Simmons & Simmons

Energy Storage

There's a storm coming

There's a storm coming.

Energy storage is poised to shake up the world's energy markets and change our relationship with energy supply beyond recognition.

The impacts of this sea-change will generate offgrid low-carbon futures for remote communities, optimise PV export revenues and enable prosumers to trade more profitably and directly with neighbours using emerging blockchain technologies.

We are excited about watching these new market opportunities unfold, and helping business navigate the emerging legal issues that come with them.

Steve McNab
London, 2016

Key themes in energy storage

The idea of energy storage is not new – pumped hydro-electric solutions have been used in the UK for decades, but advancement in battery technologies and a sharp decline in the cost of the key ingredient of a leading technology – lithium - means that the energy storage is finally becoming an economically viable answer to variable energy demand problems.

The US energy storage market grew 243% in 2015

In the US, where energy storage is ahead of Europe in many respects, the market grew by 243% in 2015. In 2013, the State of California mandated the three largest state utilities to procure more than 1325 megawatts of energy storage by 2020 and install them by 2024. To facilitate this, the state has been removing regulatory barriers and formulating incentives to promote this technology.

The situation in Europe is less clear cut, despite the need for storage being arguably greater than in the sunnier climes of California. The Northern European climate is a bar to independence from traditional electricity. Neither solar generation – at its peak between 11am and 3pm, nor wind generation – at its peak at night, are aligned with demand which peaks between 4pm and 6pm. The obvious solution is to store renewable energy for use when it is most needed and in the last few years commercially viable solutions are finally available to achieve that. The UK is predicted to grow its storage capacity from 24MW in 2016 to 1.6GW by 2020.

On a business-as-usual basis, energy storage has the potential to save the UK an estimated £2.4 billion per year in 2030

It is widely acknowledged that there are legal barriers stopping the market from expanding as quickly as it would like. Much of the legislation on electricity is almost 20 years old and ill-suited to regulate a technology it could not have predicted. The Electricity Act 1989 regards energy storage as a generator of electricity (and in some instances also a consumer), when it fits neatly into neither category.

On a business-as-usual basis, energy storage has the potential to save the UK an estimated £2.4 billion per year in 2030, according to a March 2016 report by three major utilities and the UK and Scottish governments. The report also finds that, if regulatory barriers are removed, this could increase to £7 billion. Both European and UK regulators are working towards appropriate solutions to balance the competing needs of consumers, renewables providers and traditional utilities, though no immediate change is on the horizon.

What has changed?

The growth of renewable energy capability resulting in more intermittent generation, and the rapid rise in relevant technologies.

Energy storage solutions allow renewable energy generators to store electricity at times of high generation (such as midday) and supply it at times when demand – and therefore price - is highest. Storage technology holds benefits for balancing electricity supply and demand both on very short timescales (such as frequency response) and for longer periods (such as participation in the capacity market to ensure availability of power at times of highest demand).

Benefits

- Renewable energy generated at off-peak times of day can be stored and used in times of high demand
- Storage technology can be used to balance supply and demand both for fast frequency response and over longer periods
- Energy storage could eventually help companies and consumers to go entirely "off grid"

Battery technology has particularly come to the fore on account of rapidly declining costs of ingredients such as lithium. Between 1990 and 2016, the cost of lithium ion batteries fell from USD 3,000/kWh to an accessible USD 200/kWh.

The UK Department of Energy and Climate Change (DECC) has been vocal in its support of energy storage and the sector expects to receive some of the £50m pledged to "energy storage, demand-side response and other smart technologies" by 2021. In March 2016, the National Infrastructure Commission was more specific and said that the UK could become a world leader in electricity storage systems provided it reviewed the regulatory and legal status of storage (by Spring 2017) and incentivised network owners to improve capacity and resilience using storage.

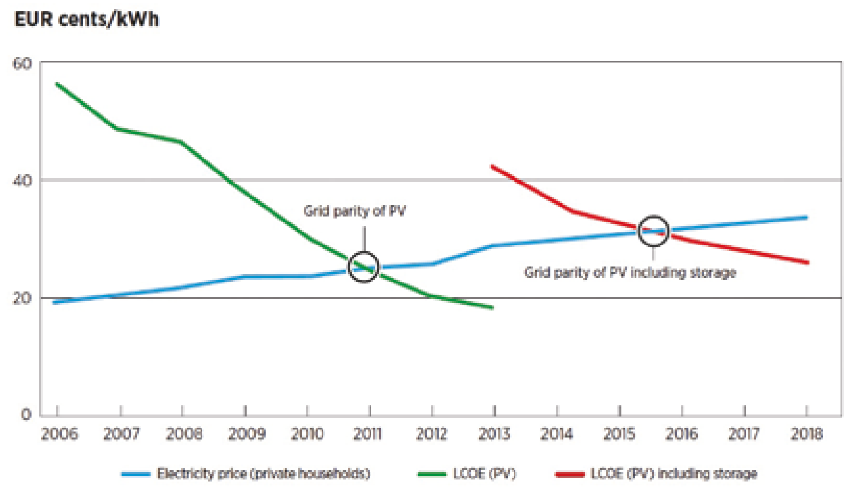
What incentives are available for energy storage?

The UK government does not currently offer and does not intend to offer any incentives or subsidies for the installation of energy storage.

Renewable energy sources benefitting from Feed-in Tariff (FIT) payments can be connected to energy storage only in limited circumstances. OFGEM's guidance issued in May 2016 clarifies that the FIT Licensee must be confident that there is no risk of the renewable electricity generated by the eligible FIT installation being mixed with any other electricity before it is metered for the purpose of calculating FIT payments. In effect this means that a battery connected directly to solar panels will be approved, whereas a wind turbine turned on by a diesel generator must be specifically set up so that the battery and the diesel generator are not connected in any way. Storage unconnected to a renewable installation is not eligible to receive FIT payments, and with reductions in FIT tariffs and deployment caps announced in early 2016, there is little prospect of this changing.

A similar situation exists in relation to the "Contracts for Difference", the renewables support scheme that is gradually replacing the Renewables Obligation scheme. As with FIT, storage cannot benefit from CfD in its own right but can be used in conjunction with renewable generation assets provided there is no mixing of renewable and grid energy. In May 2016, DECC launched a consultation for changes to the CfD contract and regulations to clarify how storage would be treated. The amendments would clarify that energy storage can be installed on CFD sites provided no imported electricity is taken into account in calculating the CfD payments, and would further ensure the separation of storage in a separate balancing mechanism unit to the generating facility.

Towards Grid parity of PV & storage in Germany



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The EU's Guidelines on State Aid for Environmental Protection for Energy (2014/C 200/01) work on an assumption that renewable energy sources will become grid-competitive at some point between 2020 and 2030, and therefore any subsidies, or exemptions from generation/supply balancing obligations, must gradually be phased out. The Guidelines further provide that from 1 January 2016, any new aid schemes and measures must subject recipients to standard balancing responsibilities (except those with an installed capacity of less than 500 kW/3 MW for wind). These balancing responsibilities can be discharged by third parties including aggregators.

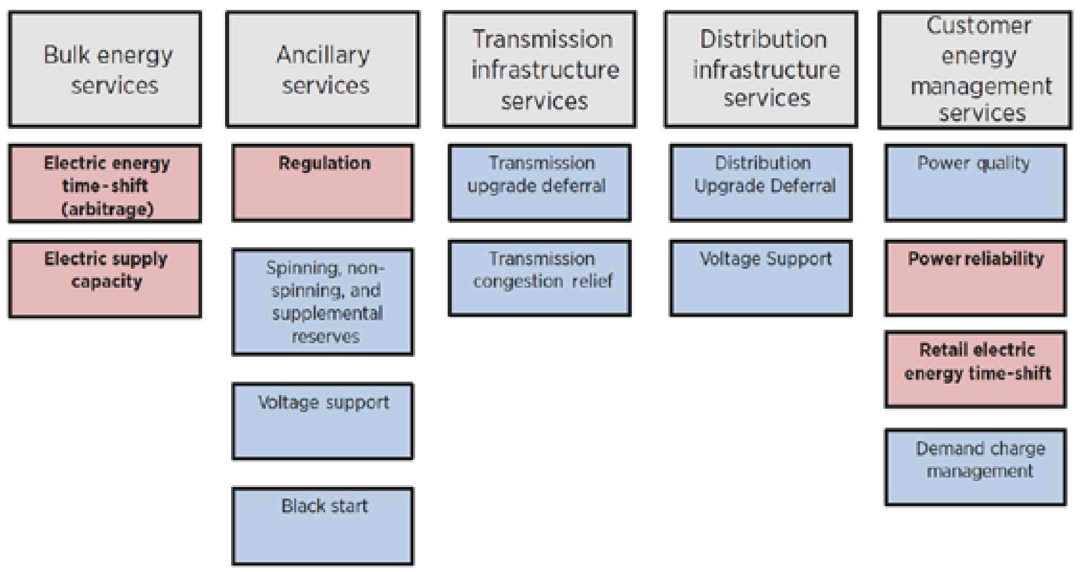
> *"The National Infrastructure Commission recently recommended that "network owners should be incentivised by Ofgem to use storage (and other sources of flexibility) to improve the capacity and resilience of their networks as part of a more actively managed system."* [2]

> *"The Government must get a move on and encourage the energy market to embrace smart technological solutions like energy storage and demand side response."*

House of Commons Energy and Climate Change Committee Chair Angus MacNeil, October 2015 [1]

1 http://www.parliament.uk/business/committees/committees-a-z/commons-select/energy-and-climate-change-committee/news-parliament-2015/energy-revolution-report-published-16-17/

2 A Smart Flexible Energy System, A Call For Evidence, November 2016 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/567006/Smart_Flexibility_Energy_-_Call_for_Evidence.pdf



Boxes in red: Energy storage services directly supporting the integration of variable renewable energy

© International Renewable Energy Agency (IRENA), Electricity Storage, 2015

How does energy storage impact traditional electricity providers?

Energy storage solutions are eligible to take part in the Capacity Market (CM) which aims to ensure uninterrupted supply of electricity by national utilities at times of highest demand.

However the contract price for electricity under the CM is unlikely to make participation attractive to storage providers at current market levels. Nonetheless, the theoretical possibility exists for storage to compete directly by bidding for contracts or indirectly by reducing the overall generation capacity needed to meet demand.

> *Utilities themselves are well placed to benefit from energy storage but must be cautious of breaching the rules on unbundling*

Utilities themselves are well placed to benefit from energy storage but must be cautious of breaching the rules on unbundling, which prohibit a network operator from generating or supplying energy. A strict interpretation of the rule would prohibit storage (as a generator) from being used by utilities, but not all member states agree. The EU acknowledges the need for a clear statement of the application of the unbundling rules to storage.

The rise in energy storage is a double-edged sword from an electric utility company's perspective – as more of its customers embrace the technology, the risk of load- or grid-defection increases. Tesla engaged in a high-profile launch of its 6.4 kWh consumer storage unit, Powerwall, in 2015 and a joint venture between Nissan and Eaton saw a similar 4.2 kWh product launched in May 2016. Nissan is also trialling a "vehicle-to-grid" or V2G system in the UK in which electric and hybrid vehicles sell the spare capacity in their car batteries back to the grid, by connecting to a bi-directional charging point. Customers may aspire to become self-sufficient by storing renewable power and supplying it back to themselves when needed, thereby circumventing the need to import grid power. Ultimately if storage capacity is great enough, customers could decide to go entirely off-grid. The European Parliament has identified this possibility of disruption of traditional utility revenue models as a risk that needs to be balanced against the Union's longer term decarbonisation goals.

Behind-the-meter storage or grid connected storage?

This key question determines how the current law impacts energy storage. In the UK, any energy storage plant which operates entirely independently of the grid and supplies electricity to the person generating without importing any power is not subject to the rigorous rules as well as fees for grid-connected storage.

Like grid-connected storage, it is still regarded as a generator but its lack of connection means that the consequences of this are limited. Ultimately the financial appeal of such an arrangement is limited however as all generated capacity must be consumed by the owner and any excess may be wasted, rather than turned to profit. Similarly, renewable energy generation incentives are based on the sale of electricity back to the grid. A one-way connection – export but not import – may allow the storage operator to sell excess power back to the grid but at this point connection fees become relevant. Though the costs of this kind of set-up are not currently comparable with buying power from the grid, it is expected that the cost of the hardware will fall to a level where this becomes attractive from an economic, as well as from a green, perspective.

> *Storage devices connected to the grid are regarded as both a generator and a consumer of energy, with all the costs and regulatory hurdles associated with those two roles.*

Storage devices connected to the grid are regarded as both a generator and a consumer of energy, with all the costs and regulatory hurdles associated with those two roles. Transmission Network Use of System (TNUoS) charges are payable to the National Grid upon generating. Unless expect on account of its size, as a generator the storage operator must also be licensed and comply with the Grid Code.

Whilst storage continues to be viewed as both a generator and end-user of electricity, it will also be subject to the Climate Change Levy - twice. This type of cost is eventually passed on to the consumer and it is therefore in the Government's interest to clarify the position of storage in the energy value chain.

The European Parliament identifies regulation of self-consumption of stored energy as an area where the EU needs to adopt and promote a harmonised approach.

Are there any routes around the regulatory hurdles?

Small storage plant may benefit from a generation licence exemption where it generates power below the specified thresholds. There is a class exemption for output below 50MW and individual exemptions are available up to 100MW on application.

This may not entirely circumvent the unbundling requirements however: the standard terms of the distribution licence require the holder to ensure it is not restricting, preventing or distorting competition in the market in managing and operating its distribution business. Taking a flexible approach, DECC said that distribution network operators can utilise energy storage provided this business is kept separate from its network operations. The engagement of third parties to operate storage services would more easily demonstrate the requisite level of independence.

Does energy storage participate in the Capacity Market?

The UK Capacity Market (CM) is designed to ensure security of electricity supply by offering subsidies to power plants that can provide back-up power

in periods of high demand, including in the future when there will be greater reliance on intermittent renewable sources.

The subsidy payments are designed to promote investment in energy generation. The CM should be a key weapon for the Government in incentivising low-carbon investment but the first two auctions which took place in December 2014 and 2015 for supply in 2018-2020 resulted in most awards going to existing fossil fuel and nuclear generators rather than clean energy production. No new-build energy storage technologies were awarded capacity contracts in the December 2015 auction.

Energy storage is eligible to participate in the Capacity Market, but benchmark prices are a barrier to participation by most energy storage projects

The December 2014 CM auction set the benchmark price at £19.40 per kW and the 2015 auction at £18 per kW, a price too low to encourage investment in energy storage projects, in contrast to traditional energy sources where investment risk is lower or non-existent.

In March 2016 DECC consulted on potential changes to the capacity market regulations and rules. In its May 2016 response[3], it stated that it would no longer allow generators to compete in the second Transitional Arrangement (TA) auction, as this technology is sufficiently mature not to need further support. Focus is thereby shifted from generation-derived demand side response to "turn-down demand-side response". TA participants are barred from competing in the main CM for three years but DECC indicated that this time period will allow the development of the "nascent" market for these technologies. To further support the market and stimulate competition, DECC (or BEIS) also intends to reduce the minimum capacity threshold from 2MW to 500kW. Changes to the CM Regulations are expected to be in place in time for pre-qualification for the T-4 auction.

Both the UK National Infrastructure Commission and the European Parliament recognises the need for incentives to be offered to encourage energy storage to compete with other flexibility options.

What role can storage play in balancing supply?

Energy storage in the UK had its first major win in late August 2016 when National Grid awarded 201 MW of enhanced frequency response at a cost of £65.95m, all to energy storage providers.

Enhanced Frequency Response (EFR) calls for 100% active power output within 1 second (or less) of registering a frequency response deviation. The required speed for EFR is in contrast to existing Firm Frequency Response (FFR), which aims to respond within 10 seconds for primary and high and within 30 seconds for secondary responses. FFR contracts are awarded once per month via a similar competitive tender process.

In August 2016, National Grid awarded 201 MW of enhanced frequency response at a cost of £65.95m, all to energy storage providers

The call for tenders prompted a massive response with 203 tenders submitted, totalling more than 5000 MW/h – 8 were finally accepted totalling 201 MW/h, with an average price of £9.44 MW/h. Contracts run for 4 years and are expected to come online between April 2017 and March 2018.

All of the chosen projects are "in front of the meter", demonstrating the benefit of connecting new storage technology to existing facilities. The biggest contract was awarded to EDF Energy Renewables for a 49MW project at its West Burton natural gas fired power plant; wind farms and CHP plants are also beneficiaries. All providers were subject to an individual cap of 50MW (the threshold for generation licence exemption), though National Grid has said that this cap will be removed in the future. The process was technology neutral but only 3 of the 64 unique sites were not storage providers (two were demand reduction and one was thermal generation).

Tenders were assessed against the same criteria as FFR market services and no reduction in the normal FFR requirement was made.

The ability to stack services will increase the overall competitiveness of the technology and ultimately drive down consumer costs

National Grid, in its tender FAQs, recognises that existing electricity market rules and mechanisms may need adjustment to take account of the new EFR services. In particular it notes the need to adjust the CM Rules to recognise EFR as a "Relevant Balancing Service" – this would prevent the EFR contract holder from being penalised for the delivery of capacity otherwise than through the Capacity Market, as is already the case for holders of FFR contracts. An application for this was submitted by one of the successful applicants, Renewable Energy Systems Group, on 18 August 2016, RES already having been awarded a 20MW frequency response contract in May 2016. RES states that the ability to stack services will increase the overall competitiveness of the technology and ultimately drive down consumer costs.

"In the UK, investment in low carbon innovation is a vital lever which the government is using to help to reduce emissions.... Energy storage is one of those 'smart energy' tools ... which we will need to keep our energy system resilient and secure."

Amber Rudd January 2015, Parliamentary Under Secretary of State at DECC

"Innovation in energy storage could create £12bn of new business revenue in the UK"

UK Government (Eight Great Technologies)

3 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/521301/Govt_response_to_March_2016_consultation_FINAL.pdf

Are storage technologies at risk from the "embedded benefits" review?

In the middle of the EFR tender period, OFGEM issued an open letter[4] regarding charging arrangements for embedded generation, which result in "embedded benefits".

By connecting directly to the distribution network and by-passing the transmission network, embedded generators below 100MW avoid transmission network charges. Furthermore, these small generators are treated as negative demand and frequently receive payments from contracted suppliers who share the benefit of avoiding transmission network use of system (TNUoS) charges during times of highest demand ("triad periods"). The level of these payments is higher than the payments received for participation in the CM, causing some investors to favour small scale generation rather than the larger, more efficient transmission-connected generators preferred by the Government. As of August 2016, there were over 230 embedded generators registered with National Grid, all falling below the 100MW threshold (though many are not yet operative) and most being renewable technologies.

The embedded benefits review has the potential to impact growth of energy storage technologies for generators below 100MW

A primary target for the embedded benefits review is controllable, non-intermittent embedded generation such as small-scale diesel reciprocating engines, and OFGEM acknowledges that intermittent generation such as solar is less likely to be generating at times of peak net demand which results in the highest benefits. It states that behind-the-meter generators "may not" be affected by changes to charging arrangements; a joint OFGEM/BEIS call for evidence on smart/flexibility services is expected in the autumn.

As noted above, energy storage is regarded as a generator and all of those involved in National Grid's tender process were below the 100MW threshold. The release of OFGEM's letter on 29 July caused 6 companies to withdraw their 10 sites from the tender process, clearly demonstrating the impact of the potential changes on technology which is only just reaching commercial viability.

The market is far from stable – the launch of OFGEM's embedded benefits review caused 6 companies to withdraw their storage offerings from the National Grid EFR tender process

OFGEM is calling for stakeholder views and evidence to support its decision-making on possible changes to the system. It rules out a Significant Code Review in favour of early action on the specific aspects of embedded benefits that it considers to be causing market distortion and impacting on CM auctions. Comments must be submitted by 23 September 2016; it is expected that the changes will be in place in time for the January 2017 CM auction which means a tight timetable for potentially high-impact changes.

National Grid is considering several proposals to amend the Connection and Use of System Code (CUSC) to reduce the value of embedded benefits.

Is energy storage regulated at the European level?

Not explicitly. There is a patchwork of regulations that currently impact energy storage to some degree, and the lack of clear and consistent rules has been noted by the European Parliament.

In contrast to the Directive 2009/73/EC on the Internal Market for Natural Gas which lays down detailed rules for gas storage, the corresponding directive on electricity (Directive 2009/72/EC) does not even mention energy storage. It requires member states to put in place demand side management measures but these envisage energy efficiency measures rather than time-shift supply.

At EU level, energy storage is not even mentioned in the Directive on the Internal Market for Electricity

The Renewable Energy Directive (2009/28/EC) recognises energy storage facilities as a factor in creating a secure electricity system based on renewables. The Energy Efficiency Directive (2012/27/EU) prohibits member states from preventing network operators or energy retailers from making available systems for demand response measures and demand management including energy storage.

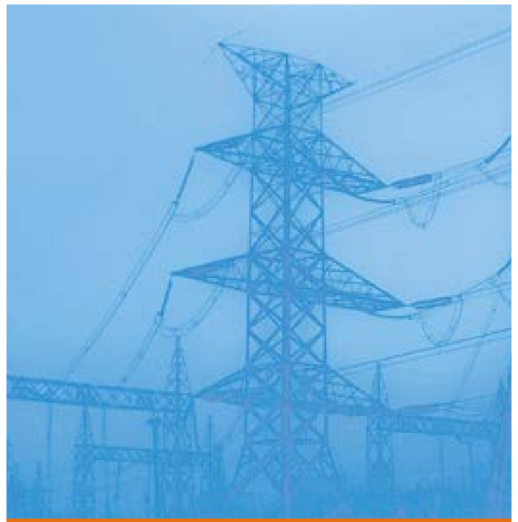
Does that mean that each member state may take a different approach?

For the time being, yes. There are several different approaches throughout the EU for encouraging investment in renewables, and approaches also vary on how the unbundling rules apply to energy storage.

However the European Parliament has made clear that it intends certain aspects of the market to be harmonised. It recommends that the design of capacity markets be harmonised, ensuring free access to these markets for storage. It also recognises the need for rules to be clarified around the position of storage in different scenarios, such as behind-the-meter, third party service and grid operation.

"Storage could offer a wide range of benefits across our energy system - from deferring network reinforcement through to helping our energy system stay in balance on a minute by minute basis"

DECC



4 https://www.ofgem.gov.uk/system/files/docs/2016/07/open_letter_-_charging_arrangments_for_embedded_generation.pdf

How do the current rules inhibit the growth of energy storage?

The two key issues identified by the European Parliament that are currently acting as barriers to development of the market are, firstly, the possibility of dual fees for storage as both a generator and a consumer (described above), and secondly the uncertainty over ownership of storage.

The European Parliament recognises that the current rules on unbling contained in the Electricity Directive require adjustment to take account of energy storage solutions. In the UK, holders of a distribution licence may not concurrently hold the type of generation licence that would be required to operate storage. The European Parliament recommends that network operators be allowed to own or control energy storage for the purpose of grid balancing, recognising that one storage facility may service a number of different parties.

Some factors for and against growth

⊕	⊖
Reducing costs	Unclear application of unbundling rules to storage assets
Wider adoption of technology – consumer and industry acceptance	Dual fees for both generation and distribution aspects
Promotion by National Grid in EFR auction	Unclear policy

What is the UK doing to better regulate energy storage?

Despite its rhetoric, the UK Government has yet to take any concrete action to support energy storage providers.

A call for evidence on smart energy including storage was expected to be launched in Spring 2016, but this was delayed and finally launched in November 2016. The consultation document discusses a number of policy options for removing regulatory barriers. Regarding licensing, for example, options include:

- Continuing to treat storage as a generation for licensing purposes
- Defining storage as a sub-set of generation in a modified generation licence, with or without a change to the primary legislation
- Establishing a new activity for storage via a change in primary legislation.

Uncertainty over the UK Government's long-term policy for decarbonisation and the promotion of renewables is a risk factor for investors in energy storage. While there is industry support for the licensing of storage as a separate activity from generation, DECC is not pursuing this at the moment, but "not ruling it out" either.

In June 2016, the House of Commons Energy and Climate Change Committee published a report on Low Carbon Network Infrastructure[5] in which it calls for storage technologies to be deployed at scale as soon as possible. In the report, it calls on the Government to urgently address the obstructions posed by "archaic regulation" and "unfair double-charging". It considers these factors to be the greatest bars to progress, more so than technological immaturity or cost. The report quotes the then Parliamentary Under-Secretary of State for Energy and Climate Change as saying that legislation on storage is "not oven-ready" nor expected in the 2016-2017 Parliamentary session.

The UK Government recognises "unfair double-charging", barring progress to widespread adoption of energy storage technologies – but we will probably not see any major legislative developments before 2018

What is the likely future direction from Brussels?

In July 2015 the EU Commission launched a consultation on a new energy market design, which will include establishment of a level playing field for energy storage across Europe, opening up the possibility for cross-border trading of storage. Responses published to date do not give any indication of the approach the Commission may take in relation to storage.

The Renewable Energy Directive is also due to be revised shortly, with the aim of ensuring that the 2030 goal of 27% share of renewables by 2030 is achieved. Adapting the market design and removing regulatory barriers is one of the thrusts of the revision. The summary of responses to the consultation indicate a general consensus that mechanisms are needed to encourage investment in energy storage and demand-shifting capacity.

In June 2016, the European Parliament passed a resolution, Towards a New Energy Market Design[6]. It again called for a revision of the existing regulatory framework to provide a "supportive framework" for energy storage technologies. Amongst the detailed recommendations for a more suitable regulation, the European Parliament calls for a clear definition of energy storage, which recognises storage's dual nature in both generation and demand, and for energy storage devices. It discourages the use of national

"energy storage has numerous benefits, not least enabling demand-side response, assisting in balancing the grid and providing a means to store excess renewable power generation"

European Parliament, September 2016

5 http://www.publications.parliament.uk/pa/cm201617/cmselect/cmenergy/267/267.pdf

6 http://www.europarl.europa.eu/sides/getDoc.do?type=REPORT&reference=A8-2016-0214&format=XML&language=EN

"energy storage is a key tool for bringing greater flexibility and efficiency to energy markets, but … there is still no regulatory mechanism in place making it possible to take advantage of an efficient storage system"

European Parliament, September 2016

capacity mechanisms and suggests that these may become redundant once storage options become more abundant and affordable. Transmission and distribution operators should both be permitted to utilise energy storage for the purpose of grid-balancing and other ancillary services, and double charging should be avoided.

The EU Parliament is calling for a supportive framework for energy storage technology, including a clear definition of storage and a recognition of its unique role in both generation and demand

How is the development of energy storage likely to be impacted by Brexit?

An immediate impact of the decision to leave the EU has been the formation of a new Government with an unclear policy as regards the energy sector.

Whilst committing to ambitious targets for carbon reduction in the fifth Carbon Budget, the abolition of a dedicated department for energy and climate change has caused some industry players to question the Government's commitment to the cause. The decision to place the development of the new Hinkley Point nuclear power plant on hold has been taken as another sign of indecision at a high level (though not by all – some credit the Government with having taken a positive step of reconsidering all options at a time when alternative energy prices are falling).

The UK is expected to remain a member of the EU until at least 2019. It will continue to be bound by existing and new EU legislation until this time, which would include any changes based on the European Parliament's June 2016 resolution to facilitate energy storage. Substantial revisions of the Renewable Energy Directive and Energy Efficiency Directive are likely to take longer, though could conceivably be enacted by the EU before Brexit happens, leaving the UK in an uncomfortable limbo during the transitional phase. Whether the UK will follow the lead that could be set by the EU (or maybe take the lead before then?) remains to be seen and is difficult to predict before more is known about the nature of the new relationship.

The Brexit Effect

- UK could become a market leader in energy storage technology
- Government intends to import almost the entire body of EU law into national law before Brexit
- Energy storage not well regulated either at EU or national level at present
- An opportunity for the UK government to lead the way?

Los Angeles Times

ENERGY STORAGE

Unlocking the potential to give the power grid a big jolt

August 2016

THE TIMES

Battery charge to power up Britain

August 2016

THE SUNDAY TIMES

You may laugh at this big battery, but it could cut your energy bills by 70%

March 2016

FINANCIAL TIMES

Energy storage – the shape of things to come

December 2015

Is battery energy storage a self-selecting solution?

Battery based energy storage is certainly a hot topic. For the first time in as long as I can remember a technology, rather than a subsidy or policy, is taking centre stage and as ever, there are plenty of opinions to go around. Based on a very unscientific straw poll, we find the that experienced industry professionals are roughly divided down the middle on batteries being a passing fad, or here to stay.

Having spent a lot of time considering the future of the UK's electricity system there are few certainties. 'The only certainty is that the future is uncertain' is a perhaps overly used phase but valid none-the-less. There are trends, however, that cannot be ignored in our transition to a low carbon future;

The first is national demand.

Today we have a summer high to winter low ratio of approximately 2.5 to 1. This ratio is certain to increase in the future, whichever path we take. With this in mind, and with the tapering off in volume of traditional thermal plants, we will see more variable generation capacity on the system relative to the energy produced. In simple terms, the value of flexibility increases as the gap between highs and lows becomes bigger.

Secondly, and more immediately, is inertia which has in the last few years become something to be concerned about.

Inertia, in simple terms is a measure of how resistant our electricity system is to rapid change. When the electricity system was made up by a majority of very large steam turbines, it took a bigger shock to the system to knock it away from a stable 50Hz operation. With the advent of large volumes of inverter connected systems (ie PV) you will see that when a summer's day is starting to dip below 20GW, there is much less inertia on the system and it becomes very susceptible to frequency deviations away from 50Hz. In these conditions, it is the rate of change of frequency (RoCoF) that gets the control room in National Grid a little tense.

Thirdly, renewables are variable in output.

This is a fact often thrown back at the industry and there is no doubting that extended periods of anticyclonic winter weather would cause issues in an extremely dominant renewables mix. But if we look out to 2030 for example, in a high renewables scenario of 30GW of wind and current predicted volumes of base load plant of the system, we can expect to see over 25% of all wind energy generated (no one could advocate turning nuclear down!) would be shed. Under no circumstances should we be wasting that volume of energy before we even contemplate the economics. However, the introduction of storage into these scenarios drastically improves the utilisation of green energy and with it, justification for the capex expenditure.

So, flexibility is showing itself to be of value in the future and flexibility is not exclusive to battery storage. I have historically gone out of my way to be agnostic to technology, however, there are some technical reasons where I believe we are living through a period when the features of battery storage mean that they are self-selecting at one major part of our energy future.

The recent Enhanced Frequency Response (EFR) tender illustrated that whilst flexibility is valuable, it is the speed that flexibility can be deployed which is the key metric for frequency in this more volatile electricity system. The speed that a system can change its state in response to a signal plays into the hands of batteries, which is highlighted by EFR requiring operators to get to full contracted capacity within 1 second. Therefore, it was no surprise that all winners were battery energy storage systems. The trials being undertaken at the moment in the Enhanced Frequency Control Capability (EFCC) project led by National Grid is looking at the value of sub 0.5 second response coupled with the assessing value of geographic location. Being able to rapidly deploy smaller systems very quickly in a particular geography looks to become the most valuable product of them all.

The economics of storage today mean that multiple value streams are often required to make the commercials work. One entity showing interest in this are the Distribution Network Operators (DNO). Already we are seeing some DNOs starting to use demand side products to defer or remove the requirement for traditional reinforcement. This is currently either demand turn down or diesel generation and therefore batteries become very interesting for DNOs, especially in urban networks. The connection of new rotating generators (e.g. diesel) with the ability to export electricity can be constrained in these networks not by capacity but by fault current potential. Battery systems do not exhibit these fault level characteristics so commercial and industrial customers looking into offset the cost of their backup power systems may find themselves constrained to battery systems from a technical, rather than commercial, position. Those looking to reduce their exposure to energy markets may also view battery systems as a quick and guaranteed way of offering flexible megawatt scale systems, compared with more traditional demand side response through the modification of industrial processes and air conditioning systems.

Finally, respected forecasts for the value of flexible services are only going in one direction – up. Today, the total value of the energy system is £25bn per annum against a £500mn spend on balancing the system. By 2030, as we move to a decarbonised system, the spend on balancing might move to 25% of the total system value.

It is for the reasons above that I propose that battery energy systems are starting to self-select as one of the technologies that will prevail in our future energy system. Watch this space.

Matt has worked across the sustainable energy market value chain from consulting services to energy supply to renewables development to demand side management focussing on business development and commercial partnerships, product design and scaling business models.

His fascination, and at times frustration, with behaviour change and the general public's lack of engagement with energy led to an idea that leading brands could drive awareness and appreciation for this hugely important service – electricity.

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Energy Storage Technologies

Electrochemical

Solid State Battery Storage

A conventional form of storage spanning a range of electrochemical solutions including Lithium-Ion, lead and Nickel-Cadmium. Research and development is also occurring in 'high temperature batteries' such as sodium sulphur batteries which are considered to be a promising candidate for high power electrical energy storage.

Flow Batteries

Energy is stored in electrolyte fluid in external tanks that is pumped through electrochemical cells during charge and discharge. Flow batteries therefore can almost instantly be recharged by replacing the electrolyte liquid, while the spent material is recovered for re-energisation. Flow batteries include redox and hybrid flow batteries. Research is being undertaken into organic flow batteries to avoid the current reliance on the toxic and rare metal such as vanadium.

Thermochemical

Solar fuels

Sunlight is used to split water and/or carbon dioxide into its constituent parts creating fuels that can be stored and subsequently used to generate electricity. A relatively new technology involving thermochemical or photosynthesis approaches. The two approaches have various drawbacks, for example artificial photosynthesis normally depends on scarce expensive elements but research is advancing the cost effectiveness.

Mechanical

Pumped Hydro

One of the most mature and widely deployed of the storage technologies. Water is pumped from a lower reservoir to a higher one and then released back through turbines when needed. In 2007 pumped Hydro represented 99% of installed electrical energy storage capacity.

Compressed Air & Liquefied Air (Cryogenic Energy Storage)

Electric motors compress air which is then stored in underground caverns or above ground tanks. The air is then released and heated (either by a combustible fuel or from heat recovered from the compression process) to drive a turbine when electricity is needed.

In liquefied air systems electricity is used to cool air until it liquefies and is stored in a tank until it is again released to turn a turbine.

Flywheel – FES

A rotor is spun rapidly thereby storing rotational kinetic energy. The rotation is slowed, discharging the kinetic energy through a generator. Flywheels can provide a rapid response, are low maintenance, high power density and use environmentally inert materials but have relatively low efficiency. Improvements in materials have increased the rotational capacity of rotors and decreased drag.

Thermal

Heat storage

A variety of technologies are being explored to store heat that can then be used to power generation or in home heating.

Electrical

Capacitors & Supercapacitors

Classical capacitors comprise two or more conductors separated by an insulator and can store small quantities of electrical energy. Capacitors can be useful for voltage correction and smoothing power supplies amongst other things.

Supercapacitors, also named double-layer capacitors have the characteristics of both traditional capacitors and electrochemical batteries, their performance has been enhanced by the use of nano materials.

Superconducting Magnetic – SMES

Current is passed through a superconductive cryogenically cooled coil to store energy in a magnetic field. Once in a steady state, the current will not deteriorate and the magnetic energy can be stored almost indefinitely. This technology is in development. Research is being undertaken to reduce the cost of superconducting coils.

Chemical

Hydrogen

Fuel cells can convert chemical energy in hydrogen and oxygen to electricity. The process is quieter, less pollutant, and more efficient than combusting fossil fuel. Still in the development stage, this approach is primarily being explored in stationary systems for industrial application.

Product Liability – is it safe?

The safety of lithium ion battery technology has rarely been out of the headlines in the last few months. Samsung issued an unprecedented worldwide recall and suspended production of its Galaxy Note 7, following a high number of incidents in which the mobile phone spontaneously burst into flames.

This is not the first time that LiOn technology has been subject to negative press: in 2013, the technology was said to be responsible for grounding the entire fleet of Boeing's Dreamliner commercial passenger jets after batteries powering on-board systems overheated. The failure rate was 1/1000, described by experts as "shockingly high". Boeing's batteries are now encased in a steel box which is capable of containing any "events", but in part at least reversing the benefit of using lightweight batteries rather than heavier, traditional chemistry batteries. Even NASA suffered an incident in June 2016 where LiOn batteries inside a robot exploded due to one faulty battery.

The precise reason for the explosions in Samsung's LiOn batteries have yet to be officially determined (the US Consumer Product Safety Council issued its own recall and will be investigating). One theory is that the negative and positive components in the battery are too close together, resulting in the separator being compromised and a short circuit occurring.

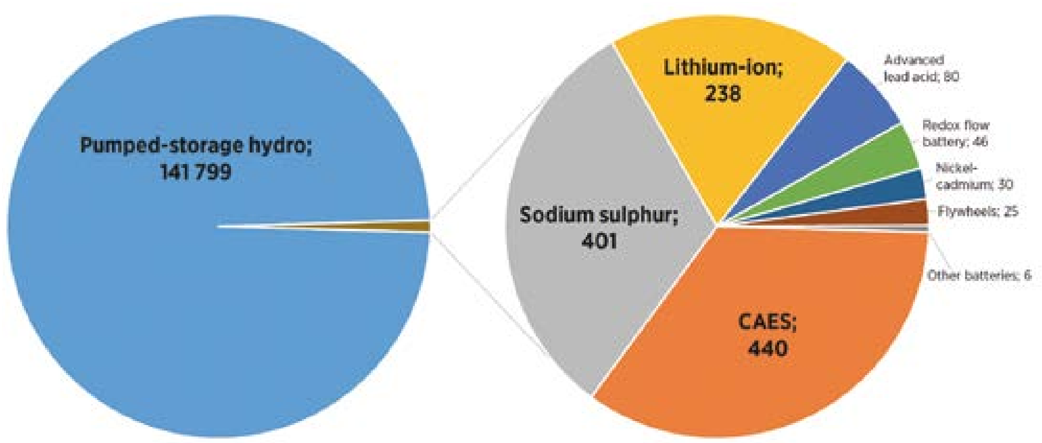
In NASA's case, the battery in question sent faulty information to a system designed to stop it being "over-charged" once reaching its maximum voltage. Interestingly, Samsung's interim fix also had the effect of preventing phone batteries from charging fully. If not specific to the slim and small nature of the battery, the concern is that the same problem could occur no matter what size the battery.

All of this raises questions about the safety of large scale LiOn batteries for energy storage. For consumers the concern will be in bringing a potentially dangerous battery pack into the home on a far larger scale than they are accustomed to – having seen the damage done by one LiOn battery, they may be reluctant to multiply this risk. For businesses, risk exists in linking potentially explosive batteries up to high-cost renewable energy infrastructure, or other expensive onsite equipment that is being supplied by the storage or generation equipment such as data storage, jeopardising not just the equipment but the stability of the system that relies on it to operate.

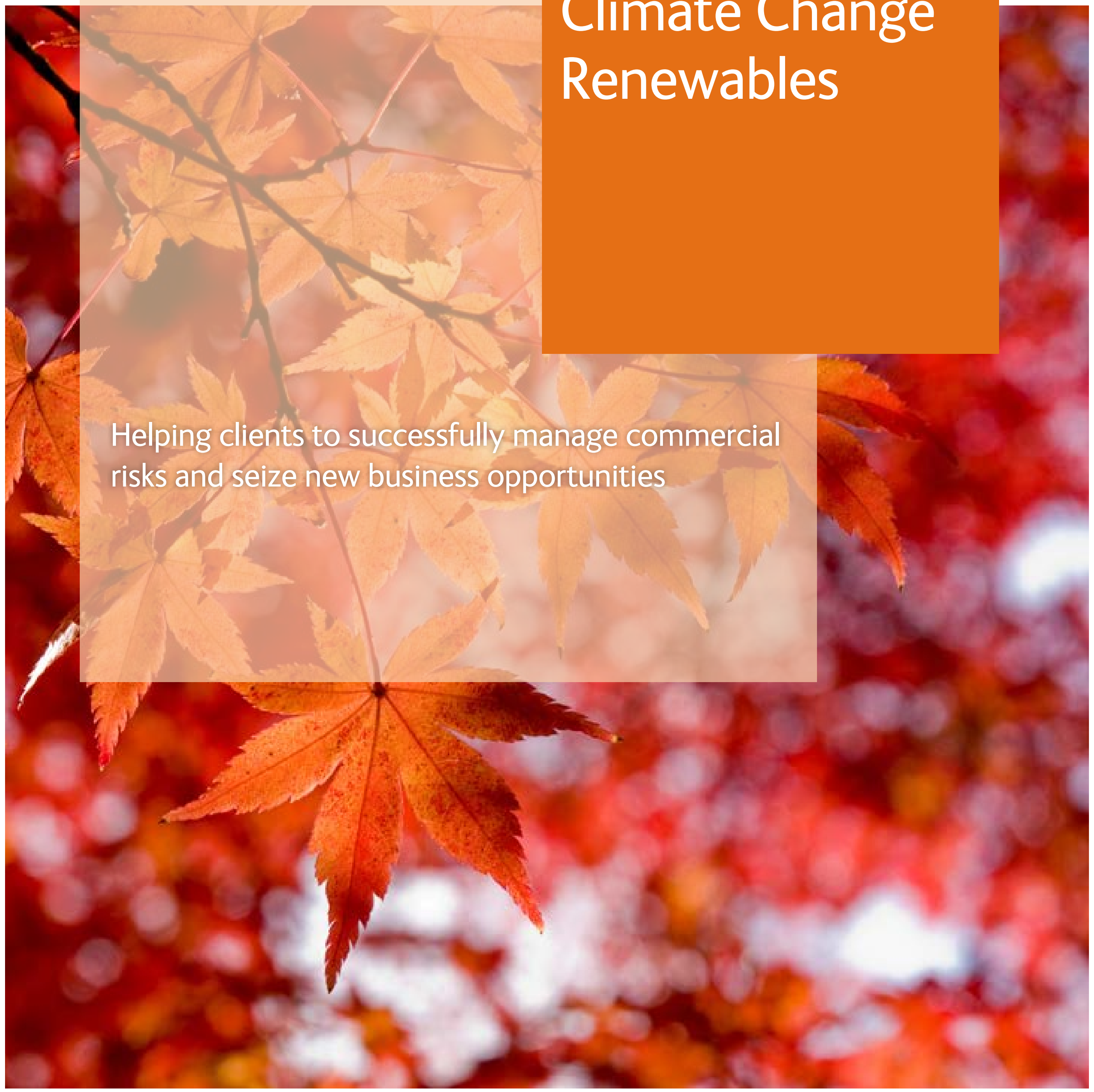
Toyota are launching a new electric only vehicle powered by LiOn batteries that it states incorporate extra safety features to avoid short circuits, including a system to monitor the temperature and condition of each of the cells. It has previously refused to use the technology in its hybrid vehicles. Battery management systems are likely to be a key point of competition between electric car manufacturers in the next few years. Ensuring longevity is another challenge.

As with other aspects, rapidly advancing technology can be seen to be leaving behind any safety standards that can be applied to energy storage systems.

Global electricity storage – technology share 2015



Cleantech Climate Change Renewables



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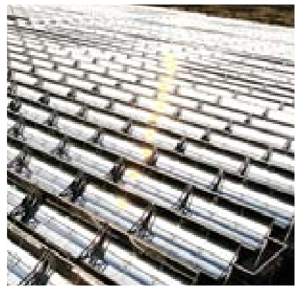

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- Green funds clients include UK Green Investment Bank, NextEnergy, Iona Capital and Acumen on fund structuring and formation, flotations, follow-on fundraisings and subsequent asset management
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- Biomass, AD, Pyrolysis and novel Energy from Waste projects for Dalkia, MVV, Iona Capital, Viridior, WRG, Veolia, Skyfall Energy and Energy China
- the financing banks on the world's largest biomass conversion project, Drax in the UK.
- ABB on several interconnector projects including BritNed, Western Link and Western Isles
- the UK Cabinet Office on its strategy to develop solar PV at scale (1GW) across the Government estate.
- Mainstream, RWE, Munich Re and IKEA on international onshore wind farms.

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