaboration mindset has the potential to pay dividends to the business in perpetuity by embedding an innovation culture – not just a programme. Utilities need to recognise that building a culture of innovation can challenge the patience of management. Companies should expect that culture adaptation will take more than five years and demand visible commitment and constant nurturing. Indicators of adoption will come in a variety of ways, both tangible and intangible.

While management will be looking for how to 'ring the cash register' from innovation, other measures are just as valuable. Utilities will need to become comfortable with measuring items they never thought about in the past, e.g. ideas and collaboration. In the future, the fact that ideation occurs more broadly and seamlessly will be considered important, but less so than understanding how many ideas were converted into accomplishments and how idea pursuits were the result of cross-business unit engagement.

Embedding a 'culture of innovation' within utilities holds the promise of real advances in market positioning and connecting to customers. Those companies that embrace innovation as a way of doing business and the responsibility of the entire enterprise can gain a recognised level of differentiation that enables both market and financial success.

Viewpoint

Perspective: Delivering competitive advantage through energy efficiency

Jon Stretch

Managing Director & CEO,
ERM Power Ltd.

ERM Power is a fast-growing Australian company specialising in electricity retailing and leading energy management solutions for businesses in Australia and the US. Chief Executive Jon Stretch has broad international experience in the information technology, telecommunications and industrial sectors. His background in systems and process engineering, and business-to-business and business-to-consumer sales and marketing, has positioned him well to lead business transformation and growth in Australia and internationally.

In a rapidly transforming environment, discussion about Australia's energy sector remains stubbornly focused on greenhouse gas emissions and the transition from coal to renewables. Decarbonisation of the economy is very important but what's missing from the national dialogue is good, practical discussion and education on the opportunity right now for businesses to reduce energy consumption to improve their energy efficiency and deliver environmental benefits.

A revolution in energy efficiency

ERM Power is a disruptor in commercial and industrial (C&I) electricity retailing and is now doing the same on the demand side of the energy equation. The company has successfully disrupted the Australian energy retail business market by delivering powerful, meaningful and accurate data to business, government and industrials. Those data and clever analytics are the key to improved energy efficiency for big business.

PwC's 'data rich' future scenario resonates with us. Rich data points to opportunity everywhere. For example, we know that in Australia, buildings account for 40% of primary energy use, 12% of water consumption and 40% of CO2 emissions. A typical office or government building is empty for 72% of the year but uses 55% of its energy during this time. Effectively capturing, analysing and using data to create intelligent and value-added services makes a profound difference to the productivity and bottom lines of our customers.

By harnessing people, process and technology, we've achieved industry-leading customer satisfaction and retention rates in the C&I market. From humble beginnings as a boutique energy consultancy, we've grown to become the second largest electricity retailer to the C&I market in Australia, with operations in every state and the Australian Capital Territory.

Looking beyond the meter

ERM Power's fundamental difference is that we look beyond the meter. Because our retail business isn't vertically integrated, we don't own big baseload power stations so we're not motivated to sell our customers ever more electricity.

We're creating energy management solutions for today and for the future, including:

- demand response programmes
- embedded generation
- sensing and controlling systems (Greensense sustainability and energy monitoring)
- lighting solutions through lighting efficiency company Lumaled
- embedded networks, metering and sub-metering
- embedded generation harnessing solar PV and batteries for peak lopping
- the internet of things and what it can do for load control, and
- fleet energy procurement.

Energy as a strategic enabler

We consider energy efficiency to be a strategic enabler that can deliver competitive advantage to businesses by helping reduce costs, increasing and improving operational efficiency, delivering environmental outcomes and supporting the employment brand. Energy has moved well beyond a grudge purchase.

Our retail customer base is engaged and connected. They're seeking real-time data that informs intelligent decision-making, helps them reduce costs and achieves environmental outcomes. Increasingly, they're turning to us for help in efficiently managing their energy consumption.

We can support them because we understand the unique complexities of their business, their energy needs and their consumption. We capture, analyse and interpret big data to deliver intelligent solutions. Smart analytics combined with great service, accurate billing and energy efficiency services underpin our success. We also understand the need for personalised customer solutions to suit the individual requirements of our customers.

The only certainty in today's Australian energy sector is the escalating pace of change. ERM Power is at the forefront and committed to remaining there.

Winning in tomorrow's market

In tomorrow's utility market environment, maintaining strategic flexibility will be a highly valued advantage, given the high degree of uncertainty over future direction, pace and conditions. But utilities should recognise that despite the lack of definition, the level of change precipitated by evolving technology and shifting customer attitudes could be momentous and unforeseen.

As the pace of technology evolution and customer behaviours changes, incumbent utility roles will need to transform in tandem. From a legacy of gradual acceptance of new technologies to one of rapid adoption of emerging technology and continuous optimisation of business models, the future utilities industry will need to accelerate its own pace of change, embracing the new approach to innovation discussed in the previous chapter.

Just as there are uncertainties over the future availability, economics and performance of future technologies, there are also ambiguities about where, when and how utilities will need to respond to or capitalise on these technologies. This uncertainty will not be resolved in the near term. Utilities will need to learn to be adaptive to market conditions and comfortable with ambiguity. They will also need to learn to harness these disruptive technologies to create competitive advantage in their selected markets. Thus, technology deployment will shift from adoption for its own sake, to commercialisation as an outcome.

Creating competitive advantage will come from utilities seeking to utilise emerging technologies as a lever to extend existing relationships, foresee future customer needs or create markets for products and services that did not previously exist. This means that executive managements will need to abandon their desire for high degrees of predictability and learn to take and manage greater market entry, business execution and technology deployment risks than they have been used to.

Knowing where and how to compete

Utilities will first need to define where to compete, i.e. define their market *purpose* and desired outcomes. This will lead the company to define whether it plays in multiple value-chain spaces or in only a selected few that match its requirements for impact and value. The utility will also need to evaluate how to play, i.e. *position* itself for value optimisation. A company may pursue multiple product and service areas or only where value is the highest. Finally, a company will need to determine how to win, i.e. what *role* it chooses to perform based on its capabilities. This will lead companies to decide whether to compete alone or align with a partner to extend market reach and optimise market outcomes.

Long-term and sustained market success requires that the utility's operating model, organisation structure and resource capacity evolve to enable

Figure 15: Capabilities for winning

New Commercial Capabilities

Description

- **Innovation:** ability to harness internal and external resources to define and creatively address opportunities for 'breakthrough' thinking
- **Technology:** adeptness at understanding, deploying and leveraging new technologies in support of customer need fulfilment
- **Offerings:** development of attractive products and services that provide solutions for customers and can be broadly deployed
- **Partnering:** relationships with preferred vendors and technology firms and the ability to develop effective working agreements
- **Pricing:** flexibility in providing customers with alternative methods and options for product and service payment
- **Origination:** resources to continually scan the market for trends and opportunities and put together persuasive offering packages
- **Channels:** skill in identifying and leveraging alternative 'go-to-market' means to access customers
- **Branding:** creativity in establishing a differentiated business position and building and sustaining market awareness and interest
- **Financing:** balance sheet strength to support customers, where needed, with up-front capital for hardware projects

continuous development of market insights to feed both innovation and technology deployment. Companies will need to build the kinds of differentiating capabilities, e.g. market scanning, technology evaluation, partnering, data analytics and commercialisation that can leverage technology in ways that bring tangible value to the network and the customer *(figure 15)*. The power of innovation will unlock the promise of evolving technology and the value of this technology will enable even more innovation to perpetuate this cycle of 'organic value'.

Future business models and technology choices

To achieve their technology adoption and innovation aspirations, utilities will need to define their business model(s) of the future. Since the current regulated and integrated business model will shift, but not disappear, these evolved models will need to coexist with traditional archetypes. In a technology-enabled world, the strategic choices of where and how a company chooses to compete will establish parameters for what these new business models will look like.

Multiple options exist for which technologies to emphasise, i.e. storage, fuel cells, micro-turbines, on-site power, beyond the meter, etc. The most relevant technologies to a utility will depend on where on the value chain it is seeking to play and what it wants to accomplish. The accessibility of the technology to customers will create a situation where 'technology push – customer pull' create a confluence of objectives and expectations.

Utilities have choices on how they will choose to leverage technology disruption – participate in a passive, deployment-only mode, or play an active market and customer-enablement role where they leverage technology availability for commercialisation and creation of revenue streams from the products and services they spawn. Where commercialisation is the objective, utilities will be able to select from alternative business models depending on the role(s) they choose to undertake, the applicability of the technologies deployed and the extent of their related execution capabilities. These business models can range from narrow and specialised participation to highly asset- or operations-focused to bundled, end-to-end services.

But no single business model will support participation in multiple products or services, or business segments. Commercial value models reflect unique approaches to converting product offerings to value and range from simple-fee-for-service models to complicated performance outcomes sharing and avoided cost determination. Depending on the industry segment and the asset versus service focus, these commercial models for revenue creation are likely to range from those that are very targeted, i.e. a single offering and structure, to others that are broadly devised, i.e. a combination of financing, performance and cost outcomes that are bundled together.

A golden opportunity ahead for utilities

The next several decades are likely to see more innovation in the utilities industry than has occurred in recent lifetimes. Foreseeable technology deployment in just the next ten years will unlock greater value discovery and technology development targeted at energy production, storage, delivery, management and optimisation.

Utilities are presented with a golden opportunity to transform how countries, economies, producers and consumers alike think about energy, its use and its value. New hardware, software and neural tools will become available that will fundamentally shift the role of the utility, the leverage of technology, the management of network and premises assets and devices, and the participation of the customer. The integration of these elements will create more connectivity, more innovation and more active markets around energy.

Whether the utilities industry benefits from or is harmed by this upheaval in technology and innovation depends on how it views the future and its place within this emerging landscape. Companies that can develop a clear view of their energy future and position in this world will have an advantage with partners, regulators and customers. These companies will survive and thrive in a future none imagined possible just a decade ago. Companies that cannot see through the haze of emerging technology development and applications, or think it is too far away for them or customers to consider today, may find they don't get a second chance to stake out a future for themselves.

Four key questions

At the outset of this paper we posed four key questions facing CEOs. There are, of course, other questions that will also occupy CEO–level agendas, but these go to the heart of the challenges faced by companies as they consider their future positioning in a new technology-driven world.

How might disruptive technologies impact our business over the next five to ten years?

We see the utility industry as being both a beneficiary and a victim of these technologies and the new disruptive environment. Opportunities to win through early, targeted and aggressive technology deployment can enable protection of the grid as well as preservation and expansion of the customer relationship, securing existing revenue stability and opening up new revenues. On the other hand, utilities may find themselves at risk on both the asset and customer levels. If not integrated appropriately, intrusive technology can create risks to the operation of the network and enable disintermediation from customers – adversely affecting future growth opportunities.

What should we do to capture value from these disruptive technologies?

While cost parity from new technologies has not fully emerged and customers are not yet exiting the grid in large numbers, the time horizon for when these outcomes might take place is not open-ended. Companies can expect the pace of change to accelerate. This means the time for watchful waiting is waning and utilities need to move in time to be first to market. Companies need to explore all available opportunities to create – and capture – new value sources through smart innovation, disciplined deployment, responsive pricing, assertive partnering, and thoughtful product and service offerings.

How do we leverage disruptive technologies to create competitive advantage?

Turning these technologies into incumbent-provided market disruptors at the customer level will be necessary if utilities are to differentiate themselves from non-traditional providers from outside the sector. This means companies need to establish an 'early-adopter' advantage that communicates market vision, openness to change and is highly visible to customers. Competitive advantage can be created and sustained by positioning future technologies as 'solutions' to current known – and future unrecognised – challenges experienced by customers, even as utilities are educating the public about the value of disruption.

What can we do to build a sustainable innovation capability that supports new business models?

The industry recognises that it is not adept at innovation and that it has a gap to close to be able to respond to new market entrants seeking a customer presence. Companies need to establish clear internal responsibility for collaborative, but cohesive, innovation and not leave it up to siloed pockets of the organisation that have just a narrow and sporadic focus. As this innovation centres on advancing the company's market position, it will lead to a natural evolution of business models and an emphasis on unlocking new revenue streams that expand both customer presence and the value delivered.

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