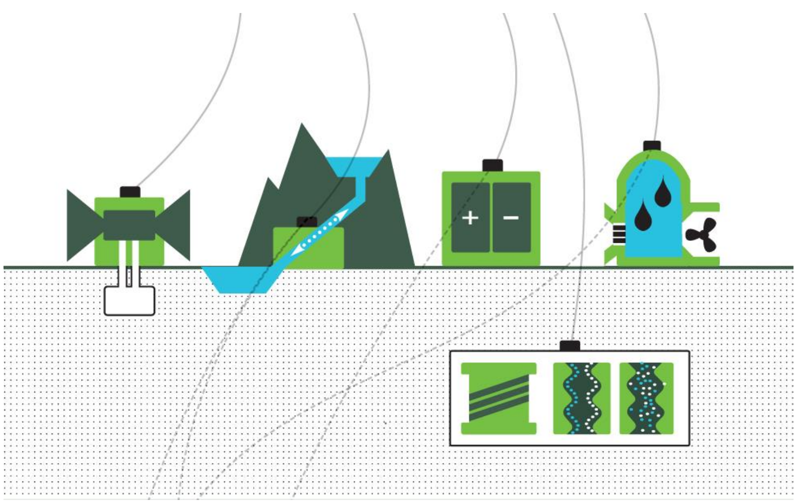
November 2014

THE ELECTRICITY STORAGE NETWORK™

Consultation Document



The UK electricity network is already under strain and our spare capacity margin is now at a 7 year low[1]. However, population growth, new housing, businesses and heavy industry are continuing to increase energy demand. Our switch to renewable energy only adds to this stress.

Electricity networks are a complex amalgamation of overhead lines, cables, transformers, switches and generation equipment – and this is all needed just to get the electricity to the consumer. Add in high voltage networks of the UK's National Grid, the System operator in Northern Ireland, and the networks of the regulated and independent distribution companies, and we can begin to see how much effort is required to ensure that the lights stay on. Electricity storage is a solution that can be applied at all levels of the power system, from the consumer, through distribution and transmission to the generator.

The UK is behind many other countries in its adoption of modern electricity storage. This consultation document demonstrates the need for electricity storage in the UK and how it can form a valuable part of our national electrical infrastructure. We have identified a number of key actions that will enhance the introduction of electricity storage into our networks, these have been grouped into the four main proposals in table one. Our intention is to identify a specific recommendation, from these proposals, that could be given to the Department of Energy and Climate Change (DECC) and the Department of Enterprise Trade and Investment (DETI) and to open up discussions with the regulatory agencies OFGEM and the Utility Regulator.

We welcome any feedback or discussion about the following proposals:

Either fill in our survey: https://www.surveymonkey.com/s/ESNconsultation

Or emails us with your views: info@electricitystorage.co.uk

[1] National Grid, Winter Outlook 2014/15

	Proposal	Impact
1	*More volatile imbalance charges*	All electricity generators would be financially motivated to generate in accordance with scheduled dispatch. This would encourage generators to seek innovative ways to balance their production schedule. Electrical storage would be a physical way to ensure balance.
2	*Improved contract terms ancillary services and energy markets*	The Transmission system operators purchase ancillary services from a number of suppliers, thereby offering an opportunity for storage developers to access an income stream. However contract terms and conditions are complex and restrict the participation of storage technologies. These contract terms should be revised.
3	*Ensure Feed-In Tariffs and Renewable Obligation Certificates can only be received if complementary electricity storage technology has also been built*	Renewable generation is supported through mechanisms such as FIT and ROC. These incentives encourage production of renewable generation, but also introduce increased requirements on flexibility from other resources. Electricity storage can provide this necessary flexibility.
4	*Introduce a mandated requirement for network companies to install storage*	Distribution companies can benefit from the introduction of storage, but the financial justification is complex. If storage is available to the distribution company, it would be able to use it to best advantage on the network.

Table 1: ESN Proposals. A detailed description of each proposal can be seen in Annex 1.

1. Introduction

Electricity storage is a worldwide industry. Currently more than 140 GW[2] of pumped hydro storage is installed and operating around the world. Some power systems have a higher proportion of storage than others, and in many countries the use of advanced storage technologies is increasing rapidly.[3] British companies are beginning to adopt some of these advanced technologies, but there is scope for much more development.

As well as our interest in developing electricity storage technologies to improve the operation and efficiency of our electricity networks, we are also keen to support the growth of the British electricity storage industry, by providing a home market for manufacturers, project developers and installers.

2. The current UK electricity network

The UK government aims that by 2050 decarbonisation of specific sectors will result in a 110 GW increase in electrical demand from transport, and a change to electric heating will add 200 GW to peak demand. Great Britain currently has a peak electrical demand of 60 GW, but the implementation of these targets will significantly increase this[4] . The current network will not be able to meet this increase in peak demand and, due to the 40yr lifetime of traditional technologies, 80% of these current network assets will still be in place by 2050.

The spare capacity margin in the UK is now at a 7 year low, with a network now reliant on Combined Cycle Gas Turbines (CCGT) as a buffer. The use of CCGT only plasters over our energy problem as natural gas is vulnerable to fluctuations in market prices and doesn't fully support the task of bringing down the UK's carbon emissions to meet binding EU targets. Electricity storage provides an alternate, stronger solution to meet peak demand and ensure flexibility of supply. Electricity storage technologies can be used to supplement peak capacity when required, (typically for the winter peak) and improves the utilisation of plants on the system, not only by providing capacity, but also flexibility. The need for flexibility and electricity storage is increasingly important, due to the rise in variable renewable technologies being introduced to the network.

---

[2] International Energy Agency, Pumped Hydro Storage Roadmap, October 2012
[3] US DOE Energy Storage Database http://www.energystorageexchange.org/
[4] Andrew Jones, S&C Electric

3. The current market doesn’t support utility scale electricity storage

The power systems of the UK are based on networks owned and operated by commercial companies, under the terms of license agreements, and are overseen by regulators. Electricity is produced by generating companies, which are also privately owned. Larger generating assets are licensed, but many smaller generating assets, such as roof top solar photovoltaics, are exempt from the requirement to hold a license. The electricity produced is either for self-consumption, or is traded through the power markets, at a national or international level. Consumers purchase electricity from supply companies, which are also licensed and subject to regulation.

Within this framework, the UK government does not directly invest in power system assets, having deregulated and privatised the industry between 1989 and the late 1990s. However, the government does provide signals to the market for companies to act in a preferred manner. Renewable Obligation Certificates (ROCs) have encouraged investment in wind power, by rewarding companies that invest in renewable generation, and obliging supply companies to purchase a proportion of renewable generation. Feed-In Tariffs (FITs) support smaller participants in the renewable sector and Contracts for Differences (CFD) give certainty of income for larger projects. Plans for a Capacity Market in Britain are well advanced. The Capacity Market is intended to incentivise investment in generating plants to provide generating capacity at critical times of the day (peak times). Successful bidders in auctions to provide capacity will receive a regular income. Such certainty of income is a key factor in the investment decision for large projects.

Just as electricity can be generated using a wide range of technologies (such as nuclear, coal, gas or renewable sources) and across a broad size range from fractions of a watt to MW and even GW, electricity storage covers an equally broad canvas. Not only as there is a wide range of electrical storage technologies, sizes and operating characteristics, but also as these technologies can be at very different stages of development. It should be noted that many electricity storage technologies are available for commercial deployment now. Many suppliers of equipment such as batteries, flywheels, compressed air and liquid air systems, as well as pumped hydro provide competitive quotations for the manufacture and delivery of electricity storage equipment and plants. However, under the present power market arrangements in the UK, it is not always possible to produce a financially robust business case. This does not mean that electricity storage is too early for the market, or that it is too expensive, it just highlights inconsistencies in the market environment that inhibit commercial development.

4. Storage: the missing link in the UK electricity network

Electricity storage can aid a greater uptake of renewable generation, increase spare capacity and improve flexibility. Householders, small industrial and commercial consumers may use locally connected electricity storage, as part of their local system balancing, to reduce voltage variations on the local network and reduce the need for local network reinforcement, such as resource intensive overhead lines and underground cables. Such local electricity storage systems, with mid to longer term storage, would be relatively low power.

At larger scales, storage complements renewable generation, by absorbing and rejecting energy to balance production with demand. High power is required for this large scale storage, but a range of storage capacity is possible, depending on whether the application is to balance short term fluctuations or longer term energy management. Onshore wind farms are currently being paid £30 million a year to switch off during the windiest weather[5]. A properly configured electricity storage plant can provide balancing services, which will become increasingly necessary as renewable generation increases variability in supply, and increased electrification increases the swings in demand. The Adam Smith Institute[6] has reported that under low level wind scenarios, the UK would require energy storage of up to 150 GWh, or the equivalent to 15 Dinorwigs.

In the mid-term, we see the increasing role of the smart grid as a means of using active network management to balance supply and demand, and thereby to optimise the use of renewable generation, while minimising additional infrastructure costs. Electricity storage, along with its companion, thermal storage, is an integral part of the smart grid. Electricity storage is necessary to absorb fluctuations on both small and long term time frames, and installation sizes will be in small, mid-size and even large scale applications. One specific concern for the system operator is the lack of inertia in the system. Inertia has traditionally been inherently supplied from large rotating synchronously connected generators. But with an increase in renewable generation, there is now a significant reduction in the inertia, of the system. Inertia is important because it slows down the rate of change of frequency when

[5] The Telegraph, Wind farms paid £30m to shut down during high winds, February 2014
[6] Adam Smith Institute, Wind Power Reassessed: A Review of the UK wind resource for electricity generation, October 2014

an event happens. Improved frequency response services, such as those provided by electricity storage, would be of increased value and these new services will need to be included in the catalogue of ancillary services purchased by the system operators.

In the long term, electricity storage can reduce the overall system operating cost, by optimising the role of generation, transmission, distribution and supply. At the same time electrical storage can increasingly integrate renewables and provide a more flexible approach to security of supply and balancing services to the network.

Our vision for a future network includes examples of storage of all types of technologies, of all sizes and in different locations. Technical integration of storage is relatively easy, it is a similar process to designing other infrastructure assets such as a new road or railway. The challenge is to design the commercial framework. Our previous publications[7] gave examples of the numerous reports and strategy documents which support this finding.

[7] Electricity Storage Network – Development of Electricity Storage in the National Interest, May 2014

5. Electricity storage in the UK

In the past 24 months, more than £80 million[8] of funding has been committed to support research and design in electricity storage programmes across the UK. However, large scale energy storage connected to the grid continues to be dominated by the four pumped hydroelectricity storage stations in North Wales and Scotland, which collectively provide 3,000 MW[9] of storage capability. A large number of batteries have been installed at sites across the UK, in a variety of sizes, but the cumulative total is still under 20 MW. [10] We exclude from this figure those batteries which are connected to consumers' premises for use as uninterruptible power supplies.

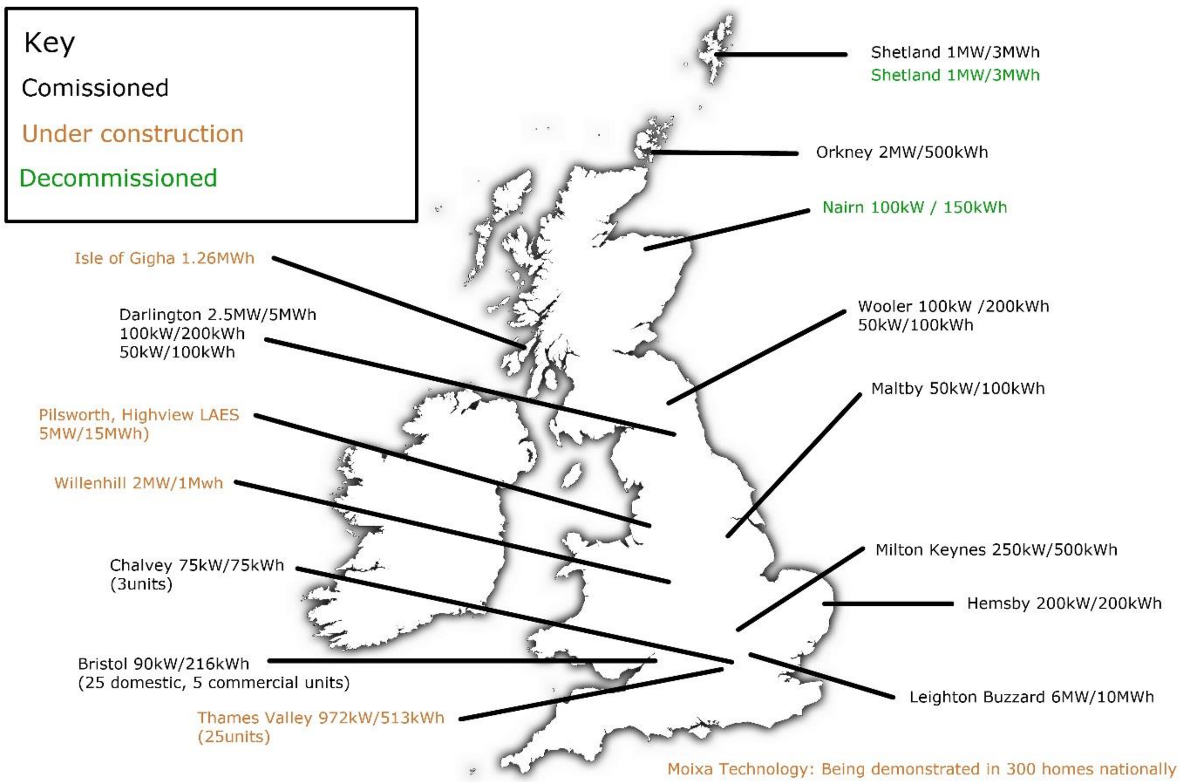


Figure 1: Demonstration Electricity Storage Projects 2010-2014

[8] David Hough, House of Commons Library, Energy Storage Research and Development, July 2014
[9] Scottish Renewables, Pumped Storage Position Paper, June 2014
[10] Electricity Storage Network http://www.electricitystorage.co.uk/links-and-reports

Projects under consideration, project development and construction

In December 2014, Europe's largest battery will be deployed at Leighton Buzzard, and in 2015 we will see a number of other grid scale projects come online across the UK, including Highview's 5MW/15MW Liquid Air Energy Storage (LAES) plant at Pilsworth in Manchester.

Funding by the Low Carbon Network Fund, DECC's Energy Storage Technology Demonstration Competition, and the ETI's Energy Storage and Distribution Programme has provided the opportunity for many distribution network operators and end users to install grid scale electricity storage as part of their innovation programmes. Projects have included:

Developer / Project	Technology	Size	Status	Location
Smarter Network Storage (SNS) Tier 2 project[11]	Lithium-Ion	6MW/10MWh	Online	Leighton Buzzard
Highview Power Storage[12]	Liquid Air Energy Storage	5MW/15MWh	Online late 2015	Pilsworth, Manchester
REDT UK	Vanadium Redox Flow Battery (VRFB)	1.26MWh	Mid 2015	Island of Gigha, Scotland
Moixa Technology Ltd[13]	Maslow	0.525Mh	Mid 2015	Demonstrated in 300 homes nationally
Isentropic[14]	Thermal storage	1.5MW/6MWh	Summer of 2018.	Western Power Distribution substation

Table 2: Recent Energy Storage projects

The third phase of the Energy Entrepreneurs Fund was launched in January 2014 and is providing an additional £10 million to support the development and demonstration of low-carbon technologies, including electrical storage. The scheme particularly aims to assist small-and-medium-sized enterprises, including start-ups. Those companies that are selected will receive additional funding for incubation support.

[11] UK Power Networks, Smarter Network Storage (SNS) 2014
[12] Press release, Department of Energy and Climate Change (DECC), February 2014
[13] Press release, DECC, November 2013
[14] Press release, Energy Technologies Institute, June 2012

Commentary on the past twelve months

During 2013 – 2014 the two major issues of costs to consumers and electricity market reform have dominated the energy debate. The passing of the Energy Act 2013[15] which opened up the new Capacity Market and CFDs has implications on investment for both conventional and renewable generation plants. The overall intention of the Capacity Market has been to ensure that there is sufficient generation capacity to meet peak time requirements and CFDs provide a new regime of support for low carbon generation. While the Capacity Market recognises the role of electricity storage and allows storage operators to tender into the market our view is that the Capacity Market does not, in itself, provide sufficient stimulus to sustain investment in network connected electricity storage. The opportunity has been missed to use storage as a low carbon, high efficiency route for providing new capacity on the network.

Energy storage is top of the class

The *Engineering and Physical Sciences Research Council (EPSRC)*[16] has invested more than £30 million in five academic centres across the UK to support new science capital facilities for grid-scale energy storage to help accelerate the development of national scale electricity storage. The five participating centres can be seen in Appendix A.

The new £4 million SUPERGEN Energy Storage Hub[17] will draw experts together from seven universities and fourteen industrial and governmental partners, which can be seen in Appendix B. They will address the technical and scientific challenges facing the wide variety of energy storage techniques.

[15] Energy Act 2013, DECC
[16] EPSRC, Capital for Great Technologies Call: Grid-scale Energy Storage, June 2013
[17] EPSRC, SUPERGEN Energy Storage Hub, June 2014

6. Looking ahead: incentivising storage in the UK

The slow take up of electricity storage is often attributed to concerns surrounding the certainty of revenue streams. A standard economic appraisal of the commercial status of a storage project would look at the balance between the costs, revenues, and lifetime, with projects proceeding if certain thresholds are achieved. In other related areas, incentives have been used, such as reducing the initial cost, reducing the cost of ownership, or improving the income stream, such as by guaranteeing a minimum or fixed income. Initial cost reductions could be achieved by providing specific grants, tax relief on investment or tax credits on the income received for certain types of investment. Other options might include reductions or exemptions on business rates for electricity storage installations.

In some countries, a mandate to use electricity storage has been adopted. This principle has elements similar to those in countries which have a centrally planned electricity system.

An alternative approach might be to provide support for increased levels of R&D into electricity storage, principally to seek cost reductions and improve performance in storage technologies. If successful this approach would make electricity storage more cost competitive. This is a strategic process and one that may not necessarily bring direct benefits to the UK's electricity infrastructure. However, such investment would bring considerable benefit to the many industrial and academic centres that are researching storage in the UK.

A range of incentives, which deal with the financial, regulatory and strategic aspects of storage project development, have been considered, within the context of power systems in Great Britain and Northern Ireland. Each mechanism has been assessed for suitability, taking into account the viability, economic benefit and simplicity/complexity, the linkage to other support mechanisms and incentives and the likelihood of detrimental unintended consequences (Appendix C details these requirements). These incentives have been discussed and assessed at recent meetings with ESN members.

From these discussions we have identified four main proposals, which are outlined in Table 2. These four incentives cover system operation, contract terms for payment, subsidy for investment, and a proposal for mandated requirement of storage. As well as these points having merit in their own right, they also attempt to correct some of the imbalances caused in parts of the power system for example, where a support mechanism for another technology penalizes operators or storage. A detailed description of each proposal can be seen in Annex 1.

Our intention is to assess which of these proposals should be further developed as a specific recommendation, or recommendations, to the Department of Energy and Climate Change (DECC) and the Department of Enterprise Trade and Investment (DETI) and to open up discussions with the regulatory agencies OFGEM and the Utility Regulator. It would be helpful to consult with the wider energy storage community, and with others in the electricity industry. Therefore we invite your comments and discussion on each of the following proposals.

	Proposal	**Impact**
1	*More volatile imbalance charges*	All electricity generators would be financially motivated to generate in accordance with scheduled dispatch. This would encourage generators to seek innovative ways to balance their production schedule. Electrical storage would be physical way to ensure balance.
2	*Improved contract terms for the ancillary service and energy markets*	The TSOs purchase ancillary services from a number of suppliers, thereby offering an opportunity for storage developers to access an income stream. However contract terms and conditions are complex and restrict the participation of storage technologies. These contract terms should be revised in light of new technologies.
3	*Ensure Feed-In Tariffs and Renewable Obligation Certificates can only be received if complementary electricity storage technology has also been built*	Renewable generation is supported through mechanisms such as FIT and ROC. These incentives encourage production of renewable generation, but also introduce increased requirements on flexibility from other resources. Electricity storage can provide this necessary flexibility.
4	*Introduce a mandated requirement for network companies to install storage*	Distribution companies can benefit from the introduction of storage, but the financial justification is complex. If storage is available to the distribution company, it would be able to use it to best advantage on the network.

Table 3: ESN Proposals. A detailed proposal can be seen in Annex 1.

The Electricity Storage Network welcomes your comments on these proposals.

Fill in our survey: https://www.surveymonkey.com/s/ESNconsultation

Or to send your comments via email to: info@electricitystorage.co.uk

It would be helpful if comments and views were to answer the following questions:

Q1: Which incentives do you think the UK Government should adopt?

Q2: Do developers of Electricity Storage projects in the UK need support or incentives to develop commercially viable projects?

Q3. If incentives are required, how should these be administered?

Q4. Should incentives for storage be long term and fixed for many years, be tapered, or be short term?

Q5. Electricity storage projects could be developed by Transmission System Owners or Operators, Distribution Network Owners or Operators, Independent Power Producers and Traders and Supply Companies and End users of electricity. Which business sectors do you think should develop storage?

Q6. If financial incentives are to be used, how should these be funded and who should administer the scheme?

Q7. What comments do you have on each of the proposals?

1. Volatile imbalance charges
2. Improved contract terms for ancillary services
3. Ensure Feed-In Tariffs and Renewable Obligation Certificates can only be received if complementary electricity storage technology has also been built
4. Introducing a mandated requirement for distribution companies to install electricity storage.

Q8. Are there any other support mechanisms that should be used to encourage the development of storage? Please provide a description and examples if possible.

Annex 1

A detailed review of proposals to enhance the development of electricity storage.

Proposal 1: A requirement for all generators to generate in accordance with a pre-determined schedule, against the penalty of increased imbalance charges.

The market rules in Great Britain treat generation differently according to size of the installation. Large generation (>50 MW) is required to be dispatched against supply schedules, whereas smaller generation is exempt from this. Indeed, small scale distributed generation, such as domestic PV or small scale commercial PV is encouraged by a generation and Feed-In Tariff to generate on an "As available" basis. The cumulative impact of this new, variable generation is reflected in the increased need for balancing services. These costs are borne by all system users, effectively providing subsided access to the network to smaller, and non-dispatchable generation at the expense of the larger forms of generation which must comply with regulations or pay imbalance charges.

Increasing imbalance costs and making generators of all sizes pay these charges will encourage generators to seek new, innovative ways to balance. This may include energy storage, as well as introducing third party financial instruments, which could be set off against independent electricity storage.

Proposal 2: Improved contract terms for the ancillary service and energy markets

Many recent studies have indicated the increased value of electricity storage when used to provide ancillary services, in comparison to the value when used solely for trading peak against off peak electricity. However the ancillary service markets have contract terms which are not necessarily supportive of large or small scale electricity storage.

In GB each service has to be contracted for separately, and contract terms amongst services are not necessarily aligned, for example tender periods for STOR differ from those for Frequency Response. The requirements for delivery of ancillary services are still based on traditional technologies. Furthermore, some services have onerous conditions, such as minimum plant size or penalties for non-performance, which increases the transaction costs, often to the point where the service becomes un-economic. These requirements and conditions should now be revised to reflect changes toward small units and different delivery lengths.

Ancillary services should provide a way for storage developers and providers to enter the power market. We recommend a review of the ancillary service market to make the services procured technology neutral, and so encouraging the uptake of storage.

There is a different set of ancillary services procured in the SEM to those procured in GB. This has cost implications as control software and reporting has to be bespoke for both markets, increasing the cost of participation. The approach in the SEM is to set out regulated rates for each service, whereas in GB the approach is to seek market based tenders whenever possible in order to ensure a competitive procurement of the lowest cost services.

It has been shown that fast acting frequency control services, have a significant effect on the need to use additional services to maintain a stable frequency. In other words, the rapid response of a storage plant can be used to rapidly arrest a decline or rise in frequency, thus reducing the overall requirement for frequency services. Therefore it can be shown that using electricity storage provides a cost saving when procuring frequency reserve, as well as an environmental saving.

Proposal 3: Ensure Feed-In-Tariffs and Renewable Obligation Certificates can only be received if complementary electricity storage technology has also been built.

In GB, support for renewable energy is based on the export from a generation site. This leads to the situation where a renewable energy producer who feeds electricity directly into storage would only receive the ROC based on the output of electricity from the store when it is discharged. This is a significant disincentive to the use of storage.

Currently the level of subsidies toward renewable energy are being removed. However, a link between support for renewable energy and storage could have desirable effects on both parts of the industry. The support for renewable energy could remain at the same level as present for new installations, provided that such plants were directly linked, and associated, to an electricity storage installation. This would enable support for renewable energy, provide additional flexibility for the system as well as increase the prevalence of storage.

There are several possible variations on this theme. Feed in tariffs could be reduced, with the exception of an enduring rate for generation directly linked to storage, or for storage owners to be eligible for a fixed rate of support, such as a capacity availability fee if the plant is directly associated with a renewable plant.

Proposal 4: A mandated requirement for network companies to install storage

Network companies are under a general licence condition to minimize expenditure on their regulated assets. This has an impact on the choice of solution for new investment, as the network company needs to ensure that the whole life cost of any investment represents the best value for money. Network companies can use electricity storage to defer or replace investment in traditional assets, such as cables or overhead lines. However the business case relies on stacking of benefits across different value streams.

Network companies can see value from storage for the following areas:

a) Deferral or replacement of traditional network reinforcement
b) Lower cost method of increasing capacity for new renewable and other distributed generation
c) Provision of voltage control to the distribution network
d) Provision of ancillary services to the transmission network

It has been pointed out [18] that distribution companies may find it difficult to collect value from all these important income streams due to the complex regulatory and commercial framework.   However a mandate that requires each network company to install say 10% of new capacity in the form of storage would enable the network company to choose storage as a solution for a significant fraction of its new investment, with the confidence that the business case would not need to be proven. This would assist the connection of renewable plants, defer network reinforcement and make storage available to provide balancing services to the transmission network. A counter-argument would be the concern of manufacturers that their market could become dominated by a small number of monopoly customers.

[18] Several authors

Appendix A: The five academic centres given funding by Engineering and Physical Sciences Research Council (EPSRC)

Title	Lead Research Organisation	Principal Investigator	Partner Research Organisation	Awarded
Energy Storage for Low-Carbon Grids	Imperial College London	Professor DCC Brandon	Cardiff, Newcastle, UCL, Birmingham, Cambridge, Oxford, Sheffield, St Andrews	£14.3 million
Grid Connected Energy Storage Research Demonstrator	University of Sheffield	Professor David Stone	Aston Southampton	£4.9 million
Manchester-Liverpool Advanced Grid-Scale Energy Storage R&D Facilities	University of Manchester	Professor Ian Cotton	University of Liverpool	£3.6 million
Centre for Cryogenic Energy Storage	University of Birmingham	Professor Richard Williams	University of Hull	£5.9 million
ThermExS Lab: Thermal Exergy Storage Laboratory	Loughborough University	Professor Philip Eames	University of Nottingham	£1.7 million

Appendix B: Partners in the SUPERGEN Energy Storage Hub

Universities involved in the Hub:

- University of Oxford
- Imperial College, London
- University of Cambridge
- University of Birmingham
- University of Bath
- University of Southampton
- University of Warwick

Project partners include:

- Arup Group Ltd
- Department for Transport
- EDF Energy
- Energy Technologies Institute
- GDF SUEZ (UK)
- Highview Power Storage
- Jaguar Land Rover
- Johnson Matthey
- National Grid
- Nexeon Ltd
- Pnu Power
- Scottish and Southern Energy (SSE)
- Sharp Laboratories of Europe Ltd
- UK Power Networks

Appendix C: Desirable requirements for incentive mechanisms

Requirements	**Assessment Criteria**
Viable	Legal (National ad EU Regulation) Fairness Transparency
Simple to Implement	Low cost to introduce Minimum requirements for legal or regulatory changes Implemented by existing department, agency or organisation
Link to other incentives or mechanisms	Should be complementary to other incentives and enhance the overall energy strategy
Economic to operate	Low cost of implementation Low cost of entry
Low risk of detrimental unintended consequences	Mechanism is developed and though through. Provides protection against future regrets

www.electricitystorage.co.uk Email: info@electricitystorage.co.uk Phone: 01666 840948
twitter@ESN_UK

The Electricity Storage Network is the special interest group for companies and organisations that are active in the deployment, design and research of electricity storage for network connected applications. The inclusion or omission of any technology or projects is not an endorsement or criticism of any technology, company or business. Published by the Electricity Storage Network 28th November 2014.