

ELECTRICITY STORAGE:
**REALISING THE
POTENTIAL**





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Greater capability to store electricity is crucial...[it]promises savings on UK energy spend of up to £10bn a year by 2050 as extra capacity for peak load is less necessary¹.

George Osborne

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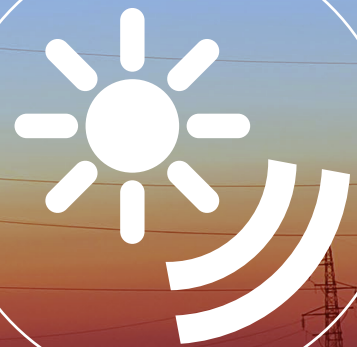


¹ Osborne (2012) 'Speech by the Chancellor of the Exchequer, Rt Hon George Osborne MP, to the Royal Society'

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If economic electricity storage, able to store large amounts of energy, were developed, it would be a 'game changer' in terms of improving resilience²

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Executive summary

This paper is an analysis of the barriers current policy structures impose on further roll out of grid-connected electricity storage, which has been described by Government as the “alchemy for energy policy”³.

The purpose is to make clear recommendations on how to improve the prospects of electricity storage on the GB system through regulatory changes and cutting red tape.

The potential for electricity storage has grown dramatically in the past few years. Electricity storage can help:

- Ease the tightening of capacity margins
- Manage increasing peak demand and the intermittency of renewables
- Meet renewables and emissions targets
- Extend aging infrastructure and stem increasing costs.

In the UK generation from renewables is now around 25%⁴ but at the same time capacity margins are tightening and network constraints are increasing. Addressing these issues is essential to meet the trilemma of achieving affordability and reliability while decarbonising.

New electricity storage would have minimal cost to the tax payer and consumer: it is the present legal and regulatory framework, plus lack of clear policy that is preventing its further deployment.

Wide varieties of electricity storage systems are available and proven to be feasible. They range from the well-established, such as pump hydro storage (PHS) and lead-acid batteries, to the more innovative such as liquid air and superconducting magnets.

Despite advances in technology and the emerging need for more storage, actual deployment of grid-connected electricity storage in the GB system is limited with less than 3 GW capacity: no significant storage has been commissioned since the opening of Dinorwig PHS over 30 years ago.

Storage has a range of benefits throughout the electricity system from small-scale renewable generators to the system operator; it has potential to deliver system value across scenarios that include Carbon Capture and Storage (CCS), nuclear and renewables dominated futures.

In order to maximise its benefits and usefulness, electricity storage should be integrated across the electricity system with independent large-scale storage developers, Distribution Network Operators (DNOs) and renewable generators⁵.

Making the policy changes recommended in this report will bring maximum benefit for our future energy systems at minimal expense to consumers. They will encourage investment in a sector with huge potential not only in response to the trilemma but also position the country as a leading technology innovator.

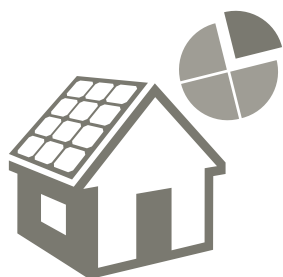
Certainty of direction on storage will give investor confidence, which in turn, will lead to new technologies developing to market and assist existing ones improve their application and efficiency. In short, the extensive benefits of action far outweighs the high costs of inaction.

Making the policy changes made in this report will also position the country as a

leading technology innovator.

In the UK generation from renewables is now around

25%



³ Ed Davey (2015) quoted in HoL Science and Technology Committee (2015) 'The Resilience of the Electricity System - Science and Technology Committee'

⁴ DECC (2015) 'Energy Trends, Section 6 – Renewables'

⁵ The focus of this paper is making least-effort policy and regulatory changes and, therefore, only considers purely grid-connected storage. This is not to say there is no role for storage elsewhere, for example 'behind the meter' for domestic and industrial customers, either connected to their own generation or, potentially through electric vehicles. While there is good potential for such system to help balance the grid, their disaggregated nature makes practical application more complicated.

The recommendations below address particular policy barriers to greater deployment of storage. The approach is to address each in the most cost effective, and technology-neutral ways possible:

Electricity storage's potential for helping balance the transmission network should be recognised by exempting operators from Balancing Services Use of System (BSUoS) charges.

Bulk storage facilities can be an effective means of balancing the network. At present, the BSUoS regime works against their further deployment: storage acts as demand while charging and generation while discharging, so operators must pay BSUoS charges twice, affecting economic viability.

Cost neutrality can be maintained by removing extraneous costs instead of providing a direct subsidy. Exempting new storage from BSUoS charges when they are acting to help balance the system would not result in National Grid losing money, nor would it add costs onto other electricity generators or customers (see section 3.1).

Enable Distribution Network Operators (DNOs) to fully develop and deploy storage through classifying it as a distinct activity.

DNOs' licences prevent them from operating generation in the market and, therefore, they cannot control storage facilities. Classifying storage as a specific activity but one that all licence holders can participate in would free up DNOs, improving grid balancing options and facilitate greater deployment of renewables.

As this policy alteration is about freeing up red tape restrictions on DNO's operations rather than providing subsidies, it will only involve minimal and one off administration costs, as opposed to ongoing support (see section 3.2).

Electricity storage co-located with renewable energy generation should be eligible for a premium Feed in Tariff (FiT), which provides a guaranteed percentage top-up to the wholesale electricity price.

The percentage premium FiT is a market-based mechanism that guarantees renewable generators with co-located storage a percentage above the real-time wholesale price of electricity. This is in contrast to the current fixed-price export tariff FiT for small-to-medium sized renewables operators that pays out a constant amount no matter when electricity is supplied.

With the percentage premium FiT, renewable generators can benefit from changes in wholesale prices; it exposes them to competitive pressure and market signals. It follows that under this model, decisions on whether, when and how much storage to build is guided by the market: new storage will be built when there is need and when it is economic (see section 3.3).

In 2014, **£68m** was paid out to wind generators in constraint payments – 20% of the total.

Premium percentage FiT for 30 MW of storage co-located with renewables would cost each domestic electricity customer no more than

27p per year.

In 2013-14 National Grid spent over **£1bn** maintaining system balance.



There are only four sizeable electricity storage facilities in the UK – the most recent was built over

30 years ago.

The largest battery in Europe is UK Power Network's

6 MW facility in Leighton Buzzard.

If existing storages' BSUoS charges were to be spread across BSC parties, the current combined generation and consumption charge would translate to only an

extra **0.3%** each.



2

Benefits and barriers to electricity storage

Unlike other forms of energy, for example natural gas, electricity cannot be retained in the network. Rather, the electricity system requires constant balance between demand and supply. If demand increases so must supply and vice versa.

While electricity cannot be stored per se, it can be converted to another form of energy, such as chemical or kinetic, and then reconverted to electricity. It is this process, which is commonly known as electricity storage. However, doing so typically results in round-trip efficiency of around 70 to 95%, depending on technology. As this paper's focus is on policy barriers to storage it does not consider individual technologies⁶.

The following sub-sections set out the main obstacles to and opportunities for development of storage in the three areas of interest:

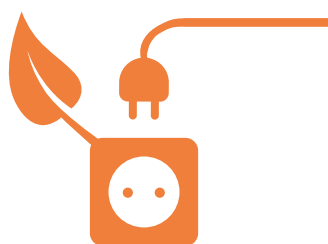
- Bulk storage on the transmission network (c. > 50MW capacity)
- Medium-sized (< 50MW) facilities for DNOs
- Smaller co-location with renewables (> 500kW).

2.1 Helping balance the transmission network with bulk storage

Bulk storage refers to large-scale electricity storage facilities taking from/supplying directly to the transmission grid – typically greater than 50 MW. At present, there are four such facilities in Britain – all PHS. Such plants have potential in helping balance the grid through both providing fast response reserve generation to meet demand and absorbing electricity at time when the system is at risk of overload. Nevertheless, the regime for funding system balancing works against storage through effectively double-charging operators.

The tightening capacity margin is largely due to the closure of coal-fired plants under the European Large Combustion Plant Directive and several nuclear plants coming to the end of their operational lives, combined with a lack of investment in replacement capacity. Meanwhile, demand on the transmission system, which had been declining over the past few years due to the economic recession, is increasing⁷.

When tightening margins combine with increasingly intermittent renewables, National Grid's balancing role becomes much more difficult. In 2013-14, the system operator spent just over £1 billion maintaining balance⁸. The majority of payments went to generators incentivising them to either increase or reduce output so as not to overload networks.



Electricity storage is unique in that it can act as both a supply and demand for electricity, improving security of supply; allowing greater use of renewables and

improving affordability in the system.

6 For more information on electricity storage technologies, including round-trip efficiencies, see, for example: IMechE (2014) 'Energy Storage: The Missing Link in the UK's Energy Commitments'; Breeze (2014) 'Power Generation Technologies' and Ibrahim and Ilincia (2013) 'Techno-Economic Analysis of Different Energy Storage Technologies'

7 DECC (2015) 'Energy Efficiency Statistical Summary'

8 NAO (2014) 'Electricity Balancing Charges'

National Grid recovers the costs of balancing the network by applying Balancing Services Use of System (BSUoS) charges, calculated on the amount of electricity large-scale operators take from, or supply to, the grid. BSUoS charges are split half-and-half between generators and suppliers according to the amount of electricity.

The relatively rapid response of a storage plant can quickly regulate frequency or, in the slightly longer-term of minutes and hours, provide power reserve. In addition, storage is unique in that it can also draw excess supply when it exceeds demand, therefore avoiding the increasingly frequent need to reduce generation and make constraint payments.

The uniqueness of storage is also a source of one of the main barriers to further deployment: as they act both as demand and generation, they pay double the amount, meaning BSUoS charges can be a significant cost for storage operators.

While every storage plant will vary according to several factors including technology, capacity and power stored, BSUoS charges can be a significant factor in the viability of operating storage. Due to commercial confidentiality, it is not known exactly what BSUoS represents as a percentage of individual plant's costs or turnover. First Hydro, which owns and operates Ffestinog and Dinorwig PHS, made a pre-tax profit in 2014 of £112.3m, virtually all from electricity sales at its two plants⁹. BSUoS charges for its facilities were £12.3m, or around 11% of pre-tax profit. (see Section 3.1 for more detail).

2.2 Freeing-up Distribution Network Operators

Distribution Network Operators (DNOs) own and operate the low voltage regional distribution networks. GB is covered by 14 DNO licence areas operated by six private companies.

Until relatively recently, the role of DNOs was to manage networks to take power flow from large-scale generation plant - arriving via the transmission network - to the point where customers connect. With the increase in renewables on the network the role of DNOs has changed. They now manage increasing power flows in both directions from multiple, and often intermittent sources, frequently located some distance from areas of greatest demand.

The typical response is to reinforce the network at particular pinch points through installing new cables and overhead lines to provide voltage control and manage changes in thermal rating. Storage could provide an alternative, for example installing a battery at the locational constraint to absorb/release electricity as required.

By utilising quick-reacting storage, DNOs can manage local constraints, minimising the impact of constraints and controlling steady-state voltages by injecting power. Storage, in particular batteries, also has the potential advantage of being both modular and movable to provide flexibility on constrained networks, which if deployed carefully can contribute to reducing distribution network reinforcement expenditure¹⁰.

However, at present, DNOs are restricted in their ability to utilise storage. There are three perceived main barriers to further deployment by DNOs:

Firstly, due to the unbundling of electricity companies at privatisation, which separated out generation from transmission, distribution and supply; DNOs are prevented from holding generation licences. As storage is effectively treated as generation, this prevents DNOs operating them.

A further problem for DNOs stems from the fact that at least in initial deployment, storage as operated by DNOs is likely to need funds from selling ancillary services and/or arbitrage to make it viable. However, in addition to DNOs being blocked from generating electricity, they are also prevented from trading energy and, therefore, barred from engaging in these markets. This cuts important revenue streams that would be crucial to building the investment business case and attracting financing.

A third difficulty for DNOs wishing to operate storage is the de minimis ('small things') constraint in their licences that restricts all non-distribution business activities – including storage – to 2.5% of turnover, consolidated reserves or share capital¹¹. While this would not in itself prevent small-scale storage, if a DNO were to operate several facilities the 2.5% limit could quickly be breached.



2.3 Improving renewable generation reliability

As the proportion of renewable generation increases so does the need to manage its output variability and temporal mismatch between generation and demand. By releasing energy at a steady rate when most needed, storage can smooth out both problems and, as such, is expected to play a significant role for further integration of renewables onto the grid¹². Despite this potential to help meet the UK's legally-binding targets there is little support available for renewables operators to develop storage.

Using storage within the export FiT regime presents difficulties as it is currently configured. Storage – no matter the technology – will involve losses. As the present export FiT regime provides a fixed p/kWh, operators would receive fewer funds if using storage compared to direct export. For example, if the storage device had 75% cycle efficiency, the operator would receive 25% less export tariff for supplying via the store rather than directly. As such, there is little incentive for renewable operators to invest in storage devices.

FiT also presents problems when looking at the current storage situation for renewables through the wider lens of network balancing. A key purpose of storage is to supply electricity when it is needed most, as opposed to when generated. A fixed-price export FiT, which guarantees an tariff no matter the wholesale price, does not encourage such operational considerations

There are three main reasons why co-location with renewable power generators is valuable. Firstly, storage can help short-term variability associated with renewables.

Such second-to-second, minute-to-minute fluctuations are most notably a problem with wind generation¹³. Storage's fast reaction ramping is ideal to help flatten such sudden spikes. With such potential, electricity storage can alleviate wind and solar intermittency problems, thereby correcting system stability risks. This increases the value of electricity generated from renewables while reducing need for sub-optimal ramping up and down of conventional, thermal generation.

Secondly, intra-day variability, for example greater solar power at midday rather than when needed at morning and evening peaks can be corrected by temporal shifting – absorbing generation for release when needed. This can also avoid the need to make constraint payments.

The third advantage to co-location is that it allows the losses incurred from storage to be kept 'on the same side of the meter' - in other words, they are picked up by the storage operator rather as opposed to the cost of network losses that are spread across electricity suppliers.

If storage is working in concert with renewable generation, it operates as a form of pre-network helping to flatten the load curve and potentially facilitating predetermined generation profiles. Storage can also assist network and renewables operators, increasing the reliability of facilities, improving dispatchability and integration with the network. In addition, it can help correct other issues, for example variability in frequency and voltage, and preventing reverse current flow caused by excess generation¹³, all of which should make renewables more economic¹⁴.



Storage, in particular batteries, also have the potential advantage of being both modular and movable to provide

flexibility on constrained networks

12 Energy Storage Association (2015) 'Renewable Integration Benefits'

13 Wind power output is proportional to the cube of wind speed. If wind speed doubles, power increases eight times and similar drop in power occurs as wind speed reduces. Therefore, while predictability is improving even small fluctuations in wind gust can have a significant effect on power output

14 Power Grid International (2013) 'Solving the Renewable Integration Puzzle with Smart Grid Technology'



Pathways to electricity storage

The further deployment of electricity storage requires regulatory and policy changes that enable flexible balancing activity. Such alterations would allow electricity storage to achieve viability through accessing appropriate support depending on their location, size and purpose.

This section sets out in detail how the three recommendations to overcome policy barriers to electricity storage can be realised.

3.1 Exemption from BSUoS charges

Large-scale electricity storage should be exempted from BSUoS to reward its two-way ability to help balance the grid. This can be done with cost neutrality by removing red tape and unfair charging, instead of providing a direct subsidy.

3.1.1 Existing storage

BSUoS charges are calculated ex-post based on the volume of energy large users (c. >50 MW)¹⁵ takes from, or supplies to, the transmission system on a half-hourly basis. The charges are paid by the 332 parties to the Balancing and Settlement Code (BSC), split evenly between generation and demand. Ultimately, both sets of costs are passed on to business and domestic customers through their bills.

As shown in Table 1, there is a current capacity of around 2.8 GW (or up to 25.5 GWh) of bulk electricity storage capacity in GB, all from pumped hydro storage (PHS). There are two plants in Wales (Ffestiniog and Dinorwig) and two in Scotland (Cruachan and Foyers).

As Table 2 sets out, the total annual BSUoS charge for the four PHS stations in 2014-15 was £14.9m. This was made up of £5.6m in charges applied to generation and £9.3m for consumption. If PHS operators were exempted from BSUoS costs, the income would not be lost to National Grid but rather reallocated for payment by the other BSC parties on a MWh basis.

Parties to the BSC are the legal entities that own the individual Balancing Mechanism Units liable for BSUoS. There are currently 332 parties but as Dinorwig and Ffestiniog are the only plants owned by First Hydro, it can be taken out of the equation, resulting in the BSUoS cost of storage operators being spread across 331 BSC parties.

BSUoS charges for existing storage were to be spread evenly across BSC parties, the current combined generation and consumption charge would translate to an extra £45,007 each equivalent to only 0.3% of total¹⁶, a relatively insignificant amount.

Table 1: GB bulk storage (all PHS) generation and consumption

Station	Nameplate capacity (MW)	Energy stored (GWh)	Electricity generated (GWh) (2014-15)	Electricity consumed (GWh) (2014-15)	Difference generation/consumption (%)
Foyers	305	6.3	194.6	206.5	-5.7*
Cruachan	440	8.8	315.3	348.5	-9.5
Ffestiniog	360	1.3	143	230	-37.8
Dinorwig	1,728	9.1	2,188.1	3,012.2	-27.3
Totals	2,833	25.5	2,841.9	3,797.3	-25.1

*Foyers includes natural flow hydro, which supplies some of the power needed for pumping.

Compiled from sources: DECC (2015) 'DUKES 2015'; International Power (2005) 'First Hydro Analysts Conference'; McKay (2008) 'Sustainable Energy Without the Hot Air' and data from National Grid.



Exempting new storage from BSUoS would be at no cost to consumer or tax payer

¹⁵ Facilities with a declared net capacity of under 100 MW where less than 50 MW is exported to the system can apply for a generation licence exemption

¹⁶ Assuming an even distribution (£14,897,632 BSUoS charges / 331 BSC parties = £45,007). In reality BSUoS is charges per MWh of Balancing Mechanism Unit, not per BSC party.

Table 2: Generation and consumption BSUoS charges¹⁷

Station	Generation BSUoS (£)	Consumption BSUoS (£)	Combined BSUoS (£)	% of combined BSUoS
Foyers	455,022	511,558	966,580	6.5
Cruachan	704,811	936,495	1,641,306	11
Ffestiniog	317,664	563,318	880,982	5.9
Dinorwig	4,115,805	7,292,959	11,408,764	76.6
Totals	5,593,302	9,304,330	14,897,632	100

Compiled from data supplied by National Grid

The cost would be expected to eventually be passed on to domestic and commercial electricity bill payers. However, this would make little, if any, practical difference to either BSC parties or bill payers: exempting storage does not alter the total charge, so it will not affect the amount to be paid by consumers.

Table 3: Proposed bulk storage¹⁸

Station name	Technology / developer	Nameplate capacity (MW)	Max. duration (hours)	Energy stored (GWh)
Coire Glas*	PHS / SSE	Up to 600	Up to 50	Up to 30
Loch Sloy**	Conversion to PHS / SSE	60	~20	~1.2
Balmacaan***	PHS / SSE	Up to 600	Up to 50	Up to 30
Cruachan upgrade****	PHS upgrade / Scottish Power	Up to +600	20	Up to +7.2
Glyn Rhonwy*****	PHS / Quarry Battery	99.8	12	~1.2
Total	-	Up to 1,959	Up to 152	Up to 69.6

*Planning permission granted

**Conversion of existing natural flow hydro scheme to PHS. Development currently on hold

*** Development currently on hold

****Planned upgrade to existing plant – figures show potential increases

*****Planning permission granted for 49.9 MW with application made for further 49.9 MW.

3.1.2 New bulk storage

Proposed new GB bulk storage is shown in Table 3. The five facilities comprise four new PHS (three in Scotland, plus Glyn Rhonwy in Wales) and the proposed upgrade of Cruachan. If all were developed to their intended capacity they would add 1,959 MW nameplate capacity, increasing it by 69%. However, due to the high generation duration of the proposed plants, the energy stored would more than double to 69.6 GWh.

Importantly, for new storage an exemption from BSUoS would not result in any further BSUoS costs for National Grid, nor other parties to the BSC. It would – at most – represent an absence of ‘new’ money raised through the regime. As storage in general will improve, rather than stress system balance new facilities would not load on any new BSUoS costs.

However, it should be noted while storage has been identified as a key mechanism for future balancing of the grid, this does not mean that storage will always have a positive effect for the system operator: as with any large demand or generation facility, its contribution depends on how it is operated. It follows exempting storage from BSUoS cannot guarantee storage will provide a net benefit. Therefore, it is further recommended that exemption on BSUoS is subject to an agreement with operators that they not charge and discharge at time which would stress rather than balance the system.



3.2 Review of storage classification

Storage deployed by DNOs is expected to have several different, often location specific applications. It has significant potential for DNOs to help improve their networks, particularly to help address increasing demand and load, both through providing balancing services and by deferring conventional line reinforcement upgrade.

In this sense, storage is a means for DNOs to fulfil their duty to provide network security to both generators and consumers. However, as most storage systems are more expensive in terms of capex (particularly as they will only be used for deferral as opposed to the alternative of reinforcement) if the wider benefits of storage are to be realised, there is a need to also develop other value, for example through providing ancillary services.

What networks do for spatial arbitrage between where electricity is available and where it is needed, storage does in time: it delivers electricity from when it was available to when it is needed. In this sense storage falls into the remit of a network operator. Therefore, changes should be made that allow for the creation of a recognised distribution activity that distinguishes its ability to provide separate generation and demand functions. Doing so would remove licensing issues faced by DNOs and lead to new business models encouraging investment by DNOs and third parties.

While storage is very promising and some technologies have been operational at scale for decades, by-and-large the types that would be deployed at the size required by DNOs remain in their infancy. At present, relatively high cost per MW and MWh of most storage means regulatory changes are required to realise its potential.

At present, operating generation under 50 MW but potentially up to 100 MW is exempt from the licencing regime and therefore potentially viable for DNOs. There is around 14 MW (20 MWh) of electricity storage either commissioned or operated by DNOs in GB. Most facilities have been developed to test the technologies involved and/or the business case, with many funded through the now ceased Low Carbon Networks Fund¹⁹. The largest of these are lithium-ion batteries: 6 MW (10 MWh) at Leighton Buzzard, and 2.5 MW (5 MWh) in Darlington²⁰.

There is, of course, a difference between exploiting these avenues for deployment of small capacity storage and roll-out either to large single sites or networks of smaller ones. Looking at current battery storage use, 100 MW for one device is a long way off for a single facility. However, the restriction actually applies to the DNO as a legal entity rather than individual facilities and if batteries are networked, the 100 MW limit could easily be reached in the near future.

In addition to the bar on generation greater than 100 MW, DNOs experience a further problem from de minimis restrictions. UK Power Networks' analysis suggests they would be able to develop around 15 projects of a similar size the Leighton Buzzard battery (added to other non-distribution income) before potentially reaching their de minimis restrictions of 2.5%²¹. Given 15 Leighton Buzzard's translates to around 90 MW/150 MWh this restriction could easily start affecting a DNO's ability to put in place even a moderate amount of storage. Other technologies – either new like liquid air or well-known such as pumped storage – could exceed this limit in a single facility. As such, the de minimis restriction could constrain development and technological innovation.

A straightforward, low cost way of freeing up DNOs to develop electricity storage is to cut red tape by altering the regulations so that it is a new licenced activity reflecting its role in generation, demand and providing network balance. If storage is no longer effectively classed as generation, then DNOs are not barred in terms of their licence in operating them, even if the facilities total over 100 MW.

However, as holders of other licences are generally prevented from participating in other licenced activities the licensing of storage would have to be a special case – treated as distribution when operated by a DNO, generation when a generators runs it etc.

This caveat is important for two reasons. Firstly, under the terms of the Electricity Act licenced activities are separated, for example the transmission system operator cannot also operate electricity supply or generation interests. This means simple creation of a new licenced activity (as for smart meter services in 2012) would not in itself allow DNOs to operate storage. Secondly, unless storage can be treated as distribution for DNOs etc. it would likely be caught in the de minimis restrictions limiting non-distribution activities.



19 Ofgem now run the annual Electricity Network Innovation Competition for 'innovation projects which help all network operators understand what they need to do to provide environmental benefits, cost reductions and security of supply'. Up to £81m per annum is available, however, the 2015 competition did not attract any submissions from electricity storage developers.

20 ESOF (2014) 'A Good Practice Guide on Electrical Energy Storage'

21 UKPN (2014) 'Smarter Network Storage Low Carbon Network Fund. Electricity storage in GB: SN54.13 – Interim Report on the Regulatory and Legal Framework'

As mentioned, DNOs are likely to need income from selling ancillary services to fund the capital investment in new storage devices, meaning there is a risk of breaching their restrictions on trading energy. However, it is becoming apparent from both UK Power Networks and SSE's use of third parties that using various contracted business models will formally allow DNOs operate within the regulations²².

Once these changes are in place, as DNO operated storage has the potential to reduce or defer the need for distribution reinforcement, while earning money through the sale of ancillary services. As such, DNO operated storage, when developed at scale is expected to be at least cost neutral with real possibility of creating a new funding stream. In turn, this means distributed storage is not expected to result in any increase cost for consumers.

3.3 Refining FiT

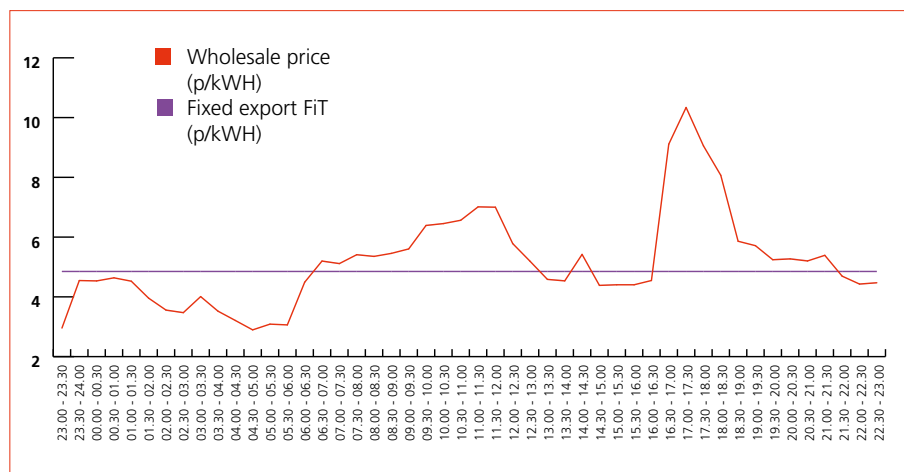
The implementation of electricity storage for improving the quality of electricity by addressing fluctuations from renewable generators should be encouraged through adaptation to the existing export FiT.

3.3.1 Percentage premium FiT

Figure 1 illustrates the fixed-price export FiT policy as currently used for small-scale renewables²³. In this mechanism, the payment levels remain independent from the market price. While this provides certainty for renewables operators, it does not incentivise supply at peak times nor storage at times of low demand or system constraint.

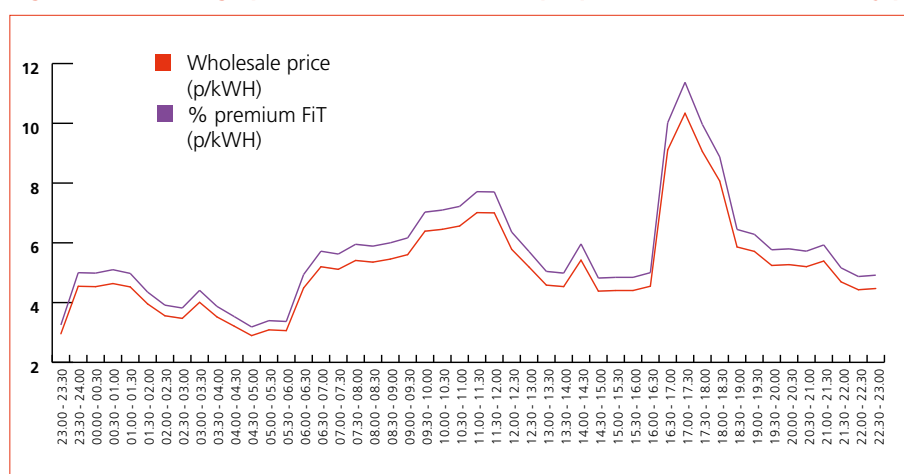
A more effective approach would be to use a percentage premium FiT as shown in Figure 2. This model offers a percentage top-up further incentivising operators to wait until peak demand before selling. The storage operator receives progressively more payment the greater the wholesale price.

Figure 1: Fixed-price FiT and wholesale electricity price



Based on data from National Grid showing wholesale electricity price for 15 January 2014

Figure 2: Percentage premium FiT with 10% top-up and wholesale electricity price



Based on data from National Grid showing wholesale electricity price for 15 January 2014

For example, Figure 2 shows a percentage top-up set at 10%. At 04.30 hrs when the wholesale price was at 2.90 p/kWh, the storage operator would receive 3.18 p/kWh (a top-up of 0.28 p/kWh).

When the wholesale price rose to 10.34 p/kWh at 17.00 hrs storage operators would receive 11.37 p/kWh (a top-up of 1.03 p/kWh). This means the storage operators would receive 0.75 p/kWh more for selling at highest, as compared to lowest demand.

Using a payment linked to market price rather than offering a fixed tariff has the potential drawback of decreasing certainty of payment. If future electricity prices increased (or decreased) more than forecast, it would lead to suppliers paying more; a cost they would, in turn, pass on to customers. Alternatively, if the electricity price dropped, storage operators would struggle to make an economic return.

A way to manage these risks is to floor and cap prices. Setting levels at which the combined revenues of the percentage price top-up and the wholesale market price cannot drop below/go over. In this way, the percentage premium FIT slides between an upper and a lower range in response to the market price.

To ensure continuing equity, the level floor and cap is set at will need to be regularly reviewed as increasing amounts of storage is deployed. However, as certainty is vital to manage the sort of long-term investment required it is essential that rates are grandfathered to ensure continuity.

3.3.2 Modelling

To keep the costs of percentage premium FIT to a minimum, ideally the top-up would be set at a level that closely matches the current export FIT rate of 4.85p/kWh.

As an illustrative example, an average was taken from the top decile of half-hourly wholesale electricity prices for 2014²⁴, giving 4.58p/kWh to use as the base price. Batteries such as lithium-ion are likely to be used for this type of storage, at least in the near future²⁵. Assuming deployment to match the size output from larger renewables (that is a 30 MW capacity)²⁶ with a typical capacity/power ratio of 1 MW/3 MWh and each store running a full charge-discharge cycle a day, every day we would expect to see an annual export of 32,850 MWh²⁷.

Table 4 shows that if a 6% top-up was applied to the base price it would work out at the current fixed export tariff of 4.85p/kWh, therefore not incurring any extra cost. However, receiving 6% more than a renewable operator would for exporting at the current fixed price export tariff is unlikely to cover the costs of losses from using storage, let alone capital and operational expenses.

Table 4: Potential percentage premium FiT levels (90 MWh)

Top-up (%)	Average p/ kWh	Total @ 32,850 MWh (£m)	Extra cost (£m)*	Projected annual cost to domestic customer**
6	4.85	15.9	0	£0.00
10	5.10	16.8	1.8	£0.06
15	5.27	17.3	2.3	£0.08
20	5.50	18.1	3.1	£0.11
25	5.73	18.8	3.8	£0.14
30	5.95	19.5	4.5	£0.16
50	6.87	22.6	7.6	£0.27

*Estimated annual cost over and above current FiT export tariff cost.

** Calculation based on 28 million domestic customers (commercial industrial excluded as numbers unknown), assuming full costs passed on from suppliers.

It is difficult to quantify these figures a range of estimates of percentage premiums are given in Table 4, ranging from 10% (which would cost £1.8m per year over the current export cost) to 50% (cost £7.6m extra per year). As with the current FiT system, it is expected that the electricity suppliers would be liable for paying the costs of the percentage premium FiT. In turn, they would be expected to pass this on to bill payers. There are 28 million domestic electricity bill payers in the UK²⁸. If the £7.6m extra cost of the 50% top-up were spread directly and evenly it would result in customers paying only 27p extra each per annum.

In 2014, the total constraint payment was £339m with an average of 20%, or £67.8m paid out to wind generators. This figure is just for wind and includes many operators who will not be under the FiT regime²⁹. It serves to give an indication that although the percentage premium FiT is likely to add to costs there will be savings made elsewhere because energy storage should mean less need for constraints, through improving dispatchability and balance.

This said, as noted in Section 3.1 with the alterations to balancing charges, attention would need to be paid to the possible divergence between load on the distribution network and the transmission network. There are times when peak national demand can coincide with a distribution network close to their load capacity meaning storage discharge should actually be discouraged although wholesale prices are high.

The current FiT regime is in a state of flux, with a consultation on its future launched in August 2015 canvassing opinion on reforming or scrapping generation FiT for new developments. In contrast, it proposes not to alter the export tariff, exploring options including for a "more dynamic link to wholesale prices for new applicants"³⁰.

More work and modelling are required to ascertain the correct level of percentage top-up level for the premium FiT. Nevertheless, it is clear from the above the concept has advantages in stimulating the take up of storage co-located with renewables. Doing so will not only facilitate a greater proportion of renewables on the network; it would also help solve their intermittency problem.

²⁴ Top decile used as storage facilities are likely to discharge a peak. Based on reference price data 01/01/14 to 31/12/14: APX Group (2014) 'Reference Price Data (RPD) HH ONLY'

²⁵ See, for example: AECOM (2015) 'Energy Storage Study: Funding and Knowledge Sharing Priorities'; Lau et al (2015) 'Overview of current development in electrical energy storage technologies and the application potential in power system operation' and Arup (Unknown date) 'Electricity Storage Technologies'

²⁶ The renewables generators currently within the FiT regime are generally under 5 MW. However, at least initially, storage would be expected to be utilised by those at the larger end of the spectrum. At March 27 2015 there was 30 MW capacity of renewables >500 kW in the FiT regime.

²⁷ Assuming total installed capacity of 30 MW: 90 MWh discharge x 365 days = 32,850 MWh per annum

²⁸ DECC (2015) 'Percentage of domestic electricity customers by region and supplier type' The number of non-domestic bill payers is unknown so has been excluded from this analysis.

²⁹ Due to commercial confidentiality, constraint payments are not available on a unit by unit basis.

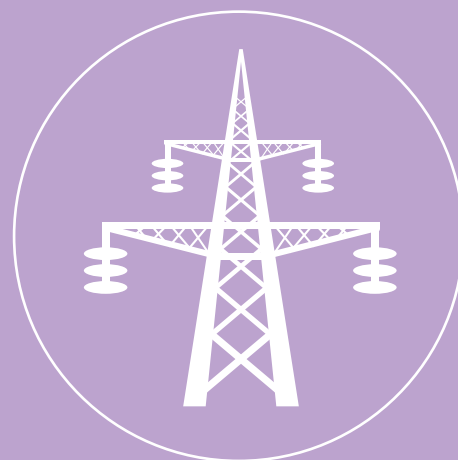
³⁰ DECC (2015) 'Consultation on a review of the Feed-in Tariffs scheme'

The extensive
benefits
of action far outweighs
the high costs of inaction.



Electricity storage can help:

- Ease the tightening of capacity margins
 - Manage increasing peak demand and the intermittency of renewables
 - Meet renewables and emissions targets
 - Extend aging infrastructure and stem increasing costs.
-



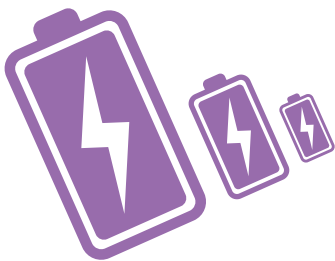
Conclusions

This paper makes three key policy/regulatory recommendations to facilitate further development and deployment of electricity storage:

- The BSUoS system unfairly penalises electricity storage by charging operators for both demand and supply. Storage's role in balancing the network should be recognised by exempting it from BSUoS charges. Doing so would be at no cost to the system operator nor electricity bill payers
- Electricity storage does not have a classification and is consequently often treated as a form of generation. DNO's licences prevent them from operating generation and therefore, cannot control storage facilities. Altering classes would allow them in a cost neutral way to balance and improve their networks
- Electricity storage co-located with renewable energy generation should be eligible for a percentage premium FiT, which provides a guaranteed top-up to the wholesale electricity price. This would increase the reliability and proportion of renewables, improving system efficiency and security at minimal cost to the consumer.

If the potential benefits of storage in future systems are to be realised, the UK Government, working with the regulator and industry should act to provide a clear statement on the future of electricity storage in the energy system setting out steps towards making the recommended policy changes.

Doing so will encourage investment in a sector with huge potential not just to improve energy efficiency and security but also position the country as a leading technology innovator. With the investor confidence provided by the certainty of direction on electricity storage, new technologies would develop to market and existing ones will improve their application and efficiency.



Storage could help meet renewables and emissions targets... the question is not how to develop but

**what is
stopping
deployment.**

The paper analyses storage from a GB policy, regulatory and legislative perspective, examining the changes required to position the country as a leading innovator in what could be the future of electricity networks. Storage could help meet renewables and emissions targets, ease the tightening of capacity margins, manage increasing peak demand and the intermittency of renewables, extend aging infrastructure and stem increasing costs. It is on the verge of being technologically and economically doable: the question is not how to develop but what is stopping deployment.



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