CORNWALL INSIGHT

CREATING CLARITY

Appendix C: Work plans

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Four community and local energy work plans prepared for the Energy Saving Trust and Local Energy Scotland.

CORNWALL INSIGHT

CREATING CLARITY

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Getting to grips with the intricacies embedded in energy and water markets can be a daunting task. There is a wealth of information online to help you keep up-to-date with the latest developments, but finding what you are looking for and understanding the impact for your business can be tough. That's where Cornwall Insight comes in, providing independent and objective expertise. You can ensure your business stays ahead of the game by taking advantage of our:

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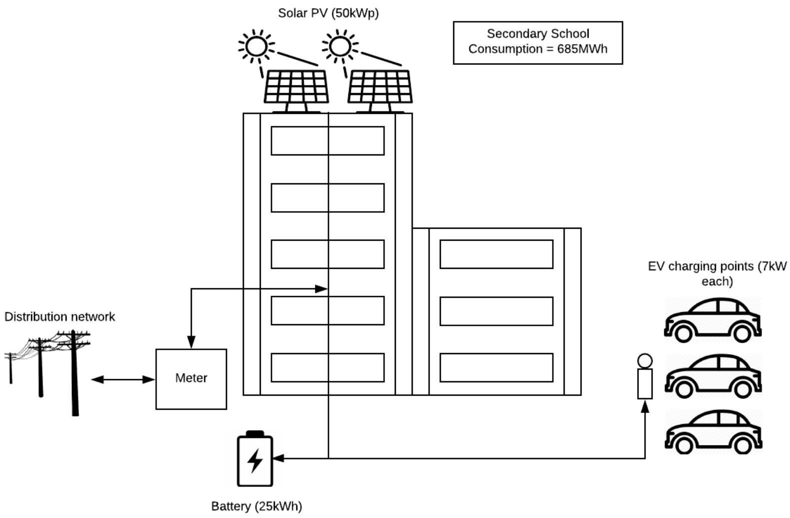
1.1 Introduction

This workplan sets out information and guidance in relation to small-scale integrated renewables opportunities on commercial sites. It is designed to be used by small and medium-sized businesses (SMEs) to help develop their own investment proposals and action plans. It considers a generic model for low-carbon deployment based around installing or extending a 10-50kW non-domestic solar photovoltaic (PV) site and combining this with the addition of battery storage and/or electric vehicle (EV) chargers. We call it the "combined technologies approach".

The generic model is shown at Figure 1 below, based on one of the larger examples we reference.

Figure 1: Diagram of proposed combined technology approach on a commercial site



This workplan is structured into six parts. They are:

- The rationale for considering adopting the combined technologies approach
- Criteria you will wish to consider for maximising benefits under this approach
- A framework for assessment of appropriate design and scale of a project
- How to develop the business case and identify finance
- Identifying future opportunities that could arise from adoption of a project as well as some risks to be aware of, and
- Six specific examples/ case studies, showing typical payback periods.

Where possible we reference other publicly available sources to help you understand the options and the opportunities, and to clarify areas where Local Energy Scotland may be able to provide assistance and support through CARES. A summary of the most useful sources referenced in this document is set out in the overview "Toolkit" at section 1.8.

A glossary of terms and abbreviations is found in the Main Report.

1.2 Rationale

First you will need to understand the rationale behind the development idea before you define and assess it.

To date commercial roofs account for around 28,500 of the UK's 817,000 plus solar PV systems and 1.8GW of the 6GW installed capacity under the Feed-in Tariff (FiT) system, with most being represented by ground mounted and domestic roof top installations. By contrast in many other European countries such as Germany more than half of solar PV development is on commercial roofs. In Scotland at the end of March 2018, there were 94 industrial, 1,577 commercial and 287 community installations accredited under the FiT regime in Scotland, representing 13.70MW, 40.28MW and 13.05MW of capacity respectively. Presently there are 46 school sites FIT registered in Scotland, with just under 1MW of installed capacity.

PV systems are already commercially mature and provide daytime power generation during hours of peak demand for many office, school and community sites[1]. They will continue to be FiT incentives for installations pre-accredited prior to 31 March 2019, and these subsidies are highest in the 10-50kW band. However, the capital cost has reduced by 80% since 2008, driven by continuous technology innovation and competitive procurement, and many sites are already viable without subsidy.

Installing solar PV on commercial and municipal roofs puts unused rooftop space to good use. PV systems can help deliver bill reductions for energy and maximise carbon savings to meet Corporate Social Responsibility (CSR) goals. They also help offset the need to purchase peak time electricity from the public network and provide protection from future electricity price changes.

Where a site has available roof area, this could allow deployment of new or larger solar PV arrays without FiTs. Costs are expected to continue to fall to 2020 and beyond. PV systems could also be combined with other technologies which, despite the removal of solar subsidies, will increase benefits. These technologies include energy storage solutions (such as batteries) and integrated electric vehicle (EV) charging points for employees during office hours, and these are the specific focus of this workplan.

Box 1 – Benefits

Incentive payments on new sites accredited before 31 March 2019

Bill reductions for energy consumed on site

Protection from peak charges and from energy price fluctuations

Carbon savings and CSR benefits

Addition of batteries and EV chargers enhance value of self-consumption

Allows you to take better control of your consumption

Flexibility values set to increase

An important factor here is the cost of electricity, which is set to rise over the coming years as the cost of historic and future policy support is recovered by suppliers from customers through energy bills. This cost pressure will steadily increase the cost of retail electricity, and therefore the value of self-supply as the avoided cost benefit increases.

Other policy changes could also increase the impact the options available to you. Network companies are actively considering how to incentivise demand-response and flexibility, and suppliers are now required to offer all premises a smart meter by the end of 2020. These changes should enable you to take better control of your energy use, encouraging you to shift demand away from periods when import costs are greatest or to move any exports to periods when the wider electricity system values the power most.

[1] Solar PV provides daytime power generation during hours of peak demand for many office, school and community sites. At the end of March 2018, there were 94 industrial, 1,577 commercial and 287 community installations accredited under the Feed-in Tariff (FiT) regime in Scotland, representing 13.70MW, 40.28MW and 13.05MW of capacity respectively. Presently there are 46 school sites FIT registered in Scotland, with just under 1MW of installed capacity.

Energy storage systems are a key enabler of these changes, and most batteries offer smart operation allowing users to track energy usage online and respond to changing circumstances appropriately. The same applies to EV chargers, which – if managed by a sophisticated control system or paired with electricity storage batteries – can be used to soak up solar power that would otherwise be exported. Going forward, all new EV chargers must be enabled for smart charging.

Time of use (ToU) pricing combined with half-hourly settlement (HHS) is already available to larger business sites, but under energy industry reforms it is also becoming available at smaller sites. By early next decade it should have market-wide application. The adoption of ToU pricing should greatly increase the benefits from incorporating storage solutions and from other techniques involving turning consumption both up and down. These within day price differentials will in turn increase opportunities for battery deployment, which would in effect enable some intermittent generation to be treated as firm. An active market is already developing in which a supplier or an aggregator can take these operational decisions on the customer's behalf.

1.3 Criteria for maximising benefits

A site's suitability to be developed in this way will depend on a number of criteria, which you will wish to consider.

Box 2 - Key success factors

High generation potential (unshaded southerly aspect, good irradiation levels)

Appropriate network access

Significant on-site demand during daylight hours, including high peak demand

Manageable consenting costs

Suitable physical conditions for battery location

Existing car park for EV chargers

Advanced metering and time of use pricing applied by your supplier to incentivise battery use

Access to adequate funding

1.3.1 High generation potential

There are several determinants of a viable PV project. Production and therefore benefits will reduce the less able you are to meet these parameters.

- The first is the level and duration of solar irradiation. The chosen location should have the highest possible solar irradiation for as much of the year as possible. The European Joint Research Centre produces comprehensive irradiation maps, and this is a good place to start
- Roof size is an obvious limiting factor on scheme size. As a rule of thumb, around 60-70m^2 of sloping roof space is required per 10kW of capacity installed (kWp). A 50kW array would require 300-350m^2
- In addition, an unshaded, rent-free roof with a southerly (or, to a more limited extent, south-easterly or south-westerly) aspect is critical for optimal deployment of PV
- Orientation (roof direction and slope) is also important, and it is addressed more fully in Local Energy Scotland's CARES PV Module Toolkit here. Ideally your roof should be at a pitched angle of around 30 degrees from the horizontal to give the best overall annual performance, and
- Remember that the life of solar panels is 20 years or more and take account of the fact that trees may grow and other buildings may be developed that might shade the site.

Other tools to evaluate the opportunity and determine the feasible levels of generation are also available online, for example the Energy Saving Trust calculator here.

Most renewable energy installers will be able to provide a shading, radiation and solar panel angle assessment.

1.3.2 Appropriate network access

You will be starting from a position of having an existing connection to the local distribution system, and if you are a larger user possibly a connection agreement with the relevant distribution network operator (DNO).[2] A necessary step is therefore understanding the existing connection terms, and whether you might need to seek variation to them. A key issue here is understanding whether you may need to change the site's maximum import capacity (MIC).

You will also want to ensure there is unrestricted access to the wider electricity system for any surplus power that you export to the public system. The metering arrangements will also need to be validated, and whether you are able to measure exports.

Further information on the more detailed steps in this area are set out in section 1.4 of this workplan.

1.3.3 Significant on-site demand during daylight hours

In most circumstances it is much more economically efficient to consume power generated on-site, reducing the amount of power which has to be bought, than to export surpluses and sell the power

[2] If your connection is not subject to a specific connection agreement, you will still be bound by the National Terms of Connection (NTC), under which your supplier effectively acts as your agent and administers the connection terms on your behalf..

wholesale. This is because the wholesale cost of electricity only makes up a proportion (as little as a third, depending on your consumption type) of the final electricity bill.

To ensure the optimal return on investment, the system should subject to availability of funding be sized to suit the site's energy profile. The demand profile of the site should be checked and validated against half hourly metering, where it is installed. Additionally, you will want to understand the factors giving rise to your consumption and how it varies over time, not just today but also going forward.

The higher the cost of energy imports (which tends to mirror higher use periods on the electricity system), the higher the value which can be obtained by avoiding these costs. All other things being equal, therefore, sites which see higher levels of demand during peak charging periods will derive greater value where PV is coupled with batteries.

We set out further information about how to estimate the avoided cost and therefore value of the generation in section 1.5 of this workplan.

1.3.4 Little or no cost to secure consents

With many types of renewables schemes, consenting costs can be significant. With PV, however, arrangements tend to be relatively straightforward because of their small scale and the proximity to consumption.

In terms of planning approvals in many instances especially if you are under 50kW you will be able to benefit from the "permitted developments" regime. The requirements on larger arrays on non-domestic properties were also eased in 2015 by the Scottish government, facilitating developments up to 1MW[3].

Installing larger solar generation in areas where grid connections are limited could entail large surcharges, which would make the project unfeasible, so you will want to consider how to define the scheme in a way that reduces the requirements in these areas. Often 50kW is seen by the Distribution Network Operators (DNOs) as a significant threshold.

1.3.5 Suitable battery storage conditions

Sunshine hours are consistently greatest during the period 10.00-16.00, and many existing PV sites have generation that they cannot consume on-site at the times it is produced. This will give rise to opportunities to deploy batteries.

Batteries are usually stored indoors on the ground floor, on load bearing walls, away from direct sunlight, though larger units tend to be ground mounted. A non-humid, non-dusty environment is recommended for their positioning, with adequate ventilation. Some manufacturers recommend a minimum distance from electrical mains.

Time of use pricing is a key enabler of incentivising demand response and use of flexibility through deployment of batteries. You will want to review the terms of your current supply deal and when it is due to expire. Most suppliers are amenable to renegotiating contracts with non-domestic customers and offering more sculpted terms based on more differentiated time of use tariffs.

An active market is already developing in which a supplier or an aggregator can take operational decisions on the customer's behalf to optimise the use of storage, and you will want to understand your current supplier's attitude on these matters, as well as that of other suppliers and aggregators.

[3] http://www.gov.scot/Publications/2015/06/6617/315206

1.3.6 Appropriate EV charging conditions

Adding EV charge-points is a good way of increasing on-site consumption during working hours, and they can act as a soak for any surplus power generation. These are best installed where cars will be parked for extended periods, for example an existing office car park.

EV motorbikes and electric bicycles may be sources of future charging demand.

Note that EV chargers will be a requirement for new and refurbished buildings, under the EU Energy Efficiency in Buildings regulations, when these are implemented in UK law (by March 2020). Under other new legislation, chargers must also be smart (that is, those which can be remotely turned on and off by the operator) allowing you to achieve maximisation of value.

1.3.7 Other things to watch out for

If the local electricity system is weak and prone to operating limitations (constraints), developing a PV system will increase your energy security. Conversely, you will want to check that operational limits on export are unlikely to bite during sunshine hours.

Where new build is involved, installing PV is more likely to enable you to meet BREEAM standards, demonstrating energy efficiency in the built environment.

Preferably you will have a single bulk meter point for the entire building for settling electricity industry charges and costs. This can be established through conversations with your supplier.

A lack of access to the gas grid is likely to indicate greater reliance on electricity, and more expense, for heating space and water. This could indicate a good project site, with the ability to divert surplus production into other storage solutions.

1.4 Assessment framework

To define the make-up of your project and to assess its viability, you will need to consider the following matters. There are at least nine discrete stages here for the PV facility (summarised at Box 3), with supplementary steps to test the merits of adding batteries and EV chargers.

1.4.1 PV evaluation

First you will want to familiarise yourself with your current supply arrangement. This is unlikely to preclude you from seeking changes behind the meter, but the current terms of supply, their duration and the associated metering arrangements will be relevant to your ability to get the best benefits out of your project.

However, you may also wish to shop around, especially if your current supply deal is due to end. There is increasing competition in the market-place for service-based offers around on-site generation and supply. The non-domestic sector is becoming increasingly intermediated, and a variety of brokers and agents are already competing vigorously to provide services. This often includes energy usage advice and support on deployment of energy services behind the meter (sometimes termed concierge services), as well as supply terms. A directory can be found here.

Second all assessments require in-depth understanding of the physical conditions on-site. The main steps are:

- You should quantify any existing generation, including back-up facilities, and the associated metering data
- You should quantify the on-site electricity load profile throughout the day
  - Many commercial sites will already have half hourly metering and be able to provide historic consumption data
  - If you do not have half hourly metering[4] or if you are a community scheme, your pattern of electricity usage will probably be determined for billing purposes under a standard consumption profile, which is unlikely to be representative of the actual consumption by half hour which you'll use to help size your array[5]
  - To obtain a more representative view, you can install a data logger. These clamp onto the main building incoming power-feed, can be used to assess electricity use. They can record this data at various granularities, including by the half hour. Many non-domestic intermediaries who help businesses procure energy supply can provide these, or your existing supplier may be able to help
  - Be cautious in using less than a full year's data when making a decision on array size, as consumption patterns can change significantly across the year

Box 3 – Main PV assessment steps

Validate current supply arrangements and tariff options

Determine your current and future generation and on-site consumption

Assess the site's generation potential (irradiation levels, roof size, orientation (slope and direction) and shading

Confirm FiT arrangements if accreditation can occur prior to 31 March 2019

Size your installation with help from your preferred installation partner

Confirm compliance with conditions in planning approvals

Identify specific approvals needed from DNO

Confirm with the DNO that no change is required to your site's MIC

Obtain MCS certification

[4] Usually suppliers would encourage you to install a half hourly meter if your maximum demand was over 70kW.
[5] In all there eight standard profiles, four of which are applied to non-half hourly metered non-domestic sites termed profile classes 5-8)., which differ by peak load factor. Further information is here.

  - The consumption profile of the site is very important, as high self-consumption factors during sunshine hours are required to ensure acceptable payback periods in a post-subsidy world
- You should consider opportunities for inclusion of other sites or additional local demand, especially where there are connected by private wires
- At around this stage you will want to identify your preferred installation contractor to support you in this process. A listing of installers in Scotland is here.

The third step is to assess the site's generation potential (irradiation levels, roof size, orientation (slope and direction) and shading). Further detail has been included above at section 1.3.1 of this workplan.

Fourth, if you are able to move forward and obtain accreditation under the FiTs regime before 31 March 2019, you will want to confirm prevailing rates.

Fifth, and crucially, you should set the size of the solar array, subject to roof space and affordability, based on expected future demand profile. n. This can be a complex process, especially where levels of demand change significantly throughout the year.

Please note that:

- The generation potential of solar panels is relatively easy to quantify and tools exist to help you do this, such as the Energy Saving Trust's calculator here, though this intended primarily for domestic installations
- Your installation contractor will be able to help you size your array to suit your consumption
- Local Energy Scotland can also be contacted for help with this, but do not provide official assessments
- You should identify opportunities to integrate with building management systems (BMS)
  - This should include demand-side response or demand turn up to make the best use of the solar assets, which may include existing or new heat pumps, air conditioning, refrigeration or energy storage technologies other than batteries
  - Control systems should be assessed to integrate solar generation meters with any existing fuelled generation on-site (such as CHPs or back-up generation), to manage the use of these while solar electricity is being produced
- In setting the size, you will also wish to fold in impacts for installation of battery and EV charging systems, and how these will affect consumption and when. We consider this further at sections 1.4.3 and 1.4.4 below.

1.4.2 Consents

A number of authorisations or consents may also need to be obtained. You will want to consider the following areas when planning your scheme.

1.4.3 Planning permission

As a sixth step you will want to ensure that planning permission is not required, or you must secure it if it is. In considering this matter, you will want to take the following into account:

- Local Energy Scotland has produced a Planning Module as part of its CARES Project Development Toolkit here, which provides useful context around the planning system in Scotland, the role of local authorities and the process for obtaining planning approvals
  - Solar generation generally does not require planning permission, being a permitted development in Scotland

- However, some sites will be restricted, especially if a listed building or the installation is over 50kW
  - Permitted developments need to observe conditions and limits, and these can be found here
- Planning permission should be checked with the planning department of the local authority, as each deals with planning differently. The Scottish government has a guide to planning permission in general here
- A useful source of information about the Scottish legislative framework is here.

1.4.4 Connection approvals

The next step is to obtain the necessary connection approvals and to satisfy yourself that no connection upgrades are required. You will want to take the following into account:

- The two Scottish DNOs provide information on the sites where generation may be connected to an unconstrained network here for the SPEN areas (south Scotland) and here for SSEN (north Scotland). However, most business and community solar schemes are connected at low voltages
- Local network maps showing lower voltages are available from your DNO. Due to the limited detail in these maps, it will be necessary to use the online tools linked below to discover whether unconstrained connections at LV levels are available for your specific location
- SPEN provides information on obtaining small connections here and SSEN provides a similar guide here
- You will also need to obtain connection permission from the DNO
  - This might require a G59 or G83 application
    - A G83 will apply to very small – generally domestic – generators up to 3.68kW or, on three-phase wiring, 11kW
    - A simplified G59 will apply to connections up to 17kW or, on three-phase, 50kW
  - From 2019 the G83 and G59 applications will become the G98 and G99 applications respectively following revisions to align with EU rules
    - The DNO and your connection partner will be able to advise on the necessary paperwork, and other advice can be found on the ENA's website
  - Connections over 50kW will be applied for under the major schemes provisions, which are more expensive and time consuming
    - It is therefore not generally recommended to install more than 50kW of capacity if you intend to seek FiT accreditation because of the scope for lengthening the process. Going above this ceiling will also lower FiT subsidies, while they continue to be available.

1.4.5 Site registration and certification

The final step, in conjunction with your chosen installation contractor, you will register the eligible assets with Ofgem where accreditation can be sought before 31 March 2019

- The Microgeneration Certification Scheme (MCS) is a national quality assurance scheme for small-scale renewables, up to 50kW for electricity and 45kW for thermal. MCS certifies both technology and installers against its standards
  - All installations seeking FiT or RHI accreditation must consist of certified technology products and have been installed by an MCS certified partner
  - Information on MCS accredited assets can be found here

  - Information on accredited installers can be found here
- After March 2019, it will not be possible to register to the FiT scheme. However, it has been indicated that all GB installations of relevant technologies will be required to obtain MCS certification from this date – further clarifications are promised closer to the time.

1.4.6 Battery use

Questions you need to address involving the practicability of deployment of batteries alongside PV are:

- Is there a need for batteries?
  - You will need a generation surplus during sunshine hours but excess consumption at other times
  - If you are not currently on a ToU tariff, there is unlikely to be sufficient cost benefit available to make the cost of batteries economically viable, though your current supplier will almost certainly be willing to revise your supply contract to enable this
  - If you are not on a ToU tariff and your existing supplier is unmilling to offer one, you may want to consider changing supplier when your contract or tariff expires. An increasing number of suppliers are offering more dynamic charging structures and it is commonplace in the business market
  - If you are on a time of use tariff, then there is more likely to be an economic case for batteries
  - The more differentiated the time banks in number and level, the more likely it is that you can benefit from the deployment of batteries
  - Below in Figure 2 we show three examples of indicative battery value creation using tariff/contract terms currently available in the market based on the stated performance of three different lithium-ion batteries but dependent on realising the temporal value of shifting consumption (that is, without on-site generation). The three batteries are (i) Powervault 3, (ii) Powerwall 27 and (iii) Moixa Smart Battery 3kWh. The tariffs used are (i) Economy 10 retail tariff (two rate, medium differential) [6]; (ii) sample time of use tariff available in the retail market (four rate, sharp differentials) [7], (iii) a representative tariff from the business market (three rate low differential)[8], and (iv) the tariff we have constructed for our worked examples[9]

Figure 2: ToU illustrative savings (p/kWh) – no generation

	Tariff 1	Tariff 2	Tariff 3	Tariff 4
Battery 1	-3.17	12.74	-5.21	10.59
Battery 2	2.44	18.34	0.39	16.19
Battery 3	1.01	16.93	-1.04	14.75

  - Figure 2 shows that wide differentials are presently required to achieve attractive savings, and tariff design and structure are critical. At current cost levels and battery efficiency rates, some batteries would not achieve savings under a purely price arbitrage model

[6] Economy 10, average of 10 suppliers, 9.35p/kWh off peak, 17.025p/kWh peak.
[7] Green Energy's TIDE tariff, 4 rates: 6.41p/kWh night and weekend low (0.00-07.00), 14.02p/kWh weekday and weekend medium (7.00-16.00), 29.99 weekday high (16.00-20.00), 14.02p/kWh weeknight medium (20.00-00.0)0
[8] BG business tariff, with 9.82p/kWh night rate, 15.45p/kWh weekday day rate and 13.57p/kWh evening and weekend rate.
[9] This is a three rate tariff: low 11.29p/kWh, medium 14.25p/kWh and high 32.72p/kWh, and is designed to reflect a business market tariff that incentivises load shifting away from peak. It is closest to the TIDE arrangement but without the very low night and weekend rates.

- The worked examples at Annex C show the economics of pairing solar PV and batteries in different size combinations based on different six case studies and the calculated payback times.

- Is there space for batteries?
  - These would need to be situated in a convenient place between the solar array and the main points of use
  - In our case studies, the largest battery added is 25kWh. Installing four 6kWh Nissan batteries or two 13kWh Tesla batteries would occupy at least 8m^2 or 2m^2 respectively
  - Depending on the battery storage product, the system would be either mounted on the floor or the wall. Lithium-ion products are usually more compact and need less space. There is currently no particular requirement in the UK in terms of where the batter storage system should be installed. In general, to reduce the wiring needed and to simplify the installation, it is a good idea to install the systems close to your electricity mains input, and DC systems close to the solar inverter. Your chosen contractor will be able to provide advice
  - Some, but not all, battery storage systems can be installed outdoors. If you are interested in installing an outdoor battery storage system, you must make sure that that it achieves the high protection class IP65 or higher (for outdoor usage). For indoor installations, you have also to take into account the noise level from the system when you decide on where to place it. The typical noise level is 30 to 50 decibels (similar to the noise level of a fridge-freezer
  - For outdoor installations, the battery system is more likely to be installed outdoors in a waterproof cabinet. Again your contractor can advise on this.

- What sort of battery is most suitable?
  - The most common batteries available are lithium ion and lead-acid. The former are more expensive, but have a lifespan two to three times longer, do not require venting, and tend to be much more efficient
  - There are many battery providers operating in the GB market and an i9ncreasing number of available battery models. These include international players such as Tesla and sonnenBatterie as well as UK companies like Moixa, Connected Energy and PowerVault. They all provide a range of capabilities but have models that are designed for business and community use
    - A good summary is here
  - Companies are frequently entering or exiting this fast-moving market, and products are evolving constantly. Your delivery partner will be able to make recommendations on battery providers.

- How large a battery and how many units should be installed?
  - The optimal size of a battery in relation to a generation asset will depend on the total consumption of your site, the consumption profile, and the size and technology of the generating asset
  - If your connection is subject to operational constraints, the battery might typically be much larger as it has to store and discharge sufficient energy for daily or seasonal troughs of power generation. In this case a lithium ion battery might be three times the size of the generation asset (say a solar array), although the generation asset should be sized sufficiently to generate enough power throughout the year to meet the customer's demand. Note again that this will vary depending on the generation asset and the user's demand
  - Community Energy England provide a "ready reckoner" (developed by Regen and Plymouth Community Energy) to help size a battery here. However, this is only a high-level view and the exact size will depend on more detailed analysis of energy use on your specific site

    - If the battery is being operated to maximise self-consumption of solar, it could be sized to accept the excess output of the array during summer peak generation days
    - If it is being operated to minimise your import during peak charging periods, then you will want to consider a battery sized to meet your typical winter evening consumption
    - If it is being operated to maximise benefits to your supplier and the grid – which is outside of the scope of this workplan – it will be dependent on the terms offered by your supplier or aggregator
  - In all these cases battery operator partner will be able to provide guidance on sizing the battery.
- What can I afford?
  - As with PV systems, cost will be a factor. Costs can vary widely by manufacturer and model as we show at Figure 5, typically varying between £4k – 8k for smaller units, working out at 10p/kWh and 30p/kWh over the typical 10-year warranty period. Your selection and the number of units you opt for will be strongly influenced by how you envisage utilising the battery.

1.4.7 EV chargers

Questions you need to address involving installation of EV chargers are:

- Is there a need for EV chargers?
  - If staff currently drive EVs, or if there are company vehicles which will be replaced by EVs, this would indicate a need. However, mass adoption is not predicted until the mid-2020s.
- Is there space for EV chargers and where should they be located?
  - Consider also the possibility of solar carports to power any EV chargers installed.
- What is the impact on your consumption profile of the different charging options?
  - A US study[10] on workplace charger use found that workplace charging sessions which commenced between 8am and 2pm, that is, before lunch had a roughly 220-minute connection period, dispensing 8.66kWh per session. Charging sessions which started later in the day, from 2pm to 6pm, had shorter connection periods of 120 minutes, dispensing 7.23kWh per session on average
    - This was based on 3.5kW chargers
  - We can therefore calculate that installing four 3.5kW chargers would add approximately 35kWh of demand for a morning charge and 30kWh for an afternoon charge per day, or 16.5MWh of demand per year, assuming that chargers were fully utilised every workday on a similar pattern to California
    - The average energy delivered would be sufficient to recharge approximately 50km of travel, which is roughly equivalent to the distance of the average commute; we can therefore suppose that individuals were engaging in daily charging behaviour
  - If 7kW rapid chargers were fitted, it is unlikely that total demand would change significantly. The “dwell times” – that is, the amount of time the EV was plugged in following completion of charging – indicate that workers would generally plug in their EV for the full period between a) arrival at work and lunchtime, or b) lunchtime and leaving work
    - This is shown by dwell times falling in vehicles plugged in closer to these break-points

[10] In California from the Luskin Centre, ref here.

- Daily EV charging volumes will depend on the vehicle use profiles
    - A typical commute in the UK is 16 miles round trip, which is unlikely to require more than a few kWh to recharge a vehicle, but some businesses may find much higher levels of charge needed especially where there are plans to develop a commercial fleet.
    - A car parked all day (for example at an office) will tend to require less energy than several different cars parked for parts of the day (for example at a shopping complex).
- How much should you charge for the service?
    - You will want to recover the cost of the charger as well as installation costs, on top of the 14p/kWh or upwards which that you wish to charge for the electricity supplied (the avoided cost of an alternative supply
    - You may also want to consider different electricity values varying by time of day. Information on time differentiated charges is set out at section 1.4.7 of this workplan
    - In structuring your pricing, you will want to ensure there are the strongest incentives for charging at times of surplus on-site generation and discourage use when grid only electricity is used.
- How are the implications of having a "smart charger"?
    - The Autonomous and Electric Vehicles Act 2018 requires that all EV chargers be "smart", i.e. be remotely controllable
    - In more detail section 15 of the Act specifies that no charge point can be sold or installed unless it meets technical specifications to be able to remotely receive and process information and react to that by adjusting the rate of charging. This means that – once the regulations of the Act come into force – all new chargers will be smart and controllable
    - Smart charging is a limited field currently, with a limited number of providers offering solutions. OVO launched its VCharge unit in April 2018 with 6kW and 7kW units available, targeted at the domestic market, and designed to integrate seamlessly with its own batteries. Nissan, manufacturer of the popular EV the Leaf, provides a similar solution under its Xcharge brand, which includes solar, storage and EV chargers
    - Other providers such as SmartEV also provide units that are capable of integrating with power plants – such as solar panels – to modify tariffs or adjust power output. Key to establishing a system which can operate efficiently will be selecting devices which are compatible with each other. The UK government is hoping to create standards to help manufacturers work together, and projects such as the Open Charge Alliance's Open Charge Point Protocol here are trying to establish market-led standards.
- The functioning of these charges should be integrated with the building energy management system to create the value of EV chargers as controllable demand.
- What can I afford?
    - It is unlikely that adding chargers will add significantly to your project costs, and OLEV grants are presently available – see here
    - There is useful information on the cost of commercial chargers here.

1.5 Business case & finance

In this section, we summarise sources of value and costs of combined technology projects. We also set out some sources of information on how you might consider financing schemes.

1.5.1 Outline business case

Once you have completed the assessment, you will need to develop a business case, which will establish the costs and benefits of the project, setting out how and when the costs will be recovered. Local Energy Scotland's CARES Investment Ready Tool provides a template, which can be used to set out the business case for a project. It forms part of the CARES Project Development toolkit.

The aim of the tool is to outline the information that needs to be collected during the development of your renewable project and provide a mechanism for recording that information that can be passed on to a potential lender. The tool is part of the Investment Ready Process which includes an online storage platform and an independent assessment by CARES technical advisors.

Box 4 – Main value drivers

Value of on-site consumption set to increase steadily

Export price for existing FiTs likely to fall in line with system spill prices

Removal of FiTs from 31 March 2019

BEIS consulting on guaranteed route to market at "meaningfully lower rate" to market prices

Levelised costs of solar and batteries set for continuing reductions

Embedded benefit values set to rise on exports

1.5.2 Sources of value

The starting point for putting together the business case will be identifying the sources of value.

1.5.3 FiT subsidies

Figure 3 sets out current FiT subsidy rates for PV installations, and future rates out to the end of the scheme in April 2019[11]. There are two payments, the generation tariff received for all electricity produced (effectively the green subsidy payment), and the export tariff received for all electricity exported to the network (effectively payment based on value of the export power to the wider electricity system).

Figure 3: FiT arrangements in 2018-19

Description	Capacity (kW)	Tariff (p/kWh) July-Sept 2018	Tariff (p/kWh) Oct-Dec 2018	Tariff (p/kWh) Jan-Mar 2019
Generation tariff	0-10	3.93	3.86	3.79
	10-50	4.17	4.11	4.03
	50-250	1.79	1.75	1.69
Export rate	All	5.24	5.24	5.24

[11] Ofgem operates a three-rate system for FiT tariffs. The higher rate, which is shown in the table applies to installations attached to buildings which have been issued an EPC certificate of level D or above prior to the installation, where the owner has fewer than 25 existing FiT accredited installations. The middle rate applies where an EPC level D or above certificate has been issued, but the owner has 25 or more existing installations. The lower rate, which is a flat-rate of 0.25p/kWh for all capacities (dropping to 0.2p/kWh and 0.15p/kWh in subsequent quarters), is paid where an EPC level D certificate has not been issued prior to the installation. It is not recommended to install solar arrays in these circumstances while subsidy is available, as subsidy-eligible opportunities should be prioritised.

Source: Cornwall Insight from Ofgem data

Projects under the FiT regime will receive the generation tariff in respect of all kWh produced, irrespective of where they are consumed. The best rates are available in the 10-50kW band. These are additional to the value you will receive for the bill saving arising from usage of the electricity on-site and the avoided import electricity cost this gives rise to.

Export payments will also be due for energy provided to the wider grid. Installations above 30kWp must be export metered under the FiT regime and are paid the administered rate of 5.24p/kWh for the 2018-19 year. However, installations under 30kWp in size have the option of "deeming", which allows collection of export payments for 50% of the energy generation, rather than measuring how much energy was actually provided to the grid. Under this approach it is not relevant whether you export the power or not, so adding batteries to a deemed site before 31 March 2019 has obvious merit provided you do not intend to use the battery to export power.

You will wish to note that current basis on which the export payment is based is subject to change under recent proposals from BEIS. The department is seeking views on linking the payment for generation pre-accredited before 31 March 2019 to the time-weighted value of the electricity imbalance price. In 2017-18 the corresponding value was 4.69p/kWh.

However, both FiT subsidies for new installations will be withdrawn from 1 April 2019, though there are likely to be transitional arrangements for sites that have obtained MCS certificates and pre-registration status from Ofgem by 31 March 2019.[12]

FiT *generation* rates increase by RPI each year, and they will continue until the twenty-year accreditation period is met. Please note, however, the BEIS is presently consulting on a change to the formula for calculating FiT *export* payments that could be brought into line with system spill prices, which are lower than current wholesale market prices.[13]

1.5.4 Export payments from 1 April 2019

As yet there is no replacement proposed for the FiT export rate from 1 April 2019, or indeed whether there will be guaranteed route to market. BEIS has, however, issued a call for evidence on the market arrangements for small-scale low-carbon generation.[14] This issue is covered in more detail at Section 3.5 of the Main Report. It is possible that smaller sites, possibly below 50kW, could retain a guaranteed route to market after 1 April 2019 but at "a meaningfully lower rate" to available rates under a PPA.

The BEIS call for evidence notes instead that "the closure of the FiT scheme would mean developers would be dependent on securing certainty over longer-term revenue streams from other sources", but it also notes the speculative nature of those potential revenue streams. This is a theme we return to in section 1.6 of this workplan below.

The call for evidence closes on 30 August 2018.

1.5.5 Avoided costs

Following closure of the FiT scheme to new installations, the business case for PV will rely much more heavily on the avoided cost of imports for the generation produced and used on site, plus any payments for exported energy and any ancillary revenues that can be achieved.

Figure 4 shows recent representative average tariff rates available in Scotland based on Cornwall Insight half-yearly assessments. For every unit you produce and consume on site, the avoided cost

[12] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/726977/FITs_closure_condoc_-_Final_version.pdf, see pp16-17.

[13] This could result in prices closer to 4.5p/kWh rather than 5.5p/kWh if BEIS confirms its proposal.

[14] https://www.gov.uk/government/consultations/the-future-for-small-scale-low-carbon-generation-a-call-for-evidence

would be around 14p/kWh (that is, a typical if prudent estimate of the volumetric charge under your current supply contract; you would still be subject to the standing charge under smaller user tariffs and the unit rate for imports). These tariff estimates are representative of smaller business rates in the wider market, but do not appear to be in-line with very favourable rates that have been negotiated for supply to the public estate in Scotland, which anecdotally are closer to [12p/kWh].

In contrast the export tariff paid by most suppliers is just over 5p/kWh.[15] The value to you is therefore to the order of 5-10p/kWh if you can consume the energy you have produced on-site.

Figure 4: Average non-domestic prices, Q2 2018

Supplier	Volumetric charge (p/kWh)
Small business North Scotland	15.0
Small business South Scotland	14.5
Large business North Scotland	14.5
Large business South Scotland	14.0

Source: Cornwall Insight

Below we show at Figure 5 a high-level cost-benefit analysis when different proportions of energy are consumed on-site using a prudent estimate of levelized cost of energy (LCOE) assessment of 12p/kWh for rooftop solar.[16] The figure compares this to revenues received under three different situations:

- First, the status quo environment for a sub-30kWhp site with 50% deemed exports, plus the FiT generation tariff, and avoided import costs at 14p/kWh (orange line). Benefit at 100% self-consumption is 20.8p/kWh; at zero self-consumption benefit it is 6.79pkWh
- Second, the status quo environment but for a half-hourly export metered exports, plus the FiT generation tariff and avoided import costs at 14p/kWh (blue line). Benefit at 100% self-consumption is 18.2p/kWh; at zero self-consumption the benefit is 9.4p/kWh
- Third, a no subsidy environment, with avoided import costs at 14p/kWh and metered export revenues at 5p/kWh (green line). Benefit is 14p/kWh at 100% self-consumption and 5p/kWh at zero self-consumption[17].

The yellow box outlines scenarios that are profitable against the 12p/kWh LCOE, highlighting that self-consumption above ~35% is required for solar PV to be profitable for a typical business user receiving subsidy in the current environment. Clearly the greater the self-consumption factor, the earlier the prospect of a payback and the higher the return.

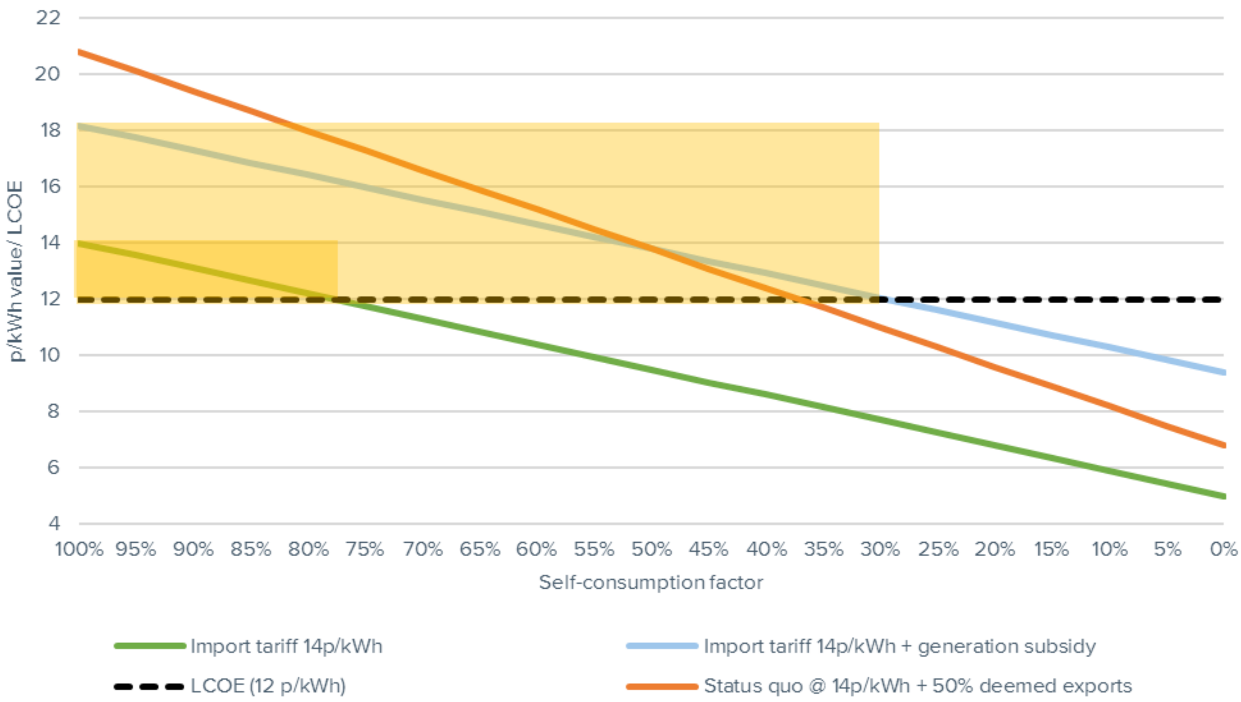
The key point to note is that the ratio increases to just under 80% with the removal of subsidy, and an avoided cost of 14p/kWh, which is presently attainable under competitive supplier offers to the market. If the avoided cost were close to 12p/kWh all the electricity would need to be consumed on

[15] Increasingly many site owners are agreeing Power Purchase Agreements (PPA) with suppliers for their exports, which have enabled slightly higher rates to be achieved.
[16] This is a prudent estimate, and larger systems have costs closer to 11p/kWh. We have used 12p/kWh to allow for annual maintenance cost and inverter replacement costs.
[17] For comparison the typical residential unit charge in the two Scottish regions are 16-17p/kWh.

site. However, this is before any export revenues are taken into account, which you can prudently assume will add at least 5p/kWh for surpluses not used on-site.

While solar installations costs are higher for smaller installations, the higher tariff costs faced by the smallest business users and householders mean that the avoidable costs are higher. In this context, the addition of battery storage and EV charging could significantly improve the amount of the electricity generated which it is possible to use on-site, and therefore reduce payback periods.

Figure 5: Cost vs benefits for PV solar with different levels of on-site consumption (today)



Further information on the rising costs of third party charges is at section 3.2 of the *Market Context and Prospects* published alongside the main report as Appendix A.

1.5.6 Embedded benefits

Where the site owner has a contract for export (that is, you decide not to take the FiT export rate but agree an export agreement with a supplier), embedded benefits can be earned. These benefits reflect a supplier's avoided costs of balancing customers with local generation, will continue to be important as an additional source of value or cost avoidance. These add up to around £10/MWh (or 1p/kWh) in Scotland to generator revenues, dependent on technology and location but assuming they are distribution connected, though PV related values are probably less than £5/MWh (0.5p/kWh).

This source of value will be relevant if you have a significant surplus of generation to export, but it does not change the basic argument in support of self supply.

Further information on embedded benefits is at section 1.3.3 and Annex E of the *Market Context and Prospects* published alongside the main report as Appendix A.

1.5.7 Costs

PVs

With the relatively low cost of solar PV – about £1,200/kWp to install, so up to £60,000 for a 50kWp array – most companies would be advised to install assets paid for out of their own resources, where this is affordable. Self-funding the facility minimises complexity and cost and allows shorter timeframes for the installation.

The ongoing operational and maintenance needs of solar arrays are low. The main expenses will be monitoring, cleaning, and the replacement of inverters. Inverters have useful lives around half those of solar panels, and you should include the cost of replacing these after ten years, depending on the warranty provided by the manufacturer. Options exist to outsource the maintenance of commercial-scale installations, providing a fixed cost for maintenance activities.

You should also consider the increased business rates, which you will have to pay as a result of installing solar. Microgeneration historically benefited from exemptions, but these have largely expired. You should check with your local authority what the business rate cost of solar is and factor this into the economic case.

MyGovScot provide a guide to rates relief which you may be eligible for here.

Batteries

The cost of electricity batteries currently typically ranges from £4,000 to £5,000 for a fully integrated 4kWh system, but this is expected to fall in the future. There are a wide-range of options (capacity and cost) available to you, as illustrated in Figure 6.

Figure 6: Battery offers and costs on the market, July 2018

Provider	Capacity (kWh)	Cost (£)	Cost per kWh (£)
Ikea	2	2,395	1,198
LG Chem	4.9	3,600	735
Moixa	2	3,000	1,500
Nissan Xstorage	4.2	6,446	1,535
PowerVault 3	5	5,484	1,097
PowerVault 3	7.5	7,320	976
Sonnen Batterie	4	4,500	1,125
Tesla Powerwall 2	13.5	5,970	442
Tesla Powerwall 2	27	11,470	425

Source: Various, assembled by Cornwall Insight

Similarly, aggregation opportunities (where you could strike a deal with a supplier or an aggregator for sale of consolidated imports or exports (flexibility services)) are emerging but as yet not at the scale of the sites we are considering in this workplan.

Further information on the characteristics, costs and benefits of batteries can be found from the Energy Saving Trust here.

We provide a range of worked examples of the impact of batteries used in combination with PV storage in the case studies summarised in section 1.7 and at Annex A to this appendix.

EV chargers

EV chargers could be deployed to maximise self-consumption and work well on business sites with car park facilities. This would come at a lower capital cost than battery storage assets, though without the benefit of being able to reduce peak period consumption (without the development and installation of vehicle to grid (V2G) technology).

Capital costs, which are falling rapidly, are shown in Figure 7 below.

Figure 7: Example cost of typical EV chargers, by capacity

Capacity	Capital cost
Slow – 3.5-7kW	£500-1,000
Fast – 7-22kW	£2,000-3,000
Rapid – 43-50kW	£20,000-40,000

Source: Cornwall Insight

The Workplace Charging Scheme offers a grant to reduce charging infrastructure costs by 75%, up to a maximum of £500 per socket. The scheme is limited to maximum of 20 sites per applicant. Installers of the charging infrastructure must be an authorised installer registered with the Office of Low Emission Vehicles (OLEV), with businesses, charities and public organisations eligible. If the charging infrastructure is in a car park, this car park must be solely for the use of the applicant. Only charging infrastructure approved by OLEV may be applicable under the scheme.

New chargers, with capacities in the 150kW or even 350kW range, are likely to come onto the market in the next few years as the EV roll-out gathers pace. Larger capacity units, as well as costing more per unit itself, will likely require reinforcement of the businesses' grid connection to meet the heavier load expected.

The value of chargers

Savings in fuel costs already appear significant as Figure 8 illustrates.

Figure 8: Example cost savings on fuel of switch to EVs, assuming average UK mileage

Fuel	Use per 100km	Cost per unit	Cost per 100km (£)	Cost/year (£)
Petrol	5.4 litres	£1.25/litre	6.75	705.98
Diesel	4.5 litres	£1.30/litre	5.85	611.85
Electric	18 kWh	14p/kWh	2.52	263.57

Source: Cornwall Insight (as per Office of National Statistics)

Currently, most sites will be best advised to install only small numbers of chargers of relatively low capacity, as the EV roll-out has not yet reached the stage where high usage can be counted on to recoup the capital costs of the units, though current indications are that savings are already achievable compared to petrol cars once fuel savings and vehicle excise duty are factored in. See here for one comparison.

Cost recovery will depend on the tariffs and fees charged to users and there does not yet appear to be a standard model. Therefore, those sites with their own EV fleet – vehicle depots, for example – might be best placed to make use of chargers in this initial period.

Further information on the characteristics, costs and benefits of EV chargers can be found from Energy Saving Trust here.

Maximising use of solar vs fleet charging

We have primarily considered EV chargers as a way to add flexible demand to a project that could help soak up some of the excess solar generation on sunny days. With a properly sized array, this should be relatively infrequent event. When excess energy is generated, the quantities are not likely be sufficient to power a charger larger than a fast charger from a 50kWp array.

When considering fleet charging – particularly where this is a heavy-duty vehicle fleet, for example buses or refuse collection vehicles – bear in mind that the quantities of electricity required, and when this is required, are unlikely to align well with solar peak generation.

1.5.8 Finance and timing

Your capital budget may well determine scheme size, especially if you are adding batteries. Each module of 10kW of solar and a 5kW battery can be expected to cost to the order of [£15,000.]

Costs can be avoided if an organisation self-funds installation, rather than taking loans. Delivery should be commenced and targeted for a short time-period to capture remaining FiT value for solar PV, so you may well want to step aside from your current annual budgeting cycle to see if you can free up spare capital to invest ahead of the 31 March 2019 deadline.

As we show in section 1.6, capital costs of PV system and battery storage systems are continuing to fall and avoided costs of on-site production will steadily increase, so capturing these factoring in your assessment will reveal better returns. The cost of EV chargers is also falling, although grants towards these are likely to continue to be available for the foreseeable future. The analysis we present in the case studies demonstrates attractive payback periods on PV and battery combinations despite remaining subsidy for solar PV being removed from the market.

Project timelines should be minimised to make sure that the best value for money on equipment is obtained and development costs are minimised. Many renewables installers are now offering PV/battery packages, and you will want to consider the investment case together.

There are a range of funding options that you will wish to explore. The simplest option – and the one with the fastest payback period – is for the business or property owner to invest in technology themselves. If insufficient capital is available, a corporate loan or, in the case of very large schemes, project finance could be sought. Interest rates will tend to be in the range of 3-10%, with repayments mostly over 5-7 years, although longer term deals can be found. High street banks will be the first port of call when seeking a loan, though lower interest rates may be obtained from specialist lenders.

If neither of these options are taken, there is also an opportunity to seek a third-party provider to own and install the panels, under a rent-a-roof arrangement. The business will then purchase energy from the third-party under a PPA, at a discount to market rates, for a period generally in the range 20-25 years. Following this, the PPA can be extended, the owner can sell to the grid and pay rent to the building owner, or the panels can pass into the ownership of the building owner.

Community energy groups often operate under this model. Some tools to help community groups to secure finance to pay for their activities are:

- Community groups and businesses can access some funding from Local Energy Scotland (through CARES) and other government agencies. The CARES sources of finance guide here sets out some of the grants and loans available for projects, although most of these have specific locational requirements or are only for innovative projects, for example
- If no cash, grants or loans are available, finance can be sought through either conventional or crowdfunded loans. Loans, or debt, can be raised against the expected revenue of the scheme. This is relatively simple to calculate under the current FiT regime, as payments are set and guaranteed by the government for a period of 20 years. In a post-FiT world, it may be more difficult to establish certain revenue streams and also secure and export contract, and therefore more difficult and expensive to secure debt
- There are many crowdfunding platforms operating in the renewables and community energy space. These include:
    - Mongoose Energy
    - Crowdfunder
    - My Green Pod
    - Pure Leapfrog, and
    - Triodos
- Community energy groups often provide other organisations with zero-cost installations, benefit being provided to the host by charging reduced-price tariffs for the solar energy generated to the

host. With the community group needing to pay its own costs, companies will experience less financial benefit than self-funding or taking a direct loan. However, there may be other benefits in terms of local reputation and community benefits from the community group

- Other tools are available that should help you:
  - The CARES Project Finance Module is here, and provides guidance on project risks and their mitigation, as well as appropriate sources of funding
  - A brief from CARES from September 2017 on sources of finance is here
  - Local Energy Scotland maintains a list of potential financial framework advisers here.

1.6 Future opportunities and risks

In this section we highlight energy industry and market changes that are likely to impact on "combined technology approaches.

1.6.1 Impacts on existing connection arrangements

The eighth step is to check whether you may need to seek revision of your site's maximum import capacity (MIC), where one has been or is required by the DNO. Please note the following:

- Changes in on-site technology could mean a greater import during day-time hours in the winter when the sun isn't shining. This could necessitate a change to the agreed MIC with the DNO, which could have cost implications dependent on size and location
- This issue should be checked with the local DNO's connections policy team to determine the classification of the connection. Links are here: SPEN, SSEN
- Note that a site may have a "deemed" MIC based on historical maximum demand even if this hasn't been confirmed through a bespoke contract with the consumer. You can check whether you have one and what it is in your connection agreement if you have one, or by contacting the connections team at your DNO.

1.6.2 No subsidy vs cost increases

From 1 April 2019, the FiT will close to new installations. However, we anticipate that the loss of subsidy will be quickly offset, based on the expected further fall in technology costs and programmed changes in energy industry charges, which will continue to put upward pressure on retail prices. Tariffs are expected to rise due to increased third party costs, including those arising from the legacy policy costs associated with the RO and FiT subsidy schemes, and the new costs of CfDs and the Capacity Market.

Below at Figure 9 we repeat the cost-benefit assessment shown at Figure 5, projecting costs forward to 2023. We have also lowered the LCOE to 10p/kWh on the basis that costs are continuing to fall.

Box 5 – Look out for

Increase in spread between wholesale and retail prices

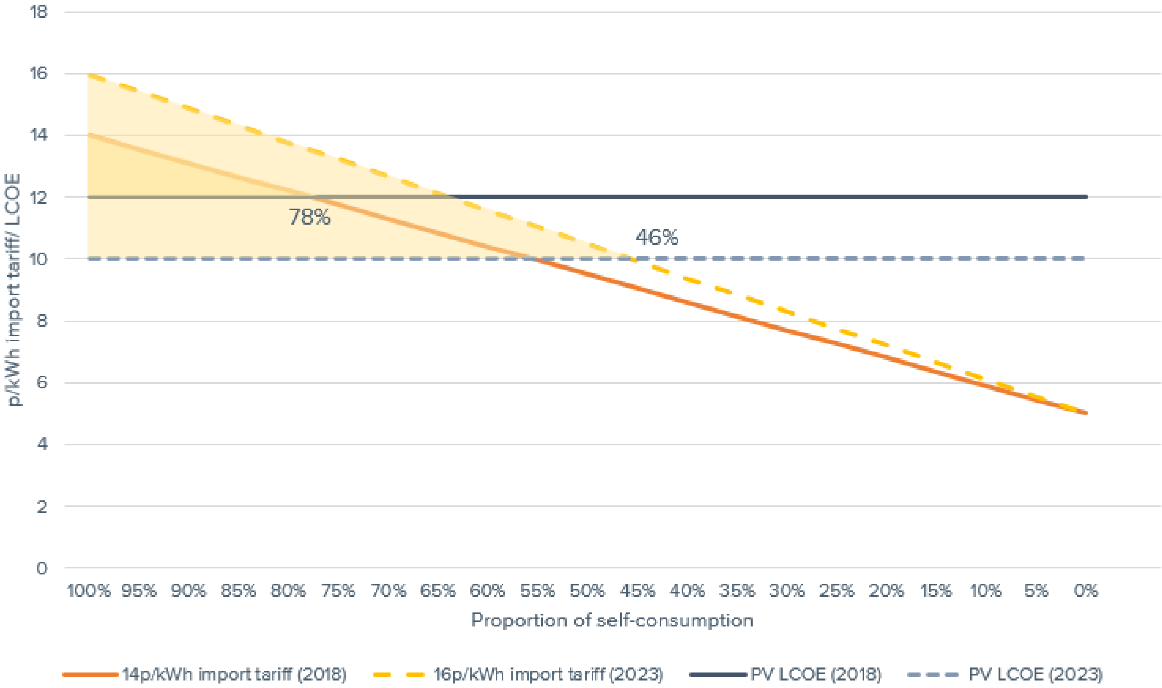
Further reductions in technology costs of solar PV, batteries and EVs

Development of new flexibility services by network operators

Introduction of mandatory half-hourly settlement

Introduction of capacity incentives

Figure 9: Cost vs benefits for PV solar with different levels of on-site consumption (2023)



As Figure 9 shows, a lower LCOE of 10p/kWh will reduce the self-consumption threshold. For comparison we show the 14p/kWh value used in Figure 5. We have inflated this showing expected rises in energy bills over the five years (14%), to 16.0p/kWh. The value of avoided cost of self-consumption has also increased so the required ratio of self-consumption falls to under 65% from 83%.and to under 56% from 71%.

Again, this is before any export revenues are taken into account, which you can prudently assume will add at least 5p/kWh for surpluses not used on-site.

1.6.3 Falling costs

The International Renewable Energy Association (IRENA) forecasts suggest a further 65% reduction in solar costs by 2030. Overall, this gives a drop by around 7.5% a year. As this cost falls, payback periods will reduce and project internal rates of return (IRRs) will increase. This will make more projects economically feasible.

Similarly, the cost of battery storage units is expected to continue falling, with IRENA projecting a fall to half current prices by 2030, or 4-5%/year.

EVs are expected to achieve parity costs with petrol fuelled cars by 2022. Over the same period cost/annum savings are expected to be maintained.

1.6.4 Other factors

Smart tariffs are likely to see both differentiated consumption tariffs (increasing value of the avoided cost at peak) and, possibly, time of use export rates. This is likely to disincentivise solar only projects (but conversely greatly incentivise projects with storage capability).

Aggregation opportunities are likely to increase for solar developments also involving storage, especially where this allows a capacity value to be claimed, assuming that Capacity Market rules are revised to allow this. This includes EV charging, especially at commercial sites (as this is where vehicles used for commuting will be located during sunny periods).

These and other emerging opportunities are set out more fully in section 4 of Appendix A, *Market Context and Prospects.*

We summarise these changes and their impact on workplan 1 at Figure 10.

Figure 10: Impact of expected changes on business case

Change	Impact (RAG-rated)	Timeline: Now to 2019	Timeline: 2019-22	Timeline: 2022 onwards	Impact: <10kW	Impact: 10-50kW	Impact: >50kW
Possible degression of FiT tariffs for new wind installations if cap is breached	Reduction in tariff rate by 10%				Low	Low	Medium
Removal of FiT subsidy	Loss of guaranteed route to market with guaranteed minimum pricing of 5.24p/kWh Limited PPA market at all levels, especially under 50kW				Medium	High	Low
Failing levelized costs	-7-8% levelised cost/year for new PV Battery storage forecast LCOE to reduce by 4-5%/year Cost reductions likely to impact larger panels and batteries first				Low	Medium	High
Embedded benefits	Tariffs to increase to around 20p/kWh for many user groups by early 2020s creating stronger incentives to match output with self-consumption				Low	Low	Low
Wholesale electricity prices	These are not expected to change significantly				Low	Low	Low
Increasing electricity tariff prices	These should increase, especially with regard to the cost of system balancing. We have assumed 2% real inflation per annum for five years, but this is likely to be prudent.				High	High	High
Smart time of export tariffs	Will create price arbitrage opportunities Market wide HHS from 2022 will increase opportunities				High	High	High
Development of an aggregation market for small-scale generation	Could develop higher prices for exports Market favours scale				Low	Low	Medium
Development of bilateral flexibility markets by DNOs	Could develop higher prices for exports at peak times, especially if co-location with batteries Market favours scale				Low	Medium	High
Capacity markets	Renewables capacity is likely to be able to participate in capacity market auctions from around 2021-22				Medium	Medium	Medium

1.7 Case Studies

In Annex A to this appendix we show a series of case studies or worked examples of representative business sites. In each case, we look at typical consumption and the impact of different levels of solar generation and storage.

Our case studies are:

- A community centre
  - Annual consumption is 78MWh, the solar array is 15kWp and the battery capacity is 7kW/kWh[18]
- A large primary school
  - Annual consumption is 144MWh, the solar array is 25kWp and the battery capacity is 12kW/kWh
- A large secondary school
  - Annual consumption is 685MWh, the solar array is 40kWp and the battery capacity is 20kW/kWh
- An office
  - Annual consumption is 687MWh, the solar array is 50kWp and the battery capacity is 25kW/kWh
- A multi-storey car park, and
  - Annual consumption is 846MWh, the solar array is 20kWp and the battery capacity is 10kW/kWh
- A leisure centre with an electrically heated swimming pool
  - Annual consumption is 479MWh, the solar array is 50kWp and the battery capacity is 25kW/kWh

Based on the analysis, we have looked at payback periods based on (i) current tariff levels and (ii) tariff levels growing by 2%/year for five years in line with industry forecasts of increases in third party charges. This shows:

- Payback periods of less than eight years with current FiTs at current tariff rates
- Payback periods of less than ten years without FiTs at current tariff rates
- Payback periods of less than seven years with FiTs at tariff rates with 2% real inflation
- Payback periods of close to nine years without FiTs at tariff rates with 2% real inflation

The indicative paybacks are summarised at Figure 11.

[18] We have used a one-hour battery.

Figure 11: Indicative paybacks on worked examples/case studies

Site / Payback	With FiT and without tariff inflation	Without FiT and withouttariff inflation	With FiT and with tariff inflation	Without FiT and with tariffinflation
Community centre	7 years 3 months	9 years 4 months	6 years 11 months	8 years 10 months
Large primary school	7 years 4 months	9 years 10 months	6 years 11 months	9 years 5 months
Large secondary school	7 years 3 months	9 years 4 months	6 years 9 months	8 years 10 months
Office	7 years 3 months	9 years 3 months	6 years 2 months	8 years 9 months
Multi-storey car park	7 years 3 months	9 years 6 months	6 years 11 months	8 years 10 months
Leisure centre with electrically heated swimming pool	7 years	9 years	6 years 8 months	9 years 6 months

1.8 Toolkit

Planning

- CARES planning module
- CARES securing a site module

Connection

- SPEN generation heatmap
- SSEPD generation heatmap
- CARES connection module

Evaluation

- CARES solar planning module
- renewables.ninja solar generation predictor
- E.ON/ Google solar
- CARES guide to electricity markets
- CARES investment ready tool
- EST calculator

Combined technology approach

Example schemes

- Community Energy Scotland
- Local Energy Scotland
- Mongoose Community Energy
- Plymouth Community Energy

Delivery

- CARES project finance module
- CARES construction module
- CARES guides to sources of finance
- CARES guide to financing
- CARES procurement module
- Plan Local contract and tendering guide

2 Wind using refurbished and life-extended turbines

2.1 Introduction

In this Community and Local Energy (CALE) workplan, we address the assessment and delivery framework for a commercial site owner considering use of life extended wind turbines. The workplan is designed to be used by businesses in a post-FiT world to help develop their own investment proposals and action plans and to locate and understand existing sources of information and assistance that might be available.

We consider two possible examples.

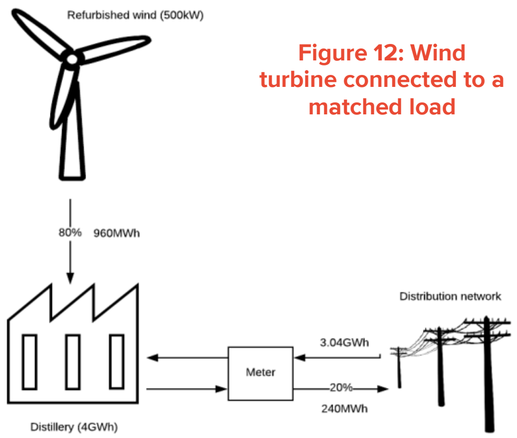


Figure 12: Wind turbine connected to a matched load

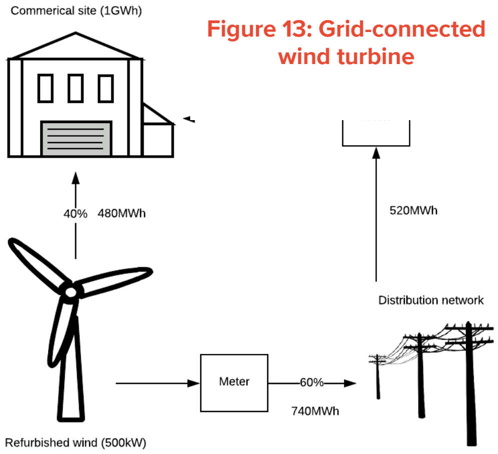


Figure 13: Grid-connected wind turbine

The first is shown at Figure 12 and targeted on behind the meter consumption. It is based on an illustrative 500kW site with significant 4GWh consumption. A 500kW turbine can be expected to operate at a capacity (or load) factor of around 28% over a year.[19] Typically, an installation of this size might provide an annual energy output of about 1.2GWh. While we term this a "matched" site, the import requirement would still be significant, to the order of 2.8GWh for a distillery producing 2mn litres a year and with a steady consumption profile.

Additionally, we also consider a grid-connected scheme of a similar turbine size but with less on-site consumption. With consumption of around 1GWh, this might represent a large hotel or small manufacturing facility. This type of configuration, which is often found in remote locations, and is shown at Figure 13.

This workplan is structured as follows:

- The rationale for considering a refurbished or life-extended wind turbine, rather than a new turbine
- Criteria you will wish to consider for maximising benefits under this project
- A framework for assessment of the appropriate scale and design of a project
- How to develop the key parameters of a business case and identify financing options for the project, and
- Identifying future opportunities which could arise, as well as some of the risks to be aware of.

A summary of the most useful sources referenced in this document is set out in the overview "toolkit" at section 1.7.

[19] This figure is recommended by BEIS as a working average in the UK, but site-specific values could be higher, depending on prevailing local wind speeds. https://www.gov.uk/government/statistics/renewable-sources-of-energy-chapter-6-digest-of-united-kingdom-energy-statistics-dukes

A glossary of terms and abbreviations used in this workplan is found in the Main Report.

2.2 Rationale

This section addresses why you might consider deployment of refurbished wind turbines.

Box 1 – Benefits

Incentive payments on new sites accredited before 31 March 2019

Cheap, clean energy

Bill reductions for energy consumed on site

Increased supply resilience

Protection from energy price fluctuations and future tariff increases

Carbon savings and CSR benefits

Potential tourist attraction

Onshore wind is already the cheapest source of new electricity generation capacity, and electricity from refurbishment projects is significantly cheaper than that from greenfield sites with new turbines.

A growing number of refurbished turbines are becoming available. As the EU onshore wind fleet ages, there will be an increasing number of such turbines to assess for relocation and lifetime extension.

With around 25% of the continent's wind resource, Scotland is the windiest country in Europe with attractive load factors. Although we assume 28% - and observed averages are in line with this – load factors at Scottish sites can be over 40% especially in the case of remote island wind sites. Historically, many wind sites have been grid connected and have tended towards over-sizing turbines with a view to maximising exports. This has happened because of the incentive to earn subsidy payments under the Renewables Obligation (RO) and Feed-in Tariff (FiT) regimes, and this has lead to a clustering in more remote areas away from major loads. This context usually requires unconstrained access to the network and the need to strike appropriate terms for export under a power purchase agreement (PPA) especially for RO schemes, and planning issues tend to be more manageable on remote sites.

Estimates suggest refurbished and life-extended turbines offer excellent payback even without subsidy. However, with the removal of all FiTs for new sites from 1 April 2019, different commercial structures will be needed to deliver a project[20]. In particular, there are now stronger incentives to site turbines behind the meter where the connection can support it. Projects under 5MW will not be eligible to qualify for contract for difference (CfD) auctions, and you will need to maximise your avoided purchase costs through on-site consumption to achieve the best returns, especially if you are using new turbines; the typical avoided retail purchase costs (at about 14p/kWh) will usually be significantly greater than typical wholesale values for exports (at about 6p/kWh). In turn, this will increase incentives to match turbine performance against minimum site load.

Where it is feasible, siting the turbine/s close to the point of consumption and behind the meter also can deliver other benefits. It can reduce network costs as well as those arising from thermal losses that arise during distribution of the electricity. If the local electricity system is weak and prone to operating limitations (constraints), developing a wind turbine system may well also increase your energy security. Matching supply and demand behind the meter also increases the business case for co-location of wind with storage technologies. We consider this more fully as part of workplan 1. Increasingly, it will also incentivise the use of power conversion schemes during periods where wind production exceeds on-site consumption or where operational limits are imposed by the local distribution network operator (DNO).

Use of refurbished wind turbines is also opening up other opportunities. Deploying them at remote sites without subsidy is becoming viable as technology costs fall below wholesale electricity prices. New options are emerging for such sites based on export models. Although many remote locations are not supported by good connections, you might wish to accept operational limits or target future opportunities at sites that might not otherwise provide an adequate return for new turbines. We reference some demand turn-up schemes at

[20] Over 100kW available FiT funding has already been used up, and given realistic planning timescales we do not consider further deployment of onshore wind under the FiT scheme further in this workplan.

section 2.3.4 and at 2.4.5 in the Main Report, and these can soak up power in areas where the local network is weak at times of high levels of export. You may also wish to consider power to gas conversion opportunities, though these have yet to be demonstrated on any scale.

Under both behind the meter and grid connected approaches achieving appropriate terms for power export under the PPA is likely to be a key element of a successful project, especially where on-site consumption is limited and there is significant export potential. You will need to include in the contract appropriate arrangements for sharing the offtaker's avoided costs (or "embedded benefits") as well as striking suitable back-up terms.

2.3 Criteria for maximising benefits

A site's suitability to be developed for refurbished turbines will depend on a number of criteria, which you will wish to consider. Several apply to all sites; some only to matched (short) or grid-connected (long) sites respectively.

2.3.1 Good prevailing wind speeds

Locating wind turbines at the windiest locations, usually at the top of hills and on tall towers, is a key consideration for choosing a site.

Wind speed is a crucial element in projecting turbine performance, and a site's wind speed is measured through wind resource assessment. Generally, annual average wind speeds greater than four meters per second (m/s) (9mph) are required for small wind electric turbines. Utility-scale wind power plants require minimum average wind speeds of 6m/s (13mph).

The power available in the wind is proportional to the cube of its speed, which means that doubling the wind speed increases the available power by a factor of eight. Thus, a turbine operating at a site with an average wind speed of 12mph will generate about 29% more electricity than one at an 11mph site.

Box 2 – Key success factors

Suitable site with high prevailing wind speeds (typically above 9-10mph)

On matched sites, sizeable on-site demand, ideally with a consistent minimum demand, and a supply agreement providing for adequate back-up

On grid-connected sites, an appropriate export PPA

Unconstrained distribution network connection equivalent to your export requirement

DNO approval to connect new generation assets to the network

Planning permission

Access to suitable refurbished wind turbines

Access to adequate funding

2.3.2 Adequate grid connection

An unconstrained grid connection would allow your project the opportunity to generate to its maximum capacity and export any surplus energy.

At times of very high market prices you might elect to reduce your on-site demand and export to the system instead (assuming your PPA allows you to access changes in market prices). But this would be dependent on the installation of smart controls and/or the capacity of the electricity network to accommodate the maximum generation output. In cases where the grid capacity is constrained, you might need to engage with local power consumers 'behind the constraint' in order to avoid curtailment.

Increasingly, innovative practices are being adopted to accommodate the existence of network constraints, especially where the local network operator imposes operational limits on the connection. These include demand-turn up schemes (such as Heat Smart Orkney) and power storage and conversion schemes (such as Levenmouth Community Energy). This means that there are still opportunities to over-size turbines even where operational limits on export can occur. Ordinarily, however, this type of arrangement raises the need for significant complexities including additional investment, that businesses and communities may not wish to address, so we are assuming that as a new project developer you will seek unconstrained distribution network connections approximate to your maximum export in the first instance.

In future we would expect opportunities for locating refurbished assets in remote parts of the system where physical circumstances can change will increase even where they are reliant on export revenues.

2.3.3 Little or no cost to secure consents

With many types of renewables schemes, consenting costs can be significant. Small-scale wind turbines can fall under the permitted development regime, which allows construction without planning permission (that is less than 50kW), but larger projects starting from a standing start are unlikely to achieve planning before the close out of the FiT regime.

Refurbished wind turbines will need to meet the same Local Authority requirements that apply to new wind turbines above 50kW (see section 2.4.3). Useful initial planning resources to begin thinking about some of the issues and toolkits to develop projects from there are listed at the end of this document. Local authority planning departments also often provide guides to where wind turbines will be considered. You can find a link to your local authority planning department here.

You should reasonably allow at least two to three months to secure planning permission even under ideal conditions, but it can take much longer especially for turbines of 500kW and above, especially where they are approximate to third party demand.

Securing the consent of the local community will be important to securing planning permission. Depending on the size and location of the turbine, this may be more or less difficult. Plan Local have published several videos on community engagement here, and the Community Planning Toolkit here was funded by the National Lottery to help drive good quality community engagement efforts.

2.3.4 Matched sites

Significant on-site demand

Although export of surplus energy from a wind turbine is inevitable at most sites, it is much more economically efficient to consume power generated on-site, reducing the amount of power which has to be imported. This is because the wholesale cost of electricity only makes up a proportion (as little as a third) of the final electricity bill. Furthermore, retail prices are set to increase consistently over the coming years, as the rising costs of legacy government support programmes are passed through to consumers.

Conversely, you will want to check that operational limits on imports are unlikely to bite.

Consistent minimum demand

Unlike other intermittent renewable technologies such as solar, wind does not follow a predictable generation pattern. In order to use most of the output of the wind generator on-site, it is important that the site have a stable (and relatively high) level of minimum demand, year-round, relative to the level of output from the turbine/s during windy periods. A consistent minimum demand would allow you to use a turbine with similar maximum output, guaranteeing that the bulk of electricity produced would be used on-site achieving the shortest payback periods.

2.3.5 Remote sites

Falling market prices of refurbished turbines and increased availability are likely to radically change the market-place. Many remote sites are fast approaching viability without subsidy with average costs falling below wholesale prices, and you may wish to explore local opportunities. Changing supply and demand patterns at the local level will continue to open up further opportunities depending upon system conditions in your area.

2.4 Assessment framework

A wind project involves management and coordination of several diverse activities and considerations. In order to define and assess your project, you will need to consider the following stages:

- Identify a suitable site, determining location-specific wind resource
- Assess resource requirements
- Determine turbine type and size
- Ensure availability of adequate grid connection capacity and technical and resource requirements
- Obtain necessary permissions engaging with the local community, and
- Identify the necessary delivery partners, including an offtaker for your exports, and addressing implementation issues.

Box 3 – Main assessment steps

Identify the site

Determine your current and future generation potential and on-site demand

Set the size of the turbine

Identify delivery partner

Identify specific approvals needed from DNO

Build community support for your generator

Confirm compliance with conditions in planning approvals

2.4.1 Identify the site

Even on an existing site, you may well have discretion over where you choose to site the turbine/s.

Assessment of the wind resource is the first step to determining the suitability of a project location. There is a useful guide from the Energy Saving Trust (EST) to measuring wind speed here and an example of a wind atlas resource that gives values of average wind speeds around Scotland from the Global Wind Atlas can be found here. Typical cut-in speeds for turbines are around 5m/s, and economic returns are marginal below 6-7m/s. Assessment of the wind resource should consider the accuracy of the recorded data.

As the windiest sites are often in places of outstanding natural beauty you should early on check for environmental and planning concerns to avoid opposition to the project[21]. Scottish Natural Heritage publishes guidance on protected areas, including protected area notices and local designations. You should also consider the distance from non-financially involved properties due to the noise made by rotating turbine blades.

Wind availability can vary even across a narrow area. Pay particular attention to spots where trees, buildings or other features of the landscape may shield a turbine from the wind or, conversely, drive additional wind to the turbine. This may be especially important to avoid interactions where multiple turbines are considered.

You should also consider how visible the turbine is and the noise produced. This is an important health and safety consideration, as well as potentially affecting the enthusiasm of the local community for the project.

The two Scottish electricity Distribution Network Operators (DNOs) provide information on the sites where generation may be connected to an unconstrained network here for the SPEN areas (south Scotland) and here for SSEN (north Scotland). However, most business and community wind project will connect at low voltages. Local network maps showing lower voltages are available from your DNO.

Due to the limited detail in these maps, it will be necessary to use the online tools to discover whether unconstrained connections at LV levels are available for your specific location. Information on where to approach the relevant department within each DNO to discuss how to make a connection application is here, and a guide for community groups is here.

[21] https://www.nature.scot/professional-advice/safeguarding-protected-areas-and-species/protected-areas/national-designations/national-scenic-areas

2.4.2 Evaluate the site

Understanding the physical conditions on-site will be key to making an assessment of the project. You should quantify any existing generation – including backup facilities – and the associated metering data, as well as quantifying the on-site electricity load profile throughout the day.

Your consumption profile is very important, as it will help you to select the right size of turbine to ensure that most power is consumed on-site. Many business sites will already have half hourly metering and be able to provide historic consumption data. If you do not have half hourly metering[22] or if you are a community scheme, your pattern of electricity usage will probably be determined for billing purposes under a standard consumption profile, which is unlikely to be representative of your actual consumption by half hour[23].

We provide further information on this issue of consumption and profiles in the Main Report.

Data loggers, which clamp onto the main incoming power-feed, can be used to assess electricity import. They can record data at various granularities, including by the half hour. Many non-domestic intermediaries who help businesses procure energy supply can provide these, or your existing supplier may be able to help. Be cautious when using less than a full year's data when making a decision on turbine size, as consumption patterns can change significantly across the year.

You should identify opportunities to integrate with building management systems. The potential for demand-side response or demand turn up, to make the best use of the wind turbines, may include existing or new electrical heating and heat pumps, air conditioning and refrigeration, or energy storage technologies other than batteries. Control systems should be assessed to integrate generation meters with any existing fuelled generation on-site (such as CHPs or back-up generation), to manage the use of these while wind electricity is being produced.

A wind turbine is a large structure that requires substantial foundations involving transport connections that facilitate passage of large, heavy vehicles to get to the site. Check whether the roads and bridges to the site are able to allow access of construction materials and the turbine you are intending to purchase. You may also need to arrange for convoy assistance for abnormal loads from the police.

Renewables First provide a wind site self-assessment tool which can help you to think about some of these issues here.

2.4.3 Select the type and size of the turbine

You should set the size of the turbine, probably subject to the minimum demand profile of the site, but also taking into account planning and connection considerations, and budgetary limits. In order to maximise the size of the scheme – and therefore economies of scale and potential benefits – you may wish to identify opportunities for inclusion of other sites or additional local demand, especially where they are connected by private wires.

Technical analyses to determine operational performance and condition, including component fatigue levels or aero-elastic simulations, are essential to assess wind turbine lifetime extension. Lifetime assessments will often involve the cooperation of the wind turbine manufacturer and independent experts, but calculations of useful lifetime still require forward predictions of component performance.

At around this stage, you will want to identify your preferred installation contractor to support you in this process. Life extended, refurbished wind turbines are available for purchase from an increasing number of sources, A listing of some refurbished wind turbine providers who you may wish to consider can be found in

[22] Suppliers will usually encourage you to install half hourly metering if your maximum demand is over 70kW.

[23] There are eight consumption profiles, four of which (profile classes 5-8) apply to non-half hourly metered non-domestic sites. These differ by peak load factor. Further information of profile classes is here.

section 2.4.7. These providers also provide maintenance services. They often also offer free services like wind-speed assessment reports.

The lifetime of a wind turbine is based upon how many cycles it is designed to withstand from the aerodynamic loads it encounters. The International Electrotechnical Commission (IEC) standards set a minimum lifetime of 20 years on new wind turbines. The turbine class is then selected according to meet the environmental conditions it will be placed in. IEC standards establish classes for wind turbines, which are exposed to different levels of average wind speed and turbulence intensity. Refurbishment cost of a turbine can be influenced by the class of turbine. Not only will the purchase cost be higher for Class 1 turbines but also the potential cost of refurbishment, operation and maintenance.

Before the business case for a refurbished wind project can be signed off and implementation commenced, it will be essential to closely assess and have an expert independently verify the purchase options. This assessment should cover recommendations for end of lifetime analysis of the used wind turbine in order to establish the remaining useful lifetime, potential for lifetime extension and cost of refurbishment.

Other necessary steps you will want to undertake as part of the technical assessment include:[24]

- Visual inspection of key components and non-destructive testing
- Analysis of operational data and inspection of maintenance logs
- Load analysis by reviewing weather data for intended site of use compared with design criteria,
- Consumption and use analysis and impact of placing generation behind the meter.

A general guide from Plan Local on procurement contracts and commissioning can be found here; a similar CARES guide on procurement of goods and services is here.

Box 4 – Selecting the turbine

Detailed information should be gathered on:

Previous country of operation and location of the turbine/s as requirements for servicing and maintenance are country specific

Preferred contractors

Generation records and operation against the manufacturer's operating curve

Service records against manufacturer's guidance

End of lifetime analysis

Detailed turbine assessment

2.4.4 Ensure adequate connection capacity

You will need to familiarise yourself with the terms of the existing connection to the public system. Most business sites with a demand in excess of 100kW and connected at voltages above 1,000 volts are likely to have their own connection agreement.

Installing a new turbine above a minimum size will almost certainly necessitate a new or revised connection agreement with your local DNO, and you will want to discuss your plans with the DNO at an early stage. You should note that:

- Connections over 50kW will be applied for under the major schemes provisions, which are more expensive and time consuming
- The full G59 connection process will apply.[25] This will require making an application to the DNO: here for SPEN in southern Scotland, here for SSEN in northern Scotland, and
- The Electricity Networks Association (ENA) has published a guide to G59 connections here.

A G59 connection is regarded as a major connection, especially in northern Scotland, and it should be remembered that – while the DNO will provide the connection agreement and undertake certain elements of

[24] Rubert et al., 2017; *A Decision Support Tool to Assist with Lifetime Extension of Wind Turbines*, Renewable Energy 120, pp423-433.

[25] The full process is required above 17kW for single phase sites, and above 50kW for three phase sites.

the work (non-contestable works) – it may be possible to have another party build most of the physical connection to the network (contestable work), and that this may be a cheaper option.

DNOs must provide a quotation, following application, within 30 days for LV and 50 days for HV applications, where only non-contestable work is applied for; when undertaking contestable work as well, the timescales are 45 and 65 days respectively. Your delivery partner will be able to help you to apply for a connection and will either build or help you secure a partner to upgrade your connection.

The two Scottish DNOs provide information on the sites where generation may be connected to an unconstrained network here for the SPEN areas (south Scotland) and here for SSEPD (north Scotland). It will be necessary to use these online tools to discover whether unconstrained connections at LV levels are available for your specific location.

The DNO and your connection partner will be able to advise on the necessary paperwork, and other advice can be found on the ENA's website.

2.4.5 Obtain the necessary planning approvals

At an early stage you will want to ensure that planning permission is not required, or secure it if it is. In considering this matter, you will want to take the following into account:

- Above 50kW generation requires planning permission, and will not be considered a permitted development in Scotland
- However, some sites will be restricted, especially if near domestic properties, areas of natural beauty, national parks and green belts
  - Even permitted developments need to observe conditions and limits, and these can be found here
- Planning permission should be checked with the planning department of the local authority, as each handles planning differently. The Scottish government has a guide to planning permission in general here
- Local Energy Scotland has produced a Planning Module as part of its CARES Project Development Toolkit here, which provides useful context around the planning system in Scotland, the role of local authorities and the process for obtaining planning approvals.

The CARES Securing Your Site module also offers guidance.

2.4.6 Engage with the community

It is good practice to engage with local stakeholders to secure buy-in, or at least acceptance, of the project. For turbines over 50kW, where planning permission is required, community assent is vital to the success of the project.

Climate Xchange's guide to good practice in community engagement for wind projects focusses on larger projects, but lessons are important for all sizes of scheme. It is found here.

2.4.7 Identify delivery partners

Delivery partners might offer valuable support in project development. They can identify the best site for a given size of turbine, establish the technical viability of the grid connection and the route to market for surplus generated power through a supplier. In addition to this they may be able to offer site management and health and safety management during the construction phase. They can also offer contracts for the maintenance of the wind site once operating.

Some examples of technical partners and refurbished turbine suppliers can be found in Figure 14 below.

Figure 14: Selected refurbished wind turbine suppliers and project partners

Provider	Location	Size of Turbines	Pricing	Terms for Installation/Maintenance
Boythorpe Wind Energy	North Yorkshire	225kW (30m), 500kW, 800kW and "larger turbines"	225kW and 500kW: cost "less than half the price of buying new"	Joint Venture Partnership: Pay 50% of turbine costs and share same % of profits from turbine for next 20 years. Option to purchase turbines outright also.
Green Energy Wind	Belfast	150kW (24 & 30m), 225kW (40 & 50m), 250kW (30m), 300kW, 500kW	Price discounts for multiple system purchases	3 maintenance services offered on 5 or 10-year contracts. Whole installation service provided at fixed cost.
MPG Wind Ltd	Belfast	150kW, 225kW, 250kW, 600kW, 660kW (40 & 50m), 850kW (36 & 50m)	-	Installation and maintenance advice available as well as turbine erection.
Envico	Scotland	225kW, 400kW, 500kW, 600kW, 800kW, 2300kW, 7500kW	-	Installation and maintenance offered. Installation involves groundworks, electrical installation and commissioning.
Spectrum Energy Systems	Nottingham	225kW (31m), 500kW (40m), 600kW (40 & 50m)	-	Installation and maintenance offered (as well as generator inspections and turbine servicing and repairs).
Second hand Wind Turbine	Scotland	2.5kW, 6kW, 75kW, 200kW (30m), 225kW (31m), 500kW (40m & 53m), 660kW (73m)	-	Installation of turbine offered – service and registration cost.
Virogen	Belfast	250kW	-	Usually sourced and refurbished in Germany and Denmark respectively. Most turbines sourced are single piece therefore attract higher transportation costs. Installation and maintenance offered.
wind-turbine.com	-	250-3000kW	Some prices for turbines shown in listings	No maintenance/installation offered from wind-turbine.com itself but links to turbine sellers given in listings (which may offer installation/maintenance services).

2.4.8 Identify an offtaker

In order to achieve a return for significant power exports for project established after the end of the FiT, you will need to enter into contract with a suitable counter-party to act as a power offtaker. Under the offtake agreement (or PPA) they will take your power and provide revenue streams based on the wholesale value of the power and the embedded benefits for the power you are not able to use on-site.

The PPA sets out the terms, including price per unit of electricity and duration, by which electricity will be purchased from you. CARES have produced a guide to PPAs here There is a range of different types of contract available in the marketplace, varying in terms of structure and length. Typical terms are shown at Figure 15.

Figure 15: Structure and elements of a PPA contract

Section	Key risks and considerations
1. Definitions	Different offtakers will have different definitions
2. General T&Cs	Terms of business, roles and responsibilities
3. Commencement and duration	Drop dead date for contract start and interactions with construction milestones

Section	Key risks and considerations
4. Obligations and metering	Forecasting responsibilities, imbalance, metering providers and costs
5. Force Majeure/ termination/ change in law	Treatment of changes in law, termination criteria
6. Credit support	Offtaker credit worthiness vs lender expectations
7. Assignment and transfer	Asset sales and re-financing
8. Notices/ dispute resolution and audit	How disputes will be notified and resolved
9. Pricing schedules	Key area for negotiation of the specific payment terms for the PPA

Licensed energy suppliers are the natural counter-party for offtake, and negotiations should be opened with suppliers to sign a PPA. There is no requirement that you sell power exports to your existing import supplier. You are free to establish a relationship with another counter-party to establish a PPA. However, given your power requirement is likely to be significant anyway, you will probably want to enter into this arrangement in parallel with renewal of your energy supply contract.

The market for offtake power has become increasing competitive as it has grown. In all there is over 12GW of low-carbon generation below 10MW. Nearly 1.5GW of FiT accredited generation has negotiated agreements. Over 40 parties currently offer PPAs.

Typically, a longer-term deal with more revenue certainty will offer lower returns while a shorter-term deal may offer more value, but less certainty on revenues across the life of the project. The different types of approach to risk management is shown at Figure 16.

Figure 16: Risk levels of a PPA

Value retention	Lower	Medium	Higher
Risk Appetite	Stable revenue	Some market exposure	Full market exposure
Contract Length	Long—10 years +	3 years to 10 years	6 months to 3 years
Contract flexibility	Unchanged over life-time	Some renegotiation at regular interval	Re-tendering/ pricing and trading options
Pricing	Fixed (with floor)	Market reference	Daily/ hourly price

Stable, long term

High value, low certainty

As larger generators tend to secure superior prices, you may wish to consider aggregating your export with that of other local sites. There are brokers and aggregators active in the market who will help you to do this, though such arrangements will introduce commercial complexity.

2.4.9 Other considerations

Once the turbines for been procured and installed, you will also want to make arrangements with regard to:

- Operations and maintenance agreements
    - Service and maintenance requirements will be the same as for new turbines, though refurbished units may require more attention
    - Choosing a widely available turbine make it more likely that spare parts are available

- Insurance
  - Contracts will be the same as for a new wind turbine, but are likely to be more expensive, reflecting the additional likelihood of component failure, and
  - Cover can include the turbine itself (for mechanical breakdown and damage), employer and public liability, and loss of earnings while the turbine is being repaired.
- Warranties
  - Understand what the warranty covers (replacement parts, labour, lost production)
  - How long does the warranty last?
  - Understand the impact of the warranty and the end of the warranty on insurance costs, and
  - What happens if the warranty provider goes out of business?

2.5 Business case and finance

We summarise in this section sources of value of medium-scale wind projects, focussing on refurbished turbines, and the costs you can expect to face.

Box 5 – Key commercial features

Connection agreement

Validated capex and opex assessments with desired return on investment

Service contract covering O&M, downtime cover

Warranties and insurance

Suitable PPA for exports, with appropriate duration

Understanding of available embedded benefits

Supply contract that allows for turbine outages

If the project is to be progressed prior to March 2019, pre-accreditation with Ofgem under the FiT regime

2.5.1 Outline business case

A business case will establish the costs and benefits of the project, setting out how and when the costs will be recovered. The CARES Investment Ready Tool provides a template to set out the business case for a project.

With the removal of Feed in Tariffs (FiTs) for new sites from 1 April 2019, different commercial structures are needed to make support the viability of projects. Achieving appropriate terms for power export under the PPA is likely to be a key element of a subsidy free project, especially where there is significant export potential, and this will need to include appropriate arrangements for sharing the offtaker's avoided costs (or "embedded benefits") as well as suitable back-up terms.

New opportunities are also set to arise as local flexibility and capacity markets will develop under wider electricity industry changes, although it is unlikely that these will be available to many projects on this scale unless they can be combined with other projects or technologies.

2.5.2 Sources of value

Identifying the value which can be accessed by the project is the first step in putting together a business case.

Avoided costs

The primary source of value you will derive is from the avoided cost of imports for the generation produced and used on site. For every unit you produce and consume on site, the avoided cost would be around 14-15p/kWh (that is, the volumetric charge under your current supply contract; you would still be subject to the standing charge under smaller user tariffs and the unit rate for imports). We use a figure of 14p/kWh below.

Retail energy costs are also expected to continue rising in the future, with third party charge increases already programmed, primarily from network use and government levies. In workplan 1, we assumed a steady real cost increase of 2% per annum over the next ten years. Further information on the rising costs of third party charges is at section 2.3.2 of the *Market Context and Prospects* published alongside the main report as Appendix A.

Wholesale energy

Generators outside of a FiT arrangement typically derive value for their energy from two sources.

2.5.3 PPAs

PPAs (or offtake agreements) are available from a wide number of parties, though different suppliers tend to target, different parts of the market. Above 250kW, there is a liquid market and a range of active counter-parties.

Under a PPA the supplier:

- Will enter into a long-term agreement to purchase offtake power at a specified price (often discounted, for reasons we have explained in section 3 of Appendix A to the Main Report, and
- Will share value it achieves from embedded benefits.

Historically wholesale prices have been lower than the administered FiT export rate (see Sections 3.2.3 and 3.2.4 of *Market Context and Prospects* published alongside the main report as Appendix A).

2.5.4 Embedded benefits

An important consideration in entering a PPA is achieving appropriate recognition of the embedded benefits, especially where there is a probability of significant export volumes. These are based on charges that the supplier counterparty can avoid by contracting with power produced locally. Benefits arise from avoiding costs of network use, thermal losses and balancing charges. Calculations are based on the technology of your generator, the voltage of your connection (low-, high- or extra high-voltage) and which of the 14 distribution regions (two in Scotland) your generator is connected to. It is because of these benefits that some existing FiT schemes have opted out of the administrated export rates and have entered into commercial PPAs.

These benefits accrue to the supplier, but it will pass a large percentage to the generator through the PPA; this pass-through can be as high as 90% or more dependent on the benefit. Calculating how much embedded benefits you will receive is difficult, as you will need to take account of all of the benefits and these change frequently, but tools like Cornwall Insight’s embedded benefits calculator can help you to make this calculation.

These add up to around £10/MWh in Scotland to generator revenues, dependent on technology and location but assuming they are distribution connected, though wind related values are probably less than £5/MWh, reflecting its intermittency. We believe embedded benefits will rise over the coming years.

Further information on embedded benefits is at section 2.3.3 and Annex E of Appendix A.

2.5.5 Other commercial avenues

Other routes to market are merging, enabled by brokers and other intermediaries. Some examples are summarised below.

e-POWER auction

The e-POWER auction is an industry trading platform open to all renewable energy generators and acts as a marketplace for securing short-term PPAs, typically for 6 to 12 months. It enables generators to gain market visibility with a large number of suppliers. In July 2018, the average price of wind power was reported at £60/MWh[26]. The NFPA also provides opportunities to aggregate export meters in the same distribution region. However, depending on how you are financing your project, you may be required to enter into a longer-term contract, which means 6-12 month arrangements may not be acceptable.

A possible Post FiT export rate

As yet, there is no replacement proposed for the FiT export rate for generation that misses the 31 March 2019 deadline, or indeed any guaranteed route to market for generation less than 5MW. While the UK Government is consulting on possible options, it is very unlikely that this will be available to generation projects above 100kW. A call for evidence on this issue is here, and future decisions will be posted on that page.

Aggregation

[26] This is much higher than previous prices, reflecting the recent surge in wholesale prices. The corresponding price from the previous January auction was at about £46/MWh

Other aggregation opportunities are emerging in addition to the facility noted on e-POWER. Consolidators and brokers are already active in this area. Suppliers most active in the sub-5MW space are shown at Figure 10 of Appendix A to the Main Report.

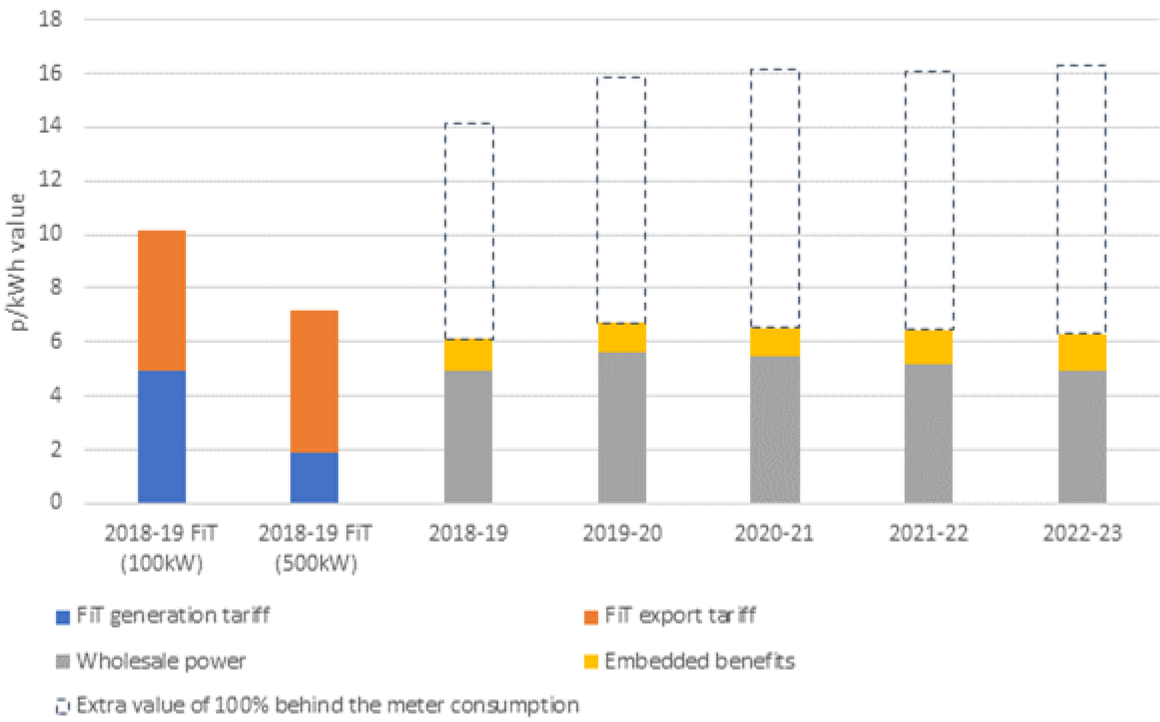
2.5.6 New projects from April 2019

The different values obtainable per unit of electricity generated for a wind turbine are illustrated in Figure 17.

In more detail:

- The 2018-19 FiT columns show the FiT generation payment per kWh that would have been paid plus the export payment assuming the scheme was grid connected in that year and exporting to the system. The value achieved would be 1.92p/kWh under the generation tariff + 5.24p/kWh = 7.16p/kWh for a >100kW turbine, or 4.94p/kWh + 5.24p/kWh = 10.18p/kWh for a 100kW turbine
- The 2018-19 column shows the value derived by a wind turbine assuming it received no FiT support but selling on a merchant basis. In this instance, the value achieved would be based on the wholesale power price plus a share of the embedded benefit specified under the PPA. Using Cornwall Insight's PPA market assessments, the value would be to the order of 6p/kWh, comprised of an achievable power value of over 5p/kWh and an embedded value of under 1p/kWh
- Subsequent columns shown the same assessments for future years, but we are not expecting the wholesale power value to rise, though the embedded value is increasing modestly in line with expected increases in grid balancing charges, and
- For all columns except the first, the dotted line tops up the value to our assessment of the avoided cost of the energy but only if it were produced behind the meter and consumed on-site.

Figure 17: Historic and forecast p/kWh revenues of a 500kW wind farm[27]



Source: Cornwall Insight

[27] The FiT cap for 500kW wind turbine sites has now been breached

Figure 6 uses a representative tariff level for a low voltage connected half-hourly metered customer in the Northern Scotland region.

The value of the power consumed on site is not related to the size of the wind turbine, as long as it is sized appropriately against the consumer's demand profile such that as much of the power generated is consumed on-site as possible. Put another way, the value of the wind output will vary between 6p/kWh and 15.5p/kWh depending on the size of the turbine and extent to which the energy from the turbine is used on site.

2.5.7 Costs

Figure 18 summarises capital cost estimates we have obtained for both new and refurbished wind turbines by size. Typically, turbine costs represent about two-thirds of the total project cost.

Figure 18: Wind turbine capital costs[28,29,30] for varying installation sizes

Turbine	New	Refurbished
50kW-55kW	£50,000 - £125,000	£18,000 - £42,000
100kW-150kW	£51,000 - £250,000	£25,000 - £43,000
500kW	£491,000 - £714,000	£54,000 - £134,000
800-850kW	£900,000 - £1,000,000	£89,000 - £429,000
1.5MW-1.8MW	£1,800,000 - £2,000,000	£54,000 - £402,000

Various sources accessed by Cornwall Insight on 13/08/18

[28] https://en.wind-turbine.com/wind-turbines/used

[29] https://www.alibaba.com/trade/search?fsb=y&IndexArea=product_en&CatId=&SearchText=100kw+wind+turbine+price&viewtype=G

[30] http://www.renewablesfirst.co.uk/windpower/windpower-learning-centre/how-much-does-a-farm-wind-turbine-small-wind-farm-turbine-cost/

Box 6 – Costs of refurbished wind turbines

Refurbishing a wind turbine can be a complicated process involving a range of parties. Using a 250kW turbine as an example:

- An investor may be able to source a turbine from Germany for £100k or perhaps €100k
- The turbine is then disassembled and transferred to a refurbishment company. This may involve tower repainting, gearbox refurbishment and oiling, rewiring of electrical components
    - It generally involves an assessment of the remaining lifetime of individual components, bearing in mind that the assets have already had an operational lifetime of 15 years or so
- This leads to a cost of circa £200k before laying the foundations for the wind turbine, trench and any possible transformer requirements. This depends on whether the turbine is being built on a green or brownfield site and whether there is an existing grid connection in place
- Assuming 28% load factor and 10-year extended lifetime this equates to a cost of at least 3.26p/kWh before operation and maintenance costs and a return on investment is included. It is possible to extend the lifetime further, but blades, gearbox and generator will likely need to be replaced over this time
- Aside from the upfront costs, there are a number of other elements to consider for refurbished turbines:
- Operational and maintenance costs are higher, as there are more frequent breakdowns due to the extended life of the assets
- Connection charges would depend on whether additional works were required by the DNO
- Generation (load factors) will typically be 20%-25% lower than that for equivalent new sites. This is due to improved technology of the turbines, including variable speed and variable pitch, maximising the generation of different wind speeds and directions
- Transport and locational costs are also highly site specific.
- We have therefore assumed a LCOE in the range of 5p/kWh for 250kW and 500kW turbines.

The conventional measure for estimating the costs of generation technology is the so-called levelised cost of energy (LCOE) calculation. LCOE – or the total cost of the project over its entire life, including construction, maintenance and all other expenses, divided by the number of units of energy expected to be produced – for refurbished wind turbines is considerably lower than for new turbines. For illustrative purposes, we use average rates of 12p/kWh for new turbines and 5p/kWh for refurbished turbines.

Using refurbished turbines clearly results in a shorter timeframe for payback of the investment. Lower turbine unit costs are offset to some extent by the higher operational costs, insurance and maintenance expected of refurbished wind plant as well as a shorter expected asset life. Transport costs can be significant but are very project, asset and site specific.

The 5p/kWh rate should be placed in context. Below we cite some estimates derived from a variety of sources. These are typically for larger units, from 900kW to 1.5MW.

Some recent estimates for set up costs for refurbished wind turbines of 900kW capacity are available[31], with LCOE estimates dependent on the proposed life extension and degree of turbine component refurbishment. The costs were calculated from data provided by DECC and ARUP applicable to repower existing sites. A central case of 2.24p/kWh was shown to be achievable for a life extension of 10 years. But this would not necessarily consider the transportation of the used wind turbine to its new location. There are greater concerns on asset life, maintenance and insurance, and health and safety, which should be taken into account.

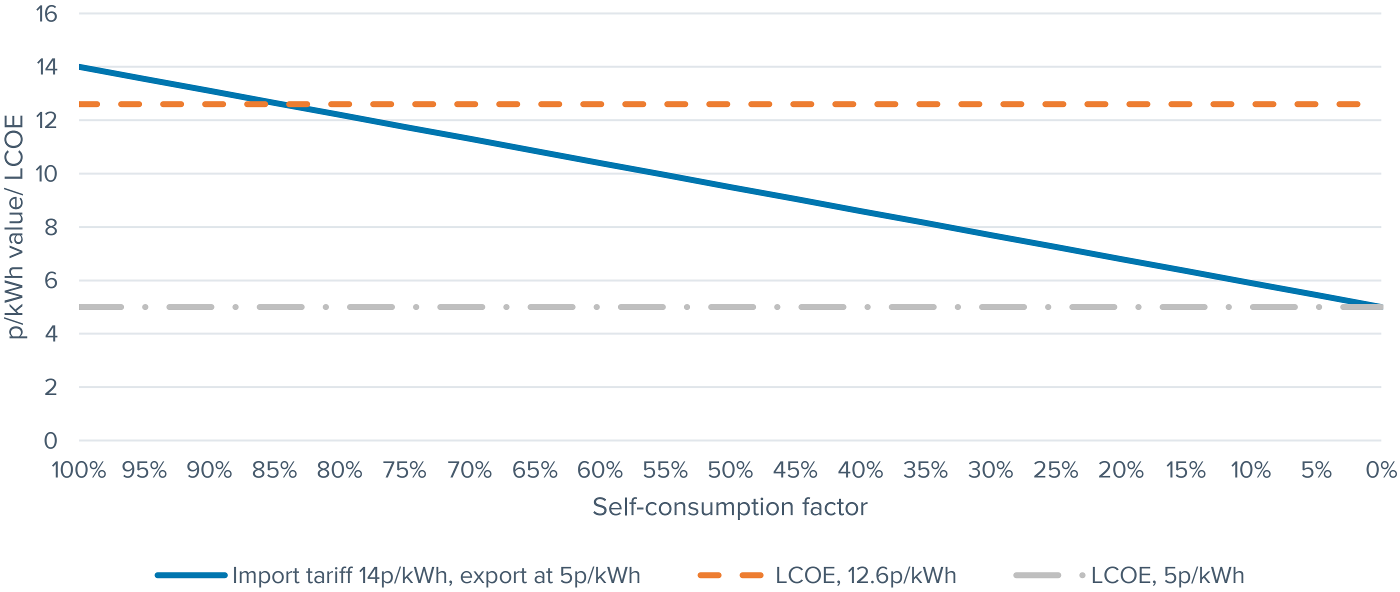
[31] Rubert et al (2018)

A Local Energy Scotland and Community and Local Energy Scotland (CARES) briefing paper on *Refurbished and Remanufactured Wind Turbines* can be found here. CARES projected a central case LCOE for a 1.5MW turbine of just under 3p/kWh, with an IRR of 18.97%.

Grannell Community Energy set out the costs of their refurbished 500kW turbine in their share offer document here. This particular turbine will have – assuming construction proceeds according to the budget – an LCOE of 5p/kWh and an IRR of 7%/year.

Given the wide range, we discussed these estimates with developers. Figure 19 shows the two reference LCOE examples. It shows that at a levelised cost of 12.6p/kWh a new turbine would be profitable where more than c.80% of the production were consumed on-site, but a refurbished turbine with a levelised cost of 5p/kWh would be profitable at any level of self-consumption.

Figure 19: The cost and value of refurbished vs new wind (today)



The overriding message is that most refurbished installations are likely to break even, with only low self-consumption required to make a project viable. Grid connected schemes also appear close to viability at these cost levels assuming a PPA could be negotiated in the 5-6p/kWh range assuming and an existing connection were used.

2.5.8 Examples

Examples of established CALE group projects employing refurbished wind turbines can be found below.

Figure 20: CALE wind project case studies

Examples of CALE wind projects
South Brent Community Energy Society
Grannell Community Energy
The Small Wind Coop at Kellybank
CRAIL wind project
Coigach Community Interest Company
Kelpie Wind

2.6 Future opportunities and risks

In this section we highlight energy industry and market changes that could impact on the options we have summarised for you in this workplan. In general, they increase profitability of the wind turbines by reducing cost and growing possible revenues.

2.6.1 Falling cost of equipment

Levelised costs of new onshore wind are expected to fall by around 35% by 2030, or around 3%/year. Similarly, we would expect the market for refurbished turbines to become more competitive as it grows and for prices to be driven down.

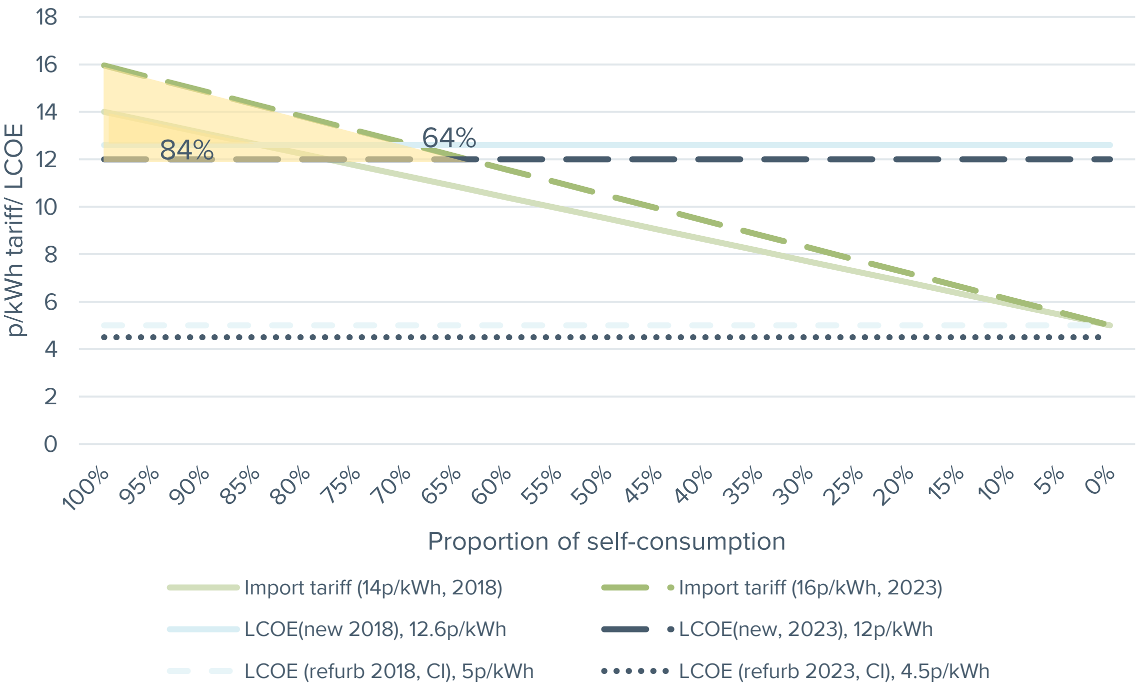
The supply of refurbished wind generators may become greater as early ROC-subsidised schemes reach the end of their 20-year subsidy lives. We project that in Scotland 42 sites, with 920MW of capacity, will come to an end of their subsidies between 2022 and 2026. As per BEIS's 2016 assessment here, we assume that by 2025 continued global deployment and increased availability of larger refurbished turbines will reduce the LCOE of new turbines in the range 100-1,500kW to 12p/kWh; we have also assumed that the LCOE of refurbished turbines falls to 4.5p/kWh.

2.6.2 Rising retail prices

Wholesale power prices are expected to remain broadly at current levels over the next few years, though they might be subject to downward pressure as more renewables plant competes to stay on the system (termed price "cannibalisation"). In contrast, embedded benefits are set to rise over the period (provided network charging methodologies are not changed, see 6.3), reflecting the increasing costs of balancing the electricity system in real time.

Simultaneously non-commodity costs (termed third party charges or TPCs) on consumers' electricity bills are set to increase over the same time period. For a low voltage connected half-hourly settled customer, TPCs are expected to rise by 27% in the North Scotland region and increase 28% in South Scotland. This is predominantly due to higher renewable levy costs, although carbon taxes and network charges are also set to increase over this timeframe. This means that retail prices are also expected to increase over this timeframe, as outlined in Figure 21.

Figure 21: The cost and value of refurbished vs new wind (today)



2.6.3 Other risks and opportunities

In the early 2020s, energy market regulator Ofgem is looking to change network "residual" charging rules (residual charges comprise 80% of transmission charges and a variable amount of distribution charges). This change is likely to particularly affect higher voltage customers, and this change could result in these customers paying these charges gross for all electricity consumed, including electricity generated on-site. This could undermine the value of electricity consumed owing to higher network charges (based on gross, not net demand). Ofgem could also reform how some network charges (and embedded benefits) are calculated, leading to the potential loss of some embedded benefits in some areas.

Offsetting this, the cost of energy consumed on-site is expected to continue to increase, increasing the avoided benefit of producing and using your own electricity. These and other change factors are summarised at Figure 21.

Wind forecasting is more difficult than estimating other renewables technologies such as solar and hydro. Any shift to time of us pricing and half hourly settlement is therefore likely to be less beneficial relative to other low-carbon technologies, and wind operators will be price takers. Co-location of batteries could help here, and we have seen a number of proposals brought forward recently. Further information on battery storage are set out in workplan 1.

Figure 22: Impact of expected changes on business case

Change	Impact (RAG-rated)	Timeline			Impact		
		Now to 2019	**2019-22**	**2022 onwards**	**100kW**	**900kW**	**1.5MW**
Possible degression of FiT tariffs for new wind installations if cap is breached	Reduction in tariff rate by 10%				High	High	High
Removal of FiT subsidy	Loss of guaranteed route to market with guaranteed minimum pricing of 5.24p/kWh Loss of guaranteed generation payments (various levels, around 2-5p/kWh in 50kW-1,500kW bands				Medium	Medium	Low
Embedded benefits	Potential fundamental reform of network charging arrangements under Ofgem's Forward Looking Charges workstream. Possible loss of some embedded benefits				High	High	High
	Tariffs to increase to around 20p/kWh for many user groups by early 2020s creating stronger incentives to match output with self consumption				Medium	Medium	Medium
Failing wind LCOE	-3-4% levelised cost/year for new onshore wind Increasing flow of old turbines onto market				Low	Medium	Medium
Wholesale electricity prices	These are not expected to change significantly				Low	Low	Low
Increasing electricity tariff prices	These should increase, especially with regard to the cost of system balancing				Medium	Medium	Medium
Smart time of export tariffs	Neutral impact on wind if not co-located with batteries				Low	Low	Low
Development of an aggregation market for small-scale generation	Could develop higher prices for exports				Low	Medium	Medium
Development of bilateral flexibility markets by DNOs	Could develop higher prices for exports at peak times, especially if co-location with batteries				Low	Low	Low
Capacity markets	Renewables capacity is likely to be able to participate in capacity market auctions from around 2021-22				Medium	Medium	Medium

2.7 Toolkit

Life extended wind turbines

Planning
- CARES planning module
- CARES securing a site module

Connection
- SPEN generation heatmap
- SSEPD generation heatmap
- CARES connection module

Evaluation
- EST guide to wind speed measurement
- Renewables first wind site assessment guide
- Global wind atlas resource
- CARES solar planning module

Example schemes
- South Brent Community Energy Society
- Grannell Community Energy
- Small Wind Cooperative
- CRAIL wind project
- Coigach wind project
- Kelpie wind

Delivery
- CARES PPA module
- CARES construction module
- Plan Local contract and tendering guide
- CARES project finance module
- CARES procurement module
- CARES investment ready tool

2.8 Other sources of information

National Grid balancing services

SSEN – Get connected

SPEN – Getting connected

Local Energy Scotland refurbished wind project briefing paper

Community and Renewable Energy Scheme (CARES) Project Development Toolkit

Energy Saving Trust Community Energy Hub

Community Energy Scotland Knowledge Centre

Community Energy Scotland – Delivering your project

Community Renewables Toolkit – Securing Your Site Module

Community and Renewable Energy Scheme Development Toolkit – Planning Module

Plan Local – Contracts, agreements and tendering

Energy Saving Trust – Measuring wind speed

Local Energy Scotland – Wind technology options

Cornwall Insight – Embedded benefits calculator

Other references

Allardyce, et al, *Balmenach Distillery Case Study*

British Wind Energy Association – Wind turbine technology

DECC, *Onshore Wind Call for Evidence: Government Response to Part A (Community Engagement and Benefits) and Part B (Costs) 7 (June)*, 2013, pp. 66-78.

Rubert et al (2018); *A Decision Support Tool to Assist with Lifetime Extension of Wind Turbines*, Renewable Energy 120, pp423-433.

Scottish National Heritage – National scenic areas

Scotch Whiskey – Future Energy Opportunities: A Guide for Distillers

Ziegler et al, 2018; *Lifetime extension of onshore wind turbines: A review covering Germany, Spain, Denmark, and the UK*, Renewable and Sustainable Energy Reviews 82, pp1261-1271

3 Collective energy action

3.1 Introduction

This workplan addresses increasing customer engagement with the energy market at the community level, especially aggregating domestic customer demand for switching. It focuses on high density housing such as tenement and tower blocks. It is written primarily with social landlords and housing associations in mind.

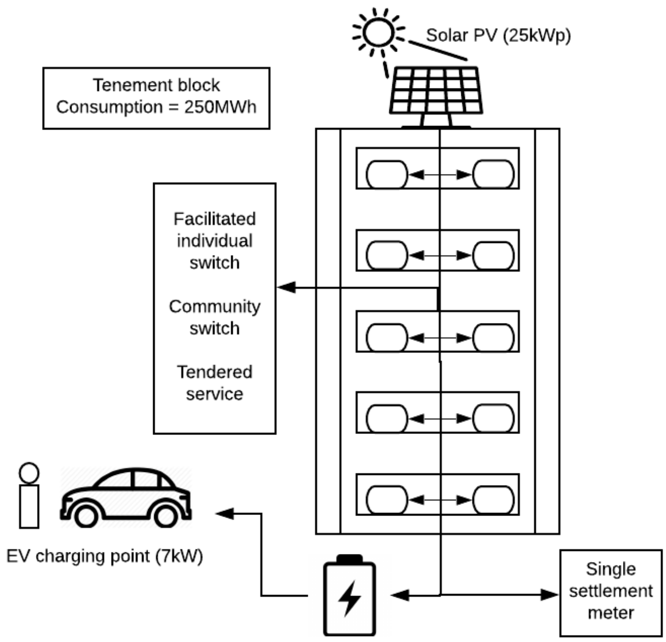
Switching supplier can deliver immediate benefits to tenants, especially if they have not recently engaged with the market. Aggregating demand can also be used to negotiate lower prices for end consumers, and it might be done through a "collective switch" or negotiating bulk supply arrangements.

There are also additional measures that can be taken along-side an initial switch. For instance, through aggregation with other neighbouring associations, it should be possible to match properties with higher deployment of free or subsidised energy efficiency measures.

In some instances where the building is under single ownership, it might also be possible to negotiate bulk supply arrangements. In turn this might increase scope for onsite generation and storage, with the benefits being shared between the tenants, and potentially the creation of a local market.

An arrangement, combining these solutions, is shown at 23. The workplan is designed to be used by landlords and social housing groups to help you and your tenants develop your own engagement action plans. Unlike other workplans, which have a more generation, technical focus that is covered by the day-to-work of Local Energy Scotland (LES), through CARES, this workplan aims to highlight other third-party sources of information and support.

Figure 23: Example of tenement block with communal energy



This workplan is structured into the following parts. They are:

- The rationale for considering adopting the "collective energy action" approach
- Criteria you will wish to consider for maximising benefits under this approach
- A framework for design and assessment of appropriate content and scale of a project
- Some specific examples, showing potential savings that can be realised. and
- Identifying future change that might impact on a project, as well as some risks to be aware of.

A Summary of the most useful sources referenced in this document is set out in the "Toolkit" at section 3.7.

A glossary of terms and abbreviations is found in the Main Report.

3.2 Rationale

Scotland has a high level of tenants in high-density housing – especially where this is owned or managed by council or social housing. According to 2011 census data, some 810,630 households in Scotland resided in purpose-built flats or tenements, just over a third (34.2%) of the total number of households. This is almost double the UK average of one-sixth.[32]

At the same time, Scotland has a high level of customers living in fuel poverty meaning many bills are higher than they should be. The England only figure (2015 data) was 11.4%, with a Scotland average (2016) of 26.5% (heavily skewed to North Scotland). This reflects lower average incomes, higher average bills and the high proportion of electricity only supply.

At the same time the supply landscape in Scotland is still relatively concentrated, especially in the north. The incumbents – Scottish Power and SSE in electricity and Scottish Gas in gas – still hold over 50% of the domestic market in the south and 70% in the north between them. Many of their customers remain on standard tariffs, which are usually at significantly higher rates than competitive fixed offers.

Box 1 – Benefits

Cheaper energy for vulnerable and fuel poor tenants, alleviating Scotland's high fuel poverty level

Greater energy literacy

Cheap way to build an energy community group

Access to vulnerable groups to investigate energy efficiency deployment

Supporting customers to engage individually with the energy markets and find the best tariffs for their consumption pattern could significantly reduce the amount spent on energy for most disengaged customers in the short term. Customers switching for the first time can realise annual savings to the order of £150-£200/year in Scotland, or £250-300/year averaged across GB. It is low cost, can be done in partnership with the community, and can readily build on existing resident communication and support structures.

Switching through a collective switch scheme is becoming mainstream. It allows consumers to group together to increase their buying power and to negotiate a better deal with energy suppliers. There is no set model for how individual schemes should operate, but there is a good track record now across a large number of schemes of realised savings, often with winning tariffs close to market leading prices. In addition, once a structure is in place it can be reused once the terms of the original switch have expired. Local authorities and community groups can facilitate these collective switches.

In the long run, energy efficiency improvements to the housing stock will be required to significantly cut fuel bills and further alleviate fuel poverty, so setting in place processes that might attract additional energy efficiency measures should also deliver benefits to your tenants. The primary scheme for supporting consumers in this area is the Energy Company Obligation (ECO) scheme, which is funded by suppliers. There are a range of eligible measures that could benefit high-density and social housing, which will improve the energy efficiency of dwellings reducing bills further. A new phase of ECO starts on 1 October 2018 and will run until 31 March 2022. Under it, incentives on suppliers are being refocussed to support mitigation plans targeted on social housing and the fuel poor.

On-site measures might extend to installation of low-carbon technologies behind the meter. Many tenement and tower blocks could accommodate 10-50kW PV arrays[33]. Battery storage systems are also being deployed and can help optimise consumption behind the meter.

In combination these measures would maximise self-supply and thus the avoided cost of purchase from the public system. For instance, a tenement block of 12 people with a load of 37.3MWh and

[32] Nearly 200,000 of these households are located in Glasgow, 133,000 in Edinburgh, nearly 50,000 in Aberdeen City, with 45,000 and 40,000 in North and South Lanarkshire respectively, around Glasgow.
[33] Feed-in Tariff incentives are still available until 31 March 2019, but we show in workplan 1 the economic case for investment in solar PV, especially in combination with battery storage.

10kW PV array could cut energy bills by a collective £1,560/ year (24%) for customers on an average standard tariff in Southern Scotland or £1,120/ year for customers on a market leading tariff. With retail prices set to continue to rise in real terms, the value of self-produced power is set to increase reducing already attractive payback periods.

These steps can be tested in stages, through learning by doing. Much will depend on the appetite of your tenants collectively to “try something different”, and each scheme will need a clear advocate. They are, however, additive.

With new energy efficiency standards requiring social housing providers to achieve specified Standard Assessment Procedure (SAP) rating targets for specified dwellings by 2020, and new targets being set up to 2050, you should be starting to consider improvement programmes now.

3.3 Criteria for maximising benefits

As a social landlord or housing association looking to maximise the benefits of collective action, you may wish to consider how the following can be aligned with your thinking.

3.3.1 Robust information

To maximise the market opportunity, you will need to gather as much information as possible on the consumption and usage within the estate.

You will want to consider how energy is provided to the site currently, including the terms of the existing supply agreement/s of all the tenants. This will also necessitate understanding the current configuration of meters. The SAP and its energy efficiency also need to be taken into account.

Box 2 – Key success factors
High density housing
Lack of energy market engagement/ energy literacy
Housing association interest and support
Broad interest and participation among local residents
Energy supplier interest in collective switching and ECO delivery

3.3.2 Critical mass

The greatest benefits from using this workplan will be derived where there is high-density housing under single ownership or where groups of tenants from different associations participate in the project. It will become much more difficult to deliver if some or most do not wish to participate, or if critical mass cannot be achieved across a range of properties.

Savings available will also be higher where tenants are paying more for their energy. This will be a factor of past switching decisions, and existing processes for dealing with voided properties[34] and the energy efficiency of the property. It is also for consideration how you might band together with other social housing providers to increase scale. Whether an individual or group approach is taken, awareness raising amongst tenants and information gathering on the energy infrastructure are essential precursors to further action.

If your tenants are supplied from the public system, encouraging consumers on to a more appropriate tariff can be delivered in weeks through individual action. Group buying through a collective switch will take longer. However, this mechanism is well-precedented in the GB domestic energy market. There are many examples where municipal authorities have actively sought to embrace social housing developments in them.

The information collation to support individual or a collective switch (for instance, occupancy and levels and time of consumption) can also form the baseline to assess the potential savings from further measures.

3.3.3 Engaged tenants

Again, the best results from using this workplan will arise where all tenants are engaged and participating in the project. Whatever actions you set out to undertake, they will involve testing tenant engagement with energy in the locale and to begin to draw the community's interest on alternative approaches. It is possible that this may require several months of community engagement and consultation, but it can deliver significant savings without significant investment.

A suggested list of contents to help inform the engagement process is at section 3.4.1 below.

[34] Voided properties are homes which have been vacated by tenants, where control of the energy supply returns to the landlord. Some landlords, especially social landlords, will switch this energy supply to a socially responsible energy supplier, to give new tenants who do not engage with the energy markets the best existing deal.

3.3.4 Clear action plan

You will need a clear action plan to share with tenants to get the best results.

Once you have gathered the relevant information, you will want to consider a hierarchy of issues and develop an action plan for discussion with tenants. These issues might include:

- Facilitating individual switching
- Undertaking a collective switch (if users are supplied from the public market)
- Reviewing or entering into bulk supply arrangements (if these are in place), and
- Identifying new energy efficiency funding opportunities.

Some considerations under each of these headings is set out below.

Facilitating individual switching

This is an easy option for all landlords and social housing groups who don't have bulk purchase agreements.

It is easy for any householder to switch, either through price comparison websites (PCWs) (of which there are many) or going directly to suppliers you believe to have a good deal (if you cannot switch to a specific supplier on your PCW of choice). Until recently all PCWs had to show all available domestic tariffs, but that "whole of market" requirement has now been relaxed, so you will need to shop around.

To help the tenant, it is important that you have to hand your tenants' annual consumption statement and recent bills, as suppliers offer different pricing structures which mean that householders with different usage and patterns are often be matched against different suppliers. In this context, the estimate of expected usage in a year is very important.

There are other key variables:

- Whether the householder has dual fuel (or have separate electricity and gas tariffs) or electricity only supply, and
- Whether you want a variable, fixed price or prepayment offer.

There is significant competition in the domestic energy market with nearly 90 suppliers and 200 tariffs. They are frequently replaced and supplemented. Obviously the lower the rate of historic switching, the higher the potential savings.

Scoping a collective switch

Collective switching describes the process by which a group of consumers secure a cheaper or better tariff through their bargaining power. They are relatively cheap to run, with the winning supplier normally paying the auctioneer commission on each account switched. They can secure an "exclusive" tariff that is not available on the wider market. A quarter of collective switches since 2015 have been cheaper than the lowest available tariff on the market. Even if they do not result in the cheapest tariff on the market, regular savings in excess of £200/year are achievable for consumers moving from standard variable tariffs paying by cash or cheque.

Overall, the trend of collective switching tariffs reflects market conditions at the time, but they have proved particularly effective with medium groups of up to 10,000 consumers tenant in a particular area.

Reviewing bulk supply arrangements

The cost advantages of a bulk supply arrangement can centre on lower network costs and potentially less onerous billing provisions if the landlord is responsible for collecting payments from tenants.

Multi-occupancy buildings usually take energy through a single point, using an electricity "rising main" (a name for the internal wiring of the building), to distribute this power to tenants. If this rising main has a revenue meter, and other onsite networks and any metering are the responsibility of the landlord, a bespoke electricity supply contract may be in place. This contract will likely be subject to commercial negotiation between the landlord and an electricity supplier. Consumers will have broadly the same protections as if they were supplied from the public networks, including the right to switch away to a domestic tariff of their own choice under third party access rules.

Existing arrangements on these lines are most prevalent in communal properties such as student or nursing accommodation where tenants can be billed for their energy as heat and light as part of their rent. Although on commercial terms, they will be with a supplier that is active in the domestic energy market in its own right and therefore prepared to fulfil the specific supply licence requirements for household consumers.

You will need to understand the configuration of wiring and meters in the building, especially whether you or the landlord owns the rising mains and whether it is feasible to identify a single point of connection to the local distribution network owner (DNO). In these circumstances there would need to be a declaration that the energy was being used for domestic purposes for VAT and Climate Change Levy exemptions. The supplier would also need to be satisfied that the licence obligations it incurs for supplying domestic customers are fulfilled.

In our experience these arrangements can be complex, which means there can be limited appetite from suppliers for new arrangements of this kind given current regulatory rules.

Identify energy efficiency opportunities

A further option available that can create benefits for tenants is for you to extend community activity to secure ECO and other energy efficiency support, possibly channelled through your local authority (LA).

ECO measures implemented to date are very unevenly dispersed, and often not well-targeted on vulnerable customers and the properties most in need. However, such schemes can enable additional insulation measures, boiler replacement, improved electric storage heaters and smart thermostatic heating controls. These are usually funded by an energy supplier (who need not be the supplier to the property).

The key parameters for ECO3 have just been set by the UK government here, with funding, which is covered by domestic energy suppliers, to be maintained at current levels. Incentives are being sharpened for suppliers to concentrate measures on fuel poor and vulnerable customers. Qualifying measures have also been updated and new suppliers introduced into the scheme progressively as the compliance threshold is lowered. A defined level of funding, near on £60mn per annum, has also been ring-fenced for expenditure in Scotland.

A key aspect of the current arrangements is the flexible eligibility mechanism targeted around LAs. Up to 25% of the total ECO target can be delivered to households which have been identified by LAs as needing subsidised energy efficiency improvements; installing measures in these properties will benefit from a 25% incentive for the most inefficient homes, where existing Energy Performance Certificates (EPCs) are in bands F or G. BEIS has undertaken to publish information on this before October.

Additionally, the Home Energy Efficiency Programmes for Scotland (HEEPS) are the Scottish Government's flagship delivery vehicles for tackling fuel poverty and improving the energy efficiency of domestic housing stock. The different HEEPS schemes are designed to work with other sources of funding to provide a broader enabling environment assisting the blending and leveraging of multiple sources of funding to deliver energy efficiency measures.

Draft legislation for a new fuel poverty strategy was released in June. It will establish a new definition of fuel poverty, create a new target that no more than 5% of Scottish homes are in fuel poverty by 2040, and set out how Energy Efficient Scotland will invest to make all homes more energy efficient, including creating a new fuel poverty assessment tool. The legislation would also increase the flexibility of delivery programmes by working with councils and providing advice to householders to save energy and engage with the energy markets.

3.4 Assessment framework

In considering the options for an improvement plan and defining your project/s, you may want to consider the following.

Box 3 – Main assessment steps

Identify the estate

Understand what metering equipment is installed

Determine current and future on-site demand

Build engagement and understanding within the community for collective energy action

Understand the collective switch providers in the marketplace

Understand the ECO framework, and other energy efficiency funding available

3.4.1 Evaluation process

Within the estate, you will want to consider:

- The amount of energy consumed by tenants and for other purposes (e.g. communal areas), their suppliers, how they pay for it and the extent to which they are vulnerable and eligible for Warm Home Discount (WHD)[35] or other support measures from their current energy suppliers
  - Identifying total demand for the high-density housing can be difficult, especially when attempting to establish a profile for energy use. Most tenants will not currently have access to half hourly metering data (though they may in future, as the smart metering roll-out continues)
  - It may be possible to use a data logger, which could be clamped onto the building's rising main, to ascertain an energy use profile for the entire building
    - Caution should be exercised when using less than a full year's data, however, as usage patterns change across the year
    - Looking at long-term changes to use-profiles, landlords will be well placed to take account of significant changes in energy use, such as those arising from energy efficiency upgrades or provision of alternative heating solutions.
- The ownership and capability of the energy networks and any other infrastructure on site including service providers and contractual counterparties
- Meters installed, for example 'dumb' meters, Economy 7 (or 10) meters, prepayment and smart meters
- Whether there are bulk supply and/or resale arrangements in place
- Whether there are bulk supply arrangements for tenants or they are subject to market tariffs, and
- What if any actions have been undertaken previously with any leaning points.

The following resources may help you here:

- Home Analytics Scotland provides essential data on Scottish housing stock. Data is provided down to the address level and is available to local authorities and registered social landlords. It is designed to assist you develop, target and deliver policies and schemes and programmes designed to improve energy efficiency and alleviate fuel poverty (also installation of microgeneration technologies)

[35] The WHD is a government scheme aimed at tackling fuel poverty in Great Britain. Under the scheme, medium and larger energy suppliers support people who are living in fuel poverty or a fuel poverty risk group. Some smaller suppliers also voluntarily participate in part of the scheme. The annual expenditure required by suppliers is £340mn.

- The Energy Saving Trust also offers a Home Energy Check tool here. This can be used to help find out how you can achieve lower energy bills and a more comfortable home. By providing basic data, tenants receive a report with details of improvement measures
- Home Energy Scotland also works in partnership with community groups to deliver free, impartial energy saving advice.

Different criteria will also apply if the housing in question already exists or is under development. From a regulatory perspective there is more flexibility to consider more innovative “bulk purchase” options for new developments rather than existing housing.

Sizing

Project sizing depends on type and project partners:

- Collective switching schemes – could have a minimum customer number that would need to be achieved before the collective switch is deemed viable
- Aggregated demand – in order to realisation maximum value this requires generation and demand to be sized sufficiently such that generation does not exceed minimum daytime (if using solar panels) demand
    - Note that this typically will not occur in a block of flats, as daytime demand will usually far exceed the relatively low generation provided by the limited roof space available
- Supporting energy efficiency – will likely be more valuable (lower cost) with each participant, and therefore the organiser should liaise with project partners to establish a desired and minimum viable size

3.4.2 Definition and scoping

Once a site has been assessed and energy use quantified, thought needs to be given to the following to develop a plan of action. This will depend on the type of community engagement being undertaken: **Facilitating individual switching** (0); **Scoping a collective switch** (0); **Reviewing bulk supply arrangements** (0); or action to **Identify energy efficiency opportunities** (0)

Organised switches

- Nominate appropriate estate coordinator and any outreach personnel
- Produce a communications plan
    - Community engagement will form the bulk of the effort in the first phase, and community groups are best placed to form their own strategies based on local conditions and resources
    - Some guides are here from Plan Local and here from the Centre for Sustainable Energy
- Determine whether individual or collective switch
- If you opt to support individual switching, identify information needs and engage a community worker to advise. A sample of best market deals in the two Scottish regions by type of consumer and meter/ payment type during October 2018 is at Annex A
    - The community work will engage with individuals in the community, guiding them through the switching process on a one-to-one basis
    - This conversation can also involve provision of other energy saving tips, and serve as a route to engagement in ECO funding
- If you elect to implement a collective switch, identify potential auction providers. A list of collective switches and their operators is at Annex B.

Undertaken through an auction process, an independent operator usually specifies the parameters of the process including consumer sign-up, timings, preferred tariff type and bidding arrangements for suppliers. Consumers sign up to participate in the process and, once they have been informed of the auction results, need to opt in if they want to take advantage of a winning offer.

Collective switches, especially municipally led, have been popular since 2012. A number of different type of arrangements of this type have occurred since. There are recognised to be problems with engagement, with customers having to opt-in once to participate and then opt in again in response to the winning tender, often with significant drop out rates.

The auction can only occur after the establishment of a consumer group. Contractors are available who have experience of running collective switches with both online and offline methodologies. Contractors include iChoosr, Energyhelpline and Moneysupermarket.

Collective switching providers have often worked with local authorities and other community groups to run auctions for groups of disengaged and vulnerable consumers. They tailor their terms to suit the needs of their users, including online direct debit tariffs, cash or cheque in arrears payment, prepayment tariffs, tariffs with boiler maintenance cover and green tariffs. These in turn open up participation in the auctions to different types of energy supplier, including specialists in all these areas. Groups of users can be engaged quickly through meetings, doorstep approaches and other information exchanges and the follow-on sign-up processes to accept the winning offers.

BEIS has produced guidance for scheme organisers, covering: set up, information gathering, negotiation with suppliers, and costs. It also runs through the relevant licence conditions.[36] The energy regulator Ofgem has also published a guidance note for purchasers.[37]

Collective switches have continued at the national level, for example Money Saving Expert's ongoing Cheap Energy Club and iChoosr's Big Community Switch, but are increasingly being offered on a regional basis, for example by local authorities. National collective switches have also been won by different suppliers in different regions.

Commission payments from the successful supplier would normally be shared between the scheme organiser and the sponsor. Some business models have seen cashback offered to participants, while others operate on a not for profit basis.

Organising a collective switch

Collective switching providers offer a service to local authorities and other community organisations to help run collective switches. The first step towards organisation is to contact providers and arrange a partnership. When selecting a partner, consider the provider's track record in securing advantageous deals for consumers and its reputation for customer service as well as the financial incentive which it is able to offer you.

The key to securing a good price in the switch is to recruit the greatest number of households to the collective switch. This will give the provider the greatest bargaining power when approaching suppliers to obtain tariffs. Marketing efforts will be key, for example setting up a website – which will also serve to collect and securely store participant details – social media awareness, advertising in local publications, distributing flyers, and engaging with local people. Plan Local provides a succinct guide to community engagement here, but your partner will also be able to help guide you.

It will be important to emphasise the potential benefits of the collective switch, that customers do not have to switch to the outcome if they do not want to, and the relative ease and simplicity of the process compared to the public perception of the difficulties of engaging with the energy market.

Once the recruitment phase is over, your partner will negotiate with suppliers on your behalf to secure the most optimal tariffs available. Larger groups of consumers tend to secure better offers,

[36] https://www.gov.uk/government/publications/collective-switching-guidance-for-scheme-organisers (January 2014)

[37] https://www.gov.uk/guidance/collective-switching-and-purchasing (January 2013)

although this will also depend on market conditions, for example whether multiple suppliers are looking to grow their customer books.

The best tariff will be made available to your participants. You will need to communicate this offer to your participants and encourage them to take it up. Usually, a supplier will make a web link available, with a simplify sign-up process.

It is possible to self-organise collective switches without a partner, but due to the complexity this is not recommended for groups organising their first collective switch.

Aggregation of demand

In order to consider the aggregation of the site under a bulk purchase arrangement, there are a number of complexities to overcome. You may wish to:

- Consider who owns and maintains the wiring and meters in the building
    - If the local distribution network owns this wiring, it is unlikely that you will be able to proceed with this scheme
    - If the landlord owns the wiring, or you are looking at a new building within which the wiring has not yet been adopted by the distribution network, it may be possible to aggregate demand
- Engage with suppliers to provide a bespoke bulk supply contract
    - You will need to find a supplier which provides energy to both commercial and domestic customers
    - Due to the relative complexity of arrangements, you will likely need to engage with one of the Big Six large energy suppliers, most of which already have arrangements of this type. However, some independent suppliers are also interested in innovation of this type
    - When negotiating contracts, you will want to bear in mind the cost of equivalent commercial tariffs, and the combined cost of the relevant number of domestic tariffs, as benchmarks
        - Also bear in mind that you will need to fund the maintenance of the internal wiring and metering, and any settlement and billing costs
        - Your supplier partner will be able to help you manage and quantify the latter

Box 4 – Aggregation

We here discuss physical aggregation of demand, using a "boundary" settlement meter interposed between the "sub" meters for customers' properties and the wider network

The section of the network between the boundary meter and customers' sub meters would be adopted by the project

Virtual aggregation, uses a virtual boundary meter and does not require adoption of any network assets or additional physical meters

- Consider metering arrangements to facilitate the billing of energy to participants
    - All meters used to bill for energy must be industry-approved models under the Measuring Instruments Directive
    - "Dumb" meters are likely to be cheaper to purchase and install but add an ongoing cost of regular meter-reading
    - "Smart" meters may be more expensive to install and have ongoing costs from a half-hourly data collector, which will collect the data
        - Groups wishing to prepare for this circumstance should begin engaging with suppliers and innovative smart energy companies, which will be at the forefront of thinking in this area and may be seeking partners for trials.

Supporting energy efficiency

Your local authority, the Energy Saving Trust and Citizens Advice Scotland can provide guidance on how to obtain advice on options and measures under ECO and how they can be accessed. In particular many local authorities offer flexible eligibility under the ECO arrangements and they have published statements of intent explaining the criteria they have adopted for administering this part of the scheme in their regions. The UK government also publishes a list of local authority statements of intent here.

Suppliers in particular will be keen to engage with groups of households which can benefit from ECO deployment to meet their "affordable warmth" obligations. Under ECO3, as we have noted, there is a ring-fenced portion of the obligation which must be delivered in Scotland.

In scoping your plan, you may wish to have regard to the following:

- Useful guidance on ECO includes the following:
  - Ofgem, which measures compliance with the scheme, produces a table of eligible measures which can be installed to deliver obligations here
  - Supplier contact details for obligated energy suppliers are here. Energy suppliers are often keen to make contact with groups which can help them provide energy efficiency solutions in order to discharge their obligations more efficiently
  - Flexibility eligibility is a process under which local authorities can designate additional households for receipt of ECO measures. A table of flexible eligibility take up by energy supplier is here
  - Details on delivery through schemes prior to HEEPS and previous HEEPS Programme report can be found here on the Energy Saving Trust (EST) website
  - EST operates the Home Energy Scotland advice and support service. This provides free and impartial advice to all householders in Scotland and ensures, where eligible, they can be referred to the most appropriate scheme specific to their personal circumstances. Home Energy Scotland can also provide tailored advice for an individual's own home

Other useful sources of information to help inform targeted areas are:

- The latest social housing local authority analysis, including fuel poverty levels are available here
  - Existing installed measures are available by LA here. This may help you to identify areas which have not yet received assistance from the ECO scheme
  - Scottish government statistics on fuel poverty are available here and here, which will highlight areas which are most in need of energy efficiency support
  - National Grid's non-gas map here includes fuel poverty statistics, although currently (August 2018) these are not displayed for Scotland. They are expected to return at a later date
    - The non-gas map's primary purpose is to identify those households which are not connected to the gas network. These properties do not have access to gas as a low-cost heating fuel, and are therefore more likely to suffer from fuel poverty
    - A recent Citizens Advice Scotland study (here) found that households relying on electric heating were twice as likely to be in fuel poverty
- SAP is a methodology used to assess the energy and environmental performance of buildings
  - The SAP is used to produce Energy Performance Certificates, which then feed in to a number of other government initiatives such as the Feed-in Tariff, the Energy Company Obligation, and the Warm Homes Discount
  - More information on SAP is found here. SAP arrangements in Scotland have bespoke elements, as explained here

- High levels of electricity consumption can also be an indicator of fuel poverty. The UK government publishes sub-national electricity consumption data here, presented as an average by local authority.

3.4.3 Community energy and local trading

A number of pilots are operating to test more extensive community-based schemes, usually under innovation trials. These include schemes that increase demand (e.g. hot water storage to use surplus energy on-site). Several of these are referenced in the main Cornwall Insight report, see notably Smart Fintry, MullACCESS, and Bethesda in section 4.5 of the Main Report.

Other examples are emerging elsewhere. For instance, in London, two peer-to-peer (P2P) trading trials are emerging. In Brixton, the CommUNITY project from Repowering London, EDF Energy, Electron and University College London's Energy Institute is using Electron's blockchain trading system to trade the benefits of community solar panels on an apartment building's roof amongst residents[38]. All participants take their energy from EDF, with the benefits of energy traded from the solar panels logged and rebated off bills.

Repowering London is also working with energy assistant provider Verv in Hackney to trial Verv's blockchain technology. Again, the trading platform, managed through Verv's in-home energy manager, will help to share the benefits of electricity generated on the roof of the building with project participants. PowerVault have also installed community batteries at the site to store and facilitate energy trading among participants.

Both London trials are benefiting from Ofgem's innovation link regulatory sandbox, which allows them to side-step certain elements of normal industry rules. In addition, at present there are a number of issues around interoperability of industry systems which the energy industry is striving to address. However, as smart metering and half hourly metering is rolled out more extensively over the coming years and months, opportunities for schemes will multiply and costs fall.

This is an area to watch, but tested solutions that can be replicated are some way off, and replication is dependent on changes to industry rules.

[38] Blockchain is a distributed ledger technology, which allows secure trading of commodities between participants without a central controller. In energy, blockchain is being trialled in applications which will allow domestic generators to sell power to their neighbours outside of central industry systems

3.5 Business case

3.5.1 Individual switch

Evidence suggests that most GB consumers (over two-thirds) are still on standard variable tariffs (SVTs) provided by one of the six large energy suppliers. Ofgem suggests here that the typical GB dual-fuel consumer could save up to £300/year by switching from a Big Six SVT to the cheapest tariff available to them. However the typical savings vary by consumption, region, payment type, and temporally and savings in Scotland are around £150-£200/annum.

Box 5 – Commercial questions

Understand if and how your group will secure revenue from switching individual participants' energy supplier

If organising a collective switch, how will the group be remunerated, and how will the provider's fees be paid?

What will the commercial arrangements be with an automated switching service?

Will an energy supplier pay to have ECO deployment sites recruited for it?

Could aggregating demand save money?

A more detailed assessment of the scope for switching and the associated benefits from switching by householders and tenants in Scotland reveals:

- There are 1.46mn domestic energy accounts in South Scotland and 0.67mn in North Scotland on SVTs served by the incumbent suppliers
- Assuming medium consumption values and tariff differentials at August 2018, customers on the average large supplier SVT in North Scotland could save £188/year on electricity and £154/year on gas (total £342/year) by switching to the cheapest fixed tariff available. For South Scotland the figures are £186/year and £165/year for electricity and gas respectively (total £351), and
- This would save Scottish domestic consumers just under £370mn/year, with nearly two-thirds of the saving arising from cheaper electricity tariffs.

Given the figures we presented earlier on high levels of social housing, and the relatively low level of switching by their tenants, it can be assumed that over £50mn of savings could be made by this sector of the domestic market each year.

Facilitating switching

Coordinated switching programmes can also allow tenants to better target suppliers with tariffs that better suit their individual circumstances. Because suppliers offer different splits between standing and commodity charges, and because suppliers assess costs differently for different payment types, different suppliers will rate differently depending on each tenant's consumption.

It is conventional to categorise domestic consumers under a series of customer archetypes. We show some of these at Annex A, together with the cheapest supplier in each of the two Scottish settlement regions in July 2018. It demonstrates clearly that, across the nine archetypes for customers likely to comprise most social housing tenancies, five different suppliers offered the cheapest tariffs in Southern Scotland and five in the North. Four of these were common in both areas (Together Energy, Ebico, Utility Point and Our Power), but the fifth for the two electrically heated archetypes differed (People's Energy in the South and Powershop in the North).

Delegating powers

It is possible for consumers to pass their choice of energy supplier to a third party, which will operate on their behalf. Services such as Flipper, Labrador and Look After My Bills offer services which automatically review the market and regularly move consumers onto the cheapest supply deal available, where an agreed level of saving can be made.

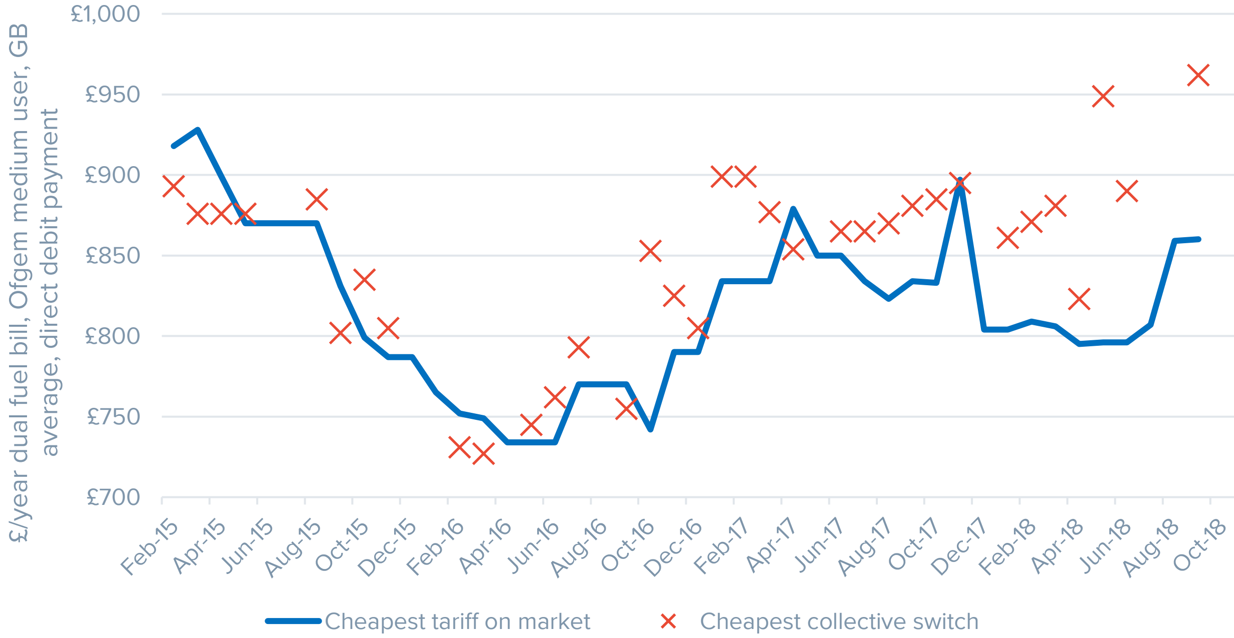
If a trusted brand such as a local authority, social housing provider or community group partnered with these services, it could recruit customers to a service which would offer sustained, long-term savings without the need for customers to re-engage with the market every year.

3.5.2 Collective switch

Figure24 shows collective switches over the last few years and their position compared to the cheapest tariff then available on the open market. Most of the price differentials are positive – up to +£350/year. However, recent deals have been at prices above market leading rates.

The past eight collective switches of which we are aware produced offers above market rates, being an average of £111/year more expensive than the cheapest tariff on the market. While individual switches can offer cheaper tariffs than collective switches, the relative ease of the collective switching process – where another party takes on responsibility for finding and vetting the new energy supplier – can be seen as advantageous.

Figure 24: Collective switches compared to the lowest tariff on the market (£/year dual fuel bill, Ofgem medium user, GB average, direct debit payment)



If collective switches could be coordinated regionally in Scotland, for instance within each of the 32 unitary authorities, and 2,500 social housing tenants were to switch within each over the year, this could result in annual customer savings to the order of £12mn if the average saving was as low as £150/household.

Using the same metrics, this might also give rise to a commission of over £0.6mn that would be shared with the scheme organiser/s.

3.5.3 Aggregation of demand

If moving to a half hourly tariff under a bulk purchasing arrangement, additional savings on the cost of energy could be realised.

Figure 25: Average offered tariff for typical non-domestic user, Q2 2018[39]

Supplier	Volumetric charge rate 1 (p/kWh)	Volumetric charge rate 2 (p/kWh)	Volumetric charge rate 3 (p/kWh)	Standing charge (p/day)	Annual consumption (MWh)
Southern Scotland	11.25	12.71	22.44	35	250+
Northern Scotland	11.37	12.84	22.62	35	250+
Consumption in this period	40%	50%	10%		

Source: Cornwall Insight SME prices quoted through energy brokers

Figure 25 above sets out achievable non-domestic half hourly tariffs for northern and southern Scotland, and how much energy typical electrically heated flats could use in each tariff band. This produces a weighted average tariff of 14.5p/kWh in Southern Scotland and 15p/kWh in Northern Scotland. A typical low-cost domestic tariff in Q2 2018 would cost in same region, with the majority of savings being on standing charges.

3.5.4 Energy efficiency

Various energy efficiency measures are suitable of installation in a flat or tenement. EST provides a guide on its website to these measures. Some of these are summarised at Figure 26. Savings are for homes fitted with gas central heating; savings for electrically heated flats would be higher, consequentially cutting payback times.

Figure 26: Energy saving measures for a flat, costs and benefits

Measure	Cost (£)	Saving (% of heat/year)	Saving (£/year)	Payback time (years)	ECO eligible
Energy efficient lighting (LED vs incandescent)	5/bulb	-	6/bulb	Under 1	No
Draught-proofing	85-275	Up to 20%	40	2-7	Yes
Loft insulation (for top-floor tenement)	230	Up to 25%	65	4	Yes
Cavity wall insulation	330	Up to 33%	115	3	Yes
Solid wall insulation (internal)	4,000-13,000	Up to 33%	115	40+	Yes
Solid wall insulation (external)	8,000-22,000	Up to 33%	115	80+	Yes
Hot water tank insulation	20	Up to 30%	80	3 months	Yes

[39] These tariffs are calculated by a Cornwall Insight model, which includes the price of wholesale energy as well as industry charges, levies and costs, and a supplier cost and profit margin of 10%

Source: Energy Saving Trust

In terms of costs, ECO qualifying measures would be paid for by a supplier.

3.6 Future opportunities and risks

In this section we highlight energy industry and market changes that could impact on the options we have summarised for you in this workplan. In general, they increase options for residents, though some industry commentators believe that imposition of the default price cap could reduce incentives to switch.

3.6.1 Retail prices

These are expected to rise in real terms, as non-energy charges increase. This will present risks to tenants through bill increases, especially for those who do not switch, but also opportunities for those who look to manage consumption by changing the times of day they use power, and those who can leverage generation behind the meter. For example by reducing consumption during peak periods (typically 4pm-7pm) a customer may be able to realise substantial savings on their retail tariff, depending on how they are billed. As the cost of energy rises, this will also reduce payback periods for energy efficiency measures.

Price caps are being progressively applied to the domestic sector. The first was the pre-payment meter (PPM) price cap, introduced by the regulator from 1 April 2017, which applied to PPM customers only. This was extended to the safeguard tariff on 2 February 2018, applying to all customers receiving the WHD payment, an additional one million customers. It was forecast to save consumers around £110/year/household.

The government is set to introduce a wider price cap on all standard variable tariffs (SVTs) from late 2018. This will be set at a level to allow suppliers to cover their reasonable costs for supplying energy but not an unreasonable profit. Ofgem will set the cap and is currently consulting on its methodology.

The Safeguard tariff is due to expire 30 March 2020. Government's broader cap will also run until 30 March 2020, though it can be extended in yearly increments out to 30 March 2023.

3.6.2 Domestic brokerage and innovation services

We expect you will be increasingly be able to access a range of innovative brokerage services from the domestic supply market, and we are already beginning to see a focus by new entrant suppliers on local offerings. These include bill management and switching assistants, as well as automated switching services, sometimes referred to as concierge services.

3.6.3 Smart meter roll-out, half hourly settlement and time of use pricing

The government's Smart Meter Implementation Programme is seeking to install 53mn smart electricity meters and 30mn smart gas meters in homes and small businesses across GB. Under licence conditions, energy suppliers are required to take all reasonable steps smart meters to install smart meters in their customers premises by the end of 2020. However, there is still a great deal of work to be done, with fewer than 15mn installed by July 2018.

As smart technology develops, and more data becomes available in the energy industry, the role of aggregators and data partners is increasing. This is likely, in the future, to open up opportunities to take advantage of more individualised pricing and negotiate benefits from conglomerations of demand.

Ofgem's market-wide half-hourly settlement programme is currently ongoing, looking to expose suppliers to the real costs of their particular consumer group's electricity consumption pattern. This will create increased differentials in the costs faced by different suppliers and is likely to lead to time of use (ToU) pricing being offered to consumers. This could open out new opportunities to those who can vary their demand or can call on on-site generation.

More generally we would expect both suppliers and distributors to develop services that seek to exploit the value of flexibility that social housing groups can provide collectively.

3.6.4 ECO reform and flexible eligibility

ECO3 will launch in October. One reform is the increase in flexibility eligibility element of the scheme which allows local authorities to designate sites for deployment of energy efficiency measures, increasing the cap from 7% to 25%. Additionally, suppliers will be incentivised to install measures in low-efficiency homes.

These incentives will create a new market for suppliers and LAs to work together to install energy efficiency in the least efficient homes, particularly in Scotland where a new ring-fence mechanism will ensure that a certain proportion of yearly spend is focused.

3.6.5 Peer to peer trading platforms

Peer-to-peer energy trading is not yet possible on the GB electricity system, but there are signs that it may be possible in the future: see section 3.4.3 for more on various current trials of local trading. Elexon – the electricity industry settlement body – published a white paper in April 2018 which set out a vision for allowing multiple parties to supply energy to the same meter, something which the current supplier allocation rules do not presently allow.

The process outlined in this paper would support the use of local generation to supply local consumers over the distribution network, with the generator remunerated directly by the consumer. However, parties would continue to be exposed to distribution charges and final consumption levies, so only limited savings are likely to be available.

3.6.6 Summary

These factors are summarised and red-amber-green rated at Figure 27.

Figure 27: Impact of expected changes on business case

		Timeline		
Change	**Impact (RAG-rated)**	**Now to 2019**	**2019-22**	**2022 onwards**
Increasing electricity tariff prices	These are likely to increase, especially with regard to the cost of policy support			
Increased service choice	New routes to market and brokerage services should increase choice and competition			
Smart meter roll-out and half-hourly settlement	Could increase costs all domestic/ small business users under ToU pricing if behavioural response does not occur			
	This could created further value in an aggregated or flexible portfolio			
ECO reform	Growth of LA flexible eligibility will give greater access to ECO funds			
Peer to peer trading	Could give access to energy generated locally, at lower cost to the consumer			

3.7 Toolkit

High-density housing communal energy action

Evaluation

- State of the Energy Market 2017
- Fuel poverty in the UK
- Non-gas map
- Fuel poverty in Scotland
- ECO deployment
- Building Network Operator guide

Example schemes

- One Big Switch Scotland
- Tower Power
- VCharge
- Verv

Delivery

- iChoosr collective switches
- My Utility Genius collective switches
- Plan Local – community engagement
- CSE – community engagement
- LA statements of intent
- Home Energy Scotland

4 Heat pumps displacing other sources of heating

4.1 Introduction

This workplan sets out information and guidance in relation to the use of heat pumps in the displacement of other heating technologies, such as electric heating, oil, coal, liquefied petroleum gas (LPG), or gas-fired heating. Heat pumps are a proven technology with the flexibility to draw and concentrate heat from the air (air-source heat pumps, ASHP), water (WSHP) or the ground (GSHP). They are used for both space and water heating and can be operated in reverse-cycle mode for space cooling.

Though there are a number of different technologies, the purpose of a heat pump is to transfer heat energy from one point to another. The heat pump consumes some electricity to power the pump, but typically delivers more units of heat than electricity consumed. Heat pumps are more efficient (transfer more units of heat per unit of electricity consumed) when the heat source is warmer.

Deployment of heat pumps can typically be subsidised under the Renewable Heat Incentive (RHI). Current tariffs for non-domestic installations – fixed until 31 December 2018 – are 2.69p/kWh for every unit of heat generated by ASHPs and 9.36p/kWh, falling to 2.79p/kWh after the first 1,314 annual hours of operation, for GSHPs. Payments are provided for twenty years under the non-domestic RHI scheme.

Figure 28 outlines the generic application of heat pumps in non-domestic properties, though the same technologies could also be applied to households. It is also possible to utilise solar thermal, PV, battery electrical storage and thermal banks as extensions of the technology options applicable to heat pumps (see Figure 29). These additional technologies could reduce the electricity required to deliver substantial quantities of heat.

Figure 28: Generic heat pump application

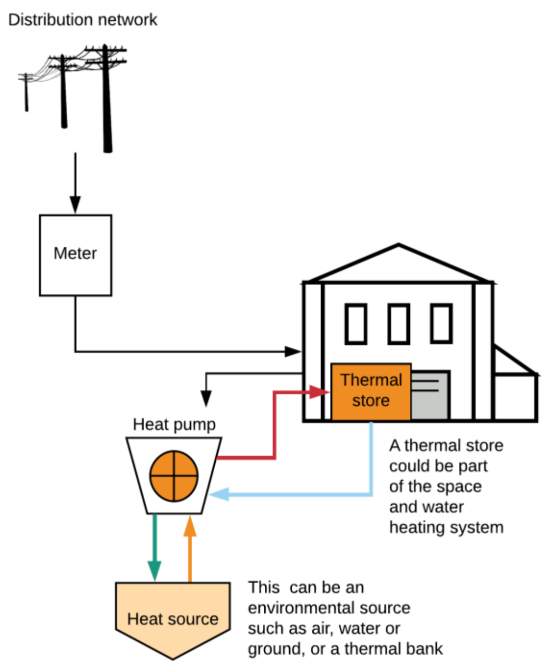
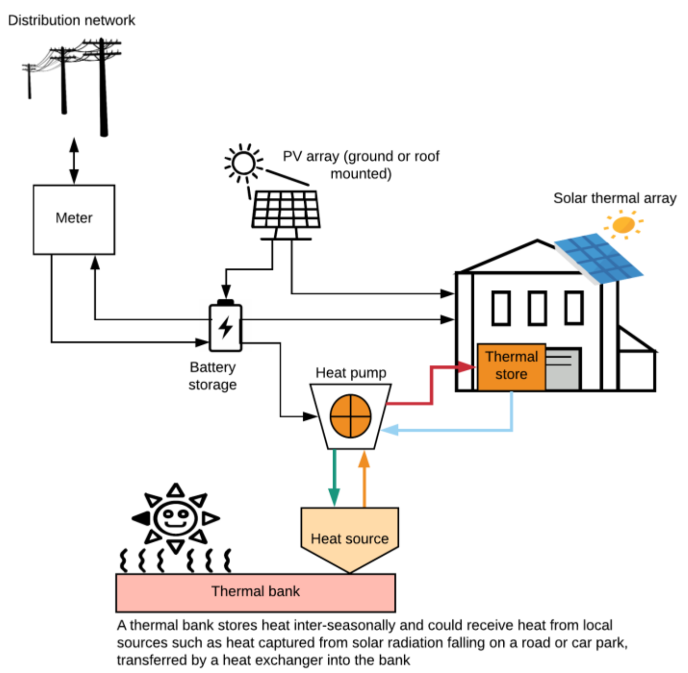


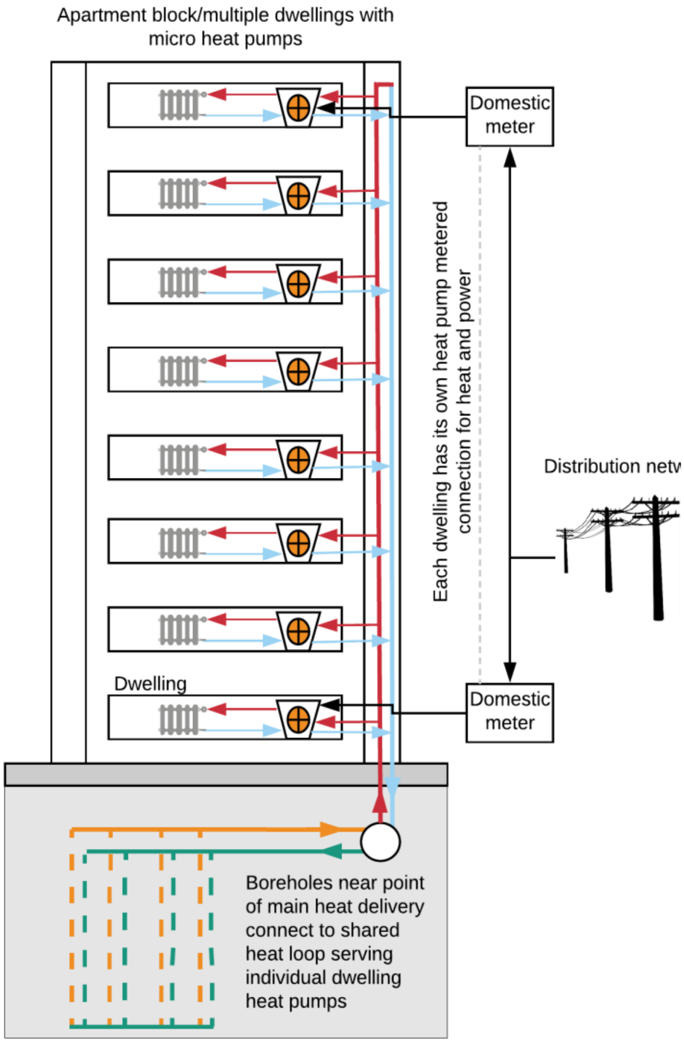
Figure 29: Technology extensions to heat pump application



Heat pumps can also be used to supply heat to networks in larger projects, alongside or replacing conventional heat sources, such as gas boilers, CHP, or biomass boilers. The designs for these systems are more bespoke than for single buildings as the system must consider numerous factors, including:

- Number of buildings, their purpose and how critical the heat demand is – a critical heat demand may be in the case of a hospital, school or home for the elderly where system downtime needs to be avoided
- Building thermal performance – will affect the sizing of the heat pump(s) supplying the system
- Available land resources and equipment space – will affect the choice of heat pump and in the case of a ground source system whether boreholes, trenches or other earth works are required
- Availability of heat sources such as water, geothermal and waste heat – there are options to recover heat from other sources. A heat network using large heat pumps could use waste industrial heat, sewer-water heat, or much larger and deeper boreholes for geothermal ground-source heat pumps
- Heat control preferences of building owners can vary between commercial buildings, and social and private housing

Figure 30: Heat looped heat network



Figures 30 presents a possible system architecture. A 'heat-loop' is shared by residents of a block of flats, with heat pumped into individual dwellings using small domestic heat pumps. This has the advantage of not requiring centralised plant and allowing participants to continue to be metered by their electricity supplier of choice.

The network could be expanded and replicated (say in an estate of high-rise blocks) and heat can be drawn by centralised boreholes in close proximity to the heat demand. The complexities of sharing the costs of the centralised elements of the system while heat pumps are operated independently, and how expansions of the network are paid for, would need to be addressed on a project specific basis. This can mean that, while a shared heat network works well on paper, the practicalities and numerous complexities of a shared network need to be solved appropriately for all users before it can be realised.

This paper focuses on developing a single site heat pump, for a community building or rural business without access to the gas network.

In the worked example given in Annex C, we address a single use application, such as implementation within a building, off the gas grid, with eligibility to subsidies provided by the Renewable Heat Incentive (RHI). This could be community-led or taken up by a rural business.

A summary of the most useful information sources referenced in this document is set out in Section 4.7.

A glossary of terms and abbreviations is found in the Main Report.

4.2 Rationale

Box 1 – Why a heat pump?

Performance advantages over conventional heating systems, saving money on heating and cooling

Reduced carbon emissions

Improved building comfort levels and lower cost of space heating

Carbon savings and CSR benefits

Gaining access to RHI payments

Use of available waste or spare heat

There are three drivers for the adoption of heat pumps: they have a lower carbon intensity than other heating methods: they are typically more efficient than traditional heating methods; and they can be a low-cost solution over their lifetime.

These potential benefits depend on heating equipment replaced. Heat pumps are usually fitted in properties that are not connected to the gas network, which typically either have conventional electric heating, or oil or LPG boilers.

EST figures show that heating oil produces around 259gCO2e per kWh of fuel burned; LPG produces around 230gCO2e per kWh. While research is underway into biofuels, which would deliver greener fuels, this has not yet produced economically viable results. Conversely, most heat-pumps are powered by electricity. This, assuming that a green electricity tariff has been selected, results in zero-carbon heat; using the standard GB electricity mix, emissions are around 283gCO2e.

While electricity use has a higher output of CO2e than other fuels, a heat pump's Coefficient of Performance (CoP) – that is, the useful amount of useful heat delivered per unit of fuel – is much higher than that of conventional boilers. Typical, this ranges between two and three for an air-source heat pump, or over this for a ground-source heat pump. This means that for every 1kWh of electricity used by a ground-source heat pump, it will output 3kWh or more of useful heat. Even in the worst conditions, heat pumps CoPs rarely fall below 1.

By contrast, a highly efficient modern gas or oil boiler might achieve a maximum CoP of 0.9. An older boiler might achieve 0.6-0.7. Therefore, emissions per unit of heat delivered by heat pumps could be much lower, as set out in Figure 31.

The efficiency of heat pumps leads directly into the low-cost element. While electricity is a higher-cost and higher-carbon fuel than gas or oil, the higher CoP acts against this. When comparing a heat pump to conventional electric heating, the electricity demand might be two or three times lower, savings half to two-thirds on the electricity bill. Savings compared to an oil boiler would be lower but could still be half the annual bill. There is also the potential for heat pumps to make use of waste heat from industrial processes, or from sewer water. This increases the energy efficiency of the heat pump and reduces the amount of energy wasted.

Figure 31: Costs and emissions of various heating fuels (2017 data)

Fuel	CoP	Cost of fuel (p/kWh)	Cost of heat delivered (p/kWh)	Emissions (gCO2e/kWh fuel consumed)	Emissions (gCO2e/kWh heat delivered)
LPG	0.9	6.53	7.3	214	237.8
Electricity (Economy7)	0.9	8.1	9	381	423.3
Heating oil	0.7	4.06	5.8	245	350.0
Gas	0.9	3.63	4.0	184	204.4
Biomass (wood)	0.9	5.44	6.0	0	0.0
Air source heat pump	2.5	14.33	5.7	381	152.4
Ground source heat pump	4	14.33	3.6	381	95.3

Source: Energy Saving Trust
Notes: - Co-efficients of performance are equal to 90% for a new condensing boiler and 70% for an non-condensing boiler. Fuel prices and carbon emissions are set to average values for the year to March 2018

Electricity pricing can be more complex than commodity pricing of other fuels. In particular, with the roll-out of smart meters the retail market is moving towards more Time of Use (ToU) pricing, where electricity costs vary according to time of day. Figure 4 should be therefore considered with the caveat that heat pumps are required to run more consistently throughout the day than other electrical heating, for example storage heaters. Households using heat pumps therefore could consume more electricity in peak periods and the home owner could see less benefit from ToU or Economy7 electricity tariffs.

We discuss the potential for deploying additional technologies alongside heat pumps, for example heat and electricity storage, to create flexibility and make best use of ToU pricing in sections 4.2.5 and 4.6.1 below.

4.2.1 Technology options

All heat pumps work on the same engineering principle: they consume energy to move heat between two locations. The typical energy source is electricity, and heat will usually be moved from a cooler source to a warmer destination. The four main components are a condenser, an expansion valve, an evaporator and a compressor, and the functioning is akin to that of a refrigerator.

There are three primary options currently available, which have differing characteristics. Water and earth (particularly at a depth of at least 1.5m) will maintain a more consistent temperature around the year than air, which is prone short-term and seasonal variations. However, extracting heat from the ground and water sources is generally more expensive due to the need to install pipework in the ground or in a water source.

The performance of heat pumps is measured by two important ratings:

- The CoP is the ratio of the amount of heating or cooling in kilowatts delivered by a heat pump to the kilowatts of power consumed by the heat pump to transfer this thermal energy, and
- The Seasonal Performance Factor (SPF) rates performance under different ambient conditions in terms of the ratio of its heat output to electricity input expressed as an average over a year.

Box 2 – Technological considerations

Air, ground and water source heat pumps are most common, although heat can be pumped from almost any source

Heat input temperatures must be maintained to ensure best inter-seasonal efficiencies for heating

Some heat pumps can be reversed to take heat out of a building for cooling

Heat pumps are performance rated by Seasonal Coefficient of Performance (SCoP) and Seasonal Energy Efficiency Ratio (SEER)

High levels of insulation are required to get the most out of heat pumps

Systems can be augmented by heat stores, which transfer energy inter-seasonally

Ofgem's Product Eligibility List (PEL) lists eligible manufacturer technologies to qualify for RHI payments

New ratings have recently been introduced under the EU's Energy Related Products (ErP) Directive, which instructs manufacturers to take into account average seasonal efficiencies for heating and cooling. These are known as the Seasonal Coefficient of Performance (SCoP) and Seasonal Energy Efficiency Ratio (SEER). These will better reflect the heat pump's energy efficiency over the entire year.

Compared to conventional heating, which consumes fuel to produce heat, heat pumps are a lower-temperature form of heating. Systems have higher efficiencies when delivering lower temperatures, systems will usually heat water to 40°C rather than the 55ºC or higher of fuelled heating. This may require adaptations to radiators or installation of underfloor heating pipes, which should be reviewed prior to installation. This will also result in the system taking much longer to change the temperature of a building and therefore heating will typically need to be run for more of the day during cold weather. This also makes proper insulation important, so heat is not lost faster than it is produced.

4.2.2 Air source heat pumps

ASHPs work on an 'air to air' basis (heat convected through circulating air) or an 'air to water' basis (heat transferred through a wet heating system). SCoPs are dependent on technology and manufacturer but will typically range from a high of about 3 with intake air temperature around 12°C, to about 2 at an ambient temperature around 3°C.

ASHPs in particular may require back-up heat sources in sub-zero intake temperatures.

4.2.3 Ground source heat pumps

SCoPs for ground source heat pumps are both higher and more stable than for air source models, reaching 4 for an unassisted GSHP and 8 for the most efficient models. A SCoP of 4 is the most common due to the likely inlet and outlet temperatures for a domestic application. GSHPs are less vulnerable to cold weather than air source, as ground temperatures 2m below surface rarely change from 11-12°C in the UK.

4.2.4 Water source heat pumps

WSHPs extract heat from a body of water such as a river, lake, well or borehole. This should ideally be close to the building in order to reduce heat losses. Like GSHPs, they have the advantage of a fairly constant heat source as ground water in the UK generally remains at a temperature between 8°C and 12°C throughout the year. Some schemes are also recovering heat from the sewerage system, which tends to be at a higher temperature than open water bodies.

4.2.5 Thermal stores

There are two types of heat stores: short-term and seasonal. The former tends to consist of hot water storage, while the latter may be underground geological, ground-water or borehole storage.

Short-term heat stores can add flexibility in electrical demand to a system, allowing it to produce hot water and store it during times of cheap electricity – for example when solar panels are generating, or grid electricity is low-cost overnight – or when heat is more available in the environment (ie avoiding colder temperature overnight). This heat will then be available for space heating or hot water at other times.

Many central heating systems already include a hot water tank, and these are relatively inexpensive to install alongside a new system. A standard copper water cylinder might cost around £200 plus thermostat and fitting costs. The benefits will depend on the customers tariff rates, but a hot water tank could allow the heat pump to be switched off during the daily peak charge period, resulting in considerable savings. See work plan 1 for more detail on the potential cost benefits of introducing flexible technologies.

Seasonal heat stores capture heat during the summer, when heat is more available in the environment from sources at higher temperatures. Some heat pump systems recover heat from summer cooling to charge the heat store. The relatively high-temperature heat store reduces the amount of energy required to recover useful heat during winter.

Dedicated seasonal stores can store much greater amounts of energy than daily stores but can be much more expensive. If installing a ground-loop or borehole to act as a heat source, then consider selecting a heat pump or installing solar thermal array which can charge this with heat during the summer at the same time. This could minimise the cost and disruption. The long-term cost benefits of this innovative technology are still unclear, however.

4.2.6 Gas powered heat pumps

While the motive force in most heat pumps is produced by electricity, some heat pumps can burn gas to provide this power. These models tend to be larger and more noisy than electric units, as they contain a gas turbine engine. We have not considered them in great depth as generally, where gas is available as a fuel, it is more economically efficient to use it in gas boilers directly than heat pumps, due to the capital cost of installing a heat pump.

4.3 Criteria for maximising benefits

The level of benefits available from implementing a heat pump solution will depend on some key criteria, so this section explains some points which you may wish to consider, to help maximise the benefits from installing a heat pump.

4.3.1 Appropriate applications

Sites with good eligibility for heat pumps will have at least some of the following characteristics:

- Close proximity to a source of ambient heat (where available)
    - Proximity will help to minimise losses and the energy required to pump the heat from the source to the load. Operating expenses will be minimised if there were a source of heat which could be accessed by the heat pump, especially where this offers good heat potential year-round
- Buildings located off the gas grid
    - Displacing conventional electrical heating or oil-fired boiler supply will bring greater carbon and bill-saving benefits than displacing modern gas-fired boilers
- Buildings with good thermal insulation
    - As relatively low temperature heat sources, heat pumps work best in well-insulated properties
    - New buildings will offer especially good opportunities, if heat pumps can be fitted during construction and pipework for a ground-source heat pump laid during other groundworks
- Generating and demand-side technologies such as solar PV, wind generation, EV charging points and battery energy storage systems either on-site or in very close proximity
    - Local generation connected via a private wire can offer low-cost power to run heat pumps, reducing the cost of electricity by avoiding charges and levies made on power supplied through the public networks.
        - While generation from solar PV does not correlate strongly with heat demand, other technologies offer more useful overlap
        - This could be existing, planned, or potential new electrical generation
        - On-site generation gains similar benefits, without the costs associated with hundreds of meters of electrical cabling
    - On-site batteries, when deployed alongside smart controls and energy management systems and a time-of-use (ToU) tariff, can avoid import during expensive peak periods
        - This allows the heat pump to continue running during peak periods without incurring the inflated electricity costs of running the pump during these periods, as the battery will import when electricity is cheap and export to meet demand (depending on sizing) during peak periods
    - Heat pump systems including thermal stores are ideal demand-side response technologies to include in a local demand-side response or balancing scheme. These can provide additional sources of revenue to the project, but may engender the additional costs of smart controls and energy management systems
        - CARES will be able to help you locate and get involved with this sort of local scheme
        - Your local DNO will also be able to provide information on any flexibility services tenders it is offering in your area, and
        - Your energy supplier might also be able to help identify and access flexibility revenues or aggregation opportunities.

4.4 Assessment framework

To define the make-up of your project and to assess its viability, you will need to consider the following matters, which are further outlined in this heat pump module from the CARES Project Development Toolkit. Contacting a local delivery partner experienced in heat pump installation will probably be a necessary first step to help you carry out the assessment and requirements of your project. There are numerous bodies that manufacture, sell and install heat pumps which offer support in this way. Links to some useful sources can be found here.

Support in deciding upon and developing a community energy project in Scotland is offered by a number of organisations including Local Energy Scotland (through the Community and Renewable Energy Scotland (CARES) programme), the Energy Saving Trust (EST), and Community Energy Scotland (CES). Useful initial planning resources to begin thinking about some of the issues and toolkits to develop projects are listed at the bottom of this document.

There are several stages for assessment.

These considerations initially depend on whether you are planning a domestic or non-domestic application, as this will affect the RHI option open to you (see 2.3.1 above). The number of buildings involved in the project and the available heat source will determine the kind of heat pump(s) you are going to need.

Box 3 – Single site heat pump assessment framework

Your site tenure is secure

The building(s) heat requirement is assessed

Thermal insulation especially in retrofits

Identify the external heat source

Thermal stores, buffer tanks and secondary heating systems

Social considerations and planning approvals

Electrical power requirements and statutory approvals

Electricity Supplier considerations

MCS certification and application to join the RHI scheme

Technology extension – batteries, PV, EV chargers

- Security of tenure
  - Heat pumps represent a long-term investment with a design life in the order of 20 years. You need to be confident that the site will be occupied and maintain a similar level of heat demand for this period
- Building heat requirement
  - It will be necessary to estimate the amount of space and water heating required. A good place to start is a Standard Assessment Procedure (SAP) report for an existing building
    - Further information on the SAP protocol can be found here. Building heat loss is normally calculated using known thermal constants for the materials used in the construction of the building fabric
  - Some useful information about the factors involved in whole building calculations can be found here. For more detailed estimates of heat demand to keep a building warm, it will be necessary to do a room by room calculation using the actual dimensions of each room, wall construction and the area and type of windows
    - Calculators for this purpose are to be found on central heating supplier websites; one of the more exacting can be found from Dimplex, here
    - It may be advisable to contract a professional assessor to provide a precise calculation to size a system. Heat pump installers will be able to carry out these calculations for you
  - If the heat pump is to replace an existing boiler system, you can calculate the required heat pump size based on the outgoing boiler power (in kW)
- Building insulation and heating system performance
  - Heat pumps are suited to new build projects that have been designed with high levels of thermal insulation in the building fabric, designed to make best use of low-temperature heating

  - However, this is not to say that heat pumps cannot be used in existing buildings with good, or uprated thermal insulation, especially where the property is off the gas grid
  - It is normal to expect larger radiator surface areas than in a fossil fuel fired central heating system to be required
    - This guidance document contains advice to help you decide on the sizes of radiators or underfloor heating within a building of given thermal performance
    - In the case of a heat pump retrofit to an existing heating system, you may either need to replace radiators with larger ones, increase the thermal efficiency of the building fabric by adding more insulation, or both
  - EPCs can be a useful source of guidance on improvements suitable to raise the energy efficiency of the building
- Identify the external source of heat for the heat pump to transfer
  - Ambient heat is available from the air, earth and water sources. Availability will affect your project design choices and the sizing of your heat pump. In most applications, it is unlikely for you to require a seasonal heat bank
  - Water offers one of the best sources of heat as it has a high heat capacity. Freshwater temperature data in Scotland has been recorded by researchers working for the ClimateXChange who may be contacted for data enquiries. The Environment Agency also offers a comprehensive UK Surface Water Temperature Archive. Water also has excellent heat transfer properties, allowing the heat to effectively pass into the heat exchanger. A costed example of a 13kW WSHP using pond mats can be found here
  - Ground source heat has a lower transfer rate than water, but it is widely available. Heat exchanger pipes can be laid in shallow trenches at a depth of 1-2m or within deep boreholes, which require less surface area. A costed example of a GSHP application using 4 heat exchangers buried in an area of 1,000sqm to feed a 13kW heat pump can be found here. A costed example of a 13kW GSHP using 360m of boreholes can be found here
  - Installers will help you understand the relative costs of the various technologies and models on offer. It is advisable to contact several installers, especially when considering WSHPs, as this is a less common technology which not all installers work with
  - The closer your heat source to the heat demand, the less cost and heat loss is likely to be incurred in transferring heat to the demand
- Investigate the need for thermal stores and hot water supply
  - Your heat pump will normally supply hot water at around 40°C, which is raised by internal electric heaters to 55-60°C. This can be held in a hot water cylinder or thermal store to be available on demand
    - Identify whether your site has a hot water cylinder of a suitable size
    - If you are unsure or you do not have such a cylinder, contact a heat pump installer for an assessment, quotation and install
  - Thermal stores buffer hot water demand and can be connected to a solar thermal heat source as well, reducing electricity bills and adding flexibility to the system
- Social considerations

  Where significant groundworks are to be undertaken, you may need to consider your neighbours. This applies principally to larger projects involving multiple structures, but also where disruption to civic spaces may be incurred during heat source construction works

  - A heat pump installer will be able to advise you on the potential impacts of each option (noise, spatial requirements, etc.)

- Electrical connection approval
  - Heat pumps may run on a single-phase connection but will demand more current than other electrical appliances. In an existing property it will be necessary to check the condition of your wiring and fuses to ensure that sufficient capacity is available to support the current required
  - Your delivery partner will be able to assist with this. They will also know whether you are required to seek permission from, or notify, your DNO about the installation. Links to apply for a heat pump electrical connection to SPEN and SSE can be found at the bottom of this document
- Supplier considerations
  - As your heat pump will be a new electrical load and increase your electricity bill, you may also want to review your electricity tariff. A different consumption level will change which tariff is cheapest for you; for example, it may be worth moving to a tariff with a higher standing charge and a lower unit rate
  - If you are currently on a two rate tariff with lower overnight charges due to the use of storage heaters, you will also want to consider whether moving to a standard tariff might be preferable. A heat pump may use less electricity overnight and more during the day, and daytime rates are typically higher on a two rate tariff
    - If you are fitting heat stores and smart energy controls, consider also the option of ToU tariffs, which could offer financial benefits to a customer who can be flexible in when they consume electricity
- Site registration and certification
  - Some heat pumps are eligible for Renewable Heat Incentive subsidies. They must be used for space heating or space and water heating and meet other criteria (explained here) to qualify for RHI subsidies under the current regulations
    - To qualify for RHI incentives, equipment with an energy output of up to 45kW must currently be certified under the Microgeneration Certification Scheme (MCS). A list of eligible products can be found here, but your installer will be able to advise which products are eligible for subsidy
  - Once physical installation and commissioning is complete, your installation provider will help you to register the heat pump into the RHI scheme. This will grant access to subsidies
    - Only the owner of the installation can register it into the RHI (or have permission to act for the others if there are several owners); this owner will receive all subsidy payments. We explain more about how to apply for the RHI in section 4.4.2 below
  - The RHI is split into domestic and non-domestic schemes. To decide which to apply for, see the Ofgem factsheet 'The Renewable Heat Incentive – Domestic or Non-Domestic?
    - If the renewable heating system is in commercial, public or industrial premises, then you would apply to the non-domestic RHI. This can include small and large businesses, hospitals, schools, and organisations with district heating schemes where one heating system serves multiple homes

4.4.1 Planning and executing your project

No two independent projects are likely to be the same but Local Energy Scotland has produced a useful heat pump project development guide to help already established community groups to plan and deliver a renewable heating scheme based on heat pumps. More information can be found here.

There are also several examples of supported projects accessible through the links at the bottom of this paper.

4.4.2 Identifying help and financial support

The primary sourcing of support for renewable heat is the RHI. This is a government incentive introduced by the Department for Business, Energy & Industrial Strategy (BEIS) to encourage the roll-out of renewable heat.

Resource Efficient Scotland also offers loans to small and medium companies, and private landlord, to pay for energy efficiency upgrades. These loans, of £1,000 to £100,000 and for terms up to 8 years, are interest free for insulation, lighting and double glazing. They also support various renewable technologies, with interest charged at 5% where the Feed-in Tariff or RHI is being claimed.

Landlords can find more information here and small and medium enterprises here.

The Renewable Heat Incentive is split by application; domestic and non-domestic. The schemes have separate tariffs, joining conditions, rules and application processes. Ofgem administers both schemes in GB.

Box 4 – Key features of RHI scheme

RHI divided into Domestic and Non-domestic funding streams paying different rates of remuneration

Domestic schemes need a building EPC

Heat pumps have minimum requirements set out under the ErP to qualify

Ofgem manage RHI in Scotland, England and Wales

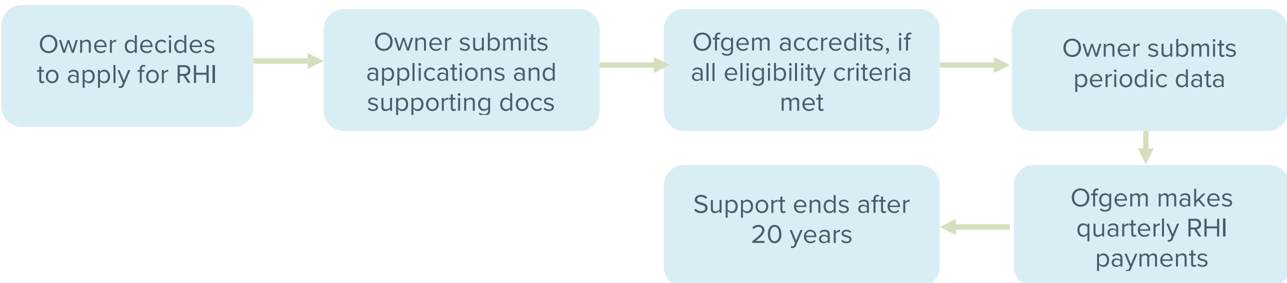
Home Energy Scotland offer interest free loans for heat pumps and thermal insulation improvements to homes

Domestic RHI subsidy tariff is paid to heat pump owners for seven years. For non-domestic applications, payments are at a lower level but last for 20 years. Domestic payments are restricted to the first 30,000kWh (GSHP) and 20,000kWh (ASHP) of heat demand each year, assuming this is lower than the property's annual heat demand. They are calculated on a nominal basis, based on the building EPC at time of registration, rather than being metered.

For non-domestic accreditations, the heat output of the heat pumps will determine the banding by which the RHI subsidies are paid although there are no upper capacity limits.

1.1.1 Applying for the RHI

Applications to the RHI are relatively complex, but your installer should be able to support you through this process. Ofgem also provides guidance here, particularly in chapters two and eight. The process operates as follows:



Eligibility criteria include:

- For installations under 45kWth, MCS-certified technology and installers are required
- A suitable heat generation technology
  - Many heat pumps are eligible, see technology list here
  - Generally, the CoP must be 2.9 and SPF 2.5
- A suitable purpose for the heat generated
  - Eligible purposed include space and water heating within a building, or carrying out industrial processes
  - Heat transferred for the purpose of cooling a building is not an eligible use, but heat pumped to ground storage can become an eligible source of heat for later extraction

- A suitable building
  - The building must be permanent or long-lasting, and wholly enclosed on all sides with a roof and walls
  - Ofgem specifically notes than moveable structures such as polytunnels would not be eligible, though permanent greenhouses would be if expected to remain in situ for a sufficient period
- Suitable metering arrangements
  - Must measure electrical input to the heat pump
  - Heat metering must only measure heating, not cooling
  - Integrated immersion heaters (used to top-up the temperature of hot water and provide additional space heating) must be declared and where practical, electricity use should be accounted for and deducted by logging hours of use

You can also apply for preliminary accreditation. This allows submission of plans and evidence for an installation ahead of commissioning, reducing the risk that an installation will be regarded as ineligible by Ofgem and therefore not able to obtain RHI subsidy. Heat pumps with capacities of over 100kWth (ground source) or 45kWth (air source) can benefit from preliminary accreditation.

Current rates for the scheme are set out in Figure 32 below.

Figure 32: RHI rates, 1 October 2018 to 31 December 2018

Technology type	Tariff rate (p/kWh)		
	Tier 1	**Tier 2**	**Tier 3**
Solid biomass CHP	4.42	-	-
Water/ground source heat pumps	9.36	2.79	-
Air source heat pumps	2.69	-	-
Deep geothermal	5.38	-	-
All solar collectors	10.75	-	-
Biomethane injection	5.60	3.29	2.53
Small biogas	4.64	-	-
Medium biogas	3.64	-	-
Large biogas	1.36	-	-
Small biomass	3.05	2.14	-
Medium biomass	3.05	2.14	-
Large biomass	3.05	2.14	-

Source: BEIS *NB – Tier 1 covers operation for the first 1,314 or 15% of the hours in a year*

There are also ongoing obligations to provide information. Ofgem provides guidance here, but briefly:

- Meter readings must be submitted to show how much useable heat has been produced and how much electricity consumed
  - This will be quarterly for installations up to 1MWth, and monthly for 1MWth or more

- Participants must declare whether fuel used meets sustainability requirements for biomass and biomethane installations
- Annually, participants will have to make a declaration to confirm that the RHI installation continues to meet eligibility criteria, equipment has been maintained, information provided has been accurate, and there has been no change in circumstances that would remove eligibility

Installations with features such as shared ground-loops or installations serving multiple domestic households add complexity to subsidies available and applications. Specialist assistance should be sought on a per-site basis.

4.5 Business case & finance

In this section, we summarise heat pumps costs, both capital and operational. Our focus will also be upon single technology projects – heat pump only – while recognising that other technologies such as PV and thermal or battery storage may provide synergies with heat demand. We also set out some sources of information for financing schemes including heat pumps.

Home Energy Scotland provides interest free loans to homeowners making thermal improvements to their homes, including installation of heat pumps, thermal insulation and storage. More information on the scheme can be found here.

4.5.1 Outline business case

Once you have completed the assessment, you will need to develop a business case, which will establish the costs and benefits of the project, setting out how and when the costs will be recovered. The CARES Investment Ready Tool, although originally designed for wind and hydro projects, provides a template which can be used to track the business case for a heat pump project. It forms part of the CARES Project Development toolkit.

The aim of the tool is to outline the information that needs to be collected during the development of your renewable project and provide a mechanism for recording information which can be passed on to a potential lender. The tool is part of the Investment Ready Process, which includes an online storage platform and an independent assessment by CARES technical advisors.

While the business case for each installation of heat pumps must be weighed on its particular circumstances, it will be predicated on establishing a sufficiently low cost of operating the heating system to pay off the capital cost of installation over the working life. The rest of this section therefore lays out the data you will need to obtain in order to work out your business case.

4.5.2 Sources of value

The starting point for putting together the business case will be identifying the sources of value. A GSHP can produce (three or more) times more heat energy than it demands in electrical energy (ASHPs have lower SCoPs), which along with RHI subsidies makes a compelling case for heating cost and carbon reduction in the right contexts (e.g. a well-insulated building with sufficient radiator surface area).

Running costs of heat pumps are not easy to estimate accurately due to the many other factors influencing their performance. We have provided costs per kWh of heat delivered in Figure 4 earlier in this workplan.

These operating expenses (OPEX) figures already indicate that the heat pump has a dramatic running cost improvement over a heating system based on electric storage heaters, and this is before the benefits of the RHI and carbon abatement are taken into account.

Figure 33 presents an assessment of savings, adjusted to reflect the current rate of the RHI (valid until 31st December 2018) for the savings over conventional heating systems, for a GSHP installed for a small business established in a building requiring 10,000kWh of heating a year. These include the associated carbon abatement.

Figure 33: Comparative savings from running a non-domestic GSHP heat pump compared to other heating systems

Displaced technology	Estimated fuel bill savings (£/year)	GSHP RHI (£/year)	Total benefit (£/year)	Carbon abated (kg/CO_2/year)
Gas (G-rated boiler, 60% efficient)	195.57	936	1131.57	1,978
Gas (A-rated boiler, 90% efficient)	-6.10	936	929.90	956

Displaced technology	Estimated fuel bill savings (£/year)	GSHP RHI (£/year)	Total benefit (£/year)	Carbon abated (kg/CO_2/year)
Electric (storage heaters, 90% efficient)	1,182.79	936	2118.79	3,145
Oil (G-rated boiler, 60% efficient)	267.24	936	977.68	2,995
Oil (A-rated boiler, 90% efficient)	41.68	936	1614.90	1,634
LPG (G-rated boiler, 60% efficient)	678.90	936	1252.13	2,478
LPG (A-rated boiler, 90% efficient)	316.13	936	936.00	1,289

The same figures for an ASHP are presented in Figure34.

Figure 34: Comparative savings from running a non-domestic ASHP heat pump compared to other heating systems

Displaced technology	Estimated fuel bill savings (£/year)	ASHP RHI (£/year)	Total benefit (£/year)	Carbon abated (kg/CO_2/year)
Gas (G-rated boiler, 60% efficient)	31.80	269	300.80	1543
Gas (A-rated boiler, 90% efficient)	-169.87	269	99.13	520
Electric (storage heaters, Economy7 tariff, 90% efficient)	1,019.02	269	1,288.02	2709
Oil (G-rated boiler, 60% efficient)	103.47	269	372.47	2559
Oil (A-rated boiler, 90% efficient)	-122.09	269	146.91	1198
LPG (G-rated boiler, 60% efficient)	515.13	269	784.13	2043
LPG (A-rated boiler, 90% efficient)	152.36	269	421.36	854

4.5.3 Costs

The Energy Saving Trust gives figures for a ‘typical system cost’ (Capex) of a GSHP as £10,000 to £18,000 and an ASHP as £6,000 to £8,000 (excluding running costs). Once again, the size required for the installation will be dependent on the size of the building and its thermal efficiency.

In Figure 35, we have compiled some comparative costs of heat pumps based on £ per kWth installed cost as this is another way to make the kind of technology cost comparisons necessary to make a business case.

Figure 35: Comparative costs for heat pumps (in kW of heat)

Technology	Capex (£/kW)	Opex (£/kW/year)	Domestic RHI (p/kWh)	Non-domestic RHI (p/kWh)
Air source	619.65	12.39	10.49	2.69
Ground or water source	1,300-1,500	13 to 15	20.46	9.36

Source: Danish energy agency (2016) and Ofgem

The annual demand for heat is subject to the building concerned and the way it is used by its occupants. BEIS produced a heat estimator tool in 2016; this was intended for use in assessing heat networks, but it also provides a view to typical heat demand per square metre in various types of building.

Figure 36: Typical heat demand of various non-domestic buildings, per square metre

Building use	Typical heat demand (kWh)	Building use	Typical heat demand (kWh)
General office	127.92	Dry sports and leisure facility	351.78
High street agency	127.92	Public buildings with light usage	111.93
General retail	181.22	Schools and seasonal public buildings	159.9
Large non-food shop	181.22	University campus	255.84
Small food store	181.22	Clinic	213.2
Large food store	111.93	Hospital (clinical and research)	447.72
Restaurant	383.32	Long term residential	447.72
Bar, pub or licensed club	366.8	General accommodation	319.8
Hotel	347.82	Emergency services	415.74
Cultural activities, Clinics and Terminals	213.2	Laboratory or operating theatre	170.56
Entertainment halls	447.72	Public waiting or circulation	127.92
Swimming pool centre	1,204.58	Terminal	213.2
Fitness and health centre	461.12	Workshop	191.88

Source: BEIS

4.5.4 Capital costs

Heat pumps are considerably more expensive to install than the modern A-rated gas boiler. The Centre for Alternative Technologies notes here that, as a rule of thumb, a ground-source system will cost around £1,000/kW, made up of £400-600 for the pump itself, with trenches costing £300 or boreholes £500. BEIS also published guidance from the Carbon Trust in 2014 suggesting similar costs here.

Costs are extremely variable, even for air-source heat pumps, as internal work on the building to install additional insulation, underfloor heating, or larger radiators may be needed to make best use of the low temperature heat produced by the heat pump.

4.6 Future opportunities and risks

Known changes – While heat pumps are very efficient, they use electricity to run. Electricity charges are expected to continue to rise over coming years, predominantly due to increasing network, green and social levy costs. This means that, despite falling costs for the technology, the business case for replacing a gas boiler with a heat pump may become weaker over time.

Heat pump Capex is predicted to fall 5% by 2020 and 20% by 2030; it was estimated in 2010 that the learning rate (cost reduction from doubling roll-out) for the technology was 35%.

The presence of local waste heat (e.g. from industrial processes) or residual heat sources (e.g. easy access to relatively high temperature geothermal heat) would increase the efficiency of a heat pump. For this reason, models are being demonstrated that draw upon waste heat from industrial and commercial processes.

Regulatory and other changes – In the short term (next 2-5 years), heat may be brought under Ofgem's purview or under that of a separate regulatory entity, resulting in the risk of an increased regulatory burden for supplying heat to domestic or commercial properties. It is understood that this is likely to focus on district heat networks (heat as a service) because the electricity and gas markets already fall under Ofgem's remit.

Policy uncertainty includes reforms to the Renewable Heat Incentive, a government policy which has recently been labelled as "ineffectual" by groups within government. Changes could improve or damage subsidy opportunities depending on the relative balance of available treasury funds and a desire to drive through heat decarbonisation. The government could separately introduce a heat decarbonisation policy that supports heat pump take-up, which could drive down unit Capex over time.

4.6.1 Augmented heat pump systems

Various technologies can be combined with heat pumps to achieve synergies. These include PV, battery storage and solar thermal. We now discuss some combinations of these in brief for further information.

With solar PV

Generation times for solar PV assets do not correlate with need for domestic space heating. However, the addition of a battery storage system or hot water tank can offer flexibility, allowing the power or heat created to be time shifted. This will impact favourably upon the cost of running the heat pump by reducing the cost of imported power.

With batteries

For larger projects, a community battery may offer a solution to imported electricity costs. The Gateshead Council district heating network includes batteries. This is to optimise the output of electricity from the station's gas-CHP turbines, ie to transfer electricity generation to peak profit times. The heat-pump led solution would use a battery to avoid drawing power during peak charge times. Pre-heating properties and controlling use during expensive periods would also offer some cost benefits.

With integrated thermal storage

A thermal store enhances heat pump efficiencies, enables greater control over the available heat and less wear on the heat pump compressor motor. A hot water tank could, for example, allow the heat pump to be switched off during peak electricity pricing periods. In concert with an aggregator and smart controls, this could also allow access to demand-side response and grid-service revenues.

Sub-surface thermal banks can enhance the performance of GSHPs and WSHPs by storing excess heat during warm periods. Thermal banks support heat pump efficiency by delivering a thermal source above ambient temperatures in winter periods. Borehole thermal energy storage is a new technology which looks to move heat from relatively high temperature areas – such as asphalt in summer, which can be 15°C hotter than ambient temperatures – and store it deep underground for retrieval in winter. This could use solar electricity and heat pumps which are not being used for domestic heating in the summer to heat deep areas from a natural 10°C to over 25°C, considerably reducing energy use in winter when solar PV is not generating as much power. Trials of this new technology have begun, but no results to ascertain economic feasibility have yet been published so it is not clear if this combination will result in a net economic benefit.

4.7 Toolkit

Heat pumps displacing other sources of heating

Planning

- CES Delivering your project
- LES Developing a heat pump

Connection

- SSE heat pump connections
- SPEN heat pump connections
- CARES connection module

Evaluation

- CES knowledge centre
- NRCAN guide to heat pumps
- Heat Pump Association
- Ground Source Heat Pump Association
- EST guide to thermal stores
- CIBSE heat pump knowledge base

Example schemes

- Antonine Sports Centre
- CES case studies
- Findhorn ECO Village heat pump study
- Clydebank district heating

Delivery

- Ofgem RHI eligible heat systems
- Home Energy Scotland loans
- Plan Local contracts and tendering guide
- MCO heat emitter sizing guide
- CARES procurement module
- District Heating Scotland

4.8 Useful sources of information

SSE – Guide to applying for a new connection including heat pumps

SSE – Community Heating Projects

SPEN – Connecting a heat pump

Local Energy Scotland – developing a community-led heat pump project

Community and Renewable Energy Scheme (CARES) Project Development Toolkit

Energy Saving Trust Community Energy Hub

Community Energy Scotland Knowledge Centre

Community Energy Scotland – Delivering your project

Community Renewables Toolkit – Securing Your Site Module

Community and Renewable Energy Scheme Development Toolkit Planning Module

Plan Local – Contracts, agreements and tendering

4.8.1 Heat pump specific information

Heat Pump Association

Ground Source Heat Pump Association

Energy Saving Trust – Thermal Stores

Interseasonal Heat Transfer

CIBSE – heat pump knowledge base

Evergreen Energy

Heating and cooling with a heat pump

Microgeneration Certification Organisation heat emitter sizing guidance

4.8.2 Financial support for eligible equipment

Ofgem – RHI eligible heating systems

Ofgem – domestic RHI Product Eligibility List (PEL)

Energy-related Products Directive and the Domestic RHI

Non-Domestic Renewable Heat Incentive

Home Energy Scotland Loan

Ofgem Domestic RHI rates

Ofgem Non-domestic RHI rates

4.8.3 Examples of financially supported heat pump projects

Antonine Sports Centre

Community Energy Scotland Heat Pump Case Studies

Findhorn Eco Village Heat Pump Case Study

Annex A: Market leading deals in Scotland October 2018

Figure A1: Leading tariffs in the Northern Scotland region (October 2018)[40]

	Tariff option		
Archetype	**Variable**	**Fixed**	**Prepayment**
1) Low-income electrically-heated (E7)	Outfox the Market-£830	Toto Energy - £975	Bulb - £972
2) All other electrically-heated (E7)	Outfox the Market-£1,192	Toto Energy - £1,375	Bulb - £1,363
3) Low-income non-metered fuel-heated	Outfox the Market - £498	ENSTROGA - £570	Bulb - £586
4) All other non-metered fuel-heated	Outfox the Market-£671	Toto Energy - £786	Bulb - £787
5) Low-income, out-of-work single adults in small 1-bed social rented flats	Powershop - £778	Orbit Energy - £862	Economy Energy - £896
6) Young working adults in rented flats	Powershop - £660	Orbit Energy - £717	Economy Energy - £764
7) Low-income single adults (lone parents or elderly) in social rented houses	Powershop - £800	Orbit Energy - £888	Economy Energy - £918
8) Younger working families in medium-sized rented houses	Powershop - £969	Orbit Energy - £1,095	Economy Energy - £1,106
9) "Average" mains gas-heated households	Powershop - £1,026	Orbit Energy - £1,166	Economy Energy - £1,173

Source: energyhelpline data as analysed in the Cornwall Insight domestic tariff report

[40] Energy consumption levels are based on the Centre for Sustainable Energy's analysis of GB domestic consumption patterns. See here for more information.

Figure A2: Leading tariffs in the Southern Scotland region (October 2018)

	Tariff option		
Archetype	**Variable**	**Fixed**	**Prepayment**
1) Low-income electrically-heated (E7)	Southern - £771	Toto Energy - £922	Nabuh Energy - £924
2) All other electrically-heated (E7)	Outfox the Market - £1,106	Toto Energy - £1,298	Nabuh Energy - £1,298
3) Low-income non-metered fuel-heated	Southern - £466	Orbit Energy - £543	Nabuh Energy - £555
4) All other non-metered fuel-heated	Outfox the Market - £625	Toto Energy - £745	Nabuh Energy - £747
5) Low-income, out-of-work single adults in small 1-bed social rented flats	Powershop - £751	Orbit Energy - £836	Economy Energy - £864
6) Young working adults in rented flats	Powershop - £635	Orbit Energy - £695	Economy Energy - £739
7) Low-income single adults (lone parents or elderly) in social rented houses	Powershop - £771	Orbit Energy - £860	Economy Energy - £885
8) Younger working families in medium-sized rented houses	Powershop - £936	Orbit Energy - £1,061	Economy Energy - £1,066
9) "Average" mains gas-heated households	Powershop - £993	Orbit Energy - £1,131	Economy Energy - £1,129

Source: energyhelpline data as analysed in the Cornwall Insight domestic tariff report

Annex B: Collective switches since January 2017

People Power	The Big Deal	Jan-17	PFP Energy	£899	One year fix
Energyhelpline	The Telegraph Big Switch	Feb-17	EDF Energy	£938	One year fix
Energyhelpline		Feb-17	Green Star Energy	£947	Two year fix
Energyhelpline		Feb-17	Green Star Energy	£949	One year fix, renewable energy
Money Saving Expert	Big Swtich 6	Feb-17	EDF Energy	£924	One year fix, £35/fuel exit fee, only available Scotland, Wales and NW England
The Big Deal		Mar-17	First Utility	£893	
The Big Deal		Feb-17	Octopus Energy	£899	One year fix
The Big Deal		Feb-17	Octopus Energy	£927	One year fix, renewable energy. 38 Degrees Clean Tariff
iChoosr		Feb-17	First Utility	£944	One year fix
MSM & MSE Exclusive		Mar-17	Flow Energy	£877	Fixed until March 2018
Money Saving Expert	Big Switch 7	Apr-17	Green Star Energy	£854	One year fix
The Big Deal	People Power (The Sun)	Apr-17	Green Star Energy	£888	
The Big Deal		Apr-17	Bristol Energy	£934	One year fix, 100% renewable energy
UK Power Collective		Jun-17	SSE	£870	Collective 1 Year Fixed v4 An early exit fee of £30 per fuel will be applied if you leave more than 49 days before the end of the 12 month period
Lets Save Money	Collective Swtich Jun 2017	Jun-17	EDF Energy	£865	One year fix, 3 regions had a cheaper SSE deal
The Big Deal	Collective Swtich Jun 2017	Jun-17	Economy Energy	£870	One year fix
MoneySuperMarket	Energy Bill Buster	Jul-17	EDF Energy	£865	One year fix
Compare the Market	-	Jul-17	EDF Energy	£865	One year fix
Energyhelpline		Aug-17	SSE	£870	One year fix
Money Saving Expert	Big Switch 8	Sep-17	EDF Energy	£881	One year fix
Energyhelpline	The Telegraph Big Switch	Oct-17			
	iChoosr	Oct-17	SSE	£889	One year fix
	energy helpline	Oct-17	SSE	£889	One year fix
The Big Deal		Oct-17	Octopus Energy	£903	One year fix
The Big Deal		Nov-17	Green Network Energy	£895	18 month fix
Money Saving Expert	Big Switch 9	Jan-18	EDF Energy	£928	two year fix
Money Saving Expert	Big Switch 9	Jan-18	Octopus Energy	£861	14 month fix
Energyhelpline	The Telegraph Big Switch	Jan-18	British Gas	£910	One year fix
Energyhelpline	The Telegraph Big Switch	Jan-18	iSupplyEnergy	£901	One year fix
Energyhelpline	This is Money/MailOnline	Feb-18	???		
iChoosr	Big Community Switch	Feb-18	So Energy	£888	One year fix
Energyhelpline	ThePeoplesPower	Feb-18	EDF Energy	£923	2 year fix
	ThePeoplesPower	Feb-18	British Gas	£910	2 year fix
Energyhelpline	Compare the Market	Feb-18	EDF Energy	£923	2 year fix
Ikea	The Big Clean Switch	Mar-18	Octopus Energy	£881	one year fix
Money Saving Expert	Big Switch 10	Apr-18	Bulb	£823	Vari-Fair (standard tariff plus £25 cashback and £30 bill credit)
Money Saving Expert	Big Switch 10	Apr-18	EDF Energy	£911	Two year fix
iChoosr	Big Switch	May-18	So Energy	£949	one year fix renewable tariff

Annex C – Costed example

Each heat pump project has unique characteristics that will determine the ultimate selection of the type of technology most suited to the site and so it is impossible to generalise on system specifications. However, in this section we present a methodology for costing a GSHP against the costs of installing and running natural gas or heating oil alternative systems for a single building. As the SCoP of ASHPs are approaching those of GSHPs, it makes them a practical alternative to consider in small to medium size heat demands, and so we have included an ASHP in the example below.

Assumptions have been made for the additional costs of sinking two 100m boreholes to supply heat to the GSHP and the installation of all associated pipework and fittings for the different systems. Life expectancy of gas and oil-fired boilers are set at 10 years and the heat pump at 20 years.

Some costed examples of heat pump applications are available on the Kensa Heat Pump manufacturer's website and the Greenmatch website. The Kensa website benchmarks its examples against different types of 13kW ground and water source heat pumps for single dwelling applications here.

Note, these examples do not account for annual maintenance costs, system longevity or fuel delivery charges in OPEX.

RHI payments are calculated the same way as presented in the Ofgem RHI factsheet with tariffs adjusted to the September 2018 rates.

Situation

A community building with 80m^2 floor area and annual heat demand of around 160kW per metre squared, as described in BEIS's heat demand figures here under "schools and seasonal public buildings". An 10kWth GSHP (SCoP of 3.5) and an 10kWth ASHP (SCoP of 2.5) are selected for comparison against natural gas and oil-fired boiler systems. The heat pumps raise the water temperature to 40°C and, in this example, require built-in electrical immersion heaters to deliver water temperature to 55°C for domestic water heating.

As the cost of heat pumps per kW falls as size increases, the economics of buying a larger heat pump and larger ground heat exchangers needs to be weighed against the cost of running immersion heaters built in to a smaller system.

Use of existing internal radiators is assumed, although the characteristics of heat pumps often demand replacing existing radiators with oversized versions to deliver sufficient space heating and therefore this should be considered a potential additional cost in a retrofit scenario.

Fuel and RHI payments are fixed going forward at October 2018 rates, although in practice these are subject to alteration. Currently they are rising, according to Government policy and the allocated budget.

Figure C1: Laying out the costs of different heating systems

Project factor	Specification	Annual demand (kWh)	OPEX	CAPEX
Building floor area	100m^2	12,800		
Demand met by natural gas combi boiler (24kW)	Boiler efficiency 90%	12,800	£516/year[1]	£2,500 installed[2]
Demand met by oil combi boiler (24kW)	Boiler efficiency 90%	12,800	£577/year[1]	£3,500 installed[3]
GSHP (10kW) space heat	SCoP 3.5	3,650kWh (electricity)	£515 (to 40°C)[1]	£6,000
GSHP ground works and installation				£6,000[4]
ASHP (10kW) space heat	SCoP 2.5	5,120kWh (electricity)	£725 (to 40°C)[1]	£7,000
ASHP installation cost				£1,500
GSHP water heater	40°C to 55°C	850kWh electricity	£120[6]	
ASHP water heater	40°C to 55°C	850kWh electricity	£120[6]	
GSHP total Opex			£635/year	
GSHP RHI payments			£1,198/year	
GSHP net cost			-£563/year	
ASHP total Opex			£845/year	
ASHP RHI payment			£344/year	
AHSP Net cost			£501/year	

Notes:
[1] Assumes fuel prices as in Figure 4
[2] Assumes boiler cost £1,000 and installation costs £1,500
[3] Assumes boiler cost £2,000 and installation cost £1,500
[4] Assumes total boreholes required are 200m at £50/m and all installation costs £2,000
[5] Assumes ASHP installation cost £1,500
[6] Hot water requirement is 20% of total heat demand and immersion heater assumed to run for 1.5hrs/day at Figure fuel cost

The results of calculations made in Figure 10 show that the GSHP has a Capex of £25,000 and an Opex – after RHI subsidy – of –£563/year to satisfy the heating demand for the example property. We shall now use this as a benchmark to compare the other heating systems against. This gives a total cost (neglecting maintenance costs) of £740 for the twenty-year lifetime. This is calculated on the basis of:

$$Total\ installation\ and\ running\ costs, after\ twenty\ years = Capex + (20\ \times Opex) - (20 \times RHI)$$

$$= 12{,}000 + (20 \times 635) - (20 \times 1{,}198) = 12{,}000 + (12{,}700) - (23{,}960)$$

$$= £740$$

We shall use the above calculation as our benchmark for the comparisons in Figure C2.

Figure C2: Comparisons of installation and running costs of other heating systems

Total after 7 years[1]	GSHP	ASHP	Natural gas	Oil
Return on investment	-£740	-£18,520	-£12,820	-£15,040

Notes:
[1] Based on Total installation and running cost after 7 years (RHI included where applicable)

The results presented in Figure 11 indicate that for the example given, investment in an GSHP is likely to be the most economical approach to space and water heating.

As stated above this worked example shows that there is an economy of scale to consider for the deployment of different heat pump technologies, where for larger projects GSHPs are probably more economical if the space is available for the necessary earthworks.

Annex D – Energy efficiency measures eligible for ECO funding

Measures Category	Measure Type	Obligation			
		CERO	HHCRO	HHMR	Social EFG
Solid Wall Insulation	Internal Wall Insulation Systems, for: a solid brick wall built before - 1967 (England and Wales) - 1965 (Scotland)	✓	✓	✓	✓
	Internal Wall Insulation Systems, for: a solid brick wall built after - 1967 (England and Wales) - 1965 (Scotland)	✓	✓	✓	✓
	External Wall Insulation Systems, for: a solid brick wall built before - 1967 (England and Wales) - 1965 (Scotland)	✓	✓	✓	✓
	External Wall Insulation Systems, for: a solid brick wall built after - 1967 (England and Wales) - 1965 (Scotland)	✓	✓	✓	✓
	Internal non-brick solid wall insulation	✓	✓	✓	✓
	External non-brick solid wall insulation	✓	✓	✓	✓
	External Wall Insulation for Cavity Walls	✓	✓	✓	✓
	Internal Wall Insulation for Cavity Walls	✓	✓	✓	✓
Park Home External Wall Insulation	Park Home External Wall Insulation Systems	✓	✓	✓	✓
Cavity Wall Insulation	Cavity Wall Insulation (0.040)	✓	✓	✓	✓
	Cavity Wall Insulation (0.033)	✓	✓	✓	✓
	Cavity Wall Insulation (0.027)	✓	✓	✓	✓
	Party Cavity Wall Insulation	✓	✓	✓	✓
Loft Insulation	Loft Insulation: where there is less than or equal to 100mm pre-existing insulation	✓	✓	✓	✓
	Loft Insulation: where there is greater than 100mm pre-existing insulation	✓	✓	✓	✓
Other Insulation	Flat Roof Insulation	✓	✓	✓	✓
	Room in Roof Insulation - residual area insulated	✓	✓	✓	✓
	Room in Roof Insulation - residual area uninsulated	✓	✓	✓	✓
	Under Floor Insulation	✓			
	Hot Water Cylinder Insulation	✓	✓	✓	✓
	Draught Proofing	✓	✓	✓	✓
	Window Glazing - single to double	✓	✓	✓	✓
	Window Glazing - improved double glazing	✓	✓	✓	✓
	High Performance External Doors with less than or equal to 60% glazing area	✓	✓	✓	✓

Measures Category	Measure Type	Obligation: CERO	HHCRO	HHMR	Social EFG
QNGB Replacement	High Performance External Doors with greater than 60% glazing area	✓	✓	✓	✓
	Qualifying non-gas boiler replacement - no preexisting heating controls		✓	✓	
	Qualifying non-gas boiler replacement - preexisting heating controls		✓	✓	
	Non-qualifying boiler installation		✓	✓	✓
	Qualifying boiler repair - no pre-existing heating controls		✓	✓	
	Qualifying boiler repair - pre-existing heating controls		✓	✓	
QESH Replacement	Qualifying electric storage heater replacement (QESH) - slimline		✓	✓	
	Qualifying electric storage heater replacement (QESH) - fan storage		✓	✓	
	Qualifying electric storage heater replacement (QESH) - High Heat Retention		✓	✓	
ESH Replacement	Electric storage heater replacement (ESH) – slimline		✓	✓	
	Electric storage heater replacement (ESH) - fan storage		✓	✓	
	Electric storage heater replacement (ESH) - High Heat Retention		✓	✓	
QESH Repair	Qualifying electric storage heater repair - slimline (1 year warranty)		✓	✓	
	Qualifying electric storage heater repair - slimline (2 year warranty)		✓	✓	
	Qualifying electric storage heater repair - fan storage (1 year warranty)		✓	✓	
	Qualifying electric storage heater repair - fan storage (2 year warranty)		✓	✓	
	Qualifying electric storage heater repair - high heat retention (1 year warranty)		✓	✓	
	Qualifying electric storage heater repair - high heat retention (2 year warranty)		✓	✓	
Other Heating	Heating Controls		✓	✓	✓
District Heating System	District Heating Connections - Upgrade (Biomass boiler)	✓	✓	✓	
	District Heating Connections - Upgrade (Gas/oil boiler)	✓	✓	✓	
	District Heating Connections - Upgrade (CHP)	✓	✓	✓	
	District Heating Connections - Upgrade (Energy from Waste)	✓	✓	✓	
	District Heating Connections - Upgrade (Ground Source Heat Pump)	✓	✓	✓	
	District Heating Connections - Upgrade (Air Source Heat Pump)	✓	✓	✓	
	District Heating Connections - Upgrade (Multi Fuel)	✓	✓	✓	
	District Heating Connections - New Connection (All generator types)	✓	✓	✓	✓
	District Heating Connections - Heat Meters	✓	✓	✓	
Micro-generation	Air Source Heat Pump		✓	✓	✓
	Ground Source Heat Pump		✓	✓	✓
	Photovoltaics		✓	✓	✓