Summary of Inputs & Scoping Workshop: Barriers to System-Wide Energy Storage
Workshop Date: Thursday 14th April, 10:00 – 15:00

Contents

Please note that this summary paper provides an accurate portrayal of views put forward by workshop participants. Some clear themes have been brought out in the key insights section, although in a few cases throughout this document, inconsistency arises due to alternative views from the wide range of attendees on the day. An overview of more detailed discussion is included in the individual table group summary sections so please use the contents list to help find the section you wish you read. Not all comments will be incorporated into ERP's publication, however discussions around these have been extremely helpful in informing ERP's work.

Summary of Inputs & Scoping Workshop: Barriers to System-Wide Energy Storage
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This paper provides the summary of a workshop organised and facilitated by the ERP to discuss *Barriers to System-Wide Energy Storage*. The workshop is part of a wider ongoing project which will result in a publication in October 2016.

A broad range of workshop attendees from across the energy system - from the electricity, gas, heat, hydrogen and transport sectors, specifically with knowledge relating to the financial, legal, political, commercial and regulatory challenges for energy storage - were invited to help ERP uncover the barriers and in turn, inform our project work.

All workshop documents and presentations are available via the ERP project webpage.

Objectives of ERP Project - Barriers to System-Wide Energy Storage

The objectives of ERP's wider project work are listed below. The workshop aims & objectives were directly related to **project objective 1** below:

- ERP's work will focus on the *financial, legal, political, commercial and regulatory* challenges to **system-wide** Energy Storage
- The work will consider the whole system need for storage and will:
    1. **Identify barriers** & ways to overcome them
    2. In doing so, will **provide clarity** for: policy-makers, regulators, network operators, customers, investors & ES developers (tech & supply chain developers) to…
    3. Where appropriate, **help catalyse & mobilise Energy Storage supply chains** of value to the UK, stimulating investment.

Workshop discussions were therefore largely focused around identifying the *barriers* to system-wide energy storage. Some solutions were also raised for discussion and have been noted in the summary below. Discussions around solutions often posed further questions however and will therefore provide ongoing considerations for the ERP.

In the first half of its work, ERP plans to focus on the barriers identified, ensuring these are highlighted amongst ERP members and wider parties for discussion. Where questions regarding solutions have been posed, these will be considered in the second half of ERP's work (post-July 2016).

Section 1 below provides key insights collated from discussions on the day.

Section 2 has been derived from table groups assigned as part of the workshop. There is some natural overlap of themes within the sections but where possible, summarised notes have been grouped accordingly.

Two additional sections (3&4) have been included below, summarising a panel debate and a short presentation from DECC regarding its recent *'Towards a Smart Energy System'* publication and upcoming call for evidence on Smart Energy.

A note to workshop attendees

ERP would like to extend their thanks to all workshop attendees for their time and contributions on the day which will help to inform ERP's overall project work & publication. If you have any further comments, considerations or feedback to add following the dissemination of this workshop summary, please contact helen.thomas@erpuk.org

1. Key insights from workshop discussion

Key insights from the day fall into two main themes. Discussions have brought to light some wider energy system issues/barriers that could affect the need and deployment of storage but could also affect technologies, services and solutions more generally. Other barriers and discussions relate to energy storage services more specifically.

Key insights regarding the energy system in the context of storage:

Market Structure:

- There is currently a fragmented, siloed institutional energy system arrangement made up of decision-makers, the system operator, network owners/operators, individual energy sectors (heat, power, transport) and consumers.
- Alignment of these groups and a more combined, coordinated arrangement would help value non-asset services that are currently undervalued or not accounted for, such as energy security, resilience and flexibility, and would help facilitate solutions such as energy storage (where there is a system need or a strong market signal). Regulatory structures that support contracting for system resilience and flexibility (and not just the cost of power) are required.
- In relation to these issues, a reconceptualisation, redesign or adaptation of the current market structure is required. A clear whole-system direction resulting from whole-system thinking would help to integrate and value solutions such as energy storage.
- A particular tool noted to enable this whole-system thinking is in the form of a “system architect”. This role should be provided by a dedicated, independent party or dedicated government body – **see interactive session results**) to design, advise on and facilitate the UK energy system from a whole-systems perspective. This will help accommodate energy storage (in all its forms) and other solutions.
- Although there is a role for markets, these alone are not enough. Whole system direction plus clearer government decisions regarding the role of the market are required.
- There is likely to be a revolution in relation to energy system regulation and governance for smaller system and localised generation. However, there is still the need for a central government push for large flexibility assets (e.g. interconnectors or large scale storage).

Policy:

- Current regulation and policy design is too ‘top-down’. There needs to be a balance between top-down decisions that should set the overall energy system framework and provide visibility of a future energy system. The market can then take over, allowing individual technologies and solutions to flourish and benefit consumers in this way.
- Policy needs to engage a wider range of consumers and in particular, engage further with smaller users / micro-generators. It is important to segment the market for policy solutions and recognise the differing needs and policy solutions required for larger vs smaller generators.
- A government report/publication on resilience and ‘the winter outlook’ is called for to enable consumers to better understand and feedback on energy security and the need/role for storage.
- To optimise the needs of varying stakeholders to ensure the full benefits of storage are achieved for consumer benefit, more in-depth coordination between institutions i.e. DECC, Ofgem, DfT, National Grid, DNOs, plus the energy sectors is required.
- Energy costs are disproportionately borne by the costs of *electricity*. Government attempts to reduce the carbon intensity of energy are therefore borne by those who use electricity rather than other/all forms of energy. This makes energy storage options more expensive and should be reconsidered.
- Regulatory systems should incentivise solutions that deliver on the long-terms energy trilemma.

Key messages relating more specifically to energy storage:

- Energy storage is currently under-valued, in part due to investment costs vs payback periods, but also because there are missing markets for valuing the services it provides.
- Storage provides additional benefits to society which are not compensated for in existing market structures.

- There is currently a commercial risk relating to storage, mainly when considering it as a bolt-on or retrofit service to be added to existing sites with existing infrastructure and commercial arrangements. In these cases, adding storage to the mix can often place at risk, or invalidate these pre-existing arrangements. Therefore even if the overall economics will be improved, if there are strong environmental and social rationales, and therefore interest from investors and generators - there is reluctance to incorporate storage because this can add risk to core arrangements in place. Examples include risk to returns gained on existing assets via offtake agreements and loss of ROC or RHI payments.
- Storage does not require its own dedicated treatment (e.g. subsidies) which it is felt would only delay the issues until subsidy end, although there are other incentives for possible consideration such as tax breaks / tax credits.
- On the whole, it is felt that a truly flexible and resilient energy system or market should be able to successfully accommodate and incorporate energy storage services.
- However, in some respects, storage may require its own regulatory framework, or adaptations to existing frameworks, to better accommodate and value its services within the energy system, and/or to provide a level-playing field against other options.
- Some energy system assets (such as storage) are currently viewed as riskier to invest in and therefore have to be financed solely by equity (at a cost of 20+%). Large pension funds are keen to inject capital but require predictable returns. The current challenge is that there is arguably a shortage of *risk capital*. Improvements of regulatory systems can address the debt vs equity allocation mismatch and ensure that the lowest cost of capital is included within the transformation of the system.
- There needs to be a shift of capital away from financing assets only, to also financing *services* that energy storage can provide. There is no shortage of capital available for energy storage and there is a keenness to invest, however there is a lack of information for the finance sector regarding the types of storage to invest in. Successfully unlocking the initial 10,000s will help facilitate investment and unlock larger amounts of capital.

Electrical Storage:

- Transmission & Distribution charges don’t currently encourage a level playing field and provide the right signals to value electrical storage at the right locations. It is best to optimise electrical energy storage at a grid level if possible, so it is important that charges should provide the right economically efficient price signals.
- Current electricity charging methods could be reconsidered towards a preference for setting charges at the consumer side as opposed to the generation side. A move away from volumetric or commodity-based charging (e.g. per kWh of usage) to capacity-based charging (e.g. charged according to the max peak used) should be considered.
- A stronger definition of electrical storage is required.
- There are distorted signals relating to regulation e.g. network costs for storage. ‘Double charging’ as both a generator and consumer is one of the factors that makes the economics of storage schemes more challenging.

Gas Storage:

- The full range of benefits that gas storage brings - particularly security of supply - is under-recognised and under-valued by both the gas and power sectors. These benefits are not reflected in today’s market prices.
- If gas storage is seen as a critical part of the whole energy system, then changes need to be made to fully value the range of services and benefits that gas storage provides.

Thermal Storage:

- Heat could be more widely used as a form of storage from electrical generation, similar to the concept of a CHP system. Dual electricity-heat benefits would incentive take-up.
- Large amounts of heat storage is currently being lost or removed from the system. There is no real incentive to retain certain forms of heat storage (e.g. hot water tanks) within homes and policy has played a part here.

Hydrogen:

- Hydrogen can provide storage in the same way as fuels. It can also provide similar services to the electricity grid similar to other options, such as batteries and pumped storage.
- A key benefit of hydrogen is that it can serve multiple markets, e.g. power-to-gas, transport and heat, and therefore does not have to be converted back to electricity. However this requires a cross-sector approach to the energy system to fully assess the value hydrogen can bring.
- In addition to other key benefits e.g. storability, transportability, mobility and suitability for larger vehicles, along with the potential to use it for heat (instead of electrification), Hydrogen will start to look more attractive when considering a valuation for resilience.
- Despite the attractiveness of Hydrogen, the finance sector are somewhat cautious regarding investment because it is not yet clear whether there will be a global market, or what the related prices for provision will be. This was particularly noted in relation to transport, where an international market for pure EVs is developing, with uncertainty about the development of Fuel-Cell EVs. This view was challenged, in relation to the benefits of Hydrogen for assisting with the seasonality of heat in particular.

Transport:

- Storage from transport (EVs) can provide a useful solution to assist with grid balancing but requires planning as part of system-wide solutions.
- There are opportunities to re-use or ‘second-life’ older batteries from EVs to assist the grid with charging requirements. These can be used as localised storage to mitigate the challenge of reinforcing local networks in order to manage a local peak load caused by multiple vehicles attempting to recharge at the same place and same time.
- The risks and trade-offs of building national infrastructure for EV charging need to be considered in terms of other solutions e.g. market entry of hydrogen/fuel cell vehicles.
- Transport currently already provides a certain level of storage in fuel tanks and within transport energy infrastructure itself.

2. Key Points - summary of Table Group Feedback & Whole Room Discussion

2.1 – Policy

How could future government policy decisions adversely affect investment / return on investment for system-wide energy storage projects? How can policy uncertainty surrounding storage be reduced? What should policy and regulation ideally provide / entail in future in order to promote investor confidence?

- Current regulation and policy design is thought to be too 'top-down' in some areas. There is a strong requirement for a system-architect to set the overall energy scene and to provide the mechanisms for valuing current externality benefits e.g. resilience, however there is also a role for the market, consumer involvement and local communities. A suitable balance is required.
- A view that supports the need for a system architect is: it is difficult to produce whole system solutions when there is a fragmented and unbundled system of policy-making, regulation, industry (and now consumer) participation. Historically, (in the days of the CEGB), all functions were combined and balanced decisions were made regarding the system. A similar function should be recreated in the governance system.
- Policy needs to increase its focus on the demand-side and customers i.e. households and small businesses, whilst maintaining focus on network scale solutions also. The differences between these, with associated policy measures should be greater recognised.
- Additionally, policy needs to engage a wider range of consumers. Whilst it is often easier to focus on the 'big players' with 'big solutions' – there is a need to engage further with smaller users / micro-generators also.
- Likewise, it is important to segment the market and recognise the different needs and policy solutions targeted at larger generation vs smaller generation. Also, as large and small generation increasingly compete with each other, it is important to maintain a level playing field to ensure competitive markets function efficiently in the best interest of society.
- As we move towards principle-based regulation, the principles around storage need to focus more on empowering the consumer, stimulating local innovation and local partnerships. Marshalling innovation will help to devise a solution for energy storage (whether that be thermal, electrical or transport). Devolved administrations need to be enabled further to devise their own local solutions. These administrations could have responsibility for the deployment of energy storage as part of devolution agreements.
- Many smaller business users are already, or are considering going 'off-grid'. There is a great opportunity for innovation here but also the risk of a further fragmented sector which will make the aggregation of policy solutions harder. This further highlights the importance of ensuring charging structures are cost reflective so that if smaller business do choose to go off-grid then their decision is in line with the interests of wider society.
- Local trials in storage should continue / increase to help test the extent of the benefits.
- Heat could be used as a form of storage from electrical generation in a similar way to CHP. Lots of heat storage e.g. hot water tanks is currently being lost or removed from the system. There is no real incentive to keep certain forms of heat storage within homes and policy has played a part here.
- A resilience and 'winter outlook' government report has been recommended with storage scenarios/implications to help consumers understand and feedback on the need for storage.

2.2 – Regulation

How should regulation be adapted to better facilitate system-wide energy storage? What are the current barriers?

- There was a similar debate in regards to 'top-down' vs 'bottom-up' interventions as per the policy table discussion. Whilst there is a role for the consumer to lead, there are also larger whole-system decisions e.g. regarding CCS, nuclear, and the conversion of the gas network to

hydrogen that need to be made at a higher level. These could affect the overall system requirement and levels of uptake for storage.
- Therefore there needs to be a balance between top-down decisions that should set the overall framework for the future energy system. The market can then take over, allowing different technologies to flourish and consumers to benefit in this way.
- There needs to be clearer government decisions regarding the role of the market.
- There is currently a very fragmented, siloed institutional arrangement of the energy system, with the separation of people (consumers), decision-makers, the system operator, and individual sectors e.g. electricity, heat and transport. A more combined, coordinated arrangement would be beneficial.
- Procurement within an individual energy sector often focuses on the best, lowest cost solution for being able to provide a service, rather than taking into account the overall benefit to the network or other systems e.g. cost in addition to carbon, or social benefit, plus benefits that satisfy both the transmission and distribution networks. The above system fragmentation means that many mutual benefits across systems/sectors aren't being recognised.
- Due to the silos that currently exist – how are trade-offs evaluated between a decision at one level vs another; or regarding one energy vector vs another? Who should take this role? There is currently a gap for a party to take this role and provide institutional ownership for evaluating these trade-offs.

2.3 - Finance (discussion mainly focused around electrical energy storage)

What are the risks and challenges of investing in a capital intensive medium such as energy storage? What types of risks do storage assets face regarding future competition eroding their future revenue?

- How can we correctly value and define resiliency and flexibility? Storage provides a very important value for these services but definitions are required. Should optimisation be managed via National Grid, DNOs, communities/residential customers, commercial/Industrial customers, intensive energy users?
- How can we finance insurance products to retain the grid and avoided stranded assets? Wholesale prices are dropping towards zero, the critical thing in delivering service levels that customers require/expect is to uphold the investment in the grid to avoid a regressive tax on those who cannot afford resilient solutions.
- The UK needs to move towards a *service-offering system* for energy. I.e. recognition and tailored treatment for those that require (and will pay) for absolute reliability of energy services e.g. big industrial users vs those who may be happy to accept 90% reliability (e.g. residential users or others). There needs to be a shift of capital away from financing assets only, to also financing *services* that energy storage can provide.
- There is no shortage of capital available for energy storage and there is a keenness to invest, however there is a lack of information for the finance sector regarding the types of storage to invest in. Successfully unlocking the initial 10,000s will help facilitate investment and unlock larger amounts of capital. However a comment was also put forward that this large amount of capital is available for low risk "infrastructure" projects and is not so readily available for merchant "risk" projects. The key is how to turn storage into a *low risk* infrastructure-type project.
- There is an issue that funding for energy storage today is currently expensive (all equity-financed, no debt-financed) because current systems are valuing only one aspect of the benefits. There is a recognition that in order to value resilience and flexibility, debt (which requires a more predictable stream of cashflows and earnings) can be layered in to significantly lower the cost

of capital and make energy storage more cost effective. It is not necessarily the best technology that wins, but often the one with the more fully financed solution.

- Energy storage is currently under-valued, most likely due to investment costs vs payback periods but also due to missing markets for valuing the services it provides.
- Financing of hydrogen is tricky as the global capital market could take a dim view of an island strategy that is not in line with broader, more global trends. It was stated that pure EV trends (not FCEVs) are clear (e.g. 25% of global vehicle fleet by 2025). The UK needs to battle this for hydrogen if it is a solution that is sought/required.
- Financiers were surprised to hear Hydrogen being discussed. They felt that the market had spoken loudly regarding batteries and demand-side measures, buffeted by large-scale pumped hydro and some distributed small thermal, with not so much of a market signal for Hydrogen solutions. This view was challenged especially in relation to the seasonality of heat.

<u>Finance - potential solutions</u>

- Regulatory structures that support contracting for system resilience and flexibility (and not just the cost of power) are required whilst upholding grid investment.
- Other example markets e.g. California, Germany, Japan are exemplifying *vertical integrated utilities* and are contracting for 20+ year PPAs for capacity and volumes of energy storage, noting the depreciating costs associated with each cycle. Is this something the UK could consider/learn from?
- Integrated Demand-Side services that create a more dynamic management of supply and demand could be encouraged as part of a regulatory framework. This follows the theme that it is not just about funding hard assets e.g. PHES or Li-Batteries but more about considering the system challenges and how we manage supply/demand.
- Regulatory systems should incentivise solutions that deliver on the long-term energy trilemma. Long-term PPAs or offtake contracts that support the lower cost of capital should deliver on the lowest cost of energy *together* with decarbonisation. It's these contracts that will drive down the lower cost of capital. Assets that age, such as diesel gen sets for providing capacity, should arguably be on very short term contracts because they don't tick all three boxes of the energy trilemma.

Comments / questions posed by workshop attendees:

> *"Following on from putting a value on long-term resilience, the next question would be – if we know the value of it, how do we pay for it? Some of the risks that a storage asset is exposed to are similar to interconnectors in terms of arbitrage spread. What would be an appropriate way to pay for this resilence? E.g. Cap & Floor for Interconnectors, CfDs, long-term contracts? Some form of insurance product?"*

> *"Different solutions e.g. energy storage and interconnectors, to some extent provide the same services, and to some extent, provide different services. There is ambiguity regarding their potential future value but they are long-lived assets and part of the energy transition. There is no effective market solution for the kind of evaluation process that will provide the right answer that makes something investable in. This is where a responsible advisory/decision party (a system architect) is valuable to state what decision we are going for and this in turn will drive down the cost of capital and increase confidence. There is space for the market creating the right market/regulation, but there is also room for a boundary condition – a type of collective insurance policy."*

> *."Part of the benefit of market liberalisation (i.e. a previous CEGB-type system) was preventing poor decisions that were potentially to be made and implemented. Creating a liberalised market is difficult however. We should be cautious of the quick-fix view that long-term revenue models to reduce the cost of capital and government decisions for clarity will provide the right solution, as some of the trade-offs that exisit between the market and a centrally-delivered solution could be forgtotten."*

2.4 - Market Distortions (market issues, signals, incentives, support and the market itself)

In relation to financial support and incentives, what distorted market price signals currently exist? How can a level playing field be achieved for energy storage, to avoid distorting competition with other similar options?

- In some areas, there are strong market signals for the requirement of energy storage. E.g. in relation to electrical storage: voltage, frequency response/regulation, inertia and other system services. There are clear market signals around constraints payments.
- Other areas of the market are naturally not signalling the need for energy storage, because there is no strong need for storage in these areas.
- Areas of potential distortion were noted:
- Where there is a perverse incentive *for* storage, or a perverse incentive *against* storage. E.g. arising from government interventions such as FiTs, CfDs, Capacity Mechanism and Triads where there may be a signal to consumers to avoid consuming electricity from the network at particular times because of the possibility of avoiding paying some customer levies. Storage can be seen as a solution for some customers to avoid paying these customer levies, therefore reduce their own electricity bills, however this can have negative social consequences because it can have the knock on effect of increasing bills for all other customers.
- There are distorted signals from regulatory areas e.g. network costs for storage. 'Double charging' of PHES schemes as both a generator and consumer is one of the factors that makes the economics of these schemes more challenging. A service that is there to assist the network operator with managing the system is being discouraged via charges that the network operator is imposing. These regulatory issues need consideration.
- There are issues around comparing LCOE and LCOS (LCOStorage) in a like-for-like manner, as this isn't always possible. There needs to be an improved way of making comparisons. It would be useful to compare storage systems via LCOS-type analysis.
- Future signals for energy storage are not emerging in the way we might expect them to. As we move towards a more variable system with inflexible energy generation, there should be stronger signals for assets that retain system resilience (of which storage is one). This is not currently happening to a large enough extent. Could this be because so much of the (electricity) market, is driven by contracts rather than market decisions themselves? Another reason put forward was because the wholesale market is based on short-run marginal cost of generation, therefore it does not trade in long-term resilience.
- Where there is a strong signal for storage, we should still question whether (in some cases) it is the right solution.
- The varying merits of regulated solutions vs market solutions need to be considered. Many successful measures to date e.g. around emissions and decarbonisation have been due to regulatory measures rather than market signals. This adds complexity to the debate, especially if market signals are in conflict with these regulatory measures.

2.5 - Missing Markets

How do we design a system with charges that encourage a level playing field between technologies in addition to location, whilst ensuring that aspects that are currently taken for granted (such as security of supply) start to be valued? And which charges/charging structures could help to facilitate the transition towards greater levels of storage into the system, or valuing the needs of existing assets?

- There is a need to balance charges and benefits across the transmission and distribution grids so that inconsistencies are mitigated. T&D charges don't currently encourage a level playing field or provide the right signals to value storage at the right locations.
- Locational signals therefore need to be maintained as this is the primary driver for central generation. However, location is a 'double-edged sword' – how do we value the optimum solutions between the individual consumer level/location vs storage at a system level? E.g. PV + storage – is it best to optimise at grid level or in the building? Grid level was considered best.
- Current charges should be reconsidered e.g. move away from something that is volumetric-based charging or commodity related (e.g. per kWh of usage) to capacity-based charging (e.g. charged according to the max peak used). Would all consumers approve this type of charging?
- If adopted, these charges would ensure the fixed costs for the grid are captured and would also ensure a preference for setting charges at the consumer side rather than the generation side. Costs end up on the consumer's bill in any case.
- There should be more of an understanding and tightening of compensation for loss of supply. I.e. continued charges for loss of supply beyond a Loss of Load Expectation (LOLE).
- Longer term signals are required to ensure that the market can predict needs and plan well in advance of potential issues. Some signals exist but more is needed to encourage early adopters.
- A 'resilience report' that articulates the value of security of supply should be produced by government to engage consumers in the supply/storage debate.
- The value of proving solutions needs to place a value on the capacity required in specific locations as well as the security to the local area. How do we bring these value streams to the market and ensure that each sector can access such value streams in relatively consistent ways?
- There is a need to optimise different needs across varying customers and stakeholders to ensure the full benefits of storage are achieved for consumer benefits. This requires a much more in depth coordination between institutions i.e. DECC, Ofgem, DfT, National Grid, DNOs, gas or other heat providers and the power and transport sectors.
- **In relation to gas**: how can we ensure that the security of supply/resilience benefits afforded to the gas system are accurately remunerated from the gas generation fleet? The interactions between supply chains and values from each supply chain is an area that some felt needed further exploration.
- The security of supply from gas storage is simply not recognised nor valued by both the gas and power sectors. Can we guarantee security for retail and/or generation consumers? Who is paying for the security and if we had to choose who should disconnected first - generators?
- **In relation to transport:** there was interest in missing markets. What infrastructure do we need to charge EV vehicles and at what times? (Twice per month? Every day?)
- Will existing transport solutions still be required in future, or will autonomous vehicles, or an uber-based taxi service take over?
- It was noted that all new black taxis have to be EV-ready. However, black cabs are already under threat from companies such as Uber which could in turn threaten efforts to introduce and ensure that these EV markets are ready.
- In terms of fuel storage for transport, a transference to EVs will require country-wide upgrades, including in isolated areas. Storage can provide a really useful solution but requires whole-system thinking at a national level.
- Hydrogen has potential because it can play a role as a vector in other parts of the system. In addition to other key benefits e.g. storability, transportability/mobility and suitability for larger vehicles, Hydrogen will start to look more attractive when beginning to valuing resilience.

2.6 - Least Regrets

What possible regrets are there to government support for energy storage? What could government do to minimise possible regrets i.e. the cost of getting it wrong? What would a least-regrets whole-system storage solution look like for maximum benefit of the energy system?

- The need for electrical energy storage was challenged – does the UK need it at this stage? Storage shouldn't be forced as an option, especially when considering *whole system* solutions.
- Heat storage is currently provided at low cost by combining gas fired boilers with hot water tanks. Electricity storage is relatively expensive at present and there are issues that arise with multi-vectors if you are considering transport, heat and electricity integration.
- Cost regrets: spending on something that doesn't necessarily / in all cases, make economic sense and address the full problem. Storage could be seen as one solution to a particular part of the problem, particularly at a whole system level.
- It is better to start with the problem and work back to possible solutions. This requires a different form of management e.g. there needs to be differentiation between supplier, DNO responsibilities and TNO responsibilities.
- Technology regrets: making sure that the technology has been properly developed and defined and addresses what it is supposed to within a system, avoiding unforeseen or unintended effects.
- Government / policy regrets: Government initiatives are almost always going to result in regret unless we conceptualise our approach.

Potential solutions:

- Reconceptualisation of the energy market (or electricity market in particular) to fully identify what is needed. Admittedly, this is no small feat.
- In terms of a regulatory focus – this needs to be more outcome-based rather than on specifics. Outcomes need to be based on and satisfy the technical, social, economic and environmental requirements.
- Government/regulation needs to provide consumers with the tools to engage in energy and to understand what it means, to address their bills and in turn help the system.
- Battery charging infrastructure, an effective heat system and CCS are all seen as least regret options.
- Given the complexity and number of 'moving parts' within the energy system - there is the need for a whole systems regulatory, independent advisory panel to help consider needs and advises at a whole systems level. This point was echoed by other attendees.

2.7 - Benefits & Demonstrating Performance

What are the key energy system benefits that storage can provide, but are not paid for (or valued) within current market structures? How can policies, regulations and markets best ensure that these multiple benefits can be shared amongst the multiple stakeholders involved?

- Storage can provide additional benefits to society which are not compensated for in existing market structures and can also provide a strategic security benefit to society.
- Energy Security isn't accounted for well enough under the current system.
- There is no direct mechanism for rewarding carbon reduction potential or clean air benefits e.g. renewables or electric vehicles.
- Local factors aren't currently properly remunerated. There is variation between charging methods but there is not enough variation to differentiate between where you would place a storage asset within the system.
- If heat and electricity storage could be combined rather than keeping them separate (in a similar way to a CHP process), then consumers would be encouraged to take up storage solutions with dual benefits.

- The current market structure (based on marginal cost of generation) was not designed for a system with storage in it – a new market structures (or an adaptation of the existing one) is needed.
- Storage is helpful from a least regrets point of view because it is multi-purpose.
- The high cost of alternatives to storage (avoided cost to society) is not currently reflected in the revenues which storage investors receive.
- Society wants the benefits storage provides but currently has no way to incentivise it.
- Paying for storage should be seen as a net saving, not a cost. This is because (up to a particular capacity), storage can reduce other costs which should more than offset the original cost of storage.
- There is a mismatch between payment and property rights, this could distort decisions so customers may buy expensive local storage instead of paying for cheaper network reinforcement.

The following externality benefits were discussed:

Variable cost of energy:

- Electrical storage displaces operation of high marginal cost generators.
- For transport, the timing of recharging vehicles can be managed to store low marginal cost energy from low carbon sources.
- Thermal storage can be used to top-up conventional natural gas heating (space and water). In periods when low marginal cost electricity generation is setting the wholesale power price, low marginal cost electricity can be used to displace higher marginal cost gas.

Capital and fixed costs of the power generation sector:

- Electrical storage displaces investment in other peaking plant.
- In terms of transport - batteries may be used for energy system management. Electric vehicles may be used to discharge onto the grid to provide additional generation at times of peak demand.

Reduced cost of constraint management and network reinforcement:

- Transmission and distribution - merchant operation of storage in a constrained zone can relieve the requirement to reinforce the network. Storage is currently not paid for this societal benefit due to inefficient prices signals within demand TNUoS and DUoS charging structures.
- For transport – localised storage could mitigate the challenge of reinforcing local networks to manage a local peak load caused by multiple vehicles attempting to recharge at the same place at the same time.
- For heat - Localised storage (e.g. in the form of electrical storage heaters) could avoid the cost of investing in community heat networks. Individuals choosing to fit local storage may not be appropriately paid for this societal benefit.

Low carbon capacity - reduced required capacity, therefore cost of low carbon generation:

- For electrical storage - higher load factors (less curtailment) of low carbon generation means the system will benefit from a higher utilisation of existing renewable capacity.
- For transport - timing of recharging vehicles can be managed to use low carbon energy which may otherwise have been curtailed e.g. sunny daytime and windy overnight.
- For heat – storage could provide higher load factors of CHP district heating. Use of locally stored energy (hot water, or electrical storage heaters) could help manage peaks in heat demand. Therefore a centralised district heating system could be built at a smaller peak capacity and operate at a higher average load factor. Individuals choosing to fit local storage may not be appropriately paid for this societal benefit.

Resilience / fuel security:

- For electricity - reduced reliance on imported fuels and electricity
- If transport is electrified there is reduced overall dependence on oil (petrol/diesel)
- For heat - reduced dependence on natural gas

And finally, local air quality could be significantly improved via the addition of storage particularly for the electricity and transport sectors.

Potential Solutions

- Time of Use Tariffs (ToU) can help to encourage storage by encouraging consumers to use energy at the right times. Electricity and heat tariffs paid by consumers need to reflect the real-time cost of that electricity and heat at the time it is supplied.
- Energy costs are distorted by the higher costs of electricity which makes costs of services such as Energy Storage more expensive: for example consider how we pay for renewables – this is paid for via electricity bills. Government attempts to reduce carbon intensity of the energy industry is therefore borne by those utilising electricity rather than other/all forms of energy.
- DNOs/TNOs are not currently permitted to run energy storage / generation sites. However, where there is a need to reinforce a particular area and energy storage is one option vs a generation option/alternative. Is there a way to close the gap in the decision-making process so that no unnecessary reinforcements take place and the market is opened up to energy storage options also?
- Direct intervention: A "system architect" takes action as a central buyer to pay for storage on society's behalf. This could be done through a competitive structure equivalent to the Cap and Floor for interconnectors, Capacity Mechanism auction, or CfD auction. Options
- Network: take a cost reflective approach to exposing storage investors to the cost/saving of network investment which they cause.
- Spread the cost of decarbonisation across all energy: storage breaks down barriers between silos and enables arbitrage of prices between the electricity system, transport and heat which have not been previously possible. Currently, the cost of government decarbonisation policy currently falls disproportionately on the price of electricity rather than heat, or transport. This causes a market distortion which would cause inefficient dispatch of storage assets to arbitrage between tax and policy regimes instead of fundamental economic value. Unless this distortion is corrected, then inefficient dispatch and investment (amount, type and location) of storage will result in higher costs to society and higher costs to customers.

"A 'system of the future' should have consumers at the heart of it and therefore we should let consumers decide what level of system resilience (insurance) they are willing to pay for, as well as where they source their energy. Consumers need to be provided with an informed choice regarding performance / availability / source / cost etc."

"Electrical energy storage is not a panacea - there are alternative solutions with similar benefits, however various system-wide energy storage mediums (including electrical storage) provide the key benefits of flexibility, resilience and security for the system. It is important to understand the different benefits which different types of solutions can provide."

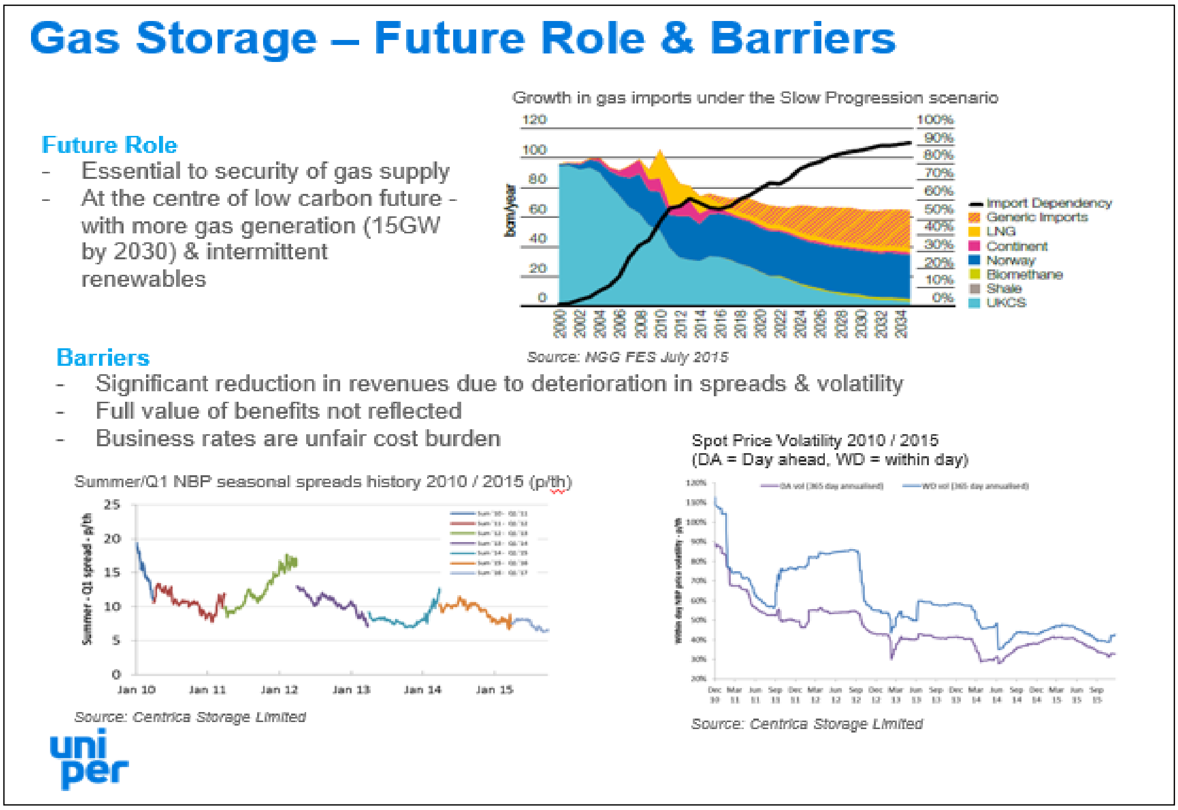
"The reason that a separate regulatory structure for storage may not be required is because we are assessing the situation in reverse. The key point is that the current regulatory structure ought to be able to accommodate storage and its services - therefore having a separate structure for storage would only make things worse."

3. Panel Session & Debate

The panel session consisted of short 5 minute thought pieces from the following guest speakers / workshop attendees. Brief notes from the sessions have been included below.

1. **David Dorsett**, Uniper Energy (Gas Storage)
2. **Keith Bevis**, EValu8 Transport Innovations Limited (Transport - EVs)
3. **Damian Clough**, National Grid (Charging Methodologies – Electricity)
4. **David Casale**, Turquoise & **Bruce Huber**, Alexa-Capital (Finance & Investment)
5. **Richard Heap**, ERP (Hydrogen)

3.1 - Gas Storage



- Gas Storage isn't always mentioned in the same debate as 'energy storage' so it is refreshing to see such broad discussion.
- Gas has an important role to play in managing the energy trilemma. It is at the centre of a low carbon future: with the closure of coal; intermittent renewable generation and more new gas fired power generation being required.
- However, viability is under threat with revenues falling dramatically, so will there be enough gas storage to fulfil the role?
- The first graph in the slide above has been extracted from National Grid. With the decline in UKCS production of gas, we are relying much more heavily on imported gas from global sources with increased security of supply risk.
- Gas storage therefore plays an important role in meeting gas generation requirements and alongside renewables and increased intermittency.
- The full value of benefits are not reflected in market prices.
- The graph at bottom-left shows how the development of the *summer/winter spread* from which the intrinsic value of gas storage is derived i.e. the value of gas storing in summer and using it in winter. We ideally want that spread to be as high as possible. That value has declined steadily over last decade and value is now very small.
- The graph on the bottom-right shows *daily* or *within day volatility.* Fast churn storage is able to

capture this extrinsic value on top of the intrinsic value. This also shows a significant decline over last decade – the value has more than halved since 2010.

- For many gas storage assets, the value today compared to 10 years ago is significantly lower. The amount earnt from the market place today would not cover the costs of owning and running the storage and certainly wouldn't receive a ROI.
- A key barrier is that if we require more gas storage in future, we certainly won't get people investing in it now and those that do own gas storage now, may well withdraw from the market because costs are not currently being met.
- If we see gas as critical to the future whole energy storage system, actions and considerations need to be taken now. How do we value the full range of services/benefits from gas storage? There are solutions to be considered e.g. support in the form of long-term contracts and reducing some of the underlying cost burdens that the gas sector has. Additionally, the tax that the industry pays through business rates is huge compared to the revenue - that is something that government can directly effect to keep the industry going.

Barrier	Y/N	Issue
Finance	Y	Unable to raise finance if future income < costs
Legal	N	No major issues
Commercial	Y	Low volatility & spreads Market does not reward full benefits of gas storage!
Political	Y	No appetite from Govt. - to address unfair cost burden i.e. business rates - to intervene to support revenues
Regulatory	Y	Burden of reporting / transparency requirements (REMIT) Uncertainty over future transportation tariffs

Possible Solutions

(proposed by GSOG)

- **Recognise the full value of the benefits provided by gas storage** e.g. direct subsidies to "top-up" revenues
- **Reduce the cost burden – make** business rates fair
- **Value the within day flexibility services** gas storage can provide gas system e.g. via an obligation on National Grid
- **Reduce network (transportation) tariffs to reflect the real value of gas** storage to the system

3.2 - Storage in Transport (EVs):

- A Project Keith Bevis and team has worked on considers two issues relating to EVs: 1) a supply of batteries and 2) a need for urgent energy. This short session focused mainly around the second issue.
- Charging of Lithium-ion batteries is an issue - how we charge them using existing electricity infrastructure.
- Secondly, what can we do with them / how can we use them most usefully?
- In terms of charging - we need to consider where do we use/require EVs most? (I.e. in what locations?) There will be lots of EVs used in the city but also increasingly over longer distances. We therefore need to plan for rapid charging in places where we hadn't necessarily planned to have that service/amount of electricity available (e.g. service stations on truck routes away from urban areas, with low capacity grid connections).
- Storage therefore becomes important as a way of coping with the instant demand for 20 minutes of high-energy use for charging. Storage can help to support charging infrastructure, instead of extending/reinforcing network infrastructure.
- A process can be developed of using batteries as storage to support the infrastructure at the locations it is needed. Instead of building a new substation or reinforcing a network circuit, you can add a small battery at the charging location that is charged slowly through the low-capacity connection at times of low demand (e.g. overnight) and can then discharged rapidly to charge EVs.
- Batteries are used across the market in three main areas: 1) the micro (domestic) level e.g. solar PV + storage to provide power in the evening 2) EVs providing storage at the end of supply infrastructure and 3) grid-support energy - a major development. Investment is pumped into these three areas for different reasons.
- In terms of EVs vs Hydrogen vehicles, there is a risk of investing in EVs when the industry may

produce lots of hydrogen vehicle options. This could make the EV investment redundant and the infrastructure would be wasted. It is a difficult decision for government/investors to make. Do we invest in infrastructure to support the system at the delivery end or will hydrogen technologies replace electrification of transport in the medium term?

3.3 – Finance (Bruce Huber, Alexa Capital)

- Re-emphasised the point that there is no shortage of capital available for energy storage. The challenge is that the low cost of capital flows around predictable cash flows and there is arguably a shortage of *risk capital*.
- The challenge for regulation or system development, is that we are going through a system change based in part on 20th century procurement strategies but we are shifting to a 21st century distributed, decentralised system so are caught between the two.
- We have certain assets (e.g. storage) that are viewed as more risky and therefore have to be financed solely with equity (at a cost of 20+%) – the cost of infrastructure debt is in the low single digits.
- Today we see big pension funds who are desperate to put capital to work into the energy market place but only where there are predictable returns of capital. There is a debt vs equity allocation mismatch and that's where improvements of regulatory systems can address this and ensure that the lowest cost of capital comes into the transformation of the system.
- There are investor biases: investors are putting a lower cost of capital on decentralised low carbon solutions and a higher cost of capital on larger projects that are deemed as risky. The capital markets are waking up to this new system paradigm – this is why storage is so 'hot' today. There is lots of interest in storage projects from investors but a challenge in where and how the capital flows?
- Average power prices are dropping as a result of renewables but price volatility is increasing – storage can address this and the market will help determine the storage system solution of choice.
- Optionality as we invest in storage and other solutions is interesting and important. E.g. multiple services from one solution for the home, vehicles and grid support – why can't we have it all? The market will be looking for opportunities and multiple streams of revenue. Solutions such as storage can provide flexibility for the system but also for investor return.
- Keeping options open is important - e.g.in the California market where they are putting larger scale storage behind the meter but still selling services into the balancing market.
- There was a useful comment which referred to the issue of the way competitive markets drive the price down to short-run marginal cost, therefore participants will find it difficult to recover their long-run marginal cost (capital investment). This is a problem for capital intensive projects such as storage. This is why the Capacity Mechanism was developed for dispatchable plant.
- Finally, there is a differentiation between infrastructure investing and risk-investing. Some investors believe they are investing in infrastructure that then turns out to be a risk investment. This is a challenge for storage as a whole. AMS – able to grow so quickly because California regulated storage so they had to. 4 year contracts aren't going to be enough for the UK.

Finance (David Casale, Turquoise):

- Should we consider an upfront payment for energy – a universal pre-payment system?
- Consumers could pick what type of energy they wanted and insurance products would be easier.
- The digital world as a driver for the energy industry and payments (e.g. smart meters) should not be underestimated. It is risky to assume that the energy industry is somehow defended from the digital era.
- Agrees there is loads of money but a lack of clarity over projects to invest in (i.e. the right ones).
- Believes there will be a revolution in relation to energy system regulation and governance - for smaller system and localised generation. However we will still need a central government push for large flexibility assets (interconnectors or large scale storage).
- Looking at energy storage issues: at the larger scale – the financial structure is more known for

OFTO (similar STOR-TO) but information/leadership is lacking. When the UK is ready to build large-scale assets, i.e. when these have been identified by a system architect and when the scale of project is known, then these can be covered by long-term contracts which lowers the cost of capital. Infrastructure investors will be queuing up to finance these but are currently very frustrated as the projects aren't coming forward.

- At smaller scale e.g. the Venture Capital world (such as Turquoise), risk capital is tricky. In the battery world, risk capital has been thrown at it for very little return.
- Finally, there are the one-off projects which are covered in terms of capital e.g. EHFR bids. Although the 4 year contracts don't reflect investor's (or the technology's) need. Financiers need a firm understanding of where the revenue will come from.

3.4 - Charging Methodologies (electrical storage):

- DUoS and BSUoS are repeatedly raised as 'blockers'.
- National Grid are open to changes here but these need justification (and need to be fair to existing storage providers as well as new ones).
- National Grid recognised that a level playing field is needed. Charges aren't necessarily cost reflective currently and they are looking at these charges (TNUoS and DUoS) to assess what can work well for all industry participants (not just Energy Storage participants).
- Greater input is required from the energy storage community as to what the benefits being provided from storage are and whether and how these need to be treated differently. National Grid are keen for the process to be two-way.
- From a charging perspective, unfortunately changes can't happen quickly. In the mean-time, are there any quick-wins that can put in place to help? E.g. Tariffs provision, information sources?
- Attendees were reminded that charging methodologies are 'open governance', and can be changed if needed. National Grid is interested in the smaller view-points, not just the big industry players.

There was a question regarding double-charging of storage, whether it is true and if so how it could be changed.

Response: It is true mainly in relation to BSUoS. However the system can be changed if there is a reason to change it. From the TNUoS perspective, if a generator is outputting at peak and the system needs to be reinforced as a result of this, or if new connections are required, then arguably there is justification for the charges. In terms of demand charges being half-hourly metered, it is then improbable that a storage developer would receive a double-charge because the storage operator is unlikely to be consuming power at the Triad times, so is unlikely to pay the Triad charge.
In relation to BSUoS – it is an issue but there are costs associated with using the system at any time, whether taking energy off, or adding to the system. However the argument is that it's double-charging. Care needs to be taken so that storage doesn't use the system and then others have to cover the charges – we need to ensure there is a reason for not paying those costs.

An additional point was raised from a workshop attendee in relation to the cyclisation of charges such as BSUoS. For example: "*National Grid is paying pumped storage for Frequency Response services. The pumped storage site is then charging National Grid to cover the transmission costs that they are having to pay because National Grid are charging them. National Grid is then re-charging via system charges to consumers. National Grid is neutral to this but at a system level it doesn't make sense to increase the cost to consumers in this way. This means new investment is particularly difficult because of these charges.*" It was noted that National Grid is open to building a case to removing this block.

3.5 - Hydrogen:

- There is a big potential market for Hydrogen but clarity is needed regarding how to source the vector at a large scale. Hydrogen can compete with the services provided or avoid some of the issues faced by other forms of storage.
- The round-trip efficiency of Hydrogen is not good so it is unable to be treated like electrical Energy Storage.
- Hydrogen isn't good at short-term time-shifting but does provide other valuable services, take for peak shaving and demand requirements.
- A key benefits is that lots of these options can be standalone and don't necessarily need a hydrogen economy in order to develop.
- There are (briefly) five main options for hydrogen (with associated hydrogen storage):
    1. **Power-to-gas** (a large electrolyser is used to convert surplus electricity to hydrogen). This can provide balancing services/ancillary services but we need to inject into existing gas network. A sub-2-second response time is achievable for grid ancillary services and there are benefits with avoided infrastructure upgrades;
    2. **Hydrogen cavern storage** - e.g. using salt caverns and running a gas turbine to meet peak demand in a similar way to water/pumped storage;
    3. **Inter-seasonal/long-term storage** – energy density is lower so the difficulty is that you need lots of hydrogen storage.
    4. **Refuelling for transport** – distributed electrolysers for services to the grid, this requires new transport hydrogen infrastructure.
    5. **Conversion of the gas (heat) system to accommodate 100% (or higher volumes) of hydrogen.** This can provide heat from hydrogen rather than gas and reduces the impact of electrification. Boilers then run directly from Hydrogen.

Challenges for hydrogen:

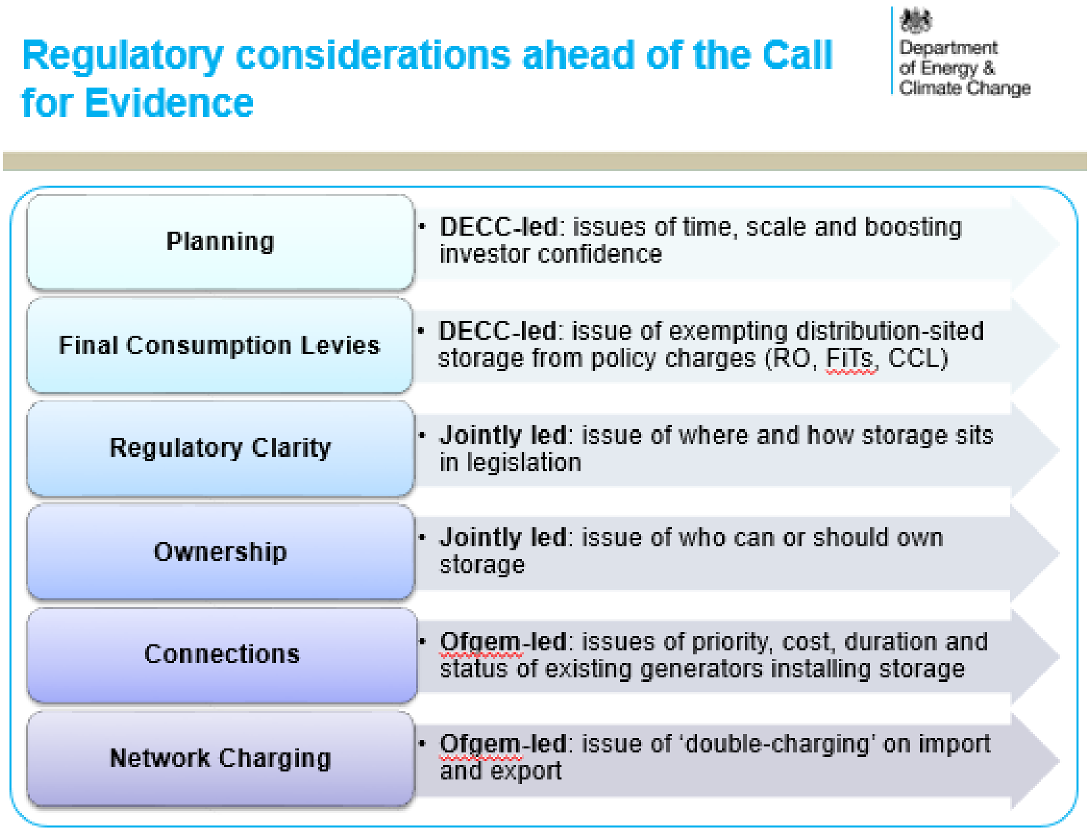
- Hydrogen needs a value due to its one-direction vector nature.
- Hydrogen needs to compete with existing/conventional gas usage and therefore needs a very low price of electricity to produce the hydrogen to make it competitive.
- The UK need CCS to generate the amounts of 'green' (low carbon) hydrogen that would be required at large scale. Could have generation from SMR→electrolysis. Electrolysis from surplus wind would potentially prove to be a difficult reliance as there would be competition for electricity from wind.
- A transition to Hydrogen would need a phased approach and lots of infrastructure upgrades.

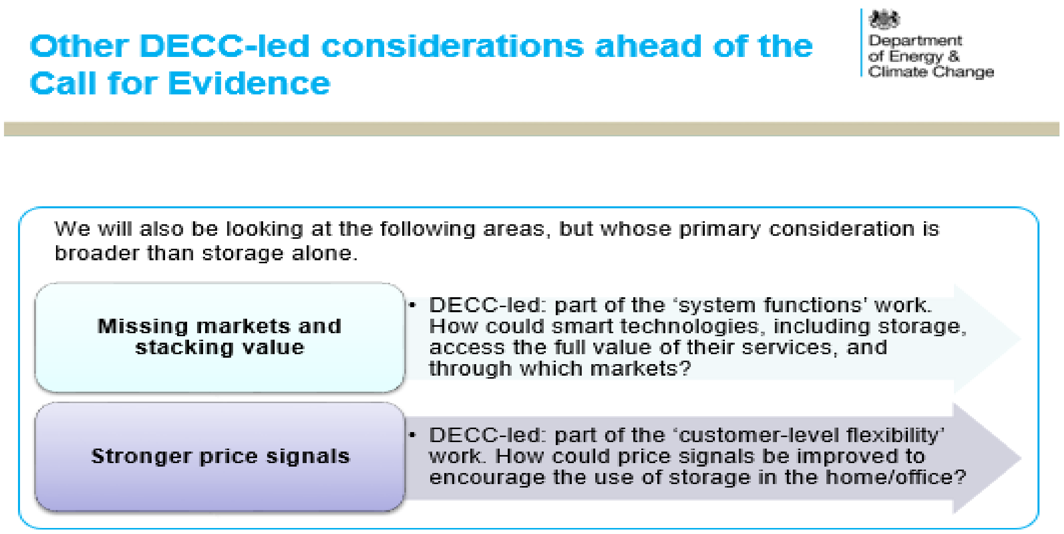
Benefits of hydrogen:

- Can use existing infrastructure – although this will need to be adapted to accommodate hydrogen (there is currently a low percentage accommodation level.)
- Can serve multiple markets: transport, heat, power - but need to use cross-sector / vector approach to assess the full value of hydrogen. The current siloed approach doesn't necessarily value this multiple service and makes it difficult to model a hydrogen world.

4. DECC Presentation & Discussion (Danae Marshall – DECC Energy Storage Policy)

- Noted the recent DECC Publication: Towards a Smart Energy System where opportunities and barriers relating to smart energy (including energy storage) are covered.
- Also noted that a DECC call for evidence will be put out shortly focusing on themes e.g.:
    - Levelling the playing field for techs such as storage (and others)
    - Delivering clearer price signals to the market/consumers
    - Catalysing further innovation for all smart technologies, again including but not confined to storage.
    - Future energy system considerations and increasing analysis and evidence base.
- Workshop attendees were encouraged to input, with the responses to this call for evidence due to be published in the autumn.
- The call for evidence will also focus on some barriers: e.g. planning for storage projects - help with getting through the planning process and improving investor confidence.
- Another focus is final consumption levies. Is storage a final consumer? At the moment it's looking as though it's not and may therefore be removed from the final levies arrangement.
- Regulatory clarity is sought - where and how should storage sit in legislation? Do we need to do something different? An Ownership question for DNOs and TSOs - should they be able to own storage? There *are* mechanisms available to allow ownership. How much should they be able to use them? How can we get storage connected more quickly and does storage need a new charging regime?
- It is recognised that storage fits into missing markets and stacking values (this is the same for DSR). How do aggregators stack value? Storage could benefit at the SME and domestic scale from stronger price signals.
- DECC's call for evidence focuses largely on electricity storage but Danae and team have strong links with the heat and hydrogen teams in DECC also.





Questions were posed to workshop attendees:

It is acknowledged that there is a lack of definition for storage in regulation and legislation in the EU & UK. How does a lack of definition for storage affect all the other barriers for storage? Does this need to be addressed and will a defintion help with the barriers? How should storage be defined and how should we approach the definitions?

It was noted that Ofgem don't believe network operators should own storage. It is a question of how storage sits within the EU's 3rd package. Storage does get caught between the supply and generation definition within the package. Therefore just like other generators, DNOs and TSOs have to unbundle and are caught by the restrictions of 'unbundling'. This doesn't mean that they can't own or operate storage devices. DECC is looking for an EU perspective on this.

- It is helpful to turn the question round: Under current mechanisms, are the incentive structures appropriate to allow network operators to procure storage from third parties so network operators have the incentives to run/maintain networks in the most efficient way possible e.g. under RIIO frameworks etc? Therefore under that system, can networks effectively use storage for management? Ofgem think 'yes' the incentive structure is there for storage, but it is something that they would like feedback on. Is the structure sufficient for network operators with storage?

A comment was made stating that: *"the reason that a separate regulatory structure for storage may not be required is because we are assessing the situation in reverse. The key point is that the current regulatory structure ought to be able to accommodate storage and its services - therefore having a separate structure for storage would only make things worse."*

"We need an overall conceptualisation of how the whole system works. There is a perfectly rational structure that states that any storage upside of the supply connection of a generator is generation and is hidden within the business model /op model of the generator. Any storage downstream of a customers' meter is consumption and is hidden within the business model of the customer and their aggregator. Therefore any storage that is connected to a network, is a regulated monopoly system resource capital asset. That seems to the most logical route for storage - whether it's right or not, or should be adopted is another question. If another model is adopted, you need another model of system services and interactions, which defines why you choose to regulate and provide guaranteed returns to some assets and not others."

DECC are looking at how to make the system better for storage. It doesn't have to be a separate system – can we tweak the current structures?

It was also noted that the UK could learn from case studies in countries on the continent such as Italy (TERNA) and Germany (VMAG) where there is already some recognition that regulation on the continent needs to change because of the added benefits that storage can bring in relation to intermittent supply of power.

From finance markets perspective, it would be frightening to down a regulatory path that is choosing champions from a technology standpoint. Solutions need to be regulated e.g. incentivisation for flexibility and resilience. Allow the innovation of the market to come up with individual technology solutions. We need to ensure there is room for innovation to stimulate capital flow.

Defintions:

- Storage - whole system storage unless specified otherwise
- 'We' - The UK
- 'Top down' – government led
- 'Bottom-up' –consumer/domestic led
- LCOE – Levelised Cost of Energy (or LCOS – levelised cost of storage)
- PPAs – Power Purchase Agreements
- UKCS – UK Continental Shelf

For information:

Project Chair: Peter Bance, Origami Energy
ERP Analyst: Helen K Thomas

Project Steering Group: Keith MacLean (ERP Co-chair), Craig Edgar (Atkins), Martin Southall (GE), Stephen Marland (National Grid), David Butler (Scottish Enterprise), Judith Ross (Ofgem), Sally Fenton (DECC), John Tindal (SSE), Allen Creedy / Andrew Poole (Federation of Small Businesses), Andrew Lever / David Sanders (Carbon Trust).

Appendix 1 – Workshop Attendees

No.	First Name	Last Name	Job Title	Organisation	Area Representing
1	Colin	Green	Head of Regulatory Affairs and Technology	**ABB**	Technical - Engineering
2	Bruce	Huber	Founder and Managing Partner	**Alexa-Capital**	Finance / Investment
3	Richard	Mizzi	Energy Consultant	**Arup**	Renewables & Hydrogen
4	Craig	Edgar	Head of Global Renewable Energy	**Atkins**	Steering Group
5	Tom	Harper	Senior Consultant	**Baringa (previously Redpoint)**	Finance/Markets Consultancy
6	Andrew	Levers	Director of Innovation, Scotland	**Carbon Trust**	Steering Group
7	Dr.Andrew	Pimm	Professor of Sustainable Energy Systems	**Centre for Integrated Energy Research - Leeds University**	Academia
8	Sally	Fenton	Project Manager - Innovation Delivery Team	**DECC**	Steering Group
9	Danae	Marshall	Smart Energy Team (Energy Storage policy)	**DECC**	Policy
10	Jo	Howes	Managing Consultant - Lausanne	**E4tech**	Consultancy
11	Chris	Bates	Modelling Team	**EON Gas Storage (Uniper Energy)**	Gas
12	David	Dorsett	Managing Director / Business Development Manager	**EON Gas Storage (Uniper Energy)**	Gas
13	Helen K	Thomas	Research Analyst	**ERP**	ERP Team
14	Richard	Heap	Executive Analyst	**ERP**	ERP Team
15	Simon	Cran-McGreehin	Executive Analyst	**ERP**	ERP Team
16	Keith	MacLean	ERP Co-chair	**ERP Co-chair**	Steering Group

17	Andew	Haslett	Chief Engineer	**ETI**	Whole System / Innovation
18	Dan	Roberts	Director	**Frontier Economics**	Consultancy
19	Allen	Creedy	Environment, Water and Energy Chairman	**Federation of Small Businesses**	Steering Group
20	Martin	Southall	Lead Project Engineer	**GE**	Steering Group
21	Bill	Weil	Partner	**Greencoat Capital**	Finance / Investment
22	Douglas	Cheng	Smart Cities Energy Group	**Hitachi**	OEM
23	Dr.Jonathan	Radcliffe	Acting Centre Director and Energy Storage Programme Director	**Low Carbon Futures - Uni. Of Birmingham**	Academia
24	Marc	Sheikh	EU & Africa Energy Business Leader	**MWH (Hydro storage design)**	Technical - Pumped Hydro
25	Stephen	Marland	Manager, Emerging Technology and Innovation	**National Grid**	Steering Group
26	Damian	Clough	Senior Commercial Analyst	**National Grid TNUoS Charging team**	Charging / Regulation
27	Deirdre	Bell	Senior Policy Manager	**Ofgem**	Regulation
28	Judith	Ross	Head of Network Regulation Policy	**Ofgem**	Steering Group
29	Peter	Bance	CEO	**Origami**	Project Chair Finance / Investment
30	Nick	Heyward	Head of Energy Storage	**Origami**	Steering Group
31	John	Prendergast	Energy Storage Manager	**RES**	Technical
32	Raphael	Sibille	Senior Consultant	**Ricardo – PPA Energy**	Renewables
33	Bridgit	Hartland-Johnson	Business Development Active Power Systems	**Siemens**	OEM
34	Daniel	Saker	Heat Networks	**SSE - Thermal**	Thermal

35	James	Huckstepp	Wholesale Strategy	**SSE Strategy Team**	Utility
36	John	Tindal	Commercial Analyst Power and Renewables	**SSE**	Steering Group
37	Jo	Boyd-Wallis	Principal Strategy Planner (Environment)	**TfL**	Transport
38	Matthew	Webb	Senior Energy & Carbon Strategy Manager	**TfL**	Transport
39	David	Casale	Director	**Turquoise International**	Finance/Investment
40	Andy	Hadland	Chief Development Officer	**Arenko CleanTech**	Energy Storage Company
41	Dr Keith	Bevis	Managing Director of EValu8 Transport Innovations Limited	**University of Hertfordshire**	Transport / Academia

Appendix 2 – Workshop Agenda

09:30 – 10:00	**REGISTRATION / NETWORKING**	**All**
10:00 – 10:15	**1. Introduction / Aims & Objectives of the Workshop**	**Peter Bance, Origami (Chair)**
10:15 – 10:30	**2. Speaker slot: Energy Storage - a service for the Whole Energy System**	**Keith MacLean, ERP Co-chair**
10:30 – 10:40	**3. Attendee Introductions in Table Groups**	**All**
10:30 – 11:40	**4. Barriers & Solutions to Energy Storage** • **Table (breakout) group discussions –** each table will have <u>two questions / statements</u> to discuss (these will differ per table). • **Feedback –** feedback from table discussions to all attendees to initiate whole room discussion.	**All**
11:40– 12:00	**TEA BREAK & SNACKS**	**All**
12:00– 12:15	**5. Whole room discussion & summary of previous session** Continue whole room discussion to fully capture thoughts regarding barriers and possible solutions.	**Peter Bance, Origami / All**
12:15 – 13:00	**6. Interactive Session** Questions regarding the need for system-wide energy storage and related barriers / solutions. Attendees to vote using online Mentimeter System (via wifi- connected mobiles & laptops).	**Helen Thomas, ERP / All**
13:00 – 13:40	**7. Panel session: System-wide Energy Storage** Thoughts from 4-5 workshop attendees regarding the future of system-wide energy storage referring to financial, legal, commercial, political and regulatory barriers. • David Dorsett, Uniper Energy **(Gas Storage)** • Keith Bevis, EValu8 Transport Innovations Limited **(Transport - EVs)** • Damian Clough, National Grid **(Charging Methodologies – Electricity)** • David Casale, Turquoise & Bruce Huber, Alexa-Capital **(Finance & Investment)** • Richard Heap, ERP **(Hydrogen Storage)**	**Panel speakers (5 mins each) / All**
13:40 – 14:00	**8. Regulatory and Market Issues Assessment** Overview of DECC's recent publication on smart energy; areas of focus for DECC's Call for Evidence and discussion of storage-specific areas. Discussion: There is a lack of a definition of storage in legislation, how should storage be defined to remove barriers? Does storage need its own regulatory treatment and its own governance framework?	**Danae Marshall, DECC**
14:00 – 14:15	**9. Conclusions & Whole Group Discussion**	**Peter Bance/All**
14:15 – 15:00	**CLOSE, LATE LUNCH & NETWORKING**	**All**