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Future of Energy

The Balance of Power

Report

Future of Energy
The Balance of Power

Few would disagree that the UK's energy network is no longer fit for purpose. Ageing power stations, climate change commitments and a volatile fuel economy all add to the pressure on our energy infrastructure. But technology is changing the way we store, consume and generate electricity.

Pressure points on the energy sector

Fuel Security
North Sea gas supplies are dwindling, and the UK needs to find more dependable domestic energy sources.

Climate
In line with its climate change commitments the UK government has set a target to cut carbon emissions by 80% by 2050. This will have inevitable effects on fossil fuel use.

Defence
Concerns exist – rightly or wrongly – that centralised energy networks are more vulnerable to attacks from terrorists or hostile states.

Investment
In a volatile market, major new power stations are a big gamble. There's therefore been a renewed interest in decentralised alternatives.

Impacts and opportunities

Diesel's demise

2025

will usher in bans on diesel engines in four major global cities. Other countries are expected to follow suit. The rise of electric vehicles is sure to create new demands on the network.

Solar opportunities soaring

154

the factor by which solar panel prices have fallen since 1970. The expansion of onsite mini-grids and other small scale systems is likely to drive further growth in the sector, making solar the largest form of energy generation across the globe.

The rise of heat

21%

is the expected growth in renewable heat use in the UK by 2021. This trend is likely to bring new opportunities, with schemes to leverage waste heat from data centres for example.

The winds of change

+50%

of the world's wind power capacity was added in the past five years. Significant opportunities still exist in the UK, while markets are also growing across Africa, Asia, Latin America and the Middle East.

Untapped potential in energy storage

fall in the cost of electric vehicle batteries within 6 years. EDF is to build Europe's largest battery storage facility in Nottinghamshire. The UK has much untapped potential in storing energy.

A brighter future with smart tech

Rapidly evolving smart meters and appliances will manage energy use automatically around availability and cost.

The ascent of renewables

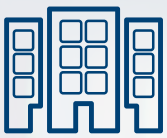
2.9%

is the estimated annual global growth rate of renewables from 2012 - 2040. Making them the most rapidly expanding source of electricity generation.

Lands of plenty

In the short to medium term, expanded CHP plants driven by gas or biomass, could offer significant revenue and enhance green credentials for any real estate project.

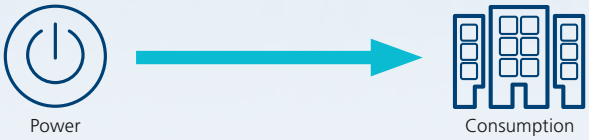
Gaining new ground on real estate



Rather than importing power from distribution grids, there'll be growth in on-site power generation and storage facilities, which will provide additional revenue opportunities for developers.

Out with the old

A *hierarchical* supply network



In with the new

A *distributed* access network

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Tomorrow's Energy: Digitised, Decentralised and Decarbonised

Energy is a high profile and often controversial topic. It is hugely affected by, and has a greater effect on, geopolitics, economics and regulation than perhaps any other sector. Energy is at the heart of everything we do, everything we use and everywhere we go. It is at the top of government agendas all over the world and is a key driver of the global economy.

However energy, like all other sectors, is susceptible to change – particularly from technology. Future of Energy: the Balance of Power is the latest thought leadership report from CMS. It considers the impact of technology on the energy sector and the likely changes this will bring.

Change can be slow to take effect but when change gains a foothold it happens fast. This is the nature of change and it is not a new phenomenon. Consider the streets of New York in the early 1900s, where the prevailing technology for transportation was the horse and cart. Fast forward ten years and all the horses had disappeared to the fields. The automobile had almost completely taken over the boulevards and avenues.

Technological advancement changes the way we do things, and if not embraced, technology has the power to make whole industries obsolete in less than a generation. Just ask the former owners of Kodak and Blockbuster Videos how change impacted their businesses. Just look at Airbnb, Uber, Twitter, Instagram, Facebook, Tesla and the iPhone – all multi-billion dollar businesses, none of which existed at the turn of the century.

Change is already happening in the energy sector. There is change in the way we generate energy, the way we distribute energy and the way we use energy. Change brings challenges but also opportunities. Future of Energy: the Balance of Power looks at likely growth areas within the energy sector which present a range of opportunities for investors, developers, contractors, operators and new entrants. Solar, heat networks, energy from waste and battery storage look to have great potential and could be very attractive markets for the future. Coal, gas and even nuclear generation may have had their day.

Whilst this report seeks to apply trends seen across other industries to the energy sector, we cannot of course completely predict the future: the events of 2016 demonstrate that we all need to be wary of relying too heavily on predictions and perceived logic. However, we hope you find the report interesting, informative and the starting point for some discussions as to how these changes may impact on your business.

Finally, I would like to take this opportunity to thank Tom Cheesewright of Applied Futurism practice Book of the Future for his work in putting together this report, and the contributors for our 'industry viewpoint' pieces: Dr Shengke Zhi of Amec Foster Wheeler, Robert Davis of EA Technology and Andrew Currie of Vital Energi.

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> I want to see an energy policy that emphasises the reliability of supply and lower costs for users.
>
> *Theresa May,*
> *UK Prime Minister 2016*

Future of Energy
The Balance of Power

The energy network is under pressure from all directions. Generating assets are ageing. Fuel economics is volatile. Security of supply is under threat. And the grid infrastructure is no longer fit for purpose.

Add technology to this volatile mix and you have the largest global change driver altering the way we consume, generate and even store energy.

The future of the UK's energy network will be defined by the intersections between technology's promise and society's needs. Those intersections demand a more diverse market and a network that is necessarily smarter and its operation more flexible and adaptive.

Introduction

Yesterday's energy network was a hierarchy of service. Supply at one end and consumption at the other. Tomorrow's network is a complex mesh of interactions. A network of constant arbitrage. The transition from yesterday to tomorrow will be full of challenge. The various forces shaping the future are forcing a change in the behaviour and involvement of every stakeholder in the energy market: generators, consumers network operators and regulators.

Not surprisingly, the primary shaping force in this transition is technology which has redefined what is possible and what is desirable, shifting the picture at every stage in the value chain.

This report, presents a horizon scan of the energy market through the lens of recent technological advances. Where these technological effects intersect with existing pressure points in the sector is where we will see the greatest and most immediate change.

Scoping 'Energy'

In referring to energy, we are referring to electricity as the core of our energy market; and in particular, the generation, supply and distribution of electricity to homes, businesses and transportation systems of tomorrow.

Technology is changing the way we consume energy, the way we generate it and promises new ways to store it.

Five Change Effects of Technology

Technology transforms every industry it touches. It can be observed to have five very distinct effects, which we can call **diversity**, **agility**, **performance**, **availability** and **scale**. These effects and their impact on the energy sector are outlined here.

100+

number of energy generating companies listed by Ofgem in the UK.

1. Diversity

Technology lowers the barriers to market entry by distributing ideas more widely and easing their discovery. Technology-driven globalisation has crashed the price of many technology components, which can often be recombined into new innovations

In the energy market this effect is already evident. The 'big six' continue to dominate both the consumer relationship (holding 86% of UK customers) and supply (owning or operating, jointly or wholly around 68% of generation). But this iron grip on the market is in rapid decline.

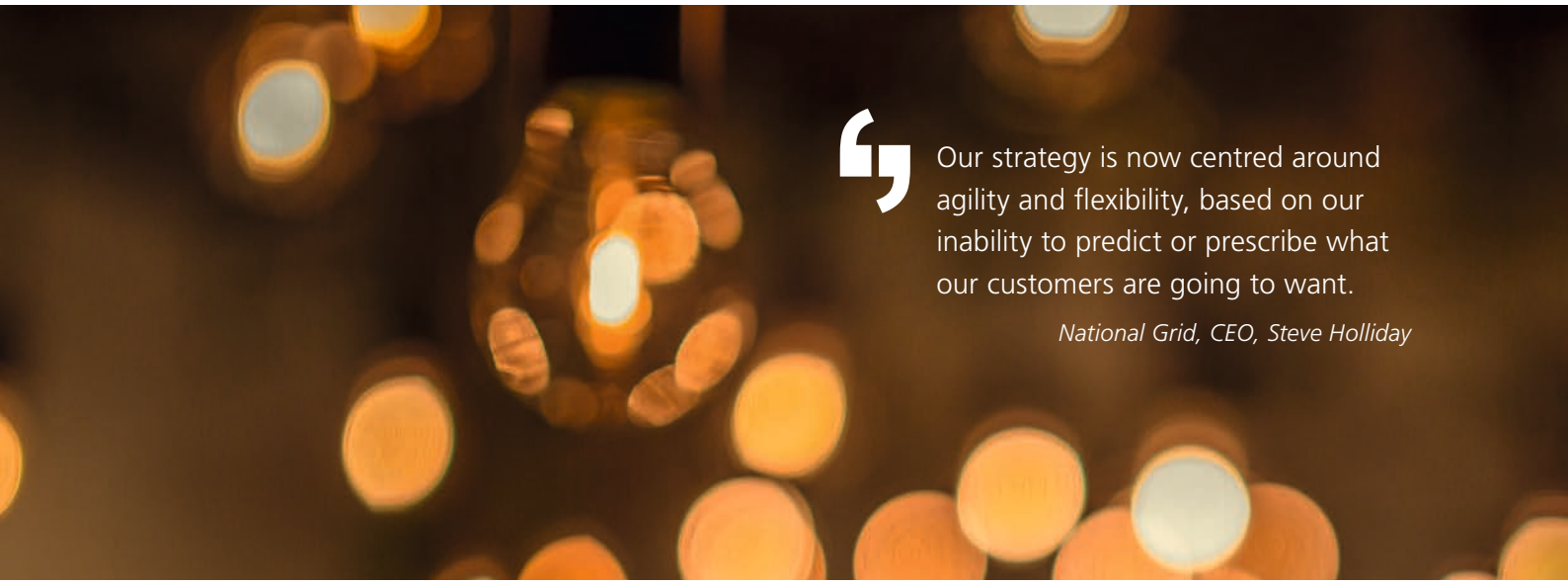
Diversity in Generation

Ofgem lists over a hundred different energy generating companies in the UK. There are many more that do not require a licence from Ofgem. Though some of these are joint ventures or subsidiaries of the big six, there is nonetheless increasing diversity in the generation of electricity. This trend will only continue. There will be more non-traditional generators like communities and small renewable energy operators involved in generation activity as technology makes generation more efficient. Further, these non-traditional outfits will be generating low carbon energy in increasingly diverse ways: solar, hydro, wind, tidal, geothermal and many different sub-categories of those.

Diversity in Supply

There is also a growing diversity in the range of domestic energy suppliers. There are over a hundred and fifty now recorded in the UK.

Though it may all flow through the same cables, our energy is generated and supplied by a diverse range of organisations today. As technology continues to lower the friction at the interfaces between the different layers of the energy market, we can expect this number to continue to grow. Specifically, the shift from human, manual interfaces between providers in the supply chain, to automated, data-driven interfaces will allow information to flow much more freely and for innovation to happen much more rapidly. The recent policy and regulatory changes coupled with the relative lack of infrastructure and investment required to be an energy supplier these days, as compared to even a few years ago, means that the barriers to entry are low, so innovative offers around consumption management, data sharing and smart home technology are likely to proliferate.



Diversity in Distribution

Perhaps the least diverse area of the market today is in distribution, where regional network operators still hold primacy for a simple reason: no-one wants to be laying multiple distribution networks around cities. We are of course starting to see the change in action by way of the recently opened up "new connections" market where Independent Distribution Network Operators (IDNOs) and Independent Connection Providers (ICPs) now compete with the local DNOs to provide new connections. But there is definitely opportunity for the market to develop even further. We may in fact see private operators foraying in to the market to deliver energy across their own property portfolios themselves using public wires. Although this is currently possible on paper, more needs to be done in terms of policy to allow this to come into practice.

Large estate holders who have generating potential may look to take control of the lines coming into and out of their facilities, just as they lease dark fibre lines for telecoms. But by taking control of the lines they can maintain their generated energy inside their own virtual grid, even though the infrastructure remains exactly the same. This will give them greater control over the inflow and outflow of energy into their campuses and perhaps shift the economics of reselling energy back to the grid.

Diversity in Consumption

One area where diversity has not been evident is in energy consumption, with persistent peaks in demand rather than an evening-out of utilisation across the day.

Both domestic and non-domestic consumption has fallen back consistently over the last ten to twenty years, while transport energy consumption has continued to rise. But patterns of energy consumption throughout the day have remained consistent. In short, we still get up in the morning, go to work, come home in the evening, cook dinner and watch TV. Our patterns of energy consumption are defined by this pattern and so our networks and generating capacity remain scaled to cope with the associated peaks in demand. However, we may see an impact from the brand new Time of Use (ToU) tariffs which will offer incentive to consumers to shift their consumption to non-peak hours by offering cheaper non-peak tariffs.

Five Change Effects of Technology

2. Agility

Technology lowers the tension in markets, allowing much more rapid change to take place.

This effect was clearly acknowledged by National Grid CEO Steve Holliday in a recent interview: "Our strategy is now centred around agility and flexibility, based on our inability to predict or prescribe what our customers are going to want."

To date, the energy market has been insulated from some of this effect by regulation, by the commercial power of the big six suppliers, and by the incredible capital costs bound up in the generation, transmission and supply infrastructure. But this rate of acceleration is fading. Every player in the energy sector will be required to exhibit greater agility, shifting their modes of operation to fit the fast-changing market.

Responding to the Transport Challenge

It is clear now that the future of transport, the UK's biggest consumer of energy, is electric. What is not clear is what impact this will have on patterns of consumption. Will the rise of electric transport strain the supply and generation networks at peak times? Or will they, with their large batteries and smart controllers, present Five Change Effects of Technology an opportunity to balance the grid, as originally proposed by Shai Agassi's ambitious (but ultimately doomed) start-up business Better Place?

3. Performance

New Time of Use (ToU) tariffs in the next five years and smart grid installations is expected to change the way we consume energy.

Technology speeds the flow of information in organisations, markets and cultures and creates an imperative on all involved in those networks to learn to collect, comprehend and act on that information more quickly. In the energy sector, it has long been acknowledged that more and faster information is needed in order to help to meet climate control and balance supply and demand, and to help consumers to manage their own consumption. Hence the long, slow, and painful rollout of smart meters, still further delayed and with security concerns remaining.

Informing Consumers

While we wait for these issues to be fixed, the performance effect is already apparent in the advent of comparison sites, allowing rich feature and price comparisons between the proliferation of suppliers and tariffs.

Arguably the next natural step along this line of growing consumer information and control is the rising demand for energy prices to fall in line with wholesale prices – information that has not previously been transparent to the consumer.

The accelerated flow of information allows consumers to see wholesale prices falling in real time and makes it easier for them to organise campaigns for their own costs to follow. Aware consumers will force utilities to be more competitive. Although the bulk of the electricity they supply is bought by suppliers in the futures market, up to two years in advance, suppliers are more likely to be forced to pass on any savings in due course. Hedging and grid costs complicate this proposition, but opening up the calculations to consumers could be a compelling marketing story.

Smart Consumption

Part of the plan for smart meters and the smart appliances that we are expected to connect to, is to balance energy consumption over the day, turning on washing machines and dishwashers at times the grid is underused, or even taking active control of freezers, which don't need to be on all the time to maintain food at a safe temperature.

Just as adding storage into the edge of the distribution network limits the need for additional network capacity to deal with peak load, the hope is that Five Change Effects of Technology software such as this can limit the need for storage by redirecting consumption to off-peak times.

Five Change Effects of Technology

Battery technology provides opportunities, but is expensive, at around £1 million per MWH.

4. Availability

As technology advances, its cost falls and its availability increases. As components become more widely used so their production volume increases and the price per unit falls.

Two key components of energy infrastructure have been subject to this effect in recent years: solar cells and lithium ion batteries. Efficiencies and energy densities continue to rise, while unit costs fall. It is clear now that solar power will be the cheapest form of energy generation in the near future, and that future advances in battery technology will make hyper-local energy storage attractive in many contexts.

Availability has also had a huge impact on the nature of our consumption. While we own more devices, they are now significantly more efficient consumers of energy, whether that is AAA rated white goods, or computing devices. The result is that domestic electricity consumption has declined significantly since the turn of the century.

Whether this trend continues will depend very much on the success of the electric car. The replacement of the internal combustion engine by an electric motor seems certain, but what is not clear is the business model in which these cars will be introduced. Will consumers own electric cars for personal use as they do now? Or will Uber-type models of transport-on-demand ultimately reduce car ownership? The business model of Uber is far from proven and it is facing significant regulatory challenges around both its human-driven operations and its future self-drive plans – always the long-term goal for the business.

Distribution network operators fear that hundreds of thousands of people completing their day's commute and plugging-in their vehicles to charge could further increase the peak load on the grid, the support of which already accounts for 40% of grid infrastructure investment.

The answer may be in leveraging the same battery technology that powers the electric cars to provide local storage to balance-out peaks. But batteries are not simple to integrate into the existing AC grid and remain expensive, at around £1m per megawatt hour.

Storage on the grid side is also currently classified as a generation asset in the UK due to the absence of a regulatory definition. This peculiarity means that storage is treated as 'demand' or 'consumption' while the batteries are charging and as 'generation' while the batteries are discharging. Storage operators therefore end up having to pay grid charges twice, rendering storage solutions particularly expensive and often unviable. Regulation will need to be reviewed and the price/ performance ratio of storage will need to continue its dramatic improvement to make this a viable option.

5. Scale

By lowering the friction in interactions between organisations, technology fundamentally changes the nature of scale. Inter-company relationships can now be entirely data-driven, eliminating the value of vertical integration, or allowing integrated businesses to expose components of their service to third parties.

To date in the energy sector this trend is best exemplified by the rapid expansion in electricity suppliers, really just marketing businesses selling power generated by and distributed on infrastructure owned by others and operating on shared data.

Re-regulation of distribution infrastructure could see this pattern of diversity move up into the next tier of the industry, particularly in the non-domestic sector. Organisations with large energy needs and/or significant generating capacity might take control of adjacent infrastructure on a leased basis, giving them greater flexibility in operations. Fast flowing data between these organisations and the primary distribution services will facilitate localised balancing of the electricity network and allow for more equitable shares of revenue and investment. Note the term 'distribution services' rather than 'network operators', perhaps more apt as the single homogenous network increasingly becomes a network of networks.

At the top tier of the market this trend might see greater interaction between international partners by way of Inter-Connectors with respect to the physical transfer of electricity and the European Market Coupling initiative with respect to the commercial transfer of electricity. Already 5% of our generating capacity and growing is serviced through international partners, though current political shifts may complicate and add cost to international transactions.

5%

of our generating capacity is serviced through international partners.

Industry viewpoint

Dr Shengke Zhi

Amec Foster Wheeler

Clean energy significantly contributes to the future of energy, which drives our development. That's why many countries committed to develop low carbon technologies including renewables, energy storage and nuclear power. The future of energy should be affordable, reliable and available. The choice for the future energy should be diversity and fit for local needs. Hence, a deep understanding of various energy technologies and a strategic plan to achieve the target of challenges are required in place sooner rather than later.

Robert Davis

Group CEO – EA Technology

The biggest challenge for government is to stimulate the right investment in the electricity generation fleet to achieve our hugely challenging carbon targets. As transport becomes increasingly electrified, with some forecasts suggesting there will be a million electric vehicles on UK roads by 2020, it is critical that carbon production isn't simply shifted from combustion engines to fossil fuel power stations. Concurrently, energy networks continue to face their renewal challenge. Ofgem is driving the network operators to ever higher reliability performance levels whilst replacing a seriously ageing network. Network operators will have to move at an ever faster pace from small scale trials of new technologies, to large scale deployment. The next decade will be one of unprecedented change.

Andrew Currie

Commercial Structuring Manager, Vital Energi

The largest battery factory in the world is currently ramping up production. Many are predicting energy storage playing a larger role in our electrical system but the factories main objective is to produce a power source for cars. Are we missing a larger opportunity to put the infrastructure in place to allow road users to sweat these assets further by using these batteries as energy storage for households? Centralised control systems could allow connected vehicles to perform a range of balancing services to the grid and provide peak lopping and targeted benefits to households. Should we be looking at putting this infrastructure in place now before the role out begins?

Pressure points on the energy sector

The likely impact of technology can be best understood by examining the current pressure points in the energy sector.

80%

the target which the UK government pledges to reduce carbon emissions by the year 2050.

Climate

The UK is bound by commitments to limit carbon emissions which naturally place pressure on fossil fuel generation. Against 1990 levels the government is now committed (as of the fifth carbon budget) to reduce carbon emissions by 57% by 2030 and by 80% by 2050.

Fossil fuels still represent the greatest proportion of UK generation, though this is falling. The growth in gas has offset most of the fall in generation from the closure of coal-fired power stations such as Longannet, Ferrybridge C and Rugeley. While some have called for large-scale expansion in UK gas generation to offset the completion of the coal phase-out by 2025, and the retirement of ageing nuclear plants, others argue that existing plans for expansions in wind generation, interconnections and demand side response mean there is only limited need for this.

Fuel Security

North Sea gas supplies are declining, and while estimates of its exhaustion by 2017 may have been overstated, it's clear that long-term the UK's gas will have to come from other sources. With the potential of fracking still uncertain, those supplies are European pipelines carrying supplies primarily from Russia and Norway, and more expensive LNG from around the world.

Given the instability in the relationship with Russia and the continuing insecurity in the Middle East, it is clear that considerations of fuel security will need to drive future energy planning.

Investment

Building new power stations is an extremely expensive gamble in a highly volatile market and one that the government has been reluctant to make. Hence the long delays in securing investment and approval for the Hinkley C project and the high long-term strike price that has been required to get even close to agreement.

Public or private, many commentators argue that it's hard to make a strong case for large capital investments in centralised generating capacity. The strike prices required to justify such investment are significantly higher than the current and forecast cost of renewables and other sources, something unpalatable to consumer groups. No-one wants to be in charge of an asset that becomes a millstone around the neck of the energy sector, supported by levies on consumer bills when the market price of electricity has fallen much lower.

The CATO (Competitively Appointed Transmission Owners) regime is designed to bring private investment into renewing on-shore transmission networks but until the first tender is completed it's not clear what level of interest this will attract.

Security

Justified or not, there are growing concerns about terrorism and the threat it poses to the UK's energy infrastructure. This isn't just the potential for attacks on nuclear plants as a direct threat to life, though those remain. Cyberterrorism has, at least in theory, the capability to disable or disconnect generating capacity and 'crash' the grid. This could indirectly cause loss of life, as well as enormous economic damage.

The CyberSquirrel project has demonstrated that the threat from international cyberterrorism to infrastructure remains an unrealised threat. It lists only one major incident of state-sponsored cyberterrorism – the Stuxnet virus that is believed to have knocked out Iran's nuclear enrichment programme but which later wreaked havoc to ordinary computer users when it escaped to the internet. Squirrels and other animals have had a much greater impact on energy infrastructure than any state actor. The CyberSquirrel project lists hundreds of animal related outages, including an eagle that cut-off electricity to 2,000 homes in Western Australia by dropping a sheep's head onto a power pole and a troop of Zimbabwean baboons that chewed through transmission cables and took a local radio station off the air for two hours, costing it $1,200 in lost advertising revenue, to name just a couple.

That said, the fear of cyber-attack against energy infrastructure and the scale of its potential effect, mean that it will remain high on the agenda.

Cyberterrorism remains a threat to UK energy infrastructure.

Five key changes to the energy sector

Considering the impact of technology and these pressure points, there are **five key changes** we can identify in the future energy sector.

1 million

estimated number of electric vehicles on UK roads by 2020.

1. The future is electric

It is clear that the costs of solar generation will continue to fall as generation efficiency grows, production techniques improve and the underlying technologies are further advanced. Storage is beginning to ramp up towards similarly exponential improvements in price and performance, with incremental advancements to lithium ion batteries in the short term, and in the medium term, new battery chemistries such as lithium/air and aluminium bases.

These advances combined with the growing costs of and risk to gas supplies means that electricity will eventually be the dominant form of energy supply to UK homes with gas dropping off sharply beyond a certain point. The current political situation combined with uncertainty about the scale of shale gas supplies makes it hard to say precisely when this transition will complete, but the general direction of travel is clear.

Transport will clearly be electric and will perhaps be the most dramatic transition, with today's hybrid vehicles rapidly being replaced with all-electric vehicles for public, private and commercial transport as battery technology crosses a price/performance threshold that puts near-petrol range and convenience inside the reach of the average buyer. The falling price-point and increasing performance of Tesla and other electric vehicles shows this trend in action already. The key to electric vehicle success will be the ability of our towns and cities to offer easy access to charging points. Many are already making EV's part of their future plans, for example, Dubai based international hotel chain Jumeirah Group is looking to install 20 new EV charging stations by 2020 as well as introducing an EV fleet.

2. Energy will be local, not national

We are likely to see more small-scale, local generation in the form of CHP plants, biomass and energy from waste (EfW).

The changing nature of generation and consumption no longer supports the idea of a traditional energy network. Wind and solar can both operate at small or micro scale. Behind the meter storage solutions are becoming more and more accessible, which will allow consumers to consume more of their own micro-generation output such as from solar panels installed on roofs before having to tap into the grid, while also enabling an export of any surplus output to the grid.

Electric vehicles may unbalance this shift, creating a short term spike in peak demand that cannot immediately be met by small scale generation and storage. But it only takes incremental improvements in generating efficiency and storage capacity for the needle to swing back towards more local production. Current investments are likely to yield continued improvements in these metrics for years to come.

It will not become any easier to justify investment in centralised and relatively expensive forms of generation, however much the national network might need them. Some further new nuclear may make it to market, particularly a new generation of more cost-effective small modular reactors, but in the short term, offsetting the peaky nature of wind generation is likely to be predominantly the role of ageing plants, pushed further beyond their original intended life span, combined with some new gas capacity. This may not be the cheapest or cleanest option but it will sustain supply to the point where more distributed options can take up the load.

More small-scale, local generation in the form of CHP plants and biomass / EfW may also start to pick up the balancing requirements, with large-scale property developments seeing the opportunity to expand existing plants. Persistent returns from local heat networks and lucrative peak-time electricity supply combined with relatively little regulation of the heat market at smaller scales could make this a very attractive option, especially as outsourced operations firms begin to become more sophisticated at taking on the planning and some of the risk.

The traditional utility generators/suppliers are likely to face significant competition from new local generation entrants who will be able to generate and supply electricity generated on-site cheaper than utility scale suppliers, which may leave them unable to compete on price. Regulation of (i.e. taxing) local and selfgeneration to help the utilities remain competitive – as has happened in Arizona – may help keep the wolf from the door for a while, but in a de-regulated market like the UK it is hard to see this being palatable to consumers or lawmakers.

Five key changes to the energy sector

3. Access networks, not supply

The idea of electricity networks as 'supply' networks needs to be abandoned. The first principle of tomorrow's electricity network is that it is a multi-way mesh, not a one-way conduit. Generation and storage will be widely distributed with 'distribution service operators' handling balancing and surety of supply.

This is a fundamental shift in the role of today's distribution network operators and supporting it will require changes in regulation to allow more flexible utilisation of existing assets, particularly where larger local generators want to take control of lines.

Consumers of energy will see a shift in their relationship with the supplier, with perhaps a greater cost risk for those who cannot generate their own energy and have to rely wholly on the network. What this will mean for unit prices will depend on how the transition is implemented and the ultimate model that tomorrow's 'supply' businesses adopt.

4. Ecology and economy align

Convincing people to do things to save the planet has proven challenging. The changing nature of the 'access vs supply' business model means there might be greater financial incentives for efficiency, both in the home and in networks and businesses.

At the home level, it will be clear when you go beyond self-sufficiency into an 'energy overdraft'. This may influence greater investment in staying inside the capacity of the property, at least for those homeowners able to afford the investment in generation and storage. This may take the form of increasing capacity but if the economics are properly designed, it could be focused on efficiency.

At the network level there are opportunities to achieve cost efficiencies, for example, by extracting useful heat from transformer cooling. Such schemes may support future upgrades to the network.

Heat networks leveraging waste heat from data centres and other energy-intensive industries, as well as growth in combined heat and power plants, present an area for potential growth that has always been under-addressed in the UK.

The Government has announced over £320 million of capital to support investment in heat networks.

5. "Smart" Opportunities

There is likely to be a massive change in the dominant business model in the energy sector, from generation to demand and arbitrage, all empowered by open and fast-flowing data. In both domestic and non-domestic markets this will create huge opportunities for disruption to both the existing players in the market and the energy sectors structure.

In the UK those with significant generation and storage capacity may be interested in co-operative models. Large property owners may find it attractive to expand supply businesses beyond their own tenants, perhaps mixing domestic and non-domestic custom to balance demand.

In between there is likely to be a lot of purely data driven players, leveraging the fast flow of information to provide comparison and trading services.

21%

expected growth in renewable heat use in the UK by 2021.

Conclusion

We are entering a period of disruption in the UK's energy supply across three clear dimensions:

— Generation is moving from large to small, from centralised to distributed and from nuclear and fossil to renewable sources

— One-way supply networks are becoming two-way interactive networks, with a system that will be built as much on cached energy in stores as in generation

— Consumption is moving from a broad energy mix to a singular focus on electricity, as generating costs look set to fall and storage becomes more affordable and practical

As with all market disruptions, this transition presents enormous opportunities.

There are short term opportunities for those who own infrastructure to help the country meet demand while replacing old infrastructure is proving challenging. In the medium term there is an opportunity to build the new infrastructure that will form part of tomorrow's distributed grid – or to ensure that you are well placed to do so when the time is right. And in the long-term, there are opportunities to redesign the business of energy, utilising the networked system, diversity of supply and rich availability of data to build new enterprises.

Opportunities for real estate

A more distributed, smart and electricity-led energy system creates new opportunities for the real estate sector, in energy generation, storage and distribution.

In generation, there is a clear opportunity to expand existing generating plans. In the short to medium term, expanded CHP (combined heat and power) plants driven by gas or biomass, could offer significant additional revenue opportunities as well as enhancing green credentials for any real estate project. Such projects may appear risky: increased capital costs combined with lack of understanding and experience of the energy market has led to a few companies suffering burnt fingers. But new intermediaries are offering to take on the management of such plants, moderating risk but still offering property owners a significantly enhanced return over time. With unit prices doubling at peak times and deep uncertainty about the ability of national generating schemes to meet this demand in the next decade, this seems like a solid and sensible investment today.

Where properties are proximate to domestic housing, heat networks look to be an additional opportunity, both with existing and new entrants benefitting from policy changes. Heat doesn't have to come from dedicated plants, with both data centres and large electrical transformers having significant cooling needs, which translates into waste heat. If this heat can be efficiently captured and redistributed then waste suddenly becomes a valuable resource. As evidenced by the resurgence of interest in district heating in the UK, a market that has seen very low levels of penetration by European standards.

The long-term opportunity is for property owners to become a major node on the distributed energy network. Solar (or wind, depending on location) generating capacity combined with significant storage will provide energy security – and price guarantees – for tenants, as well as an opportunity to tap into the premiums for meeting peak demand through smart grids on the wider network. As costs of storage fall and taxation issues are addressed, those with the space, location and access to capital to provide high-efficiency local networks will be in an excellent position.

In addition, the global rooftop solar PV market looks set to soar over the coming years and is expected to be worth £3.66 billion by 2023. The market is anticipated to expand at a rate of 11% between 2015 and 2023. This will be a key area for real estate for the future and one which should not be ignored.

11%

the rate at which the global rooftop solar PV market is expected to expand between 2015 and 2023.

What does the future have in store for the energy sub-sectors?

Solar

Deployment of solar capacity is already surpassing all expectations around the world. The price/performance ratio continues to improve, with labs producing wave after wave of innovation in efficiency and manufacture. It's not quite on a 'Moore's Law' style exponential curve yet, but nonetheless, the solar story is highly compelling.

Challenges remain though. Solar cell efficiency generally tops out at around the 40% mark and is (so far) strongly affected by the form in which they are produced: arguments rage over whether solar 'shingles' that directly replace roofing tiles can come close to matching the efficiency of 'bolt-on' alternatives, albeit the obvious aesthetic advantages.

Production of so-called 'second generation' cells continues to rely on fairly exotic materials such as cadmium telluride, but recycling plans are expected to minimise the cost impact of such materials for the next couple of decades.

Wind

Wind has been the early renewable hero in countries across Europe and now generates more energy in the UK than coal. Wind costs have also been falling dramatically, with offshore costs falling 32% in the last four years, an onshore wind now being the most cost-effective means of energy generation in the UK.

Wind though suffers most obviously from problems of intermittency and while small-scale wind is possible it is large scale programmes – necessarily distant from consumption – that make up the bulk of capacity.

Tidal

Tidal power has seen renewed focus in recent years, with UK sites offering apparent huge potential – up to 20% of UK demand, by some estimates. The test project at Swansea Bay looks set to go ahead, with other schemes in Cornwall and Cumbria to be considered if it is a success. That success would mean generating electricity at a cost competitive with the Hinkley C strike price.

Unlike other renewable sources, tidal power is eminently predictable and there are multiple means to flatten out the generation troughs at the turn of the tide.

Hydro

England and Wales have limited capacity for major expansion in hydro power, and while Scotland does have potential, large schemes would likely be remote and hence relatively expensive. Small scale community schemes have suffered from the end of the feed in tariff but may see renewed focus in an environment where distributed generation becomes the norm.

Oil & gas

Diesel generation has been the big winner from the capacity market, picking up hundreds of millions in subsidies, at a clear cost to the UK's clean energy credentials. Its long-term future remains clear but in the short to medium term, it is likely to remain a part of the mix while alternatives are uncertain.

Gas was long the big bet for the long-term future of national generation, alongside wind and new nuclear. But to date, the capacity market has not supported the commissioning of any new combined cycle plants, despite the approval for up to 10GW of capacity around the country. Without this guaranteed subsidy and with uncertainties elsewhere in the gas market, these plants are unlikely to be built, suggesting a re-engineering of the capacity market rules.

Nuclear

Nuclear power remains a large, long-term, high risk investment. Commercial companies laying this type of bet want long-term guarantees from government that their investment will be worthwhile. The uncertain political and economic situation and the rate of change in alternative generating technologies has meant that nuclear has been hard to get off the ground. It is likely that some nuclear generating capacity will make it through these hurdles, with Hinkley C now given the go-ahead, but until nuclear can effectively be shrunk it is not a mode of generation that fits neatly into the likely future grid picture, albeit there currently appears to be the political will to back nuclear. This is likely to continue as nuclear seems to be part of the price to be paid by the UK to strengthen its relationships with trading partners such as China in a post-Brexit environment.

Waste/Anaerobic Digestion

CHP plants running on biogas from waste are a great fit for our predicted future energy landscape, where heat networks are more common and energy production is more distributed. This is particularly true in more rural areas where the bulk of potential supply material – agricultural sources are five times greater than domestic waste. Government estimates suggest biogas from anaerobic digestion could represent 7.5% of renewable energy needs by 2020.

About us

About CMS

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Future of Energy: The Balance of Power is the latest report from the CMS thought leadership range. For other reports such as *Infrastructure Index – Bridging the gap* and *UK real estate in the digital age* please visit cms.law.

About the research

Book of the Future

This report was produced in conjunction with Book of the Future – an Applied Futurism practice. Book of the Future is led by Tom Cheesewright. Tom is one of the UK's leading commentators on technology and the future and is a frequent 'talking head' on BBC TV and radio, Sky News and Channel 4. He is a regular speaker at live events, conferences, round table debates and dinners. The report examines the five primary change effects of technology and applies them directly to the energy sector. For further information please visit **www.bookofthefuture.co.uk**.

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