POLICY & REGULATORY LANDSCAPE REVIEW SERIES

Working Paper 1: Electricity storage & electric vehicles

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This report has been reviewed internally by EnergyREV colleagues: David Elmes, Rebecca Ford, Matthew Hannon, Cameron Hepburn, and Jonathan Radcliffe.

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About this report

This is the first Working Paper in a series that reviews the current policy and regulatory landscape related to smart local energy systems (SLES) in the UK. Each review will have a particular focus; this report focuses on policy and regulation related to electricity storage and electric vehicles.

Our aim is to produce useful and usable outputs to our stakeholders as soon as we have information. We're seeking your feedback on how useful and informative these outputs are so that we can improve future reports, in particular on the following:

- Have we captured all the relevant information – if not, what have we missed?
- How could we improve the presentation of the information?
- How could we improve the clarity of the information?
- What future SLES relevant topics should we prioritise?
- How can we best keep these outputs live and relevant – are you aware of approaches we could draw inspiration from?

Please send feedback to policy@energyrev.org.uk.

This feedback will allow us to continually improve our outputs to provide the most useful and usable resources on SLES policy and regulation. At the end of the wider review process we'll tie together the findings into one comprehensive snapshot of today's policy and regulatory environment.

Contents

1 Why are we doing this?

1.1 The energy transition

Energy systems in the UK and around the world are going through a phase of rapid change. In June 2019, the Government committed to reducing the UK's greenhouse gas (GHG) emissions to net zero, i.e. the amount of GHGs being emitted is at least matched by that being removed.

The drive to decarbonise is anticipated to equate to a significant a rise in renewable energy, which is coupled with a trend of smaller, more modular power sources generating electricity closer to point of use. Boundaries between sectors in today's system – such as power, heat and transport – are also becoming blurred and insignificant. Smart local energy systems (SLES) have the potential to provide a more efficient, safer and better experience all round.

1.2 The Energy Revolution Research Consortium (EnergyREV)

EnergyREV was formed under the UK Government's Prospering from the Energy Revolution (PFER) programme to "bring forward novel research in local energy systems and accelerate uptake, value and impact". The consortium works closely with the four PFER funded demonstrator projects.[1]

1.2.1 What are smart local energy systems?

One of our first tasks was a review of how SLES are conceptualised in the literature and by those researching the space.

Findings suggest that while there is no set definition of what an SLES is, there are some common themes in how they are conceptualised (Ford 2019):

1. The purpose or goals of a SLES often extend beyond delivering energy services to end users, and are frequently intertwined with delivery of additional environmental, social and economic benefits.
2. 'Smart' elements typically include the information and communications technologies to generate data that can be used to optimise energy flows in a locality, either through autonomous or human-in-the-loop mechanisms.
3. Locality is hard to define and will likely be context-specific and depend on the ultimate goal of the system, and the actors and infrastructure involved.
4. The ultimate goals of an SLES may not be realised unless the system elements and their interconnections are understood, and can be mapped to these goals.

1 The funded projects are a) The Energy Superhub Oxford, b) ReFLEX Orkney, c) Project Leo (Local Energy Oxfordshire) and d) Smart Hub SLES (West Sussex) (UK Research and Innovation, 2019).

1.2.2 The purpose of this review

Within the EnergyREV Institutions theme, our focus is understanding the policy and regulatory environment in which SLES can operate optimally in the future.

There is an incomplete understanding of the current policy, regulatory and market frameworks surrounding SLES in the UK. In order to understand what needs to change to enable SLES to thrive, it is important to have a baseline of what today's arrangements are.

The purpose of this review is to analyse the evidence and gaps in the policy and regulatory landscape of (smart) local energy systems in the UK.

2 How did we do it?

2.1 Review series: sprints

Our review is a series of 'sprints' or mini-reviews, each of which is dedicated to a particular activity or topic within the energy system. Prioritisation of the topics for each sprint is made with the activities of the PFER demonstrators in mind, but our aim is to cover a wide range of activities and themes relevant to SLES in general.

This first sprint focuses on electrical storage and electric vehicles (EVs). All four PFER demonstrator projects are undertaking related activities: EVs and electricity storage are closely linked to the low-carbon energy transition.

2.2 Evidence review: quick scoping review

The quick scoping review is less time and resource intensive than a full systematic review, yet applies the same rigorous and robust methodology; evidence is gathered, subjected to a set of exclusion and inclusion criteria, and analysed to identify themes.

The full review methodology can be found in the Annex. Our approach is outlined briefly here, and the process is shown diagrammatically in Figure 1.

2.2.1 Search strategy

Our main source of evidence came from systematic searches of websites of official bodies, including the UK Government, the Devolved Administrations and Ofgem (the energy regulator).

In addition, because the landscape is broad, technical and complicated, we also adopted a crowdsourcing approach where we invited stakeholders to submit further evidence on the policies and/or regulations that are hindering – or indeed enabling – SLES activities.

We adopted four methods to gather information:

1. Crowdsourcing

We released a call for evidence at the beginning of this sprint to a wide community of participants, asking for examples of policy, regulation or rules that are hindering activities related to SLES, or have the potential to do so in the future.

Stakeholders contributed more than 30 separate pieces of evidence for this sprint, for which we are extremely grateful. Interestingly, the evidence gathered through crowdsourcing did not overlap with what we found through our own searches. This confirms that the policies and regulations that affect SLES are complex, wide-ranging and can be nuanced, and are therefore difficult to find. This means that our crowdsourcing evidence was extremely valuable, and uncovered issues that we might never have found without help from the informed community.

2. Online search

Keyword searches were performed on key institution websites. For more information, see Annex: Quick scoping review methodology.

3. Background documents

We included documents already known to the authors to be relevant for the topics.

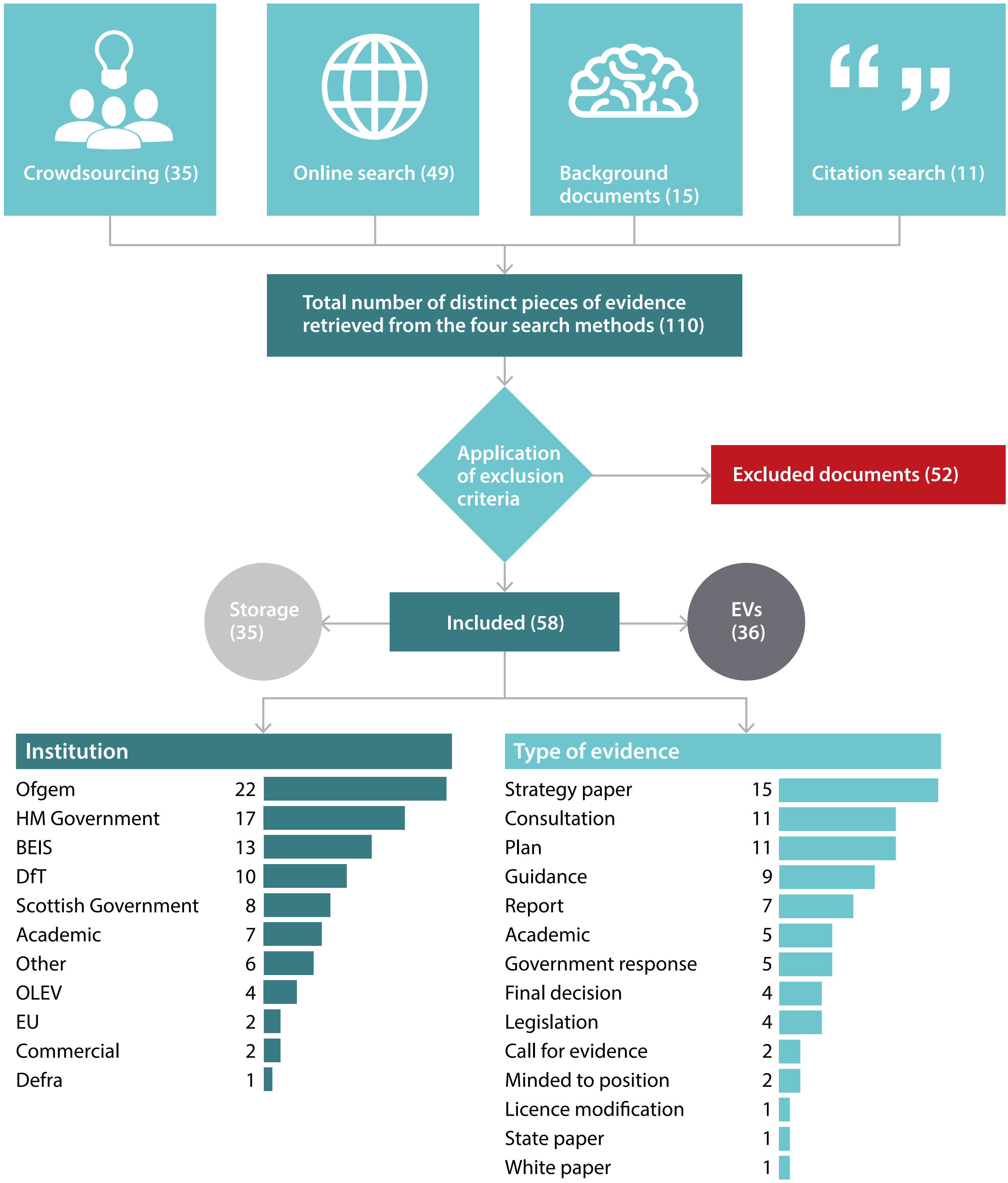

Figure 1: The quick scoping review process and outcomes for Sprint 1: EV infrastructure and storage. Four search methods – crowdsourcing, systematic online keyword searches, background knowledge and citation searches – were used to gather a body of evidence consisting of 110 distinct documents. The pieces of evidence were screened for relevance and 58 were included in this review. Evidence was characterised according to factors such as publishing institution and type of publication. Note that, in some cases, more than one institution is attributed to pieces of evidence.

4. Citation searches

Many of the documents retrieved through the other three search methods contained references to other relevant documents. These were retrieved and subjected to the same exclusion criteria.

For this sprint, 36 pieces of relevant information were included for the electric vehicle infrastructure category, and 35 for storage.

2.3 Outputs

We will release a working paper that has been reviewed internally by EnergyREV members at the end of each sprint, and progress to the next topic.

We are seeking feedback from all stakeholders on our process and outputs (see page 2 for details), to ensure that we are providing useful and usable outputs. At the end of the wider review process we will consolidate the findings and learning into a comprehensive landscape of the current policy and regulatory environment.

Energy is a rapidly changing sector, and the findings will therefore reflect what is true at the time of reviewing, but we'll try to point to where important changes are imminent. Where appropriate we will return to topics when the landscape has changed significantly.

2.4 Considerations for the next sprint

The first sprint has been a valuable learning experience from which we identified a number of considerations for the rest of the review process.

2.4.1 Systematic search approach

Performing systematic searches on institution websites presented some challenges. For example, both the Scottish and Welsh Governments are (at the time of writing) in the process of migrating their websites to new platforms, including publication repositories. Searches had to be performed on both old and new sites, and results were inconsistent.

We also encountered issues with search engine limitations. In some instances, searching for exact phrases was impossible. Multiple-word searches returned large numbers of results containing any of the search terms.

We are engaging with these institutions to improve the search process for users in the future.

2.4.2 Policy and regulatory status and version

Some of the documents we reviewed turned out not to be the latest position. Institutional websites do not always link documents to the latest version, for example, linking a consultation web page to a decision web page. This resulted in some unnecessary reviews of older materials.

2.4.3 Differing styles of document, including metadata

Documents differ in their structures and associated metadata. For example, some institutions produce documents with associated metadata suited to citation software, others do not. Also, some documents are clearly structured with a summary, purpose and citation of other relevant policies or regulations. Finally, some are easier to review than other because of language, for example, legislation and licences are more difficult to interpret given the necessity of the legal language. That said, some legislation has accompanying notes that makes this process easier.

3 Findings: electrical storage

Electricity storage in the UK is important and is expected to become even more so in the future. According to RenewableUK and the UK Solar Trade Association energy storage database (Renewable UK, 2018), in 2018 cumulative applications for grid connected batteries alone reached nearly 7 GW, although Solar Power Portal put this figure even higher at 11 GW (Solar Power Portal, 2019). This is in addition to other grid connected large pumped hydro facilities and other electricity storage technologies such as liquid air storage (Department of Energy, 2019). There is also increasing demand for behind the meter batteries in homes, businesses and on wheels (see electric vehicle section, above).

Electricity storage recently played an important role in responding to UK power cuts. Of the 1 GW of rapid response power called to stabilise the system, nearly half of this (450 MW) came from battery storage (Green, 2019). Interestingly, a further 350 MW came from demand response, which we will no doubt return to at a later point in this review series.

The future for electricity storage looks promising. The size of the prize for future assets is a share of the £17–40bn pot outlined in the BEIS and Ofgem Smart Systems and Flexibility Plan (Ofgem, 2017a). In the modelling associated with the plan, the potential market size for storage is up to 27 GW by 2050 (Carbon Trust, 2016). National Grid's Future Energy Scenarios show a similar picture with 7– 12 GW storage by 2030 and 14–28 GW by 2050 (National Grid ESO, 2019f).

The value of technologies such as electricity storage are three-fold (Carbon Trust, 2016). First, they reduce the capacity of low carbon generation needed to achieve carbon reduction targets by improving the utilisation of intermittent low carbon generation. Second, they enable system balancing at a lower cost by displacing more expensive flexibility options such as peaking plants. Third, they improve the application of existing conventional generation, and defer investments in transmission and distribution network reinforcement.

To deliver essential electricity system functions and realise value for electricity storage requires a policy and regulatory environment that understands the technology and supports it. In our review, two main themes emerged relating to electricity storage – regulation and market access.

3.1 Regulatory issues

The most common issues we identified relate to regulatory and policy issues associated with electricity storage, including ownership of storage by electricity distribution companies, defining storage as electricity generation, planning issues, co-location with existing renewables and network access and charging.

3.1.1 Ownership by electricity network operators

3.1.1.1 What is the issue?

Ownership and operation of storage facilities by monopoly electricity network companies creates the potential for competition to be distorted, for new market entrants to be deterred, and for investment in distribution networks to be affected (Ofgem, 2018f).

This is consistent with the direction of potential future European rules on storage ownership. In its Clean Energy for all Europeans package (European Commission, 2019), the European Commission proposes to prohibit distribution network operators (DNOs) from owning, managing or operating storage facilities – except in very limited circumstances (Ofgem, 2018c).

3.1.1.2 Electricity Distribution Licence changes

As a result of these issues, Ofgem has changed the DNO licence to make it clear that licensees must not engage in generation (see Section 3.1.2 for definition of storage) – including storage – of electricity, unless an exception applies.[2]

Ofgem recognises that under certain circumstances it may be in the interest of consumers for the licensee to operate storage in a manner that would otherwise be prohibited by the licence conditions. Ofgem outline three such circumstances (Ofgem, 2018g):

Category A: Island-based networks:[3] A licensee can operate generation assets as part of island-based electricity systems without the requirement to seek a direction under Category C: Generation pursuant to a direction by the Authority.

Category B: Generation for specific authorised activities: This recognises that there are certain small-scale applications of licensee-operated generation that help to ensure continuity of supply and the safe and reliable operation of the network. These include:

- Uninterruptable power supply
- Emergency response
- Energy management[4] at licensee-owned sites.

Category C: Generation pursuant to a direction by the Authority: Network operators will need to apply for a direction from Ofgem in cases where it generates electricity, including through an asset, and neither a Category A nor a Category B exception applies. Several criteria will need to be met for a direction to be made.

3.1.2 Electricity storage classed as electricity generation

3.1.2.1 What's the issue?

Energy storage assets could pay twice for costs such as network charges because they are both generators and consumers of energy (Bray et al, 2018). This double-charging would make some such assets uneconomic, and means that the benefits of storage to the electricity system are not reflected in network charges (Gissey, 2017).

3.1.2.2 Changes to Electricity Generation Licence

Ofgem proposes (decision pending as of 10/09/19) two main changes to the electricity generation licence to address the issues of double-charging (Ofgem, 2019b).

2 The changes apply to Electricity Distribution Licence for both DNOs and independent DNOs (IDNOs). The relevant Standard Licence Conditions (SLC) are SLC 31D for IDNOs and SLC 43B for DNOs in the Electricity Distribution Licence. These conditions: "…aim to ensure that licensees apply effective operational unbundling to all generation assets which they may own, including licence exempt generation such as storage. The new condition will apply to the operation of any unlicensed generation8 (including assets with less than 50MW of capacity). This guarantees that protections are in place to minimise the risk of conflicts of interest. These proposals intend to give deeper effect to the unbundling requirements for distribution system operators set out at Article 26 of the Electricity Directive." Furthermore, to ensure transparency, Ofgem states: "…should take all reasonable steps to proactively publish information on all generation assets owned (irrespective of operator), or operated by licensees under the provisions outlined above." (Ofgem, 2018g)

3 Ofgem define Island-based networks as "…electrical systems which serve physical islands within the jurisdiction of Ofgem, other than mainland Great Britain." (Ofgem, 2018g).

4 These are devices with generation capability with the sole purpose to generate or conserve electricity produced at licensee sites for later consumption at that same site. Such generation must be designed to match on-site demand, but shall not, at any point in time, be exported to the grid or be used to provide flexibility services for the grid (Ofgem, 2018g).

First, to add a definition of 'electricity storage' and 'electricity storage facility' to the licence to clarify what activities fall under the licence. The definition of electricity storage and electricity storage facility proposed is as follows (Ofgem, 2019b):

"Electricity Storage", in the electricity system, is the conversion of electrical energy into a form of energy which can be stored, the storing of that energy, and the subsequent reconversion of that energy back into electrical energy. "Electricity Storage Facility" means a facility where Electricity Storage occurs or can occur and includes all assets performing or contributing to any such Electricity Storage.

Second, introduce a new licence condition, E1, into the generation licence that is only applicable to electricity storage providers. Under this proposal, licence holders would be required to make available to their supplier information to support the correct identification of storage facilities at sites, and enable the accurate estimation of supply volumes necessary for calculating final consumption levies. Licensees will also be required to publish certain information on their website to facilitate transparent information-sharing among industry parties to support the efficient deployment and use of flexibility.

3.1.2.3 Relevant other measures to watch

Five industry code modifications are exploring solutions for storage residuals charging.[5] Industry working groups have identified the need for more granular data on the electricity consumed by storage sites in order to facilitate the correct calculation of charges. To achieve this, the modification proposals are considering a requirement for storage to provide a set of information to other interested industry parties so that exemption from demand residuals and use of system charges are applied correctly.

3.1.3 Electricity storage and planning

3.1.3.1 Issue

The planning system can affect how easy it is for assets to be deployed, or indeed whether it is allowed at all. Planning rules can be different at national, devolved and local levels.

Electricity storage is classed as electricity generation, and for planning purposes faces a similar regime to other non-wind onshore generating stations.[6] BEIS has recently consulted on two issues related to electricity storage.[7]

First, whether the level and unit of the 50MW capacity threshold for non-wind onshore generating stations in the Nationally Significant Infrastructure Projects (NSIP) regime is appropriate for electricity storage.

Second, clarification of how composite projects, consisting of storage and another form of generation, should be treated with regards to the NSIP capacity threshold (see Section 3.1.3).

3.1.3.2 Background on GB planning system

The GB planning system features both national and local elements, and is largely devolved in Scotland and Wales, with roles and responsibilities shared between Local Planning Authorities (LPAs), the Secretary of State (SoS) and the devolved administrations.

Planning permission under Town and Country Planning legislation is typically required to undertake building work, alter an existing building, or change the use of land or a building.

5 The relevant industry code modifications are: CUSC modification proposals CMP280 and CMP281; DCUSA change proposals DCP34115 and DCP34216; and BSC modification P383 (Ofgem, 2019b).

6 BEIS did not consider offshore generating stations citing that to date no problems have been identified impacting the deployment of storage within this area (BEIS, 2019b).

7 The consultation is currently closed (as of 7 August 2019) pending a decision.

In most cases, parties should apply for planning permission from their LPA, however, depending on the nature and size of the development, it may be captured by the Nationally Significant Infrastructure Projects (NSIP) regime which requires a grant of development consent from the SoS under the Planning Act 2008.

From 1 April 2019, section 39 of the Wales Act 2017 amended the Planning Act 2008 to remove Welsh onshore non-wind powered generating stations and generating stations in Welsh waters with a capacity of up to and including 350MW from the NSIP regime.

This means that storage facilities (except pumped hydro) with a capacity of up to and including 350MW will need to seek consent from the relevant LPA, and all storage projects with a capacity of more than 350MW will continue to be consented by the SoS as a NSIP.

The current planning system for electricity storage across GB is summarised in Table 1 below.

Table 1: Current planning system for electricity storage across GB

Territory	Type of planning consent for standalone electricity storage projects		
	Planning permission under Town and Country Planning legislation	**Consent from Welsh Ministers (DNS) or Scottish Ministers (s.36 consent)**	**Development Consent under the Planning Act 2008**
England	Where is generating capacity is up to and including 50 MW, permission is sought from the relevant LPA under TCPA.	N/A	Where the generating capacity is more than 50 MW, permission is sought from the BEIS SoS under the Planning Act 2008
Wales	Where generating capacity is up to and including 10 MW, permissions is sought from the relevant LPA under the TCPA.	Where the generating capacity is between 10 MW and 50 MW, permission is sought from Welsh Ministers under the TCPA.	Where the generating capacity is more than 50 MW permissions is sought from the BEIS SoS under the Planning Act 2008.
Scotland	Where the generating capacity is up to and including 50 MW, permission is sought from the relevant LPA under the TCPA.	Where the generating capacity is more than 50MW, permission is sought from the Scottish /minsters under the Electricity Act 1989.	N/A

Source: Department for Business, Energy and Industrial Strategy (BEIS, 2019b).

3.1.3.3 Proposals for treatment of electricity storage in planning regime

There are two proposals made by BEIS (BEIS, 2019b):

First, retaining the 50MW NSIP capacity threshold that applies to standalone storage projects.

Second, amending the Planning Act 2008 to establish a new capacity threshold for composite projects including storage and another form of generation, such that a composite project in England would fall into the NSIP regime where either its capacity, excluding any electricity storage, is more than 50MW; or, the capacity of any electricity storage is more than 50 MW. Therefore, where the capacity of both the storage and non-storage elements of the generating station are less than 50 MW individually, but over 50 MW in combination, the generating station would fall under the local planning regime.

In response to the consultation, the Electricity Storage Network (ESN) (Regen, 2019b) raised issues with the Government's proposal, which are relevant to smart local energy systems (The Electricity Storage Network, 2019). Evidence from the ESN found that the 50 MW threshold is a barrier due to the cost and time (between 1.5 and 3-years) that the NISP process entails:

> "The connection data from National Grid ESO illustrates this aversion of projects over 50 MW – 35 out of 41 battery storage projects at various stages of connection are at 49.9 MW."

The ESN also note issues with local planning:

> "…at the local planning level, there is often inconsistent treatment of storage by planning officials, even within one county according to some members. With no guidance and very little precedent to refer to, planning officials, local authorities and committees are often making decisions contrary to the expert evidence and reports provided by the developers. Noise is the most frequent example of inconsistent treatment, with decisions often being made that go against the expert evidence due to a lack of other evidence and guidance available to the committee."

3.1.4 Co-location with renewables

3.1.4.1 Issue

Co-located storage is where storage is located with a renewable generating station or installation. The legislation underpinning the Renewables Obligation (RO) and Feed-in Tariff (FIT) schemes does not refer to or define storage or storage facilities. This means that the co-location of storage with accredited renewable generation is neither expressly prohibited nor expressly provided for under the schemes. As a result, co-locating storage alongside existing renewable generation could risk eligibility for subsidy schemes such as FIT and RO (Bray et al, 2018). Co-location is expected to grow substantially in local energy systems in the future.

In order to mitigate these risks, Ofgem published guidance for generators on the co-location of electricity storage facilities with renewable generation supported under the RO or FIT schemes (Ofgem, 2018d). Ofgem's position is that:

> "…we consider that where the requirements of the schemes continue to be met, storage can be deployed and the accreditation of RO generating stations or FIT installations can remain valid under the existing legislative framework."
> (Ofgem, 2018d).

However:

> "Generators should consider carefully the requirements of the scheme to ensure their proposed configuration does not adversely affect their ability to receive support under the schemes." (Ofgem, 2018d).

3.1.4.2 What does the guidance say?

There are four overarching principles that operators of existing[8] RO generating stations or owners of FIT installations should consider when thinking about co-locating storage with generation accredited under the schemes. These are:

Co-located storage does not change generators' obligations to comply with the RO and FIT scheme requirements. It is incumbent on the generator to convince Ofgem that co-location of storage does not impact compliance with scheme requirements, including whether changes to the site accreditation are required.

Generators can only receive support for eligible renewable electricity generated by an accredited RO generating station or FIT installation. When storage is co-located there must be no risk that support is claimed for, and issued upon, electricity that was not generated by the accredited generating station or installation. Such electricity includes: Electricity produced by a standby generator or auxiliary power supply; electricity imported from the grid; or electricity produced by other non-accredited renewable generation.

Installing storage will not alter the Total Installed Capacity of the RO generating station or FIT installation. For the purposes of the RO and FIT schemes, in most cases a co-located storage facility would not be considered part of the RO generating station or the FIT installation. This is because storage is not directly referenced as an eligible generating technology under either of the RO or FIT schemes, and in most cases, the storage facility will not be essential to the operation of the generating station or installation. As a result, in most cases, the co-located storage will not affect the Total Installed Capacity (TIC) or Declared Net Capacity (DNC) of the generating station or installation.

The schemes' eligibility requirements are not changed by the type of storage technology. The type of storage technology to be co-located does not affect Ofgem's assessment on the availability of support for any eligible electricity generated. In effect, the assessment is "technology neutral" in relation to storage.

The guidance outlines several scenarios relevant to SLES including different configurations of renewable generation, storage and metering. Regardless of the configuration, the onus is on the site operator to demonstrate compliance with the requirements of the RO and FIT schemes.

3.1.5 Network charges

3.1.5.1 Issue

Electricity storage and other electricity generation assets need to access the electricity networks and pay a share of the costs. Due to their flexibility, electricity storage assets can be optimised to allow users to avoid paying a proportion of the current network charges. Given the importance of storage as a technology in the future, Ofgem is currently exploring access rights, for example, connecting to and using electricity networks) and network costs. Network costs are recovered through two types of charges: 'forward-looking charges' which send signals about how much costs will increase (or decrease) with network usage, and 'residual charges' which recover the remainder of the costs. These reviews have important implications for electricity storage assets.

3.1.5.2 Targeted charging review

The Ofgem Targeted Charging Review (TCR) is a consultation on potential changes to the way in which the costs of the networks used to transport electricity to homes, public organisations and businesses are recovered (Ofgem, 2018h).

8 The RO and FIT schemes are now closed to new entry. This guidance relates to existing schemes receiving RO or FIT subsidy where co-locating electricity storage could affect their accreditation.

The TCR focuses on residual charges and balancing charges to the extent they provide benefits to particular generators.

The review has two objectives (Ofgem, 2019c):

1. Consider reform of residual charging arrangements for both generation and demand, to ensure it meets the interests of current and future consumers.
2. Keep the other 'embedded benefits'[9] that may distort investment or dispatch decisions under review.

The TCR is a complicated and technical study. It is also a live process and thus subject to change: we explored only the high-level aspects of the TCR, and the impacts for electricity storage.

On residual charging arrangements, Ofgem's 'minded to position' is to implement a fixed charge, with charges set for individuals in customer segments, with these segments based on an existing industry approach.

The impact for electricity storage is potentially negative because these residual charges are currently collected through consumption. As a result, measures that reduce demand, such as installing renewable electricity generation and a battery, can reduce these costs. A fixed charge means that these costs cannot be avoided, reducing the business case for measures that reduce demand. This approach is considered fairer to electricity consumers that cannot avoid these costs.

On embedded benefits, Ofgem proposes removing some of the remaining embedded benefits, specifically:

- Set the Transmission Generation Residual to zero, subject to maintaining compliance with the current cap on overall transmission charges to generators. This will remove a benefit to larger generators which receive a credit from these charges at present.
- Remove the Embedded Benefit relating to charging suppliers for balancing services on the basis of gross demand at the relevant grid supply point.
- Apply balancing services charges to smaller embedded generation.

According to RegenSW, the combination of removing some embedded benefits and adding balancing service charges potentially reduces the revenue prospects of distribution connected assets (Regen, 2019a).

Aurora have undertaken an analysis of the TCR on embedded battery storage projects (Aurora Energy Research, 2019). According to their analysis:

> "…the TCR changes, taken in isolation, undermine the economics of [distribution connected renewables and batteries]. Embedded battery storage projects would see higher network charges under the proposals; whilst demand response and Behind the Meter schemes would see a significant source of value removed. Batteries would be unable to make these revenues up in the Capacity Market due to their low de-rating factor. Since batteries are often deployed alongside renewables, battery economics would be further affected due to the fact that the TCR will hold back the rollout of renewables."

A further issue identified by stakeholders is that timelines of the TCR and the Ofgem Forward-looking and Access review [see next Section 3.1.5.3.] should be aligned to reduce uncertainty for renewables and storage projects.

9 According to Ofgem: Embedded benefits are payments or benefits that some smaller generators receive. This includes providing electricity to the grid when required. In June 2017 Ofgem reduced a specific payment some embedded generators received for producing electricity at peak times.

3.1.5.3 Electricity Network Access and Forward-Looking Charging Review

In 2018, Ofgem launched a Significant Code Review[10] into Electricity Network Access and Forward-Looking Charging (Ofgem, 2018h). This is a separate process to the TCR outlined in the previous section.

Ofgem's rationale for the review is that it does not think that the current electricity network access arrangements and forward-looking charges will achieve the required potential savings of £4–15bn cumulatively to 2050 through reducing capital expenditure on electricity network reinforcement, if flexible technologies can be used to help address network constraints (Carbon Trust, 2016).

The scope of the review is:

- A review of the definition and choice of access rights for transmission and distribution users
- A wide-ranging review of distribution network charges (Distribution Use of System (DUoS) charges)
- A review of the distribution connection charging boundary
- A focused review of transmission network charges (Transmission Network Use of System (TNUoS) charges)

Ofgem has also suggested that the Electricity System Operator and network companies undertake additional tasks, including:

- A review of aspects of allocation of access rights, including improved queue management and the scope for trading
- A review of balancing services charges. This is being taken forward by the Electricity System Operator through a balancing services charges task force (Charging Futures, 2019)

At this stage it is unclear what the impacts of this review on electricity storage will be.[11]

3.2 Market access

The second major theme that emerged is market access and value of electricity storage. This is an important issue as electricity storage could have multiple benefits for the electricity system, but unless storage can stack up the value available in different markets, such as balancing, capacity, and local flexibility markets, it may not make economic sense.

3.2.1 Value of storage

Electricity storage can, in principle, access multiple value streams and provide a range of essential services to the electricity system. Its potential benefits and value include (Bray et al, 2018):

- Provision of ancillary services to the System Operator and DNOs.
- Supplying electricity during outages, enhancing system stability and resilience.
- Storing power produced by renewable sources when output is high, and exporting the power when generation is low (or prices are high).
- Storing power during times of network stress or to overcome a network constraint.
- Reducing peak loads.
- Price arbitrage (taking advantage of price differences in different markets for the same asset) including charging when prices are low and also charging and discharging to avoid network charge costs (Few, 2019). (See Section 3.1.5.2 on Targeted Charging Review which is addressing this benefit).

10 The Significant Code Review (SCR) process provides a tool for Ofgem to initiate wide ranging and holistic change and to implement reform to a code-based issue (Ofgem, 2016).

11 On 6 September 2019, Ofgem released Access and Forward-Looking Charges Significant Code Review – Summer 2019 working paper. We will likely review this in a subsequent sprint (Ofgem, 2019a).

- Depending on the site, storage can reduce losses on transmission or distribution lines, as well as reducing the need for network upgrades or reinforcement by optimising supply and demand at specific locations.

Electricity storage technologies have high capital costs and access to multiple value streams is important in order to make them economic (Gissey et al, 2018).

During this review, several issues with electricity storage market access, including stacking value across multiple markets, were identified. These are summarised in the subsequent sections.

3.2.2 Balancing services

3.2.2.1 What are balancing services?

National Grid, the Electricity System Operator (ESO), procures a range of services to balance demand and supply and to ensure the security and quality of electricity supply across Britain's transmission system (National Grid ESO, 2019b). It has produced guidance on contracting, tendering and providing response and reserve services (National Grid ESO, 2019d).

Balancing services fall into several categories:

- Frequency response services – National Grid is obligated to control system frequency at 50 Hz plus or minus 1% (National Grid ESO, 2019e).
- Reserve services – Access to sources of extra power in the form of either increased generation or demand reduction to enable National Grid to manage greater than forecast electricity demand on Britain's transmission system (National Grid ESO, 2019h).
- Reactive power services – To make sure voltage levels on the system remain within a given range National Grid instructs generators or other asset owners to either absorb or generate reactive power (National Grid ESO, 2019g).
- Restoration services – Black start is a procedure to recover from a total or partial shutdown of the national electricity transmission system (NETS). Black start services are procured from power stations that have the capability to start main blocks of generation on-site, without reliance on external supplies (National Grid ESO, 2019c).
- Balancing mechanism access – The balancing mechanism is used to balance supply and demand in each half hour trading period of every day. The ESO is seeking to widen access to the Balancing Mechanism (National Grid ESO, 2019a).

Whether generators and storage facilities can access multiple markets for balancing services to stack up the value is an issue. The ESO has published guidance which clarifies the circumstances where this value stacking is possible (National Grid ESO, 2019d).

Two live initiatives were identified with a focus on increasing access to balancing:

Power Responsive

National Grid as ESO facilitates a stakeholder-led programme Power Responsive (Power Responsive, 2019) to stimulate increased participation by DSR and storage in electricity system balancing by 2020. The ESO has an ambition to procure 30–50% of its balancing services by 2020 through demand side measures (Bray et al, 2018).

Project TERRE

Ofgem, the ESO, and industry, supported by the Government, have been working to open access to the balancing mechanism through implementing the European Balancing Project TERRE – Trans European Replacement Reserves Exchange (Entsoe, 2017). These changes will, amongst other things, enable access for aggregators as well as flexibility providers connected to the distribution network. This will release another source of revenue for aggregators, and smaller storage and DSR providers, and has the potential to reduce costs in the balancing mechanism through increasing liquidity in the market (Ofgem, 2018i).

3.2.3 Capacity market access

The Capacity Market aims to ensure security of electricity supply by providing a payment for reliable sources of capacity, alongside their electricity revenues, to ensure they deliver energy when needed (BEIS, 2019a). The Capacity Market is currently at a standstill, pending a decision from the Court of Justice of the European Union.

Electricity storage facilities have bid into, and been successful in, Capacity Market auctions. However, several issues are apparent.

Recent clearing prices of Capacity Market contracts have fallen, which is proving unattractive for storage providers (Bray et al, 2018). For example, the 2017/18 T-4 Capacity Auction (i.e. capacity to be delivered in four years' time) cleared at a price of £8.40/kW/year, the lowest of all the T-4 auctions to date. For comparison, the 2016/17 T-4 auction cleared at £27.50 kW/year (Ofgem, 2018a). Of the 50.4 GW contracts awarded, just under 1 GW was energy storage (ca. 2%), with much of this being existing rather than new storage.

There can be issues where electricity storage is co-located with renewable generation as operators cannot receive support for the same generating capacity under both the RO scheme and the Capacity Market and a clear choice between schemes must be made. Ofgem has clarified that it may be possible for a storage co-located with, or supplied by, a renewable generating station or installation accredited under the RO or FIT schemes to participate in the Capacity Market without affecting scheme accreditation. However, this may depend upon the particular arrangement's generators decide to pursue (Ofgem, 2018d).

The Government has introduced changes to the Capacity Market in order that the contribution made by short duration batteries is not overvalued, which has reduced the business case these electricity storage assets (Ofgem, 2018i).

As covered in Section 3.1.3, batteries over 50MW in England and Wales can fall under the NISP framework, which can add cost and time to deployment.

3.2.4 Local network flexibility

Recently, Distribution Network Operators (DNOs) have committed to opening up network requirements to markets and competition (Ofgem, 2018i). Several DNOs have already launched tenders for flexible solutions to network issues, for example through the Piclo Flexibility Marketplace (Piclo Flex, 2019). This is a revenue opportunity for non-traditional network solutions such as storage, DSR and energy efficiency.

Ofgem and the UK Government consider this to be an element of DNOs becoming Distribution System Operators (DSOs) where they are more active managers of their networks, implementing innovative solutions as alternatives to network reinforcement.

Whilst there is an opportunity for electricity storage to access new value in distribution networks through emerging flexibility markets, potential barriers to storage also arise from how DNOs connect assets and manage their networks.

3.2.4.1 Connecting to distribution networks

Electricity storage is a flexible asset that can help alleviate network issues, such as constraints and power quality issues. However, these benefits are not recognised in the network connections process, where storage assets queue up in the same way as all other connecting parties.

One suggested approach for Government to consider is for charging models and network connection tariffs that reflect the size, use and location of the storage connection (Bray et al, 2018). This has been recognised in the BEIS and Ofgem Smart Systems and Flexibility Plan, which notes (Ofgem, 2018i):

> "Network connection rules were not designed with storage in mind, which can lead to a number of issues including a lack of understanding of how storage connections should be treated (by both network operators and connecting customers) and the cost and time of connecting."

The Plan update comments that some action is underway:

- SSE and WPD have published fast-track approaches for connecting small-scale storage systems to the network. This follows a similar approach published by UK Power Networks in 2017.
- The Institution of Engineering and Technology has published a code of practice which includes network connections for storage systems.
- The Government introduced regulations allowing DNOs to charge assessment and design fees to recover the costs of providing connections offers, which will enable improvements to be made to the connection process.
- The Energy Networks Association (ENA), through the Open Networks Project, has established a working group to improve the connections process, and consulted on whether to promote flexibility providers, including storage, within the connection queue.

Distribution and transmission network access rights are part of a current Significant Code Review, covered in Section 3.1.5.3.

3.2.5 Incentivising storage

The review identified several schemes to incentivise or accelerate electricity storage, summarised below. These are all from the Smart Systems and Flexibility Plan update (Ofgem, 2018i):

- To date, Government has supported the creation of the £78 million Faraday Institution to speed up research into battery technologies; the £80 million UK Battery Industrialisation Centre (UKBIC) to help upscale the supply chain; and, collaborative research and development projects, including improving battery lifespan and range, and how to reuse, re-manufacture and recycle batteries at their end-of-life.
- Storage has been trialled through Ofgem's electricity Network Innovation Competition, with £600 million available between 2013–2021, but further trials may be needed outside the parameters of these competitions.
- The Government launched a competition to reduce the cost of large-scale energy storage technologies (including electricity storage, thermal storage, and power-to-gas technologies). Funding has now been committed, and projects are underway and due to complete in 2021.
- The £102.5 million Prospering from the Energy Revolution competition will develop and demonstrate integrated local energy solutions across power, heat, and transport to provide cleaner, cheaper, and more resilient energy for consumers.

3.2.6 Potential issues identified

Two issues were identified by stakeholders through the crowdsourcing process where we were unable to verify the issue itself or whether action is currently being undertaken. These are summarised with the relevant reference below.

Battery trip units (BTU) are utilised in industrial areas where DC supply in switch rooms and substations is required for the protection of a power distribution device against faults. There is a grey area on guidelines for safety tests/alarms which has led to sites having issues at substations with BTU (Department of Health, 2017).

Another issue relates to behind-the-meter batteries, and whether such batteries could be aggregated together by businesses or homes to enable 'flexible connections' to the grid, so the batteries themselves can be part-funded through avoided cost of the electricity network reinforcement investment (Hilson Moran, 2018).

3.3 Summing up – relevance for SLES

Our review identified a range of policy and regulatory issues and opportunities for electricity storage. Several of these relate to how storage is defined, which affects who can own and operate it, what electricity system costs storage facilities must pay and what value streams it can access, and what happens when it is co-located with other assets, such as renewable electricity generation.

Clarity for definitions, ownership and market access

Some clarity has been provided by the introduction of a formal definition of storage as a generation asset. This addresses the issue of electricity storage (local or otherwise) being double charged. There are also now clear rules around who can own and operate electrical storage assets on the electricity distribution networks; those holding a DNO licence must not engage in generation activities, which now explicitly includes storage.

In addition, emerging clarity and new opportunities are arising in the markets that electricity storage can access. The ESO is seeking to ease access to multiple Balancing Services markets for storage and other flexible resources, such as demand-side response. DNOs are opening competition for flexibility services as they transition to DSOs.

Capacity market access and planning complications

On the downside, the Capacity Market, currently at a standstill pending a court decision, looks like a less attractive source of revenue for electricity storage as clearing prices have been falling, and short duration batteries have been de-rated reducing their business appeal.

With regard to the two proposals made by BEIS on how electricity storage is treated in the planning system, the Electricity Storage Network has raised concerns that the NISP regime could add cost and time to the development of projects over 50MW (and consequently, few such projects are under development). This could affect the size of storage being deployed, locally or otherwise.

Uncertainties for network charging

The largest uncertainty for electricity storage assets is focused on the two Ofgem Significant Code Reviews currently underway, the Targeted Charing Review (TCR) and the Electricity Network Access and Forward-Looking Charging Review. Analysis by Aurora suggests this will reduce the business case for electricity storage by imposing new charges and reducing sources of value. At this stage it is unclear whether the second of the reviews might improve the business case for batteries. Many stakeholders are asking for the timelines of the two reviews to be better aligned in order to reduce uncertainties.

Overall, it is quite a complicated picture for electricity storage, with apparent opportunities and uncertainties. Many of the issues are recognised by Government and regulators, but it may be a few years before there is clarity of some of the main issues, such as the contribution of storage to residual and forward-looking charges.

4 Findings – Electric Vehicles

4.1 Context

Even before committing to a net zero target, the UK Government said it would ban the sale of new conventional petrol and diesel cars from 2040, whilst the Scottish Government is aiming for a ban by 2032 (which is more in line with recommendations from the Committee on Climate Change (CCC), along with many others).

One of the main strategies to decarbonise transport is to increase the adoption of 'ultra low emission vehicles' (ULEVs), a category which includes electric vehicles (EVs).[12] Several Government strategies released in the last few years make specific reference to increasing the uptake of EVs, including:

- The Smart Systems and Flexibility Plan (BEIS, 2018d) (July 2017, progress update October 2018)
- The Industrial Strategy (BEIS, 2017a) (November 2017, progress update October 2018 – BEIS, 2018b)
- Automotive Sector Deal (BEIS, 2018c) (January 2018, part of the wider Industrial Strategy)
- The Clean Growth Strategy (BEIS, 2018a) (October 2017)
- The Road to Zero (Department for Transport, 2018) (July 2018)
- The Clean Air Strategy (Defra, 2019) (January 2019)

Box 1: Electric vehicles

The term 'electric vehicles' encompasses different types, which are classified depending on the extent to which electricity can be used to power the motor. Some common examples are

Battery electric vehicles (BEVs)

- Powered only by electricity, as they do not have an internal combustion engine (ICE) (also known as 'pure', 'fully-' or 'all-' electric vehicles)
- Battery is charged by an external source
- Produce no tailpipe emissions

Plug-in hybrids (PHEVs)

- Have both an ICE (petrol or diesel) and an electric motor (battery-powered) – either or both can be used to drive the vehicle with a typical range of 30 miles on electricity
- Battery can be recharged by plugging in to an external power source
- Tailpipe emissions from ICE

Hybrid electric vehicles (HEVs)

- Have both an ICE and an electric motor
- Cannot be plugged in; the battery is recharged through regenerative braking (capturing 'wasted' energy from braking)
- Tailpipe emissions from ICE

12 At the time of writing, an ultra low emission vehicle is defined as one emitting less than 75 g/km of CO_2. This limit reflects current technology standards, and will change as advancements lead to vehicles with even lower emission levels; from 2021, the limit will be 50 g CO_2/km) (Energy Saving Trust, 2019).

The UK stock of electric cars grew from fewer than 4000 in 2013 to around 200,000 in 2019 (to date). Despite the significant increase, electric vehicles represent just 0.6% of the market share of the 35 million vehicles in the UK (UK Research and Innovation, 2019). Whilst plug-in hybrids (PHEVs) have tended to hold a higher overall market share than the fully electric battery EVs (BEVs), which have lower emissions, recent statistics from the Society of Motor Manufacturers and Traders (SMMT), suggest that this is changing (SMMT, 2018). In August 2019, the SMMT reported a year-on-year increase in BEV vehicle registrations of 93.1%, whilst new PHEV registrations decreased[13] by 37% in the same period (National Grid ESO, 2019g). The total number of plug-in electric vehicles in the UK has gone up since the previous year, despite the overall number of new car registrations going down (National Grid ESO, 2019g).

Most scenarios show that EVs will be a key component in meeting both carbon reduction and air quality targets. In their 2019 Future Energy Scenarios report, National Grid indicates that there could be up to 11 million electric vehicles by 2030 and up to 35 million by 2050 (National Grid ESO, 2019). A fully electric transport sector will be a major challenge to our grid infrastructure from the potential increase in total and peak electricity demand. The issues will predominantly affect the low voltage, local distribution networks, since it is expected that most people will plug in when they get home, when the grid is already working at near-capacity. EVs could therefore have a significant impact on local networks, which is a challenge that SLES will need to overcome.

From this review, we identified two major themes – accelerating EV uptake and managing the resultant electricity demand of EVs.

4.2 Accelerating EV uptake

Since the market share of EVs is still very small (less than 1%), it is unsurprising that the most common topics that arose in this review were related to the Government's strategy to accelerating the uptake of EVs across the UK. The approach involves making EVs more affordable, and establishing a charging network that is convenient and functional.

4.2.1 Reducing the financial burden

Despite estimates that EVs are already cheaper to run in the long term than their petrol or diesel counterparts, their upfront cost is a major barrier for many (Wappelhorst et al, 2018). Part of the Government's strategy is therefore to accelerate EV uptake by making it more affordable to buy an EV through schemes such as the Plug-in Car (Office for Low Emission Vehicles, 2018b), Taxi (Office for Low Emission Vehicles, 2018d), Motorcycle (Office for Low Emission Vehicles, 2018c) Grants, and Electric Vehicle Loan (Energy Saving Trust, 2020) (Scotland only).[14]

These are temporary measures, however, and have already been reviewed in line with Government objectives (Energy Saving Trust, 202). As the technology and market both mature, the upfront cost barrier of EVs should be reduced.

4.2.2 Increasing access to chargepoints

The UK currently doesn't have enough chargepoints for users to feel confident that they can plug in whenever and wherever they need to, which is frequently cited as a barrier to mass EV market adoption (Automotive Council UK, 2018; Department for Transport, 2019a; Department for Transport, 2019b; Office for Low Emission Vehicles, 2019b). Other issues include the physical space required for chargepoints.

13 This decrease in PHEV registrations has been linked to a change in the eligibility criteria of the Government's Plug-in Car Grant, which reduces upfront costs of low emission vehicles. Changes in parameters (such as emissions) now excludes many PHEVs from receiving the grant (Financial Times, 2019).

14 Information regarding the level of support and eligibility of these grants can be found on the Government's (Office for Low Emission Vehicles, 2018a).

For example, to be eligible for the Government's Electric Vehicle Homecharge Scheme (EVHS) (Office for Low Emission Vehicles, 2019a), applicants must have access to off-street parking, which is a clear barrier for many, particularly in cities where the requirement for ultra-low emission vehicles is arguably highest due to the increasing number of low emission zones.

The Government therefore wants to increase the number of chargepoints throughout the country, in homes and across the public network.

4.2.2.1 Home charging network

Around 98% of journeys in the UK are under than 50 miles (Department for Transport, 2019a; Department for Transport, 2017) and it's expected that the majority of EV users will charge at home (around 80%, if today's charging patterns continue) (Renewable Energy Association (REA), 2018). As a result, many users may never need to use a public charging point. The EVHS already exists to help individuals with off-street parking with the costs of installing a chargepoint in homes.

This retrofitting of existing buildings is, however, expensive. Looking towards a future where EVs are the most commonly used form of personal transport, the EU amended the Energy Performance of Buildings Directive (EPBD) to mandate that all member states set minimum requirements for chargepoints in new residential and existing non-residential buildings (European Commission, 2018). The UK Government is currently seeking views on its proposals to meet these commitments through the Department for Transport's open consultation on Electric Vehicle Charging in Residential and Non-Residential Buildings (closing date 7th October) (Department for Transport, 2019a). This would see a requirement for electric vehicle charging infrastructure in new residential and non-residential buildings in England.

It would also have implications for some new and existing non-residential buildings, such as workplaces and supermarkets.

For the most part, the UK Government's proposals go further than the new elements of the EPBD which was revised in April 2018. Building Regulations are, however, a devolved matter. It is unclear at this point what the Devolved Administrations are planning to do, although they must include something in national law by 10th March 2020.

The Government also provides funding (which was recently doubled) for local authorities to provide chargepoints on residential streets (Department for Transport and Office for Low Emission Vehicles, 2019b), to address the fact that not everyone has access to off-street parking (especially in cities). In addition to this, local authorities can access the Implementation (Defra, 2018a) and Clean Air (Defra, 2018b) Funds to improve EV charging infrastructure where appropriate.

4.2.2.2 Public charging network

To provide drivers with confidence and to enable longer distance journeys (particularly important for goods vehicles), efforts are being made to develop the EV charging network across the UK's strategic road network. The AEV Act 2018 gave the UK Government the powers to require large fuel retailers and service area operators, for example, along motorways, to provide access to public chargepoints (HM Government, 2018).

UK Government

The UK Government and Highways England are investing a combined £95 million to ensure rapid chargepoints are available every 20 miles across 95% of England's Strategic Road Network (BEIS, 2017b).

Importantly, all chargepoints in the UK are owned and operated by private companies,[15] and although it continues to provide support for the development of public EV charging infrastructure, the Government 'will not own or operate a chargepoint network now or in the future' (Department for Transport, 2018). The strategy therefore is to 'encourage and leverage private sector investment to build and operate a self-sustaining public network' (Department for Transport, 2019b).

The Government recognises that local authorities in the UK also have a role to play, particularly in overcoming barriers related to parking. The On-street Residential Chargepoint Scheme (which has recently received a further £2.5 million of funding (Department for Transport and Office for Low Emission Vehicles, 2019b), doubling the amount initially made available) provides funding to local authorities, on a first-come, first-served basis, to install chargepoints on publicly-owned residential streets, targeting those without access to off-street parking (Department for Transport, 2018). Two additional funding schemes – an implementation fund and the Clean Air fund – can be also used by local authorities to minimise the impacts of local plans on individuals and businesses, and could therefore cover EV charging infrastructure development (Defra, 2019).

Devolved Administrations

The Scottish Government intends to phase out the 'need' for new petrol and diesel cars and vans by 2032, a more ambitious target than that of the UK Government (2040) (Scottish Government, 2017). They do, however, assert that many of the fiscal levers – such as vehicle standards and taxation – lie outside of the Devolved Administration's control, but have published their own strategies which set out policy proposals.

Transport Scotland's 'Switched on Scotland Roadmap' was first released in 2013 specifically to encourage widespread adoption of plug-in vehicles. To build on this strategy, 'Phase Two' was published in 2017 and set out a 10-point action plan (Transport Scotland, 2017). Amongst these actions is a notable recognition that local authorities are uniquely positioned to understand the needs of their communities; Action 8 is to 'Support local authorities in deploying measures that encourage adoption of EVs,' although the nature of the support isn't outlined further.

Similarly to the UK Government, the Scottish Government has pledged to improve access to public chargepoints on strategic roads by enabling the development of an 'electric highway' on the A9, although it has not set specific targets on the number, distribution or technical specifications of chargepoints, as well as the creation of 20 'electric towns' (Scottish Government, 2017).

The Welsh Government has also pledged funding to improve access to public charging points (Department for Transport, 2018). We were not able to find evidence of a pledge in Northern Ireland.

4.2.3 A safer, more user-friendly charging network: interoperability and minimum standards

No standard definition for interoperability currently exists in the context of EV charging infrastructure (REA, 2018), but it is generally accepted that a fully interoperable network would allow any user to plug any (certified) EV into any chargepoint on the network, regardless of its operator.

Technical standards in this context refer to the specifications and protocols of the chargepoint which define the performance requirements, such as charging speed and cyber security, and covers both the physical infrastructure as well as access and payment methods (REA, 2018).

15 A 'charge point' (or chargepoint) is defined, in the AEV Act 2018, as 'a device intended for charging a vehicle that is capable of being propelled by electrical power derived from a storage battery (or for discharging electricity stored in such a vehicle)' and is classed as 'public' if it is provided for use by members of the general public.

4.2.3.1 Why is it necessary?

An industry-led approach to development of the charging network poses the risk of limiting access to chargepoints across the network because of a lack of compatibility, technological or otherwise, for example, restricting usage to customers of the chargepoint operator through a contract. It has so far resulted in users needing apps, cards and/or membership accounts to access chargepoints, which has restricted access and become another potential barrier to EV uptake (REA, 2018). Implementing interoperability requirements at this relatively early stage of infrastructure development could reduce these barriers.

The amount and nature of data handled and transmitted by smart chargepoints means that cyber security – both for the grid and for consumers – is of high importance. Smart charging also involves remote control of a high-energy device, potentially when the owner/user is not present, for example, a chargepoint responds to signals when the vehicle is plugged in for an extended period of time, such as overnight, and consequently introduces safety concerns (Department for Transport and Office for Low Emission Vehicles, 2019a).

To achieve a fully interoperable charging network that provides adequate protection for both consumers and the grid, chargepoints must all meet a minimum set of technical standards.

4.2.3.2 What's being done?

There are already safety laws and guidance in place that provide a framework which cover, by extension, chargepoint installations and products.[16]

The Government requires compliance with some of these existing regulations for any chargepoint installed under the Electric Vehicle Homecharge Scheme (Department for Transport and Office for Low Emission Vehicles, 2019a), and has made moves to ensure some standardisation across all chargepoints.

The Alternative Fuels Infrastructure Regulations 2017 aims to improve interoperability. Since 17 November 2018, infrastructure operators have been obliged to ensure that:

- All public chargepoints, including those already installed, provide 'ad-hoc' access for electric vehicle users, i.e. users do not need a pre-existing contract;
- Chargepoint connectors meet minimum technical specifications; and
- The geographic location of all chargepoints is made publicly available.

The Government commissioned the British Standards Institute (BSI) to develop 'appropriate technical standards of energy smart appliances (EV chargepoints included)', the results of which are expected in 2020 following a period of public consultation (Department for Transport and Office for Low Emission Vehicles, 2019a). Since EV infrastructure interoperability has implications beyond the UK, it is notable that this process is taking into account European and International standards.

The AEV Act 2018 gave Government the powers to impose further requirements for standards, such as payment methods, performance, maintenance and components. In line with the policies set out in the Road to Zero (Department for Transport, 2018) the Government plans to take forward these powers and is currently seeking views on its proposals to do so through its Electric Vehicle Smart Charging Open Consultation (with a closing date of 7 October 2019) (Department for Transport and Office for Low Emission Vehicles, 2019a).

16 For example a) Electricity Safety, Quality and Continuity Regulations b) IET Wiring Regulations (BS 7671) c) IET Code of Practice for Electric Vehicle Charging Equipment Installations d) Electric Vehicle Conductive Charging System standard (BS EN 61851) e) Highways and Electrical Registration Scheme (for installations on a public highway) f) The Low Voltage Directive and Electrical Equipment (Safety) Regulations g) The Electromagnetic Compatibility Regulations h) The Health and Safety at Work Act i) Building Regulations (Department for Transport and Office for Low Emission Vehicles, 2019a).

4.3 Managing the increased uptake of EVs

The second major theme that emerged during this review focuses on managing the consequences of an electrified transport sector.

Successful initiatives to accelerate EV uptake will require network operators to manage significantly increased electricity demand. The issues will mainly manifest at local electricity distribution networks, since most EV owners are expected to plug in at the same time and during peak demand. Ofgem have estimated that 32% of the low-voltage networks across the UK would need costly upgrades once 40% of customers have EVs (My Electric Avenue, 2016).

However, the EVs themselves could actually be part of the solution by contributing to a smart and flexible energy system. It is already recognised that the current network will rapidly become unfit for purpose if the same usage patterns continue. Without some level of control of EV charging, low voltage substations could breach their constraint levels which could cause problems for both users and the grid.

4.3.1 Smart charging

The UK Government is taking steps to ensure that all chargepoints have 'smart' capabilities:

> "…so that consumers become more familiar with the concept and have the option to take advantage of it if they wish."
> (Office for Low Emission Vehicles, 2019b)

4.3.1.1. What is it?

The Department for Transport defines smart charging as 'shifting the time of day when an EV charges, or modulating the rate of charge at different times, in response to signals (e.g. electricity tariff information)' (Department for Transport and Office for Low Emission Vehicles, 2019a).

In other words, smart charging would allow either the user or the operator to change the speed or delay the onset of charging, based on variables such as demand and carbon intensity of the grid, or based on price signals.

4.3.1.2 Why is it necessary?

Without some level of control over charging, electrifying the transport sector could require a significant increase in peak power generation (Crozier et al, 2018). This would put huge pressure on the electricity grids, particularly at local levels since it's expected that most people will charge their EVs at home and at times of peak demand (Regen, 2018). As a result, mass uptake of EVs might could cause low voltage substations to breach their constraint levels. Smart charging is expected to provide some protection for both consumers and the grid by giving the operator the power to delay the onset of charging or alter the speed of charging to manage grid stability.

4.3.1.3 What's being done?

The Alternative Fuels Infrastructure Regulations 2017 (HM Government, 2017) is a statutory instrument which transposes EU Directive 2014/94/EU on the deployment of alternative fuels[17] infrastructure. It obliges operators of public chargepoints to comply with requirements for 'intelligent' metering systems: this is defined as simply being able to 'measure energy consumption, providing more information than a conventional meter and can transmit and receive data using a form of electronic communication'.

The Automated and Electric Vehicles (AEV) Act 2018 (Automotive Council UK, 2018) goes further than this and specifically creates regulations relating to the installation and operation of charging points for electric vehicles in the UK. Section 15 gives the Government the power to oblige operators to ensure that all chargepoints hold smart charging capabilities.

17 An alternative fuel, as defined in the Directive, means a fuel or power source which serves, at least partly, as a substitute for fossil oil sources to supply to transport (thus including electricity) (HM Government, 2017).

As well as the functions mandated by the Alternative Fuels Infrastructure Regulations 2017, this Act makes it clear that chargepoints should be able to 'react to information, for example, by adjusting the rate of charging or discharging' and also be accessed remotely, which are two main functions for smart charging.

Government-funded home chargepoints (under the Electric Vehicle Homecharge Scheme) must already use smart technology from July 2019 (Department for Transport, 2019b), and a public consultation on Electric Vehicle Smart Charging (Department for Transport and Office for Low Emission Vehicles, 2019a) was open until 7 October 2019 which outlined the Government's proposed phased approach to put into force the powers given by section 15 of AEV Act to set requirements.

In the first phase, the preferred approach outlined in the consultation is to mandate that all new non-public chargepoints would be required to have smart functionality and meet a minimum set of standards. A second phase would see requirements extended to the operators of the chargepoints. The consultation seeks views on the proposed regulations for the first phase which will initially require compliance with British Standards Institute (BSI) standards currently under development. Government holds the view that there is not yet enough evidence to determine what the long-term requirements of the second phase should be, so the consultation also contains a call for evidence. It proposes that a decision on this course of action should be made between 2020–2022 for implementation in 2025.

Importantly, the proposal covers only non-public chargepoints. Public chargepoints must conform to requirements set out in the Alternative Fuels Infrastructure Regulations, i.e. are 'intelligent', but there is no obligation to make them 'smart'. It also stipulates that consumers should "ideally" be able to choose how – and indeed if – they use the smart functionality.

4.3.2 EVs as storage

An electric vehicle contains a sizeable battery,[18] and so could provide an additional route to flexibility in the form of storage. Smart charging and bidirectional charging functions enable 'vehicle-to-grid' (V2G) technology to allow EVs to export electricity back to the grid. As a pooled resource, then, the nation's growing EV fleet could provide valuable grid services such as demand side response and voltage regulation.

This technology is still in the development stage; Government support is mostly in the form of funding for research and development, including £20 million over five years (to 2023) allocated in the Clean Growth Strategy (BEIS, 2017b) for V2G products and services as part of wider support for innovation in storage and DSR, and £30 million allocated in the Industrial Strategy (BEIS, 2017a) for new business models, consumer awareness and technological solutions supporting vehicle/grid interactions.

The increasing importance and use of electric storage has exposed some challenges with the current regulatory framework, details of which are discussed in Section 3 above.

4.3.3 Distribution of costs

The current situation means that consumers in vulnerable situations who are, in general, unable to share in the benefits of EVs, will, in effect, be subsidising early adopters of EVs who are already benefiting from cost-savings. In addition, even with smart charging and advanced V2G capabilities, it is likely that the grid will need significant upgrades. Ofgem estimates that 32% of the low-voltage network will need upgrading when 40% of customers own EVs.[57] These upgrades are disruptive and costly, and devising the fairest way of distributing these costs is essential. Ofgem recognises that:

18 Batteries capacities in battery electric vehicles are typically up to 50 kWh for average-sided cars, and up to 100 kWh for high-performance cars and larger vans (BEAMA, 2015). For comparison, the typical weekly household electricity consumption is on the order of 70 kWh (OVO Energy, 2019; Ofgem, 2017b).

> “The regulations that govern the energy sector were not explicitly designed with the foresight of EV charging and bundled energy and transport services.”

It also recognises that major changes in how network costs are distributed are needed as a result. It is therefore undertaking two major reviews of network charges, the Targeted Charging Review (Ofgem, 2018h) and the Electricity Network Access and Forward-Looking Charging Review (Ofgem, 2018b). Details of these reviews are covered in Section 3.1.5.

4.4 Summing up – implications for SLES

This review provides a snapshot of the current policy and regulatory environment for electric vehicles in the UK. The Government expects that the industry will develop 'one of the best EV charging networks in the world,' and is providing support mainly in the form of funding to try to accelerate this. Recognising that this industry-led approach could result in a medley of chargepoint types and a headache for users, it is ramping up its actions to set some ground rules on minimum specifications and compatibility. The industry and the Government have already identified some of the challenges of increased electricity demand and are taking pre-emptive measures. Technological advancements, particularly in V2G capabilities will hopefully help, but are raising more questions about regulation in a future where the boundaries between sectors such as energy and transport are increasingly blurred.

Whilst a number of the issues identified are national in nature, there are implications for SLES in particular.

SLES could help manage the increase in electricity demand from EVs

The suite of Government initiatives (Road to Zero Strategy, Smart Systems and Flexibility Plan etc.) designed to increase EV uptake seems set to add significant local EV charging infrastructure. Managing the consequences of electrifying our transport will be a challenge that is intensified for local distribution networks.

SLES which allow grid reinforcement to be deferred could have a particularly high impact in the energy transition.

Network charging reviews could have an impact on revenue streams

The outcomes of the Ofgem network charging reviews are, however, likely to affect the economics of storage and local renewables as Ofgem tries to address market distortions and distribute costs more fairly. Players will need to keep an eye on movements in this area when assessing revenue streams and establishing successful business models.

Smart infrastructure will be essential for SLES

There is an opportunity to make this infrastructure 'smart ready' and interoperable so that SLES are in a good position to manage EV uptake and reap the potential rewards, including having a substantial fleet of EVs to provide network flexibility.

Ensuring interoperability is built into this EV infrastructure is critical to improving the user experience – expected to be a crucial factor in driving uptake – and reducing tech redundancy, for example, non-compatible chargepoints in close proximity. It is also an opportunity to develop a smart charging EV charging infrastructure if common signals, such as price signals, can be passed across all chargers. This will help SLES to manage local energy supply and demand, as smart charging capabilities are vital for flexible energy systems: it will be beneficial for vehicle-to-grid technologies and allows charging patterns to be managed. As EV uptake increases, this will be especially important at the local level.

5 Discussion

Our review has cast some light on issues that may recur in future subjects, as well as issues specific to the activities reviewed. Whilst electricity storage and electric vehicles share batteries in common, they are not the same activities, and with differing issues. However, our review has raised several common themes.

As the energy system decarbonises, many new technologies such as electric vehicles and electricity storage will be deployed at the local level. These technologies can be different – physically, operationally, etc. – to traditional energy technologies, even if they ultimately serve a similar purpose. For example, in some ways a large battery provides similar services to that of some forms of flexible electricity technologies, such as flexible generation. Because they are new, the rules and laws of the system in which they are deployed can lead to issues, creating opportunities and barriers. An obvious issue here is that the evolution of the energy system – and the corresponding governance and rules – has resulted in a design that, today, works on a national level, but which makes it hard for local assets to operate successfully.

For example, with electricity storage, a lack of official definition created a risk for owners and operators that their asset could be double-charged for electricity system costs, which was a barrier to deployment. However, solving this issue alone has not resolved the business case for electricity storage. Electricity storage, particularly batteries, create maximum value when they provide a range of services across the energy system (local and national).

Currently, such assets struggle to maximise their value because market rules cause barriers and some markets, such as local flexibility markets, are immature. In addition, as a new asset class, planning rules are playing catch-up and knowledge of the technology, particularly amongst local planning authorities, is incomplete, potentially causing issues with new projects. In order to create an favourable environment for local electricity storage, all these issues will need to be addressed.

Another issue is the knock-on impacts created by ambitious greenhouse gas targets. EVs are a perfect example. Ambitious targets indicate that transport must be decarbonised and EVs are a technology that, assuming the power sector decarbonises as well, can contribute massively. As a result, EVs need to be incentivised. However, mass deployment of EVs has knock-on effects on the electricity system, as if all EVs charge at the same time, it adds significantly to peak demand with commensurate requirements for new electricity generation and network infrastructure – some of which might not be low-carbon, for example rapid response open-cycle gas turbines. EVs need to charge in a way that minimises this impact, hence the need for a smart approach to EV charging.

This review has shown that both issues are in hand. There are incentives for EVs, and the Government is legislating for smart charging. The important balance is how to do both, without one creating issues for the other. For example, if EV rollout is faster than the development of smart charging approaches, or if smart charging approaches reduce the economic or desirability of EVs, meaning rollout is slower than required.

Increasingly, successful businesses are adopting user- or consumer-centric business models, and perhaps there are lessons to be learned for EV charging and other energy related businesses. Designing propositions around user needs could be a route to maximising uptake and benefits. This also requires policy and regulation to be aligned so that such user-centric propositions are permitted in the market, and that they have access to the information and resources that they need, such as data.

The visibility of new assets, both locally and nationally is an important issue to resolve. For both electricity storage and EV charging infrastructure visibility of assets is important for in order to comply with rules and regulations (for example, proof of ownership of electricity storage), accessibility of assets (for example, information about where public EV charging infrastructure is located) and also, potentially, for energy system operation (for example, assets in specific locations such as electricity storage and smart EV charging infrastructure could be important for managing localised grid issues). In addition, given that new assets can both harm (for example, EVs can cause additional stress on electricity generation and networks) and help (for example, electricity storage can alleviate system issues), it is important that these assets are visible to the system and all appropriate markets so that they can play a full role in smart local (and national) energy systems.

The bigger picture

This is the first sprint in our wider review process. As we complete more of these sprints on other topics, we will to build up a picture of the current system, with a view to identifying barriers and enablers for SLES. Clearly, there are issues with the current policy and regulatory framework surrounding SLES. Some of these are known and are being acted upon, some are known but are not yet being addressed, and others, undoubtedly, are unknown. By conducting these reviews, we aim to build up a baseline knowledge of today's environment so that we have a strong understanding of what – and how – things need to change so that SLES can deliver the benefits they are capable of and avoid repeating the mistakes that have led to the flawed system we currently have.

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Appendix: Systematic review results

Crosstabs were generated using the EPPI-Reviewer software to help identify emerging themes within and across the two topics. Each cell in the crosstab indicates the number of distinct pieces of evidence containing the two corresponding codes. For example, 10 documents coded with 'Storage' are also coded with 'Government incentives'. Table 2 shows the crosstab of activities (Storage and EV charging infrastructure) against cross-cutting issues, Table 3 is a crosstab of activities against position in the energy value chain, and Table 4 is a crosstab of all activity codes against each other.

The latter crosstab begins to give an insight into how component parts of the energy system interact with each other. As we continue with our wider review process and look at other topics, we will build up a more complete picture of the energy system, where its component parts sit within the value chain and how they relate to each other, as well as the cross-cutting issues that emerge.

It should be noted, however, that due to the nature of some of the reviewed documents, the crosstabs do not necessarily indicate relationships between activities and issues. Documents covering a wide range of topics (such as Clean Growth Strategy and Industrial Strategy) were given multiple codes that do not relate to each other. For example, in Table 4, there are three instances of 'Heat' and 'EV charging infrastructure' coded in the same document; no relationship between heat and EVs emerged, but both are talked about in at least three documents.

Once all documents were coded in EPPI-Reviewer, thematic analysis was performed in NVivo to identify true relationships and emerging themes.

Table 2: Crosstab of activity (storage and EV charging infrastructure) vs cross-cutting issues

Code	Storage	EV charging infrastructure
Flexibility	12	9
Government incentives	10	9
Behaviours	1	1
Local authorities	5	6
Local Energy	7	7
EU	8	10
Benefits/issues	2	1
Consumer protection	1	3
Industry codes	2	1
Planning	1	1
Resources	2	2
Security of system	2	1
Smart	11	10

Table 3: Crosstab of activities (storage and EV charging infrastructure) vs energy value chain		
Code	**Storage**	**EV charging infrastructure**
Supply	4	2
Generation	17	7
Transmission and Distribution	12	8

Table 4: Activities vs activities cross-tab							
Code	**Aggregator**	**Electricity**	**Grid service platforms**	**Heat**	**Market integration platforms**	**Storage**	**EV charging infrastructure**
Electricity	0	5	0	1	0	4	3
Storage	4	4	4	2	3	35	14
EV charging infrastructure	3	3	3	3	2	14	36
Heat	0	1	0	3	0	2	3
Aggregator	4	0	3	0	2	4	3
Grid service platforms	3	0	4	0	3	4	3
Market integration platforms	2	0	3	0	3	3	2

Annex: Quick scoping review methodology

Rationale for the review

This review is an important baseline of knowledge for WP3.1 and for the wider EnergyREV consortium, as it outlines the current policy, regulatory and market environment for SLES. There is no equivalent resource available for the UK. There is, however, ad hoc evidence from the SLES demonstrators and other actors (for example, IGov, 2019) that the current policy and regulatory arrangements are complicated and ill-suited to local energy.

This review provides a foundation for understanding which aspects of policy, regulatory and market environment are preventing SLES from realising their potential. It also helps to understand common and specific issues across different local energy projects and initiatives. Evidence of these are important to guide issues brought to the EnergyREV Policy Contact Group.

Objectives and focus of the review

This review collates, analyses and describes the evidence on the current policy, regulatory and market environment in relation to the activities of (smart) local energy system organisations and projects in the UK. We used an agile and open approach, crowdsourcing information held by stakeholders. We will applied a systematic approach to reviewing the evidence.

Approach

A quick scoping review (QSR) is a type of evidence review defined by the UK Civil Service (Defra, 2016) as:

> "A type of evidence review that aims to provide an informed conclusion on the volume and characteristics of an evidence base and a synthesis of what that evidence indicates in relation to a question."

It is less time and resource intensive than a full systematic review, however the same methodology is applied in order to be transparent and minimise bias. It should be noted that whilst sourced evidence was assessed against a set of minimum inclusion criteria, no formal critical appraisals were carried out. Where evidence has been published by Government agencies, departments or public bodies, assessment of the evidence is deemed unnecessary.

Beyond this, only evidence deemed robust enough for inclusion cleared the screening stage. The flow chart in Figure 2 indicates the steps taken throughout the process.

In the initial stages, important pieces of evidence were identified from the background knowledge of the authors and colleagues. The literature search was conducted in two stages:

1. Crowdsourcing via a 'networks of networks' approach; and
2. Online search using defined search strings. Titles and summaries (where available) were screened for relevance, and literature that passed this stage were keyworded, text coded and stored using EPPI-Reviewer software.

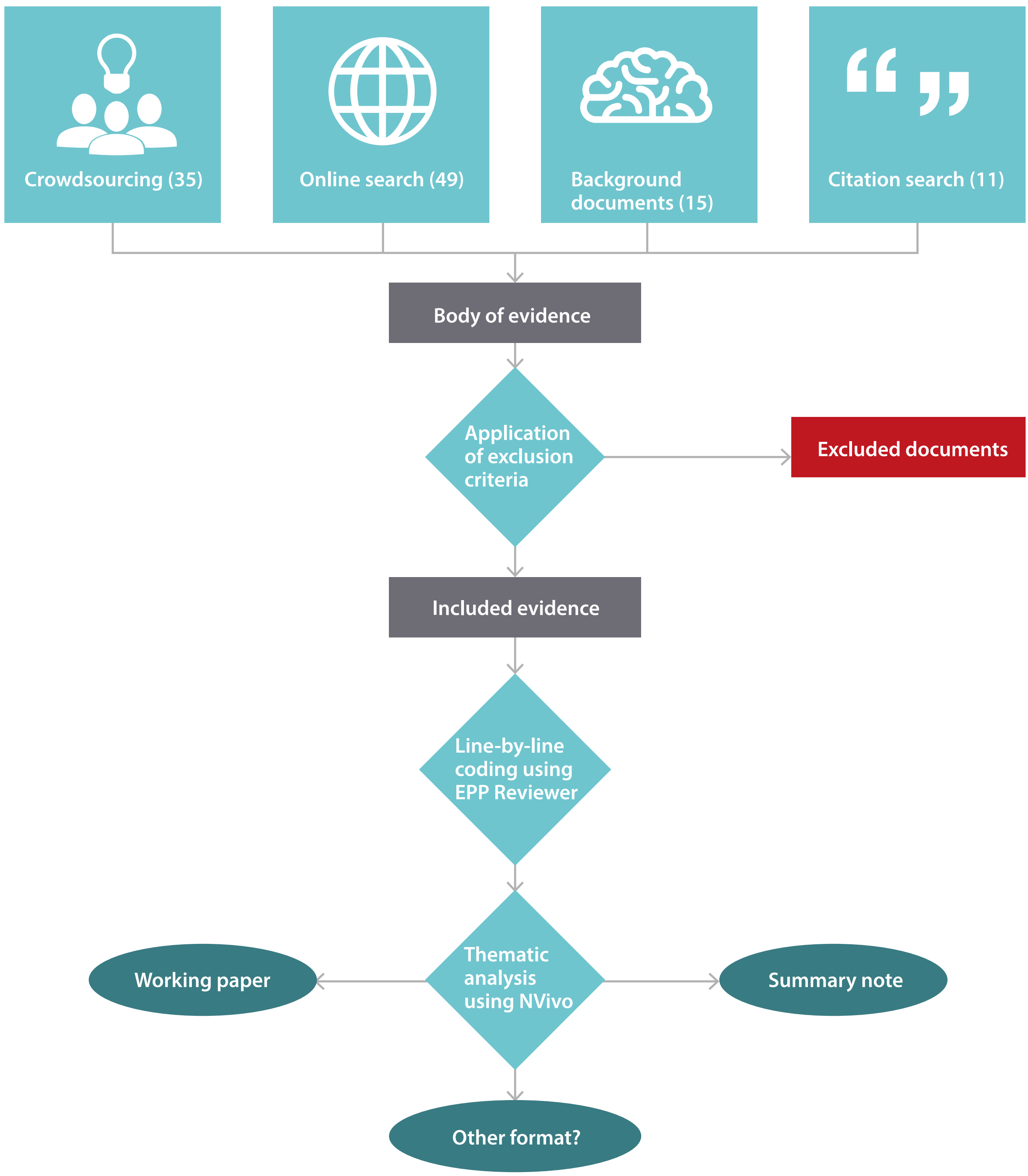

Figure 2: Flow chart indicating the steps in the review process

Applying "Agile" principles

Agile project management, conceived for software development but now used widely for project management (Ciric, 2017; Manifesto for Agile software development, 2001), adopts iterative approaches to planning and process. It puts a focus on harnessing change for customer benefit, and facilitates early and continuous delivery of valuable outputs.

Our main stakeholders seek rapid research to enable timely decision-making – we have therefore adopted Agile-inspired principles throughout this process.

The overall review was conducted via a series of 'sprints' or mini-reviews in which a defined set of topics or areas of the literature were chosen, and the search and quick scoping review process completed within a set period of time (1–2 months). This process was repeated until a sufficient coverage level was reached.

Selection and prioritisation of topics included in each sprint was initially conducted by considering the proposed activities of the PFER demonstrator projects. For example, since all four projects involve both battery storage and electric vehicles, our first sprint has covered these topics. Throughout the process we sought better understanding of priorities through communication with stakeholders, which was used to identify the most appropriate topics for the next sprints.

At the end of each sprint, our findings will be released to stakeholders, in a format appropriate for both the nature of the findings and the target audience, and feedback sought to improve the process and outputs of the next sprint.

Search strategy

Websites and databases

Much of the literature included in the overall review is 'grey literature', that is, produced by non-commercial publishers including Government departments, academics, business and industry. It has been reported that, whilst academic citation search engines such as Google Scholar can be useful in searching for evidence in grey literature, they have limitations that must be recognised. They tend to be subject to the 'filter bubble' effect (Pariser, 2011), where algorithms are used to selectively expose information to a user based on personalisation.

Further, the majority of grey literature results may not appear until after 20 pages of results (Haddaway et al, 2015).

An iterative search strategy was combined with the authors' background knowledge to gather relevant documents from known sources, and citation/bibliographic searches conducted on these documents to identify other important evidence.

The focus of the review is of policies and regulations which are currently in place in the UK. The most immediately relevant sources are therefore bodies responsible for developing these, mainly information published on the UK Government and Ofgem websites.

Sprint 1: EV infrastructure and electricity storage search terms

Database searches were performed using the search function of the institution websites, and included:

- www.gov.uk
- www.ofgem.gov.uk
- www.gov.scot[19]
- www2.gov.scot[19]
- www.gov.wales

19 Scottish Government is in the process of migrating its website. Not all publications are available on the new site (www.gov.scot) so the old website (www2.gov.scot) was also searched.

Three search terms were used:

- "electric vehicles"
- "electrical storage"
- "battery storage"

The relevance of returned results was assessed by considering factors such as the type and date of publication. Related links were also assessed for relevance. For example, news reports and blogs were not downloaded, but any relevant publications mentioned were downloaded.

In addition to database searches, the website navigation on www.gov.uk was also used to find relevant documents. The approach found some documents that weren't returned using the search engine, as well as there being significant overlap in places. Where a large number of documents was listed, search terms were used to find the most relevant evidence.

Crowdsourcing

We chose to adopt a crowdsourcing approach alongside a traditional search strategy. We recognise that local energy systems are integrated across energy services (electricity, heat and transport) whereas policy and regulation are siloed across those services: as a result, traditional search strings may not capture all the relevant information across the different silos, for example, because different terms may be used to describe similar things in different (or indeed the same) organisations. We have determined that a traditional database search alone is not sufficient for the scope of this review. Alongside traditional search strategies, we implemented a crowdsourcing technique to engage with stakeholders external to the review team in order to source the breadth and depth of material required to conduct a comprehensive and valuable review of the literature.

A call for evidence detailing both the scope of the entire review and the relevant topic(s) for a given sprint will be circulated for each review using a combination of professional, public and personal networks. All received documents will be imported first into a reference management software (Mendeley) for tracking purposes, and then into the EPPI-Centre systematic EPPI-Reviewer software.

Any personal details and affiliations supplied are not associated with documents deemed relevant for inclusion in the review. Details are not processed or shared for any further purposes, and responses were deleted at the project's conclusion.

Below is a list of the primary networks we used to gather evidence. This list is likely to evolve throughout the reviews, and is not exhaustive.

Navigation	Search term
Home > Organisations > Office for Low Emission Vehicles > Policy papers and consultations	none
Home > Organisations > Office for Low Emission Vehicles > Guidance and regulation	none
Home > Organisations > BEIS > Policy papers and consultations	"electric vehicles"
Home > Organisations > BEIS > Policy papers and consultations	"storage"
Home > Policy papers and consultations	"electric vehicles"
Home > Guidance and regulation	"electric vehicles"

General	
Network	**Description**
Association of Decentralised Energy	Trade Association for Decentralised Energy organisations
Association of Public Service Excellence (APSE)	Not for profit unincorporated association
Centre for Environmental Policy (CEP)	Academic research institute based at Imperial College London
Centre for Research into Energy Demand Solution (CREDS)	UK academic and industry research centre
Community Energy England	Not for profit organisation
Community Energy Scotland	Charity
Community Energy Wales	Not for profit membership organisation
Energy Futures Lab (EFL)	Academic research institute based at Imperial College London
Energy Institute	Society for Energy Professionals
Energy Systems Catapult Energy Revolution Integration Service (ERIS)	Expert guidance and support for selected PFER projects
EnergyREV consortium	PFER Academic Consortium. Policy Contact Group Advisory Group Consortium mailing list
Grantham Institute	Academic climate and environment research institute based at Imperial College London. Channels include Blog Twitter Newsletter Mailing lists (staff, affiliates)
IGov	Established Career Fellowship based at The University of Exeter
Local Enterprise Partnerships (LEPS)	Business-led partnerships between local authorities and local private sector businesses
Personal Networks	Channels include LinkedIn, Twitter, email
PFER SLES demonstrators and related projects	Including the four funded demonstrators and design projects
Powerswarm	Open network for power system transformation
RegenSW	Not for profit centre of energy expertise and market
The UK Energy Research Centre (UKERC)	Academic research centre based at University College London
UK100	Local Government leader network

Specific to Sprint 1: Energy Storage & EVs	
Network	**Description**
British Electrotechnical and Allied Manufacturers' Association (BEAMA)	UK trade association for manufacturers and providers of energy infrastructure technologies and systems.
Electricity Storage Network	UK industry group dedicated to electricity storage
Faraday Institute	Interdisciplinary research enterprise based in Cambridge
Innovate UK (V2G and EV Charging)	UK's innovation agency, part of UK Research and Innovation
Office for Low Emission Vehicles	Part of the Department for Transport and Department for Business, Energy and Industrial Strategy

We recognise that the crowdsourcing process is liable to be subject to personal bias. To ensure the integrity of the review, the crowdsourcing was conducted in addition to website/database searching, described above.

Inclusion and exclusion criteria

All documents obtained through both crowdsourcing and online searching were imported into EPPI for assessment of relevance.

Documents obtained through both crowdsourcing and online searching were assessed for inclusion based on the following criteria:

- Substantive description or mention of current policies and regulation which influences activities of (smart) local energy systems, including, but not limited to, the four PFER funded demonstrator projects.
- Is applicable to the UK, but not limited to publications from UK institutions.
- Since the scope of this review is concerned only with policy and regulation which affects (smart) local energy systems in the UK at the time of writing, we excluded documents which meet at least one of the following exclusion criteria:
- Are not relevant for the UK.
- Are published by institutions or bodies which do not have the authority to set national policies or rules.
- Do not contain sufficient information about UK policy or regulation.

Where appropriate, we conducted bibliographic searches of documents which met one or more of the exclusion criteria.

Screening process: applying inclusion and exclusion criteria

Inclusion and exclusion criteria was applied to titles and publishing institutions, and, where available, abstracts/overviews/summaries, whichever was appropriate. Where an initial document summary was not available, or where the title and publishing institution did not provide enough information for certainty, the full document was obtained and the inclusion and exclusion criteria reapplied. Documents which did not meet the inclusion criteria were excluded.

Characterising included documents

Documents meeting the inclusion criteria after the initial screening were coded using keywords specific to this particular study.

- Date of publication/release
- Publishing institution
- Type/category of the document
- Geographical area covered

Analysis

Line-by-line coding of the text was developed from an initial framework of activities and technologies across the electricity, heat and transport sectors, and across production, transmission and supply chains.

> 'Coding' in this sense refers to the labelling or categorisation of information within a piece of evidence. It is used so that 'data' – in this case, text – can be organised, examined and analysed in a structured way.

The working codeset – i.e. the categorisation structure – is shown in the table below. The codeset was developed via an inductive process and is neither fixed nor absolute. It is intended to be used throughout the wider review process, and the structure is likely to evolve as other topics are explored.

For this sprint, electrical storage and electric vehicles fall under 'activities,' one of the three overarching themes. The other two overarching themes against which data were coded are the 'energy value chain' and 'cross-cutting issues'.

Activities

- Aggregator
- Electricity
- Grid service platforms
- Heat
- Heat networks
  - Heat pumps
    - Domestic
    - Large
  - Hydrogen
- Market integration platforms
  - Peer-to-peer
- Storage
  - Definition (storage)
  - Batteries
- Transport
  - EV charging infrastructure
    - Autonomous EVs
    - Chargers
    - EVs
    - Incentives
    - V2G
  - Hydrogen

Energy value chain

- Markets
  - Ancillary market
  - Balancing market
  - Capacity Market
  - Market competition
  - Wholesale market
    - Locational marginal pricing
- Behaviours
- Benefits/issues
- Consumer protection
- Flexibility
- Government incentives
- Industry codes
- Local authorities
- Local Energy
  - Community energy
- Planning
  - Resources
  - Security of system
  - Smart
    - Interoperabilty
    - Standards
    - Security
- EU
  - unbundling (EU)

Cross-cutting issues

- Energy demand
  - Buildings
    - Homes
    - Non-residential
  - Businesses
  - Consumers
    - Business consumers
    - Domestic consumers
  - Energy efficiency
- Supply
  - Energy service provision
- Generation
  - Licence (generation)
- Transmission and Distribution
- DNOs
    - Licence (DNO)
  - DSOs
    - TOs
    - System operator
    - RIIO (price control)
    - Network charges
    - Access rights
    - IDNO

Once all included documents were coded in EPPI-Reviewer, all data coded as 'Storage' and 'EV charging infrastructure' were (separately) imported into NVivo, and thematic analysis was applied to identify emerging concepts and themes within each activity. The results of this analysis are included in the working paper.

Dissemination

The findings of each sprint will be written up as a report with accompanying summary note to be circulated to stakeholders within the broad PFER programme, and to all networks contacted throughout the crowdsourcing process. We have invited feedback on the review process (including the crowdsourcing stage) and content of the outputs which was used to hone the procedure and maximise the value for our stakeholders.

For this first sprint, the report is written as a working paper with an accompanying document summarising the key points. We have asked stakeholders for feedback on how we can improve on this format to make it more useful and usable.

Thank you for your interest in EnergyREV! Would you like to know more? Let's get in touch!

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About EnergyREV

EnergyREV was established in 2018 (December) under the UK's Industrial Strategy Challenge Fund Prospering from the Energy Revolution programme. It brings together a team of over 50 people across 22 UK universities to help drive forward research and innovation in Smart Local Energy Systems.

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