SMART POWER

NATIONAL
INFRASTRUCTURE
COMMISSION

EXECUTIVE SUMMARY – SMART POWER

The National Infrastructure Commission (NIC) was asked to consider how infrastructure and policies to promote interconnection, storage and demand flexibility could create a more efficient and cheaper electricity system. The Commission has engaged with a range of stakeholders across industry, government and civil society, and received more than 130 formal submissions to its Call for Evidence.

The Commission's central finding is that Smart Power – principally built around three innovations, Interconnection, Storage, and Demand Flexibility – could save consumers up to £8 billion a year by 2030, help the UK meet its 2050 carbon targets, and secure the UK's energy supply for generations.

PART ONE: ALL CHANGE

Around two-thirds of our existing power stations are expected to close down by 2030 as our coal, nuclear, and oldest gas fired power stations reach the end of their lives.

To meet the UK's legally binding climate change goal – to cut $C0_2$ emissions by 80% by 2050 – power stations must be largely decarbonised. Complete future reliance on unabated industrial fossil fuel power stations is unsustainable.

There is a near term need to build new sources of power to ensure we have the electricity we need. Over the next decade, new and more diverse sources of electricity generation will need to come on stream, including more renewable energy, new gas fired plants and new nuclear capacity.

Nuclear power is inflexible: nuclear plants are best run at a continuous rate - delivering a stable base load of power rather than ramping up and down to match demand. The shift to more low carbon technologies will also mean more smaller power stations connected to the distribution network, for example onshore wind, solar power, and combined heat and power plants.

Alongside a generational shift in our supply, demand for electricity is also likely to change as new parts of our economy start to electrify such as heat and transport.

But the underlying mechanics of the electricity system won't change. Electricity demand and supply must be balanced on a second by second basis in order to maintain secure supply. If electricity supply is insufficient to meet demand or exceeds it the system can become unstable, ultimately leading to blackouts. The network needs to be resilient to unexpected events, such as a surge in demand or a power station going offline without inconveniencing consumers. In order for the network to continue operating efficiently, future requirements will demand a smarter way of controlling generating capacity and demand in the UK.

This will come partly from increased interconnection to overseas energy suppliers, significantly increased storage and more efficient flexibility of demand. The NIC has examined the potential of these innovations, and we believe them to be hugely significant to future policy and infrastructure.

PART TWO: SMART POWER

In the coming decades three innovations will help fire a smart power revolution. The UK is uniquely placed to benefit from each of them.

Interconnection

Interconnection is the physical linking of electricity markets across borders which allows the trading of electricity. It allows the UK to connect our network to those of our neighbours.

Great Britain has historically had low levels of interconnection relative to other countries, due to the distance to other countries and the need to lay subsea cables.

Interconnectors offer a number of benefits to the UK and are a key source of flexibility to the electricity system. They are one of the few existing technologies that can shift large volumes of electricity from where it isn't needed to where it is. By doing this they have the potential to lower prices for consumers, improve the investment case for power stations, help us meet our carbon targets at a lower cost and improve security of supply.

Interconnectors can be thought of as both additional generation capacity and power exporters. This is because they allow electricity to be imported at times of peak demand but are also able to sell electricity abroad when we have more than we need.

A better connected network

Great Britain currently has 4 GW of interconnection capacity, around 5% of total generation capacity, through four interconnectors - two to the island of Ireland, one to France and one to the Netherlands. The existing 'cap and floor' regulatory regime has started to bring forward a healthy pipeline of interconnection projects that will deliver significant benefits to UK consumers. By the early 2020s we expect to have around 11.3 GW of capacity with new connections to France, Norway, Denmark, Ireland and Belgium, and other projects are in train.

Great Britain currently has 4GW of interconnection capacity, around 5% of total generation.

The role of interconnectors will evolve over time and will be determined by factors such as the precise makeup of the UK's generation mix and the markets we interconnect with.

Progress so far has been good but there is potential for more.

Recommendation 1: Government should pursue additional interconnectors with other European countries where the benefits are most significant.

Interconnection investment decisions should continue to sit primarily with the private sector but there is a role for government-led diplomacy to unlock those markets that can offer potentially large benefits to UK consumers. The government should therefore focus its efforts on exploring increased interconnection to markets with abundant sources of flexible low carbon electricity, such as Norway and Iceland.

Storage

Storage allows consumers and suppliers to take energy and store it so that it can be used when it is most needed.

Electricity prices vary throughout the day, and across the year. When demand is higher, prices rise. Storage technology allows consumers to buy electricity when it is cheap and use it later when it is needed.

There are a number of ways electricity can be stored. Today, our main source of storage is through pumped hydro – simply converting electric energy into potential energy and back by moving water up and down a hill. There is, however, an increasing range of alternative ways to store energy including; chemical batteries, compressed air and supercapacitors.

Huge technological advances, tremendous potential, no subsidies required

Electricity has historically been difficult and expensive to store.

However, over the last decade there has been a great deal of innovation in electricity storage technologies driven mostly by consumer electronics like mobile phones and investment in electric vehicles.

This rapidly evolving environment has driven innovation and reduced costs. For example, the cost of lithium ion batteries has decreased from more than $3,000/kWh in 1990 to less than $200/kWh today.

These technologies are now on the verge of being able to compete with power stations for some of the services they provide.

Crucially, storage technology will not need subsidies to be attractive to investors – businesses are already queuing up to invest.

Regulation, on the other hand, does require attention. When our electricity markets were designed these technologies did not exist. The result is a market that is opaque, and operated in a way that unintentionally disadvantages storage providers; preventing them from participating across the various electricity markets.

For example, storage assets face 'double charging' for the various government levies that are added to electricity costs. These taxes are placed on the electricity used to charge up the store and again when the electricity is exported.

Even if storage could undercut generators, providers currently struggle to get finance because the lack of transparency in the market makes it difficult to put together a compelling business case.

The result is that barriers to the market are hindering a technology that could bring down bills, prevent the need for additional power stations and help secure the power mix that could ensure we hit our legally binding climate change targets.

Not only can storage can help reduce the impact of peak demand and provide demand for power stations at other times of day, it also has the potential to ease constraints on our grids.

Like a river with an off flow to a reservoir, storage can allow the network to siphon off electricity rather than being forced to curtail generation – for example putting an end to paying wind farms not to produce electricity, which currently costs £90 million a year.

The cost of lithium ion batteries has decreased from more than

$3,000/kWh in 1990

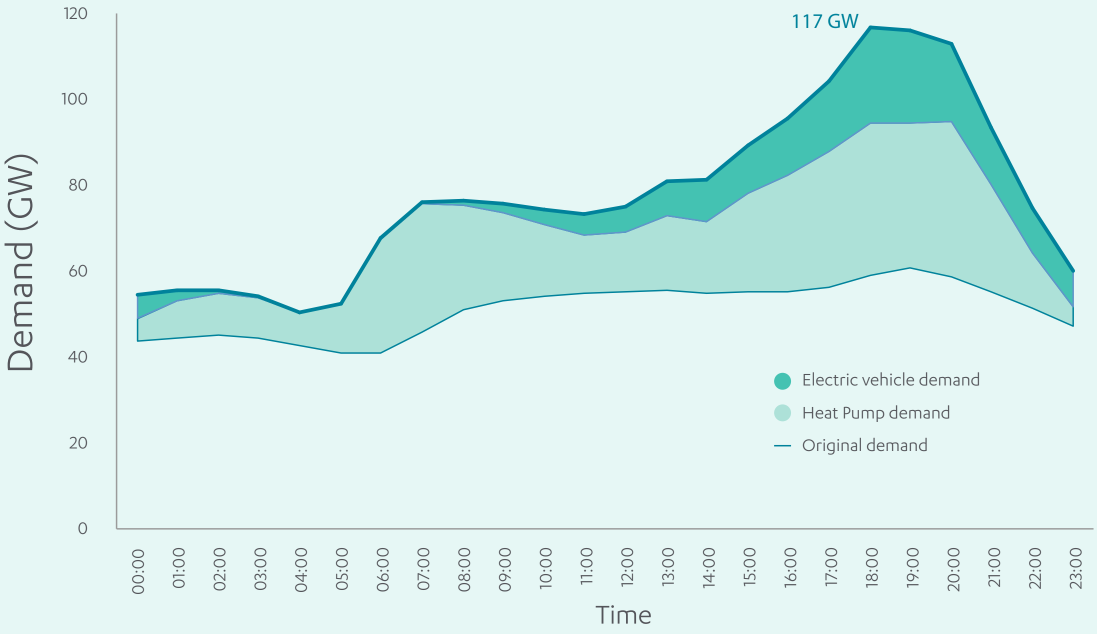
to less than

$200/kWh today

Demand for electricity is likely to change

1.21 Our demand for electricity is also likely to change through the rollout of electric vehicles, the decarbonisation of our heat supply, the introduction of smart technologies, and increased energy efficiency. This could lead to radical shifts in our patterns of electricity consumption. The need for electricity at peak times of the day could double, whilst the total amount of energy we use will only slightly increase.[9]

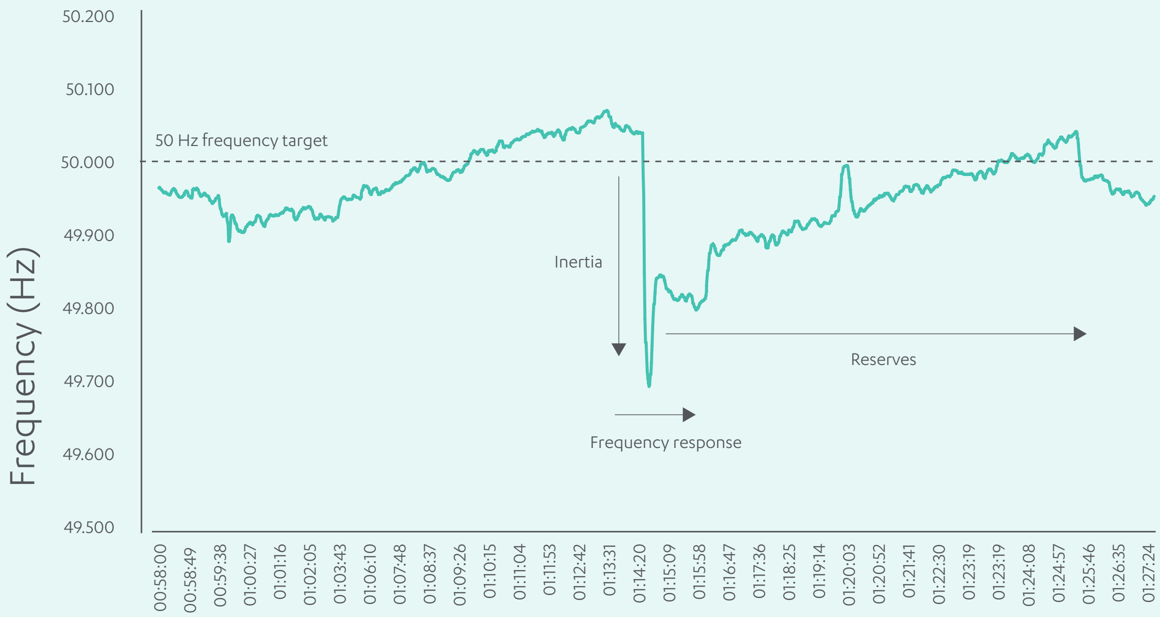
Possible future daily demand scenario with sub-optimal power system[10]



The network needs to be resilient to unexpected events

1.22 Finally, the electricity system also needs to be flexible enough to meet very rapid changes in demand and supply, for example due to a power station suddenly failing. This is the second part of the System Operator's role, which it fulfils by ensuring there is sufficient inertia in the power system to manage imbalances in the very short term (the first few minutes after a shock to the system) and by having sources of power (typically fossil fuel plants or hydro power stations) in reserve that can adjust their output quickly over the slightly longer term. The mechanism through which the System Operator procures these is known as the ancillary services market.

How the GB electricity system returns to balance after a sudden loss of supply[11]



1.23 As we switch to a more intermittent and less flexible low carbon generation mix, demand for these services is expected to multiply by up to ten times.[12] Continuing to use fossil fuelled power stations to provide the majority of these services which keep our system stable would require them to run part-loaded. This would be expensive, inefficient and limit the amount of low carbon power that the system can absorb.[13]

1.24 Procuring flexibility from other sources across the electricity markets would mean that the UK could build fewer new power stations, integrate more low carbon electricity at a lower cost and use all the assets in the electricity system more efficiently, leading to significant cost savings for consumers.

Storage

Storage allows consumers and suppliers to take energy from the grid or a generator and store it so that it can be used when it is most needed.

Electricity has historically been difficult and expensive to store. The UK's current main source of storage is pumped hydro, for which water is pumped upwards into reservoirs from where it can be released to generate power.

However, the last decade has seen a great deal of innovation, and there is now an increasing range of other ways to store energy including chemical batteries, compressed air and supercapacitors. Much of this innovation has been driven by consumer electronics and investment in electric vehicles. This has rapidly reduced costs: for example, the cost of lithium ion batteries has decreased from more than $3,000/kWh in 1990 to less than $200/kWh today.[28]

Storage technology is now on the verge of being able to compete with power stations for some of the services they provide. Crucially, it will not need subsidy to be attractive to investors, but it does need changes to the existing electricity market frameworks.

When our electricity markets were designed these technologies did not exist. The result is a market that is opaque, closed to storage technology, and regulated in a way that often disadvantages storage providers. This makes it harder for them to establish a viable business model, as they are unable to participate across the various electricity markets in the same way as generators.

In this way, barriers to the market are preventing a technology from being effectively deployed that could increase the resilience of the electricity system, prevent the need for additional power stations and help secure the power mix needed to hit our legally binding climate change targets.

The benefits of storage could be substantial. It can help reduce the impact of peak demand, provide an outlet for power stations at other times of day, and ease constraints on our grids.

Network owners are only just starting to make use of storage technologies. There is now enormous potential to make storage technologies an integral part of our networks. Network owners should be encouraged to see storage as a central tool to improve the capacity and resilience of their networks as part of a more actively managed system.

The UK should become a world leader in electricity storage systems. We can achieve that, not through subsidies, but simply by ensuring that better regulation creates an equal playing field, to unlock its full potential.

2.24 Electricity storage can play a key part in delivering a flexible electricity system. Traditionally, Great Britain has principally relied upon the ability to generate more electricity as and when it is needed, with the energy stored in the form of fossil fuels. To date there has been relatively little dedicated storage, with the vast majority, about 3,000 MW of capacity, provided by large scale pumped hydroelectric power stations in North Wales and Scotland connected to the transmission network.[29] These play a crucial role in the immediate short term management of sudden spikes in demand and unexpected losses of capacity, but they cannot contribute to managing more localised patterns of demand. In the future a wide range of storage technologies deployed at every level from the large scale through to households could help deliver the flexibility we need. If costs continue to fall, up to 15,000 MW could be economically deployed by 2030.[30]

2.25 Developments in electricity storage have the ability to radically change the electricity system. A recent report by Energy UK (the largest trade association for the energy industry) looking at the development of the sector stated that 'electricity storage is widely regarded to be the single most important technological breakthrough likely to happen over the period to 2030 and a complete 'game changer' in the way that the power system operates'.[31]

2.26 It is important to recognise that electricity storage is not one single technology, but a diverse range including batteries, pumped hydropower and supercapacitors. This allows storage to play more than one role in increasing the flexibility and robustness of the electricity system, including:

- Making the system more resilient to short term imbalances in demand and supply and allowing the integration of a larger share of renewables in the generation mix.
- Enabling network owners to increase the capacity of their networks more cost effectively than simply building additional cables.
- Allowing customers (including households, businesses and electricity suppliers) to manage their usage more actively, taking and storing electricity at times of low demand and prices and then using it at peak times, which both reduces costs and helps to balance production and demand.

2.27 Making effective use of storage will strengthen network capacity and minimise the need to build new power stations that only operate for a few hours each day when demand peaks. It can also provide a source of demand for electricity at times when intermittent generation (e.g. wind and solar power) is generating but demand would otherwise be low. This increases the profitability of renewables, reducing their need for subsidy and their cost to consumers. The variety of technologies available also means that storage can be deployed at a range of scales and locations from large scale storage connected to the national transmission network to small batteries in people's homes.

Types of energy storage

Pumped Hydropower – this is the most mature of all the storage technologies and widely deployed around the world. Energy is stored by pumping water up to a reservoir to be released when needed, generating electricity through hydro-electric turbines. Relatively large amounts of energy can be stored, determined by the sized of the reservoirs.

Compressed Air Energy Storage (CAES) – air is compressed and stored under pressure either in underground caverns or in above ground vessels. The air can then be released to drive a turbine and generate electricity.

Liquid Air Storage – similar to CAES, air is liquefied and stored in vessels. It can then be evaporated to drive a turbine and generate electricity.

Solid State Batteries – a range of electrochemical storage solutions. Lithium ion batteries are one of the key battery technologies, with deployment and cost reductions having been driven by their use in consumer electronics and electric vehicles. Sodium sulphur batteries are also being explored for commercial deployment.

Flow Batteries - batteries where the energy is stored directly in the chemicals making up the electrolyte solution.

Thermal – principally using heat and cold to store energy as a form of demand side response. However, various other applications allow electricity to be generated from stored heat.

Flywheels – energy is stored by rapidly spinning a rotor using an electric motor. The rotor can then be slowed, with the motor acting as a generator. Flywheels are starting to be deployed in grid applications, especially as they can respond to system needs very quickly.

Supercapacitors – these can store relatively large amounts of electricity which can be released in a short amount of time. Like flywheels, they are able to respond to the needs of the system very quickly.

Supporting the stability of the grid and increased renewables deployment

2.28 A key role for storage technology will be to provide some of the grid stability services needed to keep the electricity system resilient to unexpected events, such as a power station failing. Pumped hydro storage is already a key provider of this type of service. Batteries and other storage technologies are also ideally suited to play this role as they can dispatch power extremely quickly, precisely matching the needs of the system. Battery technologies are already more effective than using existing power stations for some of these services, demand for which will grow as the electricity generation mix develops and an increasing share of generation comes from intermittent renewables such as wind and solar power.

"Primary frequency response requirement [a type of ancillary service] could increase by 30-40% in the next 5 years, and by 2030 the response requirement will be between 3 and 4 times today's level."[32]

2.29 These challenges are already apparent in Ireland, whose Single Electricity Market is experiencing periods when around 50% of generation comes from renewables.[33] At this point, some renewable generation needs to be curtailed in order to maintain system stability, as there is a limit to the extent to which generation from fossil fuel plants can be switched off without affecting their ability to provide sufficient back-up. To deal with this, Ireland is starting to develop new ancillary services to bring forward new technologies, including storage, to maintain system stability with a lower level of continuing generation from fossil-fuelled plants. One such technology is the Kilroot battery, described in the box below, which can provide up to 20MW of flexible power to manage sudden changes in demand. With solutions like this, Ireland is seeking to achieve the goal of being able to manage periods where up to 75% of its generation comes from renewables.[34]

The Kilroot Battery

In January of this year AES UK & Ireland announced the completion of the first UK transmission scale battery storage facility in the UK. The 'Kilroot Advancion® Energy Storage Array' is based in Carrickfergus in Northern Ireland and offers 10 MW of interconnected energy storage, equivalent to 20 MW flexible resource. This storage – which is comprised of over 53,000 batteries – is able to respond to changes in the grid in less than a second, providing a very fast response ancillary service to help balance the electricity system at times of high demand. The array is a fully commercial project, with no additional costs for consumers.

This 10 MW array represents the first step towards a planned 100 MW energy storage array at the same location. If completed, this much larger array has been estimated to provide £8.5m in system savings and the equivalent of 123,000 tonnes of CO_2 eliminated per year, by displacing fossil fuel generation for peaking and balancing requirements, and facilitating fuller integration of existing renewables.

The potential benefits of this project are being closely monitored by the System Operator Northern Ireland (SONI). Robin McCormick, General Manager of SONI explains: "Integrating battery storage solutions onto the system is an important development which should bring real benefits to customers across the island. As the transmission system operator, this innovation provides a significant learning opportunity; we will assess the role that battery storage will play in the increasingly diverse portfolio of generation sources."

2.30 Whilst Great Britain does not yet have the same share of renewables as Ireland, some future scenarios have levels of renewables that would result in similar issues.

2.31 For this reason, National Grid, in its role as System Operator, has taken some steps to increase the range of technologies able to participate in its ancillary services market. In particular, it recently tendered for 200 MW of Enhanced Frequency Response (EFR) capacity – technologies that can supply power to the network in less than a second – to better balance the electricity system, on the basis that batteries (and interconnectors) have the ability to offer these services. This tender received expressions of interest totaling more than 1.3 GW of capacity from over 65 projects.[35] This is clear evidence that there is a strong appetite from storage providers to deliver system services, although as set out in Part 3 of this report, changes to the operation of the UK's distribution networks will be needed to make the most effective use of these technologies.

2.32 Tendering for new types of ancillary service in this way is helping to support the deployment of new battery and other technologies. At the moment, revenues from ancillary service contracts form the central part of the investment cases for lithium ion battery projects. However, these tenders remain a marginal element of the overall market, and without more widespread opportunities to tender and a level playing field, it is difficult for potential storage investors to develop business cases and access finance for their projects. The barriers to storage technologies participating more fully in the ancillary services market are discussed in paragraphs 2.49-2.51 below.

Mitigating the need for expensive network upgrades

2.33 Another important role storage technologies can play in the electricity system is to offer a cheaper way of ensuring that our networks, both at the national and local level, are able to deal with peaks and troughs in the flow of electricity.

2.34 Like other parts of the electricity system, the transmission and distribution networks are set up to meet relatively short periods of peak demand and supply. Capacity constraints have been managed by either reinforcing the network by building more cables, paying power stations to prevent them from exporting to the electricity network – known as 'constraining off' – or preventing sources of demand and supply connecting until the network has been strengthened.

2.35 Building new cables to reinforce the network to meet a level of demand it might face for just a few hours of the day or year is expensive when compared to the benefits it delivers. This is why it is often more cost effective to pay some power stations not to generate for short periods of time.

2.36 Having storage connected to the system means that instead of exporting power on to the network when it is suffering from constraints, generators can instead store the power, for example by compressing air, creating heat or charging batteries. This energy can be released at a later time when the grid is no longer constrained, avoiding the need to lay more cables. The same approach can be used for sources of demand; consumers can store the power they need when there is significant grid capacity and prices are low, avoiding the need to draw on the network later in the day.

2.37 The UK's electricity networks, both at the transmission and distribution level, vary substantially in terms of their age, design and the types of load they must accommodate. For this reason, different types and scales of storage will likely be needed.

2.38 Some network owners have already started to invest in storage (for example, the Leighton Buzzard battery described in the box below) as a way to defer or avoid investments and better manage their networks. Given the nascent state of storage technologies, these investments have been supported through Ofgem's Low Carbon Network Fund (LCNF), with the findings from these investments being shared with other network owners and the wider industry. But these investments remain small-scale and few in number. More widespread roll-out will be needed to fully realise the network benefits of storage technologies, which will require a number of regulatory and market barriers to be tackled, as set out below.

The 'Big Battery' in Leighton Buzzard

The UK Power Networks substation in Leighton Buzzard, Bedfordshire, has been in need of reinforcement over recent years due to capacity constraints. In other words, local electricity demand has at times been higher than the level that the substation could supply, for example during periods of cold weather.

To address this UK Power Networks looked to the possibilities of electricity storage and in 2013 it was awarded £13.2m from Ofgem's Low Carbon Network Fund to add to its own £4m funding to push forward the Smarter Network Storage project (SNS). This scheme features a 6MW/10MWh storage solution comprising approximately 50,000 lithium ion batteries, which has enabled UK Power Networks to manage electricity demand at peak times without building excess capacity. By charging during the day, the Big Battery stores electricity that can then be dispatched in the evening when residential customers in Leighton Buzzard need it. During low or average electricity demand times, the storage capacity of the Big Battery is enough to power about 1,100 UK homes for a whole day or over 27,000 homes for one hour.

UK Power Networks is now using SNS to explore ways to maximise the value from storage by offering multiple benefits to both network operators and the wider UK electricity system. It is the first storage solution of its kind to be commissioned in the UK and the first large scale battery to support National Grid. To date SNS has offered over 2,900 hours of transmission network services and has exported electricity to the distribution network at periods of high demand on more than 120 occasions.

Suleman Alli, Strategy, Safety and Services Director at UKPN said "Our 'Big Battery' in Leighton Buzzard is the first grid-scale storage of its kind, providing clarity to DNOs and the industry of the real opportunities of this technology as well as identifying the barriers preventing its wider uptake."

Managing power usage to deal with periods of peak supply and demand

2.39 The third role energy storage can play in increasing flexibility is by providing a source of electricity supply at times of peak demand and a source of demand when otherwise surplus electricity is being generated. In this way it is similar to both interconnectors and demand flexibility. Owners of storage technologies can arbitrage between periods of low prices and high prices – buying power when prices are low and storing it, so that it can be sold at a competitive price when the costs of generated capacity are higher – as a means of creating revenues and cutting costs for consumers through greater price competition for power to meet periods of peak demand.

2.40 Like other forms of flexibility, this enables storage technology to reduce the need to build conventional power stations that only operate to meet short periods of peak demand, which will also save consumers money through lower capital expenditure.

2.41 The greatest investment case for electricity storage being used in this way lies where it can charge and then discharge electricity over relatively short periods of time. This approach means that the storage capacity needed remains relatively small, reducing the capital cost of investment, and that revenues can be generated over a large number of charging/discharging cycles, meaning that the price difference between charging and discharging can also be smaller. Analysis by Imperial College indicates that electricity storage over longer durations adds little additional commercial value.[36]

2.42 There is also increasing potential for storage to be deployed in people's homes, especially as part of a smart household network. There are a number of providers of domestic scale storage, from companies such as Tesla and Moixa. DECC are currently supporting a demonstration project deploying domestic scale storage in around 250 sites to evaluate the role it can play in reducing peak demand, and how through aggregation, small scale storage can offer services to the network. At the moment deployment of storage at this scale makes most sense where it is linked to onsite power generation such as rooftop solar panels, making sure a household is able to use a larger share of the electricity it generates and reducing bills. As costs of storage fall and with the roll-out of smart meters and time of use tariffs it is likely that storage at the household level will become increasingly attractive.

2.43 In a future scenario with a significant share of the generation mix coming from intermittent sources, there will be increasing opportunities for storage to balance relatively short term differences in demand and supply. However, while effective deployment of storage technologies can significantly reduce the need for generating capacity to meet peak demand, it is not the case, particularly in the near term, that storage will eliminate the need for flexible forms of electricity generation (including gas fired plants) entirely. In particular, it will be necessary to ensure that there is sufficient capacity to provide security of supply when there is little wind or sunshine for a prolonged period. Analysis by the Energy Research

Partnership suggests that 'neither storage nor demand side management seem to be credible solutions to the security of supply issue caused by lulls in renewable output lasting 2-3 weeks'.[37] Managing a long period of insufficient generation through storage could require each household to have around 300 kWh of storage, equivalent to approximately 15 electric vehicles, which is unlikely to be a deliverable or cost-effective solution.[38]

Regulatory barriers to deployment of storage

2.44 As set out above, storage has the ability to offer valuable services to the electricity system. The increasing value of these services as our electricity system evolves combined with the falling costs of storage technologies mean that there is not a case for driving deployment through subsidies. However, a theme of many of the Commission's Call for Evidence responses was that resolving a number of regulatory barriers is the key factor in allowing storage to be deployed to its full potential.

2.45 The current electricity market regulations do not recognise storage as a distinct activity, but instead treat it as a form of generation and consumption. This approach ignores the other benefits that storage can play in the electricity system and creates barriers to investment in storage assets. For example, it increases costs for storage asset owners by requiring storage to be charged twice for using the electricity network – once as a generator when exporting electricity and again as a consumer when electricity is being taken from the network to be stored. Whilst storage technologies are clearly making use of the network both as a consumer and producer, charging in this way takes no account of the fact that storage assets are likely to be exporting power at times of peak load, and drawing power at times of peak generation, reducing the stresses faced by the network rather than increasing them.

2.46 Storage assets also face 'double charging' for the various government levies that are added to electricity costs, such as the Contract for Difference and Feed-in tariff schemes. These taxes are placed on the electricity used to charge-up the store and again to consumers when the electricity is exported. A better approach would be to charge these levies on the basis of the electricity actually used, reflecting that no storage technology is 100% efficient, rather than on both inflows and outflows. Not only would this be a fairer treatment, creating a level playing field with other technologies, but it would also incentivise more efficient storage technologies.

2.47 Storage's definition as a generation asset also makes it difficult for network owners, who have the best information where storage could provide value, to deploy it effectively. This is due to strict 'unbundling' regulations designed to allow equal access to networks. Whilst the Commission accepts that network owners should not be the owners of large storage assets, the regulations and associated contractual arrangements need to allow network owners to buy services from storage assets where appropriate.

Barriers to developing an investment case for storage

2.48 The complicated nature of storage, which could play a number of different roles in the electricity system and get revenues from each, means that it can be difficult for storage providers to develop a business case which relies on the stacking of these revenues.

2.49 Contracts to provide ancillary services underpin much of the current pipeline of storage projects. The nature of these contracts – in particular the fact that it is necessarily uncertain when a service might be called upon – presents challenges for storage owners in accessing the sources of revenue that would support their investments. In contrast, generators are able to provide ancillary services as a secondary element of their business model, with the primary source of revenues being the longer term and more secure contracts offered through the wholesale market.

2.50 This reflects the fact that the ancillary services market was designed when there was a limited need for flexibility, which could easily be delivered by large generators as a small additional service rather than as the core rationale for investment. As a result, many flexibility services (such as fast reserve)[ii] are procured through bilateral contracts between the System Operator and major generating companies with little transparency about prices or potential revenues. Without this information it is difficult for new developers to determine whether an investment in storage, or other emerging technologies such as demand flexibility, to deliver ancillary services would be worthwhile.

2.51 Increased tendering for ancillary services by the System Operator, with price information set out in market reports, has helped to make the market clearer for participants. Work has also started to make service contracts more open, allowing a single storage asset to target revenues across a number of roles (e.g. offering both network improvements and ancillary services). This work, accompanied by a number of pilots, has enabled progress to be made in developing business models and contracts that address some of these issues, but broader changes to the ancillary services market will be needed to enable more widespread and efficient deployment of these technologies and to allow storage investors to optimise where their assets are best used at each point in time. Because the need for flexibility will increase significantly in future, identifying and implementing those broader changes must be considered a priority.

Recommendation 2: The UK should become a world leader in electricity storage systems. Two steps are required:

a) DECC and Ofgem should review the regulatory and legal status of storage to remove outdated barriers and to enable storage to compete fairly with generation across the various interlinked electricity markets. The reforms should be proposed by Spring 2017 and implemented as soon as possible thereafter.

[ii] Fast reserve provides the rapid and reliable delivery of power through an increased output from generation or a reduction in consumption from demand sources, allowing the system operator to manage the frequency on the grid – for example in the event of a power station failing, providers of fast reserve must be available with 2 minutes of being called upon and able to deliver power for 15 minutes.

b) **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.**

Demand flexibility

Demand flexibility can allow families and businesses to change how they use electricity. Deploying automated systems to reduce consumption at times of high demand and high prices and increase it at times of low demand, will allow consumers to save money and cut emissions without inconvenience.

In addition, demand flexibility can support the integration of low carbon generation. Flexibility in how we consume energy lowers the need for flexibility in supply, supporting the integration of inflexible low carbon generation such as wind, solar or nuclear.

Demand flexibility is commonplace in other countries, such as Australia and the US, and new technologies in this area are advancing. But it is currently underused in the UK.

Some of the best British businesses are already making use of flexible power, but there is potential for much wider take up. With the roll out of smart meters in every home in the 2020s, the domestic market for flexible demand could be significant. However, without tackling regulatory and cultural barriers, it is unlikely that the full benefits offered by demand flexibility will be achieved.

There is an opportunity here for UK firms. We are a world leader in the data analytics and software development that can be used to manage energy demand seamlessly: showing what can be achieved will enable these capabilities to be marketed to the world.