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10 March 2011

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Response to the Electricity Market Reform Consultation by the Electricity Storage Network

The Electricity Storage Network (ESN) is a group comprising developers, manufacturers, users and others interested in the application and deployment of electrical energy storage in the UK and Europe. This response has been prepared as a result of an open meeting held in January 2011 to discuss this response and follow on discussions amongst the members of the ESN. Attendees at the meeting included project developers, manufacturers, consultants, trade associations, energy generators and suppliers and network companies.

The Network welcomes the opportunity to respond to this consultation, and members of the group are willing to discuss any points with DECC, either individually or collectively. This response is in three sections, an executive summary, responses to specific questions raised in the consultation document and an annex containing supporting information.

[redacted]

1. Executive Summary

Her Majesty's Government has set out its objectives for an energy policy based on national security of supply, sustainability and energy economy. These principles are fundamental to national productivity. The electricity sector is a significant component of the national energy infrastructure, and as other parts of the energy sector begin to move towards lower carbon energy sources, the development of the electricity sector will increase. [1]

Electricity storage is recognised as a key component of the nation's energy strategy. Embracing a range of technologies, the concept is fundamental to increasing the utilisation of all assets on the power system, thereby lowering costs, reducing emissions and improving security of supply. Electricity storage is the one technology that acts both to absorb and discharge energy as required. This combination has been undervalued in the post privatisation power markets and must be correctly valued in the future, and storage should not be considered only as generation or reserves but as having broader system and environmental benefits. The structure of the electricity market reform consultation is based on bringing more generating capacity into service, and increasing flexibility in response, but should include improvement of the whole electricity system. We are also mindful of the severe constraints in capacity which are expected before 2020 that will be caused by the closure of existing generation. The short lead times for permitting and construction of energy storage plants will alleviate some of the expected capacity shortfalls.

Critically the electricity system is facing a fundamental change by the commitment to focus on low carbon generation and the issue of intermittency. According to Poyry [2] (The variability of wind output), the output from wind generation by 2030 will swing from a peak of 40GWh to a low of 1-2GWh. This can either be managed by additional fast response fossil fuel, high emission plant or energy storage - absorbing wrong time energy (i.e high generation and low demand) and discharging at times of high system demand. Curtailment of renewable energy is not a satisfactory solution.

In order to maintain or increase the rate of development of renewables it is acknowledged [3] that significant changes are needed in the operation of the electricity network - "the Grid." In order to provide the additional reserves to ensure security of supply there are a number of alternatives that may be considered and including energy storage. The introduction of peaking plants, typically open cycle gas turbines (OCGT), provides a simple solution, but these are still emitters of greenhouse gases. Adding nuclear to the baseload component of the generating sector reduces the need to use fossil fuel, but in order for it to be used effectively some form of energy storage would be required to modulate the output or provide shape to the supply curve.

[1] For example HM Government Pathways to 2050, published 2010, URN 10D/764
[2] Poyry Energy Consultancy, The impact of intemittency, July 2009, http://www.poyry.com/linked/group/study accessed 7 March 2011
[3] National Grid Briefing note "Gone Green" http://www.nationalgrid.com/NR/rdonlyres/9A4B4080-3344-4C6D-8A19-411A867682F2/26834/GoneGreenfor2021.pdf accessed on 16 Feb 2011

While interconnectors may be able to transfer power between markets where there is a time difference in supply and demand peaks, interconnectors rely on a cost differential between markets to recover the costs of investment.

Electricity storage provides a flexible solution to the challenges of the future power system which meets the requirements to:

- deliver security of electricity supply;
- increase the sustainability of electricity generation through reducing greenhouse gases; and
- reduce overall the total system operating costs of the national electricity system.

In so doing, energy storage can provide the necessary ancillary services for providing security of supply (such as short term operating reserve (STOR), fast reserve, frequency response, Transmission Use of System Charges (TUoS) Management, etc) as well as such services as black start. Furthermore, the issues of curtailment of renewable generation can be mitigated by the use of storage.

Although electricity storage is often regarded as a form of generation (such as an alternative to peaking generation), we wish to place on record our concern that electricity storage should be considered as an enabling technology that enhances the value of the entire network including the support for a larger penetration of renewables than would otherwise be the case.

The ESN is concerned that the analysis of the power system which has been carried out by consultants for DECC has incorrectly considered the concept and role of electrical energy storage and therefore underestimated the contribution of electrical energy storage to the future power system, particularly in the unique contribution that storage can bring to deliver energy security and reduce emissions of GHGs (greenhouse gases) of which carbon dioxide is one. The analysis presented does not take into account the overall value of energy storage in economic and lower emission terms[4], producing a view that underestimates the future contribution of storage. If this is reflected in lower capacity payments for energy storage, then less energy storage will be built and the future system (of generation, transmission and distribution) will not be optimised for lowest operating cost and lowest emissions.[5] Of necessity, we will then have to rely on existing (capitalised) fossil plant to balance intermittency.

The Government seeks to encourage new baseload nuclear capacity by means of carbon price support. As electricity storage is a means of absorbing, storing as a commodity and best managing energy, its actions in the market will be to support base load prices as well as the price of renewable generation at times of surplus. [6]

It is proposed by some that the change to lower carbon fuels in the energy system may be encouraged by switching the end use of energy from fossil fuel (such as natural gas for heating and oil products for transport) to electric heating and electric vehicles . This change depends on a surplus of electricity generated from renewable resources for which there is no other application. The transfer into the electricity sector will place a significant burden on the future

[4] The Royal Commission on Environmental Pollution calculated the savings in emissions attributable to storage. See http://www.rcep.org.uk/reports/22-energy/22-energyreport.pdf page 166

[5] Comments on the analysis are given in Annex A to this response

[6] This effect is being modelled and results of the analysis will be available in due course.

network - already network companies are considering asset upgrades. Electricity storage allows assets to be installed to meet the average demand and not the peak demand, presenting a further significant benefit of storage.

We believe that action is required at an early stage to ensure that sufficient new capacity is available to counter the expected shortfall in conventional capacity and to balance the increased production from renewable resources. Critically it needs to be on line before the effects of the large plant directive remove baseload plant from the network. Electricity storage is the one technology that is not supported by any other mechanism at the present time. It does not receive Renewable Obligation Certificates (ROC) or Feed in tariffs (FIT), and investment by the Distribution Network Owners (DNO) under innovation funding is naturally restricted by the limits on storage operation set under the Electricity Act. Support and large scale demonstration programmes are currently underway to support other technologies that demonstrate flexibility, such as Carbon capture and Storage (CCS), Electric Vehicles (EV), Renewable and Demand Side Response (DSR) with Smart meters. We recommend that the government instructs DECC and OFGEM to provide a technology neutral approach to all of these mechanisms which can offer flexibility and support to reduce the use of fossil fuel in the energy infrastructure and not to exclude electricity storage. Storage will work in combination with Demand Side Response and EVs, but it has enhanced attributes over both, as it can absorb and replace power, adding a time value to its services - thereby enhancing its value. It is also fast to permit, site and construct and therefore its development should be accelerated.

Others propose that the use of batteries in vehicle to grid applications would have an effect similar to that of directly controlled storage, but the methodology and public acceptance of charging and discharging by a network operator or Supply Company has not yet been tested. While it may play a part, it is not capable of providing a realistic total solution.

The opportunity exists now to develop the infrastructure using electricity storage which will provide flexible low carbon fuel solutions to complement future plant choices and without restricting choice in the future. Electricity storage brings together the attributes of the smart grid, demand side measures, and network reinforcement. Furthermore, storage may be used to facilitate connection of new renewable generation, particularly in areas of weak transmission and distribution in order to overcome network capacity constraints.

Reviewing the electricity market now is appropriate because there are several issues under the present arrangements that need to be corrected in order to increase the proportion of electricity storage available on the network. We have compared actions towards electricity storage in other jurisdictions and where electricity storage is treated in a positive way, system benefits accrue across the system.[7]

The thrust of the market reform consultation is towards the provision of base load capacity and renewable generation and balancing services to support them. Non traditional means to provide balancing services will be required, and the additional benefits should also be recognised. We believe that electrical energy storage is a vital part of the future energy infrastructure and it should play an ever increasing role in the operation of power industry. It will have direct and

[7] For example "Energy Storage in the New York Electricity Markets" NYISO March 2010

indirect benefits and where these benefits are not rewarded directly, a stimulus should be provided. As a result of introducing energy storage there will be:

An improvement in asset utilisation of the most environmentally efficient plant;
Savings in CO_2 and other emissions;
Improved system efficiency;
Support for the price of base load generation and renewable capacity.

We recommend:

a) Electricity storage should be given at least equal support to other technologies which are key to improving the sustainability of the electricity supply industry;
b) Initial capital support is provided to demonstrate initial electricity storage projects;
c) Capacity payments should be made available for electricity storage, reflecting the characteristics of the storage system and rewarding both the ability to absorb and discharge energy, flexibility, speed of response, capacity (power rating), energy capability (energy storage rating) and location;
d) That transmission and distribution licence s clearly permit the ownership and operation of electricity storage and they receive capacity payments for these services;
e) Energy storage devices should be able to be integrated with other renewable and low carbon generation solutions, including biomass/energy from waste, without compromising their subsidies.

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2. Responses to specific questions

We are responding to the questions in the consultation document in a changed order to that published. However we have retained the numbering of the questions for ease of reference.

Because our activities and interest lie with electricity storage and the need to address the market reform and structural changes which will be most related to the proposed capacity payments we address the section on capacity payments first.

Options for Market Efficiency and Security of Supply
19. Do you agree with our assessment of the pros and cons of introducing a capacity mechanism?

The DECC assessment starts from the thesis that at present the market decides through investment what the capacity margin is to be. When capacity is tight, prices rise, sending a signal for more investment. The expected effect is an efficient open market, where generation is provided at least cost. This does not happen because of the less than perfect market conditions. New capacity can take several years to plan, construct and commission, yet the market can be made short on capacity rapidly through either planned or unplanned outages.

The security of supply is predominantly a generating capacity issue, (Network constraints may become more significant in future). At present, generating capacity is only rewarded through the energy market when energy is sold, so a capacity payment which provided a certain level of income would add certainty to the revenue, decrease the cost of capital and encourage further development leading to a more certain capacity margin than currently exists. However the risk is now transferred from the market to the regulator or capacity purchaser who sets the target.

As electrical energy storage can offer capacity into the market to cover a number of scenarios (depending on the precise technical parameters of each), a capacity mechanism for storage offers a more flexible approach than other types of capacity. It is the preferred way of contributing both to the lower carbon fuel objectives and to the improvement of the security of supply. Lead times for the construction of storage are also shorter than for pure generation plant. However the capacity mechanism must reflect the capability of energy storage to respond flexibly, by absorbing and discharging energy.

20. Do you agree with the Government's preferred policy of introducing a capacity mechanism in addition to the improvements to the current market?

Yes, we believe that this is the appropriate way forward, subject to a number of issues which need careful consideration. The capacity mechanism should reward flexible and sustainable capacity as these investments are likely to result in the installation of long term capital assets. The scale of new capacity required and the timing of its introduction must be monitored to ensure long term pragmatic solutions are reached.

21. What do you think the impacts of introducing a targeted capacity mechanism will be on prices in the wholesale electricity market?

If the market fails to respond to the present signals to invest, and reliance is placed on a central agency to determine that there is insufficient capacity before new investors are targeted, this will have the effect of increasing the reluctance of investors to commit in the early stages. This initial reluctance to commit to new capacity will therefore shorten the market and lead to increases in wholesale prices, at least in the near term.

22. Do you agree with Government's preference for the design of a capacity mechanism:

- **a central body holding the responsibility;**
- **volume based, not price based; and**
- **a targeted mechanism, rather than market-wide?**

Our preference is for support specifically for electrical energy storage, which rewards energy storage plant for its ability to provide both upward and downward capacity and fast and flexible response times.

A move to a central body holding the responsibility for the capacity mechanism, whilst not perfect, would offer a form of market continuity, which does not penalise those who are already operating in the market, or who may be about to do so.

The logic set out in paragraph 45 on page 90 of the consultation document explains that setting a price for capacity may result in either overpayment or non delivery of sufficient capacity. While we agree that setting out a volume based competitive purchasing mechanism, which tends towards price discovery may have a better outcome, care needs to be taken in constructing the market. Incentivising the lowest cost technology may not fully reward the benefits offered by a transition to generation with lower emissions.

The targeted capacity mechanism, which seeks offers in a range of categories to meet a shortfall in the provision of capacity, might be used to seek flexible or responsive capacity and reward it at a premium to simple capacity. For example storage with low energy capacity, (such as flywheels or capacitors) would have a lower benefit than storage with high energy capacity such as pumped hydro, compressed air, cryogenic, thermal or batteries. Also, storage should have a higher value to the purchasing agency than some other technologies, such as DSR or plug in vehicles because of its size, certainty of availability and characteristics of duration. The disadvantage is that because capacity is not rewarded unless there is a shortfall, under the proposed mechanism, there might be no storage built.

In contrast, a full capacity mechanism will set a reward for plant to provide capacity in order to meet both the short term hourly and daily balancing requirements as well as the longer term periods when there is a severe shortfall in renewable generation. **In the absence of direct support for electricity energy storage**, we therefore support a capacity payment, administered by a central body, volume based, which rewards both upward and downward capacity with premium payments for flexible and fast acting response.

23. What do you think the impact of introducing a capacity mechanism would be on incentives to invest in demand-side response, storage, interconnection and energy efficiency? Will the preferred package of options allow these technologies to play more of a role?

These questions are asked in the context of improving market efficiency, sustainability and the security of electricity supply. Against the background of the requirement to add system flexibility into the generation mix there are a number of technologies that can be applied, which include interconnection, demand side response and energy efficiency, conventional peaking capacity such as diesels or OCGT and energy storage. The importance of energy conservation and energy efficiency should not be overlooked. It is realistic to plan for the introduction of a range of these technologies in order to provide true flexibility to meet emission targets and security of supply concerns.

By developing a capacity mechanism, appropriate incentives will be in place for the investment in assets to be used to support network management in the future. It is assumed that these assets will be rewarded in two ways: first by the capacity payment on the basis of their availability and secondly by charging for the electricity generated when called into service. It is further assumed that any generation (from base load or capacity assets) will be subject to the cost of carbon if they involve the emission of carbon dioxide.

If these assumptions are correct, then the combination of capacity payment and cost of carbon will incentivise DSR, storage and energy efficiency. It is an interesting point that interconnection providing access to other nations' generation appears to offer little in the way of lowering greenhouse gas emissions if the source of the electricity is unknown.

Increasing flexibility is critical to the need to provide increased security of supply in the future generation mix. Energy storage is the preferred option as it:

Allows both upwards and downwards flexibility;
Has fast speed of response;
Is locatable across the system;
Makes maximum advantage of existing generation;
Optimises use of transmission and distribution;
Improves the operation of the entire system with associated societal benefits.

The consultation document cites three main barriers to future investment in storage

Uncertainty over future levels of volatility
High Capital costs
Geographic limitations

While volatility is a significant factor in assessing the future business model for storage it does not represent the entire income stream for storage. This point is discussed in our supplementary information in section 3 of this response. Storage is recognised as having a positive effect to reduce volatility in electricity markets, thereby bringing benefits to the whole market.

Whole life costs and not just the initial capital costs should be used in a business assessment for the value of storage. Most storage devices have very low operating and maintenance costs, and as the input energy is usually low cost or base load energy, the marginal operating cost is low.

The consultation document has been written from a perspective which considers storage to be pumped hydro. While this is a significant technology, it is not the only storage technology. The geographical constraints can be overcome with other systems, which are modular, readily sited and re-locatable if necessary.

Substantial cost reductions are expected as the economics of scale and replication are brought into play. Newer technologies are already lowering the system installed costs and are expected to continue.

Investments in the energy market are long term, with long term payback periods. The barriers to entry are high, those faced by energy storage developers are similar to those which have been faced by other new energy technologies, particularly renewables.

Early projects suffer from a lack of familiarity with storage technology by investors, which is either expressed as a failure to invest, or by setting a higher financial hurdle rate. Uncertainty in the power market leads to a prediction of uncertain income streams. Issues concerning legal, consenting and permitting are also costly and disproportionate. These costs may be as high for a 1 MW project as for a 10 MW project. Costs of connection also are not directly scalable, which leads to further distortion in the market.

New entrant storage developers and manufacturers may themselves lack the resources, knowhow and energy market position to extract maximum value from the energy and ancillary services markets. Hence unless storage services are sold on a non-trading basis (such as use on distribution networks), the support of an established trading company is required. The costs of trading electricity and ancillary services can be high. For a new entrant, due diligence costs and prequalification are additional expenses. For a storage project to be worthwhile, the projects must be of significant size and financial quality. To meet this requirement, long term, low cost financing is required and some security of income stream is necessary. While this is a general requirement for many power projects, the income stream may be much more uncertain for a storage project than for a conventional generation project. The capacity payment, which moves the financial basis away from arbitrage as the sole income stream will support the development of storage.

However an additional barrier to investment is that there is no clear model for ownership of energy storage installations: because there are restrictions on network companies operating electricity storage when it involves purchasing and selling electricity, a storage operator that relies solely on purchases and sales of energy and power does not realise the full value, which therefore leads to undervaluation of the market resource.[8]

Providing a payment for capacity offered by electricity storage would add certainty to developers' proposals and encourage investment. The capacity payment should be proportional to power rating, energy capacity and speed of response, all of which are desirable parameters on the system. Furthermore we believe that an initial capital grant should be made available

[8] This point is expanded in the Annex to this response

for energy storage installations in order to prime the market, place the technology on an equal footing with other technologies to provide flexibility and to compensate for the lack of viable longer term contracts. If this is coupled with licence changes to network operators so that they may operate storage, then options exist for the network operators to own the storage or lease it from a developer. Other renewable energy related technologies have been heavily subsidised for demonstrations and received on going subsidies for early stage and subsequent installations through long term arrangements such as ROC or FIT. We would encourage consideration of rewarding the ROC or FIT at the point of consumption of the renewable energy, not at its generation, thereby allowing reward for storage, where the use of storage is to absorb energy that would otherwise be curtailed.

Summary of response to Q23

We agree that the preferred package of options will allow energy storage, DSR and energy efficiency to play more of a role in the provision of grid services, but the detail of the proposals combined with other aspects of market reform, need to be considered as a whole. We propose an initial capital grant to support the initial installation of new electricity storage facilities as well as the targeted capacity payment which includes compensation for both absorbing and discharging energy.

24. Which of the two models of targeted capacity mechanism would you prefer to see implemented:

- Last-resort dispatch; or
- Economic dispatch?

Our preference is **against** a targeted capacity payment because of the effects of market distortion. However in the context of this question, addressing the case that there is insufficient capacity deemed to be available to meet either regular or infrequent capacity shortfalls, we agree that last resort dispatch minimises market distortion, but in the case of electricity storage, for the most part, this would be an inefficient use of a valuable resource.

25. Do you think there should be a locational element to capacity pricing?

Yes: The purpose of capacity pricing is to encourage investment in the network for societal benefit. Introducing a locational signal incentivises investment in places where it is required, or might be required in the future. Although the energy management aspect of storage is applicable wherever storage is located, the closer storage is placed to a demand centre, the more effective the storage becomes as it increases the utilisation of all the assets: generation, transmission and distribution, upstream of the storage plant. This model has been successfully adopted in a number of markets in North America.[9] The capacity element should take into account the benefits of both positive and negative capacity, which is a unique characteristic of electricity storage.

[9] References are given in the Annex to this response

The Electricity Act 1989 and subsequent legislation does not restrict the ownership of any particular asset by licence holders or otherwise.[10] However licence conditions govern the sale of electricity by licence holders, thereby restricting the use of electricity storage by network holders. Although some network connected electricity storage (as battery systems) has been installed by Distribution Network Operators[11], these installations are primarily seen as assets to either defer or avoid alternative network investment. The actual energy flow through the storage devices is low and as relatively small installations, a derogation to the licence condition has been given.

A storage operator, acting on behalf of the network, could be financed not only from energy trades, but also from the value of network asset displacements.

Using locational pricing to signal the optimum places for investment would be a sensible next step in developing the future power network.

[10] At the time of vesting, pumped hydro storage was owned and operated by a subsidiary of the National Grid Company.

[11] For example EDF Energy Networks, now UK Power Networks, installed 600kVA battery at Martham Sub Station, Norfolk

We now respond to the other questions in the consultation document which are relevant to electrical energy storage.

1. Do you agree with the Government's assessment of the ability of the current market to support the investment in low-carbon generation needed to meet environmental targets?

The current market arrangements are not adequate to encourage the development of non fossil fuel energy at the scale which is required to meet environmental targets. Support is required for the installation of low or zero producing CO_2 plant, as well as for revisions to the network and associated infrastructure to support widespread new generation and to deal with the arising problems of imbalance. The ROC's methodology downplays the significance of reconciling supply and demand of electricity. The current market does not reward all participants in an equitable manner. In order to meet environmental targets, new forms of generation and two way flexibility will be required.

2. Do you agree with the Government's assessment of the future risks to the UK's security of electricity supplies?

The nation's security of its electricity supply depends on maintaining adequate fuel or renewable energy sources as well as a network infrastructure and plant margin. The requirement is to provide capacity, in terms of a plant margin to meet the demand requirement and to have sufficient flexible positive and negative capacity available to provide system balance to meet variable and rapid changes to generation or demand.
These challenges are summarised in Appendix A.

8. What impact do you think the different models of FITs will have on the availability of finance for low-carbon electricity generation investments from both new investors and the existing investor base?

The impact of subsidies in one area of energy investment has a detrimental effect on other areas. For example, ROCs have driven investment high in wind power, and FIT have pushed investment into PV, while other sectors have not received as much attention from investors. High and certain rates of return for renewable energy drive the expectation of rates of return higher for other investments within the industry, as no logical investor would choose to invest at a lower rate of return than can be achieved elsewhere. If the sectors are not balanced in terms of support, other sectors will attract less or even no investment.

11. Should the FIT be paid on availability or output?

The nature of the FIT is to provide a simple payment for small scale generation from renewables. A significant proportion of the renewable generation that will be installed is not dispatchable and although is a substantial part of the energy mix, does not represent firm capacity. The business model should reward the energy through the output, without an availability payment.

Energy produced at a time when the system cannot absorb it should not be subsidised through a renewable mechanism such as FIT or ROC (or subsidised at a lesser rate). The FIT should be linked to energy that is delivered, not curtailed. This would give better value for money to the tax payer Under these circumstances, storage which is linked technically and / or commercially to renewable generation would contribute to a dispatchable (and hence more valuable) renewable resource.

26. Do you agree with the Government's preferred package of options (carbon price support, feed-in tariff (CfD or premium), emission performance standard, peak capacity tender)? Why?

The carbon price support is a necessary mechanism to incentivise low carbon generation and to restrict the growth of carbon based energy supply. Similarly the emission performance standard will incentivise environmentally efficient generating plant. We believe that capacity payments are necessary to incentivise providers of balancing services, and especially to ensure that the nation takes advantage of the total system benefits of electricity storage.

28. Will the proposed package of options have wider impacts on the electricity system that have not been identified in this document, for example on electricity networks?

The significant changes required in order to reduce the reliance on energy supply from fossil fuels, while maintaining affordability and security of supply are likely to require a doubling of the electricity assets in the years up to 2050. While the proposals offer a route to increasing the energy supplied by renewable generation, and the introduction of new capacity to replace generating capacity scheduled for closure, there is no clear picture of how the industry and the electricity market will operate in 2050. Structural changes caused by aligning the energy markets to those within mainland Europe may restrict the freedom to operate the electricity network in the most sustainable way.

There are also concerns about the overall stability of the AC system, which will be influenced heavily by a dependence on an increase in windpower and larger baseload generating unit sizes and interconnectors, and the likelihood of the loss of a large single supply. At present, the rotary inertia of AC synchronous generators reduces the rate of fall of frequency arising from the loss of generation. Wind power generation must be downrated in order to supply a similar response when required. The greater use of electricity storage on the network will provide a synthetic rotary inertia to counter falls in frequency as well as providing faster acting reserves.[12]

New technologies may offer simpler solutions which have not been foreseen in this review and the linking of electricity with heat networks presents additional challenges, both technically and commercially. The Electricity Storage Network would be pleased to support further work and reviews of the development of the electricity networks.

[12] Although rare, such events do happen. See National Grid, 27 May 2008 seehttp://www.nationalgrid.com/NR/rdonlyres/DC83D60E-14F4-432A-8D5C-AA9A24271E48/27568/27_May_2008Event_final.pdf

32. What changes do you think would be necessary to the institutional arrangements in the electricity sector to support these market reforms?

We have already commented in our response to question 23 on the need to reform parts of the Electricity Act and the details of the licences held by the transmission and distribution companies. The current restrictions on network companies operating electricity storage when it involves purchasing and selling electricity should be withdrawn. Network companies are ideally placed to take full advantage of network connected electricity storage and should be encouraged to do so. A storage operator that relies solely on purchases and sales of energy and power does not realise the full value, which therefore leads to undervaluation of the market resource.

33. Do you have view on how market distortion and any other unintended consequences of a FIT or a targeted capacity mechanism can be minimised?

All market distortions are likely to lead to one or more unintended consequences. The process for settling FiT and Capacity payments must be transparent. It should be aimed at those technologies which are most relevant to contributing to a solution to the problems and allocated by volume to ensure a controlled response.

34. Do you agree with the Government's assessment of the risks of delays to planned investments while the preferred package is implemented?

We believe that action is required at an early stage to ensure that sufficient new capacity is available to counter the expected shortfall in conventional capacity and to balance the increased production from renewable resources. Electricity storage is the one technology that is not supported by any other mechanism at the present time. It can be installed relatively quickly, either in distributed or centralised installations, yet as it does not receive ROC or FIT, and investment by the DNO under innovation funding is naturally restricted. Its deployment to date has been limited. Subsidies and large scale demonstration programmes are currently underway to underpin other technologies that support lower CO_2 emitting developments, either directly or indirectly, such as CCS, EV, Renewable and DSR with Smart meters. We recommend that the government instructs DECC and OFGEM to provide a technology neutral approach to all of these mechanisms which can offer flexibility and not to exclude electricity storage. Furthermore we recommend that initial capital grants for electricity storage are made available at similar or greater levels than those allocated to other flexibility activities, and that these are put into place immediately in order to compensate for delays while the changes to the market mechanisms are put into place.

Annex A to the Electricity Storage Network's response to the EMR Consultation Document

A Status Report on Electricity Storage

The Electricity Market Reform analysis carried out by DECC's consultants does not consider the role of new energy storage plants in the UK as a means of meeting the low greenhouse gas and energy security issues for the country. Although storage is commercially available in a number of formats its use in the UK has so far been restricted to legacy installations and niche applications. Nevertheless, the technology is widely regarded as an essential aid in any transition of the electricity industry away from fossil fuels. The number of developed and developing technology options requires that energy market and infrastructure planning should include recognition of these important technologies, especially as these are in many instances more technically and commercially secure than alternatives such as smart metering, plug in electric vehicles and DSR. If government policy is to be technology neutral in its choice of solutions for grid balancing, then storage should be considered equally with the alternatives. Storage should also be considered in its own right as a contributor to capacity, and as means of lowering the overall system cost.

Technologies

The current predominant large scale technology is pumped hydro, but suggestions that new pumped hydro is unlikely is not supported by the evidence of new and planned construction in the United Kingdom, Europe and elsewhere. While sites may be limited, the main factor to be considered is the construction timescale and payback period. Pumped hydro power, whether new build or up-rating existing facilities is available at lower capital costs than suggested by Redpoint[13].[14] Site specific factors are the predominant issue in determining costs.

Besides pumped hydro, the UK has expertise in most storage technologies, and many of the technologies are now available for deployment on a practical basis. We note that there are a number of different storage technologies each with their own characteristics and so some technologies are more suitable than others for specific applications. Some British interests in storage technologies are summarised in table 1.

Table 1- Development State of Technologies

Technology	Status	UK Capability
Batteries & Flow Cells	Developing to Mature	UK developers, UK system integrators - demonstrations underway.
Pumped hydro	Mature	UK owner-operators-constructors
Compressed air	Developing to Mature	Sites available, UK R&D underway
Cryogenic	Developing	Demonstration using mature sub systems underway
Thermal	Developing	UK developers - demonstrators required

[13] Redpoint, EMR analysis of policy options, December 2010, available at DECC
[14] [14] EON's Waldeck II 300MW expansion, €250M, GBP=1.2EUR,available at http://www.eon.com/en/media/ accessed 12th January 2011; Uprating by 60MW, >£30M, http://www.scottish-southern.co.uk/SSEInternet accessed 12th January 2011

The state of maturity of these products should be ascertained from the commercial term sheets offered by developers for the installation of each technology. Pumped hydro and compressed air and cryogenic systems use established technologies from established providers with minimum technical risk. Many battery manufacturers offer warranties, service and support for their technology. It is important to differentiate between technical maturity and commercial maturity. The absence of current projects using these technologies in the UK does not mean that the products are technically immature; the indication is that the commercial framework for their operation does not reward the investment.

As a further example, in many countries[15], there has been a substantial increase in the number of large scale (>1 MW) battery installations connected to power networks during the past ten years. Currently, the largest commercial installation is rated at 34 MW and over 200 MWh,[16] and there are numerous installations of more than 5 MW providing a range of services. The example of Tokyo Electric Power Corporation which is linking their network of 200 individual MW size batteries to form a smart grid solution provides an example of innovative development in this area.

Extensive programmes in the USA under the American Recovery and Reinvestment Act are now underway, supporting technology development and commercial demonstration of energy storage on the power network. Projects include large scale flywheels for frequency regulation,[17] battery projects for energy management and compressed air developments.

Costs

Cost and technology comparisons should be considered with care. While the capital cost of installed capacity for a peaking OCGT plant may be considered to be low, (in the range [£500 - 700 / kW]) this should not be used as the yardstick for comparison with storage. The metrics for assessing the benefit of storage should include its contribution to security of supply, sustainability of the power sector as well as cost efficiency. Storage also provides both positive and negative energy services. These points are aligned to the objectives of the EMR consultation. Similar valuations should be applied to comparisons with other system solutions, such as plug in electric vehicles, smart metering, interconnections and hydrogen storage.

It is important to note that while some storage devices are modular and therefore costs are scaleable, others are not, and the cost profile will vary depending on size of installation. The total project cost needs to be taken into consideration rather than simply the cost of the basic equipment. In comparing storage with other solutions, the total lifetime cost should be used, As storage has lower fuel costs than many other solutions, overall costs will tend to be lower, after the technologies have been successfully introduced into the market place.

Costs are expected to fall as economies of manufacture, replication and scale are realised, as well as continued technical improvements which raise the performance of these systems.

[15] Installations in for example in Japan, USA, Chile, French overseas territories, Germany, UK and underway in Canada, Spain.

[16] Japan Wind Power has installed a 34 MW sodium sulphur battery at Rokkasho, Japan

[17] Beacon Power is commissioning a 20 MW flywheel for frequency regulation in New York State.

The nature of distributed resources on the power network mean that electricity storage may be centralised, distributed at major nodes on the distribution network or dispersed. However the benefit may be valued differently depending on the size and availability of the resources. Some services required by the TSO require fast acting large scale response, while other services may be provided by a greater number of smaller resources.

Smaller resources may be associated with local generation, providing local energy management services.

Applications of storage

Storage is often considered as a form of generation, and this is frequently the starting point for an economic analysis which turns out to be incorrect. Owners and operators of storage usually understand the wider system benefits that storage brings.

Before construction of the transmission grid, local generation comprised small inefficient units. The grid changed the economics of generation, allowing much larger more efficient plants to be built, because the grid increased their utilisation by sharing generation and reserves across the network and power was distributed to serve a wide area. Even after the cost of the grid and distribution losses, the resulting system was much more efficient, resulting in an overall reduction in system capital and operating costs. Adding storage to the network provides a similar benefit, as the electricity may be distributed over time. Currently, varying demand (and variable renewable generation) requires small inefficient, low capital utilisation peaking plant to be built to cover changes in the balance of supply and demand. Storage makes it possible to have only large, efficient, high capacity utilisation plants on the system (nuclear, CCS, wind) and variations in demand over time to be met by means of storage. As these large efficient, high capacity utilisation plants produce cheaper electricity (and lower CO_2) than peaking plants, it is clear that, were storage free (which it is plainly not) storage would significantly reduce the average cost of electricity on a system and the overall CO_2 output. Estimates of the economic and emission savings from storage are unique to each combination of generating types and fuel source, demand profiles and time periods. It is clear that the more generation can be taken from non fossil fuel sources, and the more that is displaced from environmentally inefficient plant, the greater the savings in greenhouse gas emissions will be.[18] Furthermore, with increases in variable generation, leading to the possible curtailment of wind power, additional savings in emissions would be possible if the electricity derived from wind power was stored rather than curtailed. [19]

It is popular misconception that the arbitrage profit available to a storage owner is the same value as the benefit to the system as a whole. Therefore, when the arbitrage profit is no longer large enough to support the building of more storage, then the system has been optimised. This is incorrect as arbitrage profits do not equate to the total system benefits. Much of the economic benefit of storage accrues to participants other than the storage owner, unless there is a vertically integrated structure which includes the ownership of storage. Following the change to a disaggregated industry, there has been little investment in large scale storage for system benefit for precisely this reason.

[18] See reference 14 above

[19] This was addressed in System Costs of Additional Renewables, Ilex Consulting and UMIST http://www.ilexenergy.com/pages/Documents/Reports/Renewables/SCAR.pdf accessed 5 March 2011

As a result of this consultation, the ESN has begun a study into the system benefits of storage and results will be published in due course. The preliminary findings confirm the hypothesis that storage acts to support the base load price, while depressing the peak price, and reducing the overall system cost. Under such circumstances the economics of high capital cost low running cost generation plant such as (nuclear, CCS, wind) will be improved as they will obtain much better prices for their off peak output because there will always be an off peak buyer at the same level as during the day. Therefore there will be no "off-peak" price. This encourages the building of plant with high capital costs that requires high capacity utilisation to be economic.

Furthermore the owners of renewable plant will be able to sell directly to the grid at all times of day or night at the same price - there will be no penalty for power not being firm. They could sell directly to the grid, not via other generators at a reduced price as at present.

As expensive electricity from peaking plant will not be part of the mix the average cost of electricity will be lower. Similarly the emissions (CO2) burden from electricity will be lower because high capital cost/low running cost plant is also low CO2 output (nuclear, CCS, wind). Because the system will only need to have enough generation and T&D for average (rather than peak) demand the capacity utilisation of the system will therefore be increased resulting in lower system operating costs.

The effect on transmission and distribution operators will be positive. Storage can be placed centrally as well as in a distributed manner. When storage is distributed across networks (as in the gas grid) infrastructure may be sized average rather than peak load. This means that upgrades to the distribution network to make them compliant with the demands of increased electric heating, electric vehicles and local microgeneration may be deferred or even abated,[20] and that connection of new renewable generation in areas of weak transmission and distribution can be simplified.

The ownership and operation of electricity storage is complex. There is no specific restriction under the Electricity Act preventing a transmission or distribution company owning electricity storage. The licence conditions of the TSO and DNOs are less clear, as energy sales are normally excluded. Some DNOs have installed demonstration storage projects under IFI, RPZ or Smart Grid Initiatives, and because of the small scale, derogations from licence conditions are believed to have been issued. However this gives no certainty to the market. If DNO are able to operate storage and gain embedded benefits as well as trading benefits, maximum value will accrue for storage and projects will be encouraged.

The key insight here is that storage, unlike peaking plant, is a buyer as well as a seller of power. Because it is a buyer, it raises the price for off-peak power and lowers the price of peak power, shifting the economics away from high cost, high CO_2 electricity towards low cost, low CO_2 electricity.

While in the long term, applications of storage will tend towards bulk timeshifting of energy, the fast acting nature of storage, which brings dynamic benefits to the system, will tend to see other applications being exploited as the first priority for developers.

[20] See for example the work of American Electric Power to promote Community Energy Storage http://www.aeptechcentral.com/CES/ accessed 5 March 2011

Storage applications range from longer-term energy storage, reserve power services, frequency response, short-term voltage to power quality support. All of these services are necessary for the operation of a power system and all these services are currently provided under market arrangements of varying types. With the exception of pumped storage and some large or aggregated demand customers these services are provided by fossil-fuelled generators, which are in some cases a very poor fit for the application. The UK TSO has forecast that a further 4GW of short-term operating reserve is required for 2020, capacity that is today being filled, mostly with highly carbon-emitting plant.

The future power system

We are entering a phase of development of our power system where

The nation's demand for power is increasing;
New capacity is required to meet increased demand;
Additional capacity is required to replace outdated and retiring plant;
There is an increased proportion of variable generation (typically from wind and solar);
Requirements for balancing the system will increase;
Proposals to add interconnection, new generation and other changes to the network will add uncertainty to network and infrastructure planning.

Now is the right time for storage plant to be built, in preference to other forms of capacity. The scale of the challenge is significant, and a variety of different solutions, including storage are going to be needed. There is scope for the current fleet of pumped hydro resources of 3 GW to be increased several times in order to meet future energy requirements. [21]

The case for support

Storage technologies are available and change can happen now. In other countries, notably the USA, substantial investments in storage are being made with joint partnerships between private investors and government. The US government includes storage projects in its loan guarantee programme, thus assuring lower financing costs and providing a degree of long-term income security. Investment tax credits have also been available in the USA for eligible grid connected energy storage projects.[22]

In North America, in some TSO areas, capacity provided by energy storage is recognised as being of an additional system benefit and qualifies for an enhanced capacity payment. The highly responsive nature of fast acting reserve is treated as "fast storage" where it provides frequency regulation with about 40% less energy than conventional fossil fuel plants. [23] The Electricity Storage Association and others are petitioning the FERC (Federal Energy Regulatory Commission) to rule on a "pay for performance" scheme for frequency regulation where the "fast storage" devices get paid a premium ($/MW) and are dispatched first by the ISO's. One ISO is going to implement this in the next few months. Because of this more than 40MW of fast acting storage is currently being installed in New York State alone. FERC has now issued a NOPR (Notice of

[21] Mackay D J C, Sustainable Energy without the Hot Air, pp 190 et seq
[22] Investment tax credits have been available in USA, and are being considered under The Storage Technology of Renewable and Green Energy Act of 2010 Act (STORAGE Act 2010 - S. 3617
[23] Electricity Storage Association information, communication 9 February 2011

Proposed Rulemaking) which allows for pay for performance tariffs for regulation services, thereby rewarding fast acting energy storage for its additional value to the system.[24]

DECC has acknowledged that in order to provide sufficient resources to balance the electricity system, a number of technologies will be required, ranging from demand side management, smart grid, curtailment, interconnections as well as the use of switchable load such as electric vehicles and CCS. In setting out these priorities for further support and investment, DECC has already decided to back technology choices and it is therefore appropriate that electricity storage is also considered as a technology choice.

It is unlikely that an operator would choose to install storage, if the income stream from trading on price differentials was thought to be declining, unless there was a compensating income stream to balance the economics. We have shown above that the benefits of storage are greater than those quantifiable by the energy market as it is currently configured. The societal benefits of energy storage go beyond those of the energy trades of the direct participants. The system benefits are reflected across the whole industry, utilisation of generation, transmission and distribution assets are increased, resulting in lower total system operating costs, increased use of the most efficient plant reduces the environmental costs of operating the system, and increased use of the most efficient plant reduces the need for consumption of scarce energy resources, thereby increasing national energy security.

Because some renewable energy sources are non dispatchable, electricity storage provides the ability to hold energy in a convenient form, and inject it back into the system at a later stage

The location of storage devices is dependent on size, point of connection and intended operation. We see storage as a necessary part of the market, and the network, with a range of installations of large and small sizes, across the transmission and distribution systems.

Storage as part of the future electricity market.

We see electricity storage devices operating in three separate application areas:

Small scale - suitable for use at the domestic or small commercial level
Mid scale - connected at the LV or MV on the distribution networks
Large scale - multi MW to 100's MW scale and MWh capability, connected at the higher voltages on the distribution network or the transmission networks.

These three levels are broadly equivalent to consideration of renewable resources

Micropower
Distribution level - small windfarms, bio-energy etc
Large scale, such as large onshore or offshore wind installations

Our view is to assess future reform of the electricity market taking these three broad power ranges into consideration when appraising proposed modifications to the rules.

The current market for electricity in GB is complex, and results from a methodology developed over more than 20 years. The pool was based on a method of dispatch for least cost, with

[24] FERC NPOR dated 17 February 2011

energy suppliers being paid the highest system cost when dispatched. Contracts for differences could be used to hedge energy prices. Generators might bid "Must run plant" at zero or negative cost to limit curtailment. In such an energy market, storage could be used as physical equivalent to a financial hedge to reduce exposure of generators to low generation prices and to suppliers to limit exposure to high prices. At high penetrations of storage, cannibalisation of prices would occur.

The introduction of NETA and BETTA replaced published pool prices with bilateral trades for energy over half hour periods. Although the market for ancillary services is one of the most open markets in Europe, it has several limitations. As there is only one purchaser, price discovery for some services is restricted, and not all services are procured in the same way (tenders, bilateral contracts and the balancing mechanism are all used).

Because most storage projects are able to operate in several different modes, it is necessary to consider a broad range of applications for storage in consideration of the role of the electricity market, and consider how these can be used to meet the objectives of reform (security of supply, sustainability and cost optimisation).

Summary

a) Electricity storage technologies are able to provide services to the power network. The technologies are available now; many have been demonstrated, although a number are under development.
b) Electricity storage can be installed at large, medium and small scale, and such systems provide a variety of services to the network
c) Electricity storage should be given equal support to other technologies which provide flexibility to the power network;
d) Transmission and distribution licence holders may be permitted to own and operate electricity storage and receive capacity payments for these services;
e) Capacity payments should be made available for electricity storage, reflecting the characteristics of the storage system and rewarding flexibility, speed of response, capacity (power rating) in both the charge and discharge mode, energy capability (energy storage rating) and location;
f) Capital funding for energy storage projects should be provided at an initial stage to bring forward investment in energy storage.

Storage will be necessary because it:

Directly reduces the output and emissions of fossil-fuelled power stations by storing surplus energy at times of low demand and providing it at high demand.[25] The use of peaking plant, which is often fossil-fuelled and of high carbon intensity is avoided and the carbon saving has been calculated as 0.12-0.25 tC/MWh[26] ;

Allows a link to be made with renewable energy sources, increasing the value of the energy generated and reducing the capacity of renewable sources required to meet peak demands;

Reduces the requirement for *spinning* reserve normally provided by conventional fossil-fuelled power stations, abatement calculated as 0.25 tC/MWh[26] Most conventional generating plant operates at highest efficiency close to maximum output and throttling back to create headroom for reserve leads to losses in efficiency;

Provides flexibility for meeting peak demand by using stored renewable energy instead of fossil-fuelled generators - and that existing plant can meet rising peak demands without the necessity for a new build program of carbon -intensive generation;

Allows transmission and distribution networks to be built to meet average rather than peak demands, thereby reducing the need for upgrades and supporting the connection of new renewable generation in areas with weak connections.

[25] Royal Commission on Environmental Pollution, 22 report, pages 166 et seq
[26] February 2008, European Parliament Economic and Scientific Policy, Outlook of Energy Storage Technologies.

Appendix A

Operating scenarios requiring the use of flexible plant, including storage

Capacity requirements:

(a) Periods of low output from variable renewable generators;

(b) Periods of low plant availability due to planned and/or unplanned outages;

(c) Periods of low interconnection availability due to planned and/or unplanned outages;

(d) Periods where network circuit failure limits supply of otherwise available plant and/or interconnection;

(e) Periods of exceptionally high demand;

Flexibility requirements: :

(a) Rapid changes (e.g. 2 MW per second) in demand;

(b) Forecast error in demand prediction;

(c) Rapid changes (e.g. 1800 MW per second, with just a single New Nuclear installation) in the output from large single unit generators - largest infeed loss;

(d) Rapid changes (e.g. 3 MW per second, with 30GW of installed wind) in the output from variable renewable generation;

(e) Forecast error in predicting out from variable renewable generation;

(f) Stabilising network voltage following a plant/circuit fault;

(g) Rapid changes in the output of generation, or demand due to network circuit failure;

(Rapid change numbers taken from National Grid: http://www.nationalgrid.com/NR/rdonlyres/32879A26-D6F2-4D82-9441-40FB2B0E2E0C/39517/Operatingin2020Consulation1.pdf)

Appendix B

Impact of EMR proposal on electricity storage

	Benefit to storage		Threat to Storage	
	Direct	Indirect	Direct	Indirect
Carbon Price support		low cost subsidised baseload increases opportunities for storage through timeshifting		
Feed in tariff				Direct payments for renewable energy reduce need to maximise value through time of day pricing, unless the FIT is linked to actual delivered energy, in which case storage would incentivise dispatchable renewables.
Capacity Payment	✓	Increases in renewable generation will increase opportunities for storage	capacity payments to primary generation take away opportunities for storage	
Emissions Performance				

Much attention is currently given to storage operating either in an arbitrage mode or as a provider of balancing services to the system operator. Under the present market conditions, balancing services are likely to present the highest value for storage.

Storage will be necessary because it

- Reduces the requirement for *spinning* reserve normally provided by conventional fossil-fuelled power stations, abatement calculated as 0.25 tC/MWh[27] Most conventional generating plant operates at highest efficiency close to maximum output and throttling back to create headroom for reserve leads to losses in efficiency
- Allows a link to be made with renewable energy sources, increasing the value of the energy generated and reducing the capacity of renewable sources required to meet peak demands
- Directly reduces the output and emissions of fossil-fuelled power stations by storing surplus energy at times of low demand and providing it at high demand.[28] The use of peaking plant, which is often fossil-fuelled and of high carbon intensity is avoided. Carbon saving calculated as 0.12-0.25 tC/MWh[26]
- Provides flexibility for meeting peak demand by using stored renewable energy instead of fossil-fuelled generators - and that existing plant can meet rising peak demands without the necessity for a new build program of carbon -intensive generation

[27] February 2008, European Parliament Economic and Scientific Policy, Outlook of Energy Storage Technologies.

[28] Royal Commission on Environmental Pollution, 22 report, pages 166 et seq