Appendix 4

Hanley Castle Parish

Renewables Assessment

For the Hanleys Energy Action Team (HEAT)

Carried out by Dave Green & Jon Hallé, Sharenergy

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Contents

Executive Summary

Sharenergy have looked at the major opportunities for renewable energy projects within Hanley Castle Parish, with a particular emphasis on those projects that might be suitable for a Community Energy ownership model. Three projects have been identified as being worthy of further investigation, however other options are available for HEAT to promote to individual building owners and landlords and further areas have been identified that HEAT could monitor for changes to the planning or financial frameworks. The technologies identified fall into four main categories;

1, Technically and Financially Feasible, Suitable for Community Energy Projects
Commercial Rooftop Solar.
Ground Mounted Solar.
Shared loop Ground Source heat pumps, new build.
These are the three projects recommended for further investigation.
In addition, large scale battery storage might be feasible, this should be considered alongside a ground mounted solar scheme if a suitable site can be found. A task list was developed to take these three forward.

2, Technically and Financially Feasible but Not Suitable for Community Energy Projects
Domestic rooftop PV, (feasible only with high direct usage).
Individual heat pumps and biomass boilers (feasible utilising the Renewable Heat Incentive)
We are recommending that HEAT can play an active role in promoting these to the inhabitants of the Parish and looking into bulk buy discounts.

3, Technically Feasible but Constrained by Planning or Lack of Financial Support
Wind turbines (constrained by planning).
Domestic batteries (still expensive).
Hydrogen (no financial support, no existing surplus of renewable energy to turn into green hydrogen).
Anaerobic Digestion (ideally suited to waste crops of which no sizeable amounts have been identified, not well suited to a Community Energy model)
We are recommending that HEAT monitor these constraints and keep an eye open for future opportunities arising.

4, Technically Not Feasible Locally
Hydro.
Waste Heat from Haylers End Incinerator (insufficient heat available)
Larger scale heat network is unlikely to work due to the scattered nature of the housing..

All options are described in detail and arranged in a matrix in Appendix 1.

The final section of the report details work carried out on the three selected projects in November and December 2020.

- The shared loop ground source heat pump work was terminated due to changes in the Non Domestic RHI and potential planning delays.
- Some progress was made with rooftop solar but no definite schemes have come forward, this work is going to be carried on outside of the RCEF process as a partnership between HEAT and the Big Solar Co-op.
- The ground mounted solar scheme cannot proceed immediately due to grid constraints. These constraints may ease in future but there is no clear plan as to when this might be.

Existing Renewables

In the Hanley Castle Parish there are:

41 domestic Photovoltaic (PV) systems, at an average of 3kWp each = 123kW,
plus approximately 30 kW of PV on the High School, and 4kW of PV on the Primary School.
Total approximately 145kW, producing around 130,500kWh of electricity/annum.

20 Solar thermal systems with around 2,000kWh/a each = 40,000kWh.

34 domestic properties with Air Source Heat Pumps (ASHP), including 11 at Chapman's Orchard (in addition,10 more ASHP's are being fitted at Chapman's Orchard phase 2).
2 properties have Ground Source Heat Pumps.
Each heat pump should contribute about 6,600kWh of renewable heat/annum
= 237,600kWh/a (using an average heat demand of 10,000kWh/a with a Coefficient of Performance of 3).

4 properties on a wood chip district heating system at Severn End, although this system has an oil boiler back-up which has seen considerable use because of issues with the chip boiler.
2 dwellings with a wood pellet boiler.
6 other dwellings with dual fuel heating systems (a multi fuel stove feeding radiators).
A large proportion of properties with dual fuel or wood stoves (50% of those with an Energy Performance Certificate)
Allowing for 20,000kWh per property and counting Severn End itself as two properties, plus 5,000kWh from each wood or multi fuel stove gives approximately, 350000kWh/annum of domestic heat from biomass.

Albion Lodge Care Home has a wood pellet biomass boiler. We understand that Malvern View, the College at Rhydd also has a biomass boiler but we have not been able to verify that. No figures are available for the amount or type of biomass used; we would expect it to be in the region of 150,000kWh/annum for each facility.
Hanley Castle High School has a biomass boiler in L Block. This used 61,000kWh of fuel in 2017 according to the building's Display Energy Certificate.

Haylers End Incinerator (currently being built) has an apparent capacity of 263kW of which 200kW will be used within the plant, so the plant should provide approximately 480,000kWh of electricity/annum (or 480MWh, *1MWH is 1,000kWh).* The company developing the plant have stated that "we operate our heat loops at medium pressure as the pressure going into the generator is circa 9bar due to the technology we have implemented. Therefore, I would imagine that any heat offtake from the site would directly impact the electrical generation."

Several of the units at Willow End and Merebrook have air conditioning units run by air source heat pumps. These have not been counted because many of these have boilers as well so the ASHPs would not be used for heating.

Domestic Renewables

	Estimate d MWh/a	%
PV	100	14%
Heat pumps	238	33%
Boilers & Stoves	350	48%
Solar Thermal	36	5%
Totals	724	

With a population of 1,500 that gives 480kWh of renewable energy/person/year, equivalent to everyone having two 250W PV panels.

Average non renewable domestic energy use/person is 10,250kWh/a *(from energy survey report, not allowing for green energy tariffs)*

Giving a total energy use of approximately 10,730kWh/p/annum. of which 5% is currently supplied by integrated renewables and biofuels.

Non-Domestic Renewables

	Estimated MWH/a	%
PV	31	4%
Boilers	361	41%
Haylers End	480	55%
Total	872	

Not including Haylers End, the Non-Domestic Renewables add 60% to the domestic renewables. Haylers End is smaller than we first thought, but it still dwarfs all other installations, providing 30% of all the renewable energy in the Parish, though possibly this should be considered as a wider resource than just the Parish's.

Adding Domestic and Non-Domestic Renewables together, including Hayler's End, the result is 1,596MWH/a or just over 1MW/a (1,064kWh/a) per resident.

These figures have been taken from a number of sources, including Energy Performance Certificates (EPCs) and Display Energy Certificates (DECs) backed up by visits to the area. Not all properties have EPCs, but properties with renewable systems should have EPCs because they are required to claim the Feed in tariff or Renewable Heat Incentive.

Infrastructure

Western Power Distribution (WPD) are the local District Network Operator (DNO) for Hanley Castle Parish.

There is a substation at Brotheridge Green which serves the Parish.

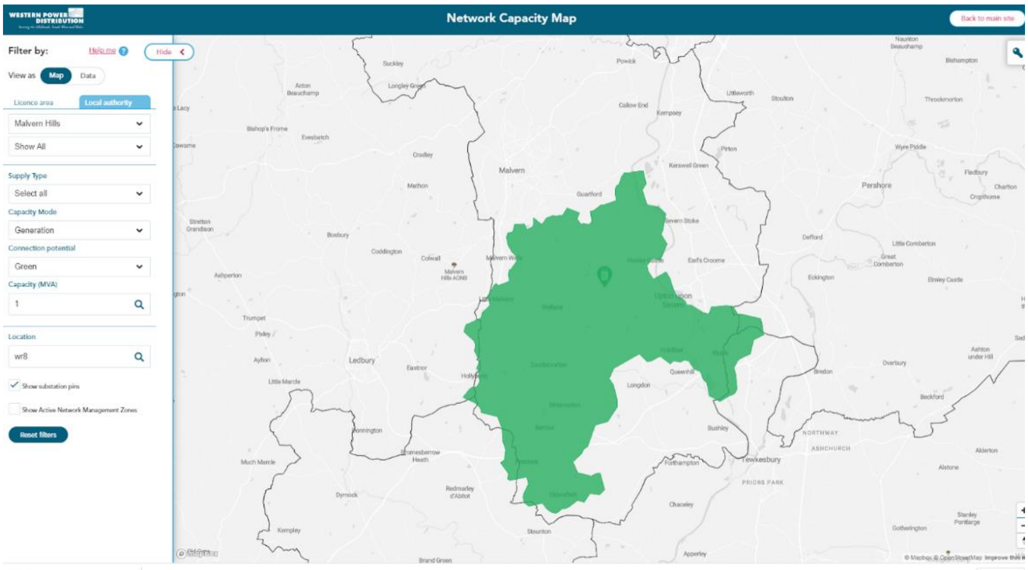


Figure 1.

WPDs capacity map[1] gives an outline of available capacity. The map shows there is a total of 4MVA of reverse power generation capacity at Brotheridge Green (roughly equivalent to 4 MW of capacity). There is a reported 600kW generation coming on stream at the Hayler's End Energy from Waste facility shortly and we will need to contact WPD to understand how this is connected and what the impact on generation connections may be. The WPD portal provides further details:

Substation Reverse Power Capability	4.00 MVA
Connected Generation	0.70 MVA
Accepted not yet connected	-
Offered not yet accepted	1.00 MVA *(possibly Haylers End? This needs to be checked)*

This implies a total available generation capacity of between 2.3 and 3.3 MW, depending on whether the outstanding grid offer for an unknown project is taken up. It is quite common for grid offers to not be taken up if projects do not progress.

That is not necessarily a hard limit for generation in the study area. Firstly, it is often possible to connect larger generation and to pay the costs of network upgrade. This is generally only an option for large projects

[1] https://www.westernpower.co.uk/our-network/network-capacity-map-application

such as large-scale ground-mounted solar. For smaller projects it may be possible to obtain an Alternative Connection. This type of connection allows generators to connect generation to the network in exchange for the facility for WPD to constrain the connection when required. Depending on the exact terms of the agreement this may enable larger generation to be connected without incurring large grid upgrade costs.

Alternative connections may allow for reduced export at certain times, either on the basis of time of day and time of year (Timed Capacity), on the basis of the output or demand of another producer or user (Soft intertrip) or dynamically responding to real-time local grid conditions (Active Network Management). According to the WPD portal the substation is within the Feckenham Active Network Management Zone. This may be good news for connecting generation locally. A sample connection offer letter gives more details on this type of connection.[2]

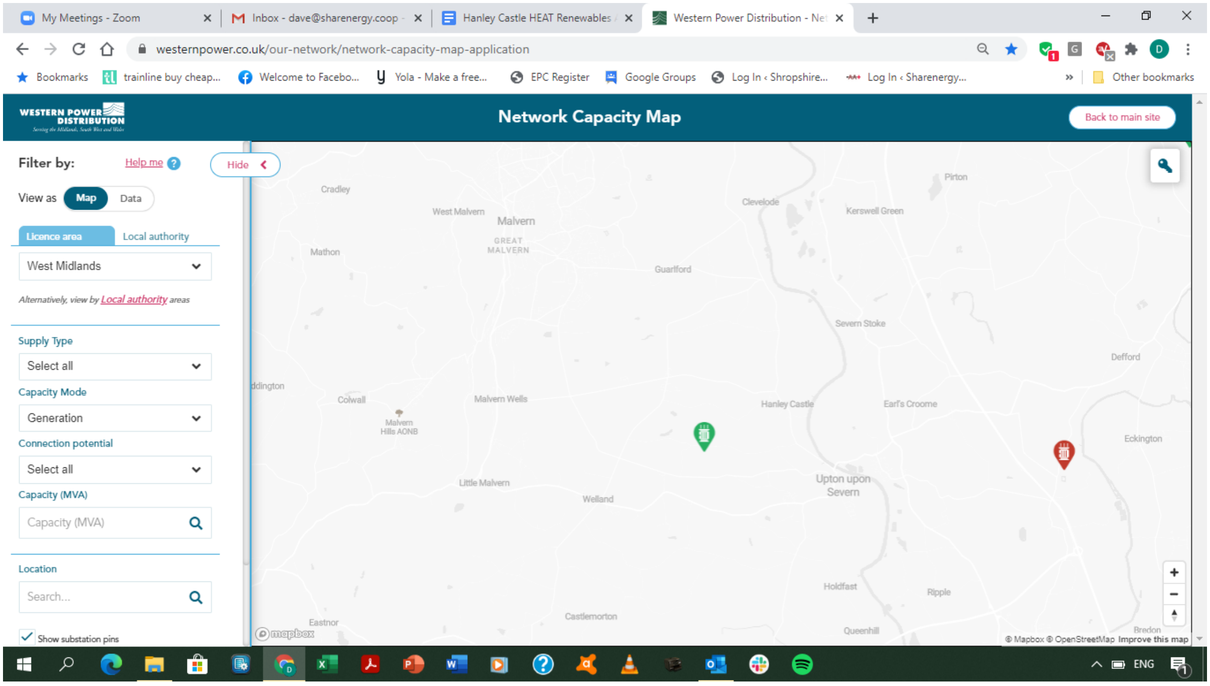


Figure 2.

[2] https://www.westernpower.co.uk/downloads-view/5917

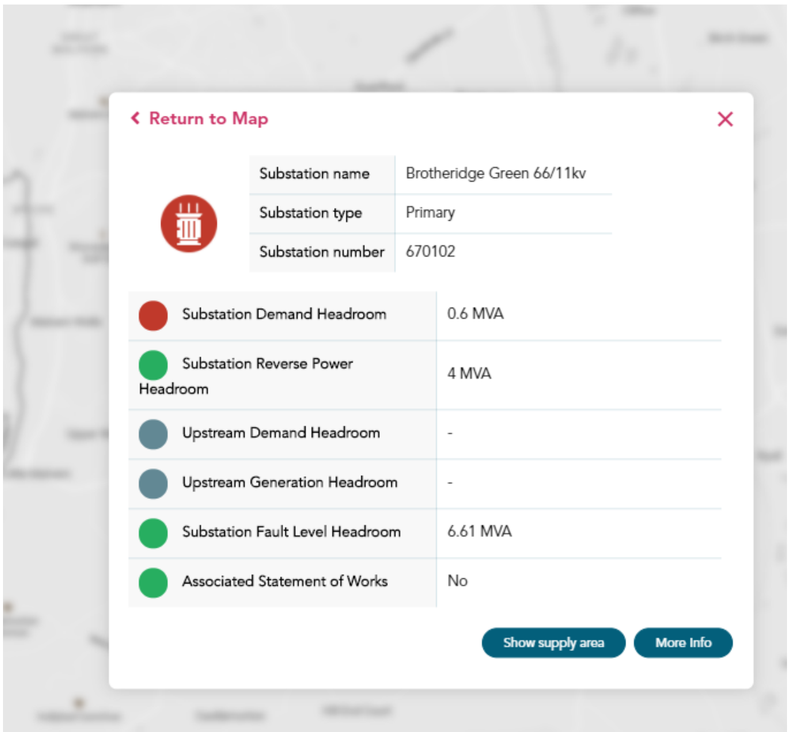


Figure 3.

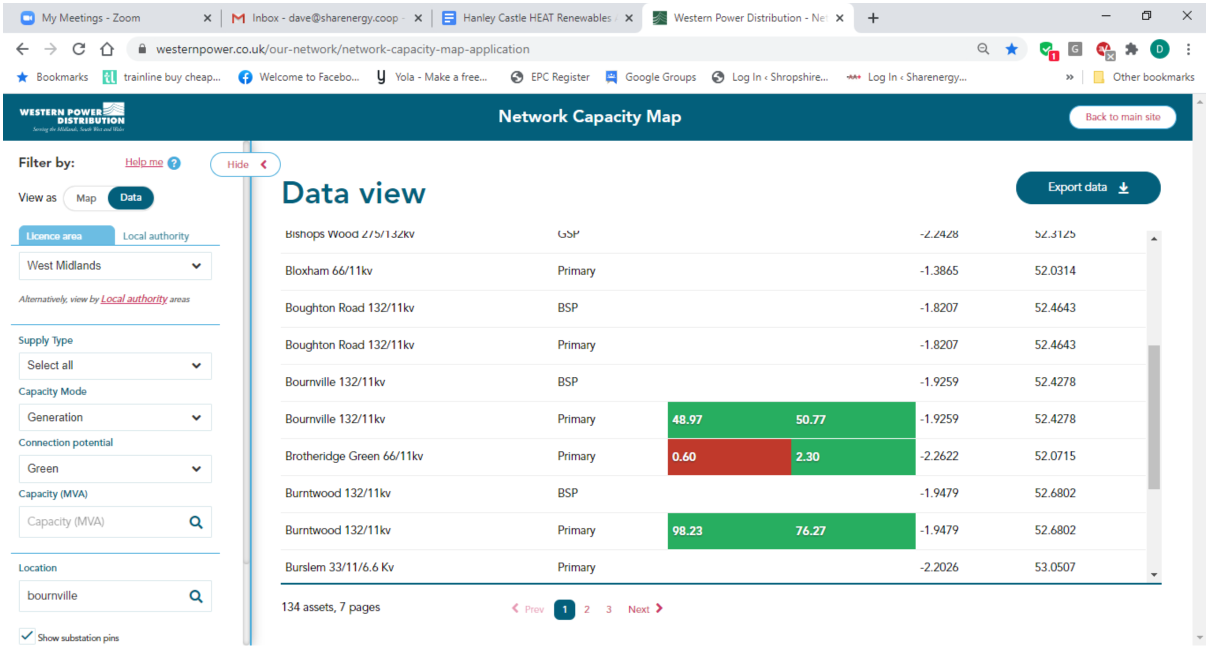


Figure 4.

The Brotheridge Green is not in an area earmarked for flexibility contracts (or demand-side response) at the moment, but further areas will be coming on stream in coming years.

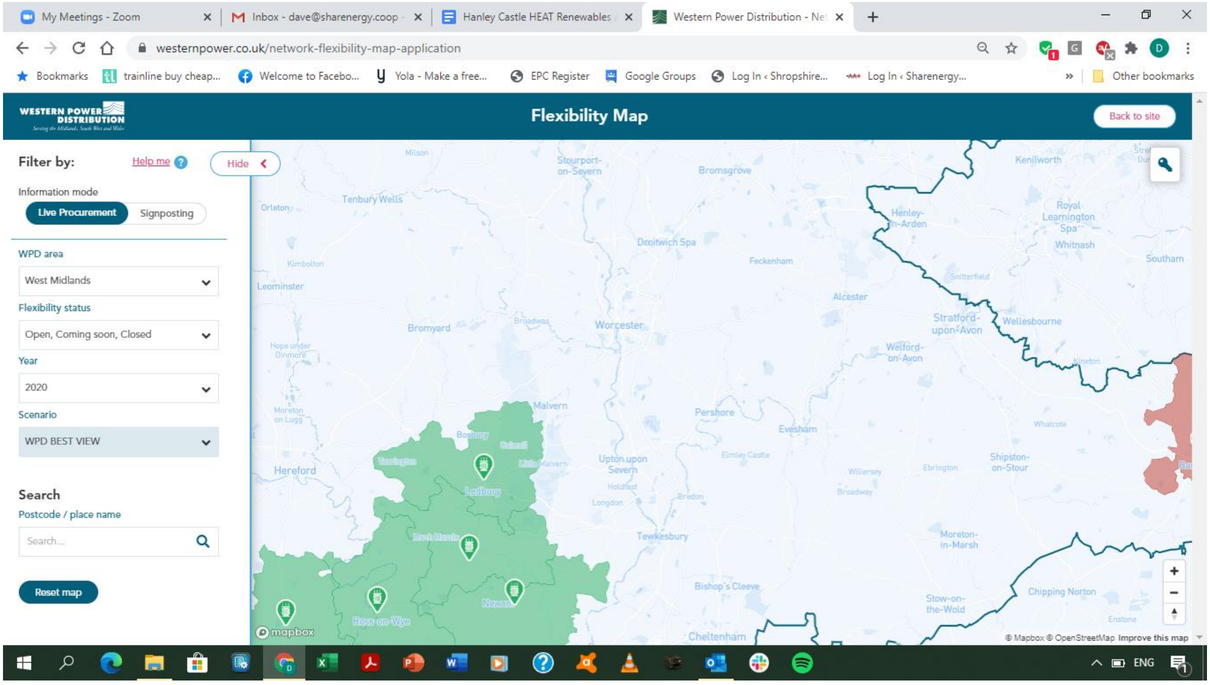
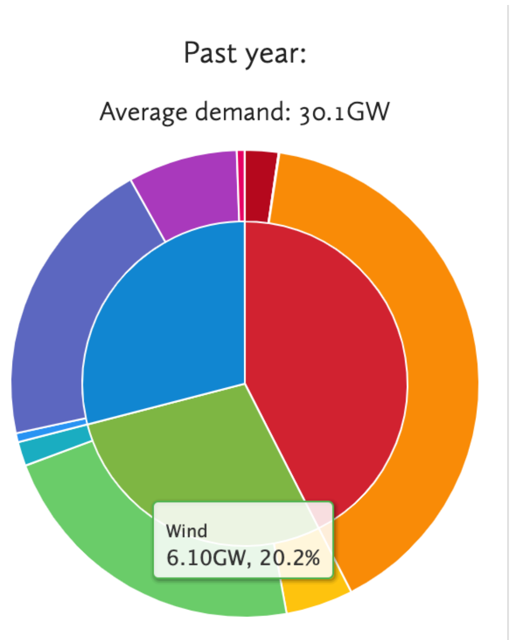


Figure 5.

However further investigation in December 2020 has revealed that the capacity map is misleading as there are constraints further upstream at Feckenham. There is awareness of the effects on generation capacity from limitations in the grid across the region and steps are being taken to reinforce the system and to change the way grid reinforcement is paid for. Any constraints should therefore not be a long-term issue, although frustrating in the short to medium term.

Wind

Wind energy currently provides over 20% of the UKs electricity generation:



The inner green segment is renewables, in the outer wheel PV is yellow, wind is green, hydro is light blue[3].

Wind turbines have several advantages over other sources of generation. They generate at times of high demand, over the winter months, and they have a very small footprint in terms of land use. At the same time large turbines are controversial for aesthetic and amenity reasons.

We can quantify the wind resource available in the parish using data originally calculated by the DTI. The NOABL dataset is a rough approximation based on modelling carried out by the Hadley Centre in 1996 which examined wind flow over topography. The resulting windspeeds for the parish are shown below:

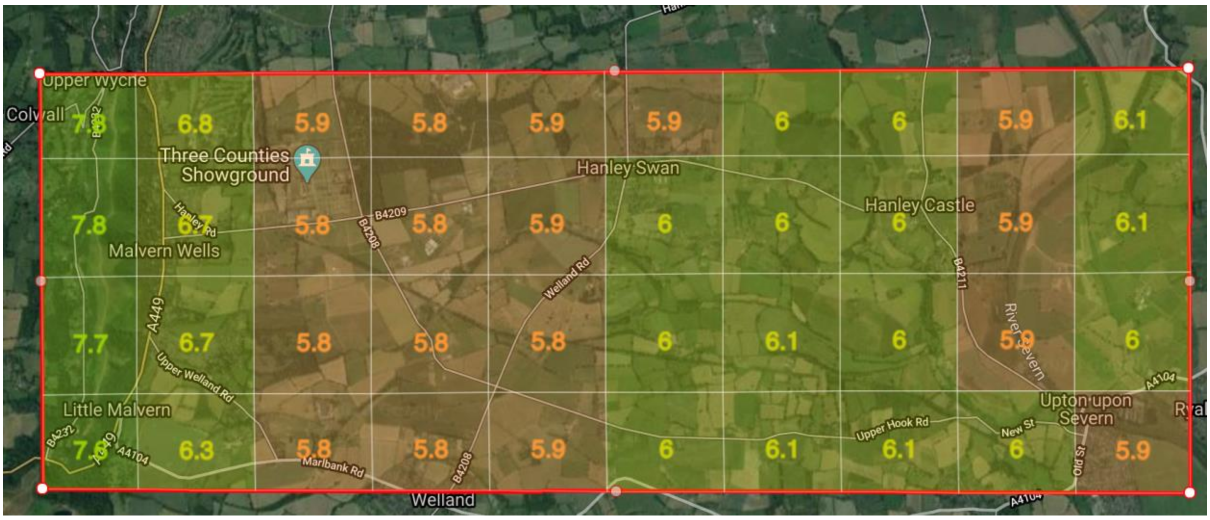


Figure 6.

[3] source: grid.iamkate.com © Kate Morley

As can be seen the modelled windspeed at 45m is around 6 m/s for most of the area. This can be compared on the map with the higher windspeeds seen on the Malvern Hills.

In practice, siting of wind turbines is carried out according to a mapping procedure which examines key site constraints. A non-exhaustive list includes:

- Maximise wind energy (high windspeed, low turbulence)
- Maximise proximity to grid connection
- Ensure access for construction (turbine parts are large)
- Minimise ecological impacts in construction and operation (particularly considering flight paths and nesting/feeding sites for birds and bats)
- Keep clear of telecommunications and television signals and airport radar sight-lines.
- Avoid underground and overground infrastructure such as gas pipes, microwave links etc
- Keep a safe distance from rights of way, train tracks, etc
- Minimise visual impact and the impact on heritage or archaeological sites
- Maintain a buffer from houses to minimise the risk of noise issues or shadow flicker from blades
- Avoid designated areas such as Areas of Outstanding Natural Beauty.

Under typical market conditions the windspeeds in the parish would be considered at the lower end of viability. While there are areas of higher windspeed nearby these are mostly not suitable for turbines. In general, turbines are not always sited where the windspeeds are the very highest - such sites also tend to be far from grid connections and may have access issues or be sited in areas with prohibitive designations, such as the Malvern Hills AONB.
The nearest operational wind turbine at scale is at Norton Fields Farm close to the new Worcestershire Parkway railway station - from the NOABL database the reported wind speed at that location is 6.3 m/s at 45m - comparable to speeds at Hanley Castle. The nearest community-owned windfarm is Westmill in Oxfordshire where the NOABL speed is reported as 6.1 m/s. The study area therefore has a theoretical wind resource which is not insignificant and could be utilised.

A full constraint mapping exercise was not carried out to identify potential sites. There may be potential sites for one or more turbines of up to 1MW class in the study area. As a rough approximation of the energy potential we modelled using a Vestas V60 turbine rated at 850kW, with a tower height of 50m and rotor radius of 30m, which would yield around 2.2 GWh/year if the windspeeds quoted above are correct. *(a GWh is 1,000MWhs)*

Financial and regulatory considerations

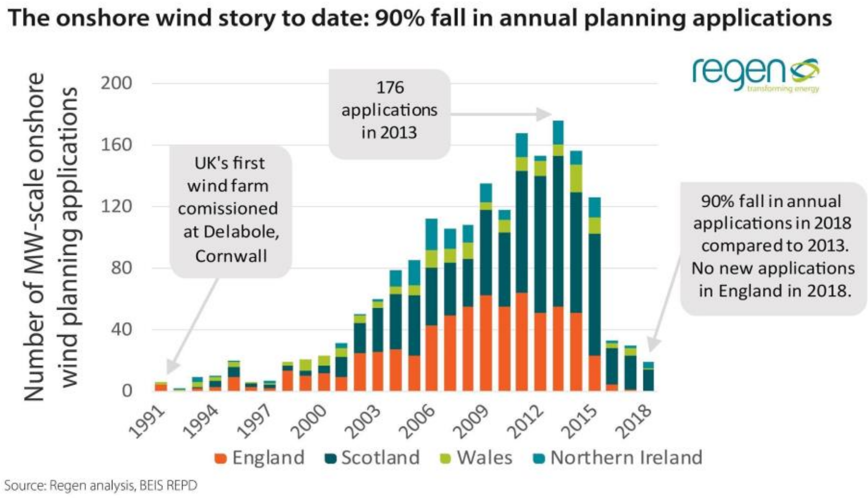
At the time of writing there is effectively a ban on wind turbine development at scale in England which has been in place for 5 years. In 2015 the Government announced that when determining planning applications for wind energy development local planning authorities should only grant planning permission if:

- the development site is in an area identified as suitable for wind energy development in a local or neighbourhood plan; and
- following consultation, it can be demonstrated that the planning impacts identified by affected local communities have been fully addressed and therefore the proposal has their backing[4].

[4] https://commonslibrary.parliament.uk/research-briefings/sn04370/

Firstly, there are very few local or neighbourhood plans which actually do identify suitable areas for wind energy development, which immediately makes it difficult for local authorities to grant planning permission for turbines in most locations. The guidance effectively gives any objector to a wind turbine a veto over the planning process. There are isolated cases of planning permission for wind turbines being given, despite not fulfilling the above criteria, for example Ambition Lawrence Weston in Avonmouth, but these are very rare.

The effect of this policy approach has been to bring all activity around onshore wind in England to a halt:



While this policy remains in place it is not considered worthwhile spending a lot of time developing new wind schemes. We note that the Hanley Castle Neighbourhood plan[5] adopted in 2019 does not identify suitable sites for wind development and indeed seeks to exclude wind from consideration:

> *"With the exception of wind turbines, proposals by the community or businesses for standalone renewable and other low carbon energy schemes will be supported if their impacts are (or can be made) acceptable."*

There is no reason in our view that a well-sited wind turbine might not have 'acceptable' impacts - the normal planning process allows for very detailed analysis of impacts from noise to aesthetics, ecology and a range of other criteria. In our view it would increase the options available to seek to remove this blanket exclusion in future Neighbourhood Plans.

The withdrawal of subsidy though FiT and RO for onshore wind is the other factor which has impacted on onshore wind development. The UK Government has announced that onshore wind projects may bid for Contracts for Difference (CfD) in future. CfD is not so much a subsidy scheme as a price guarantee scheme and will probably not in any case apply to any but the largest windfarms. Nevertheless, a scheme in the study area might be viable without subsidy, potentially using high-quality refurbished turbines sourced from mainland Europe to reduce capital costs.

[5] https://www.malvernhills.gov.uk/planning/planning-policy/neighbourhood-planning/hanley-castle

Scale

One possible response to the issue of scale is to consider smaller turbines - a turbine of up to 11m height can be installed without planning permission.

Such approaches are unfortunately unlikely to be worth pursuing. There are several factors which work against small turbines. Wind power increases with height - all other things being the same, wind power at 50m is twice that at 10m. Quality of wind can be an even greater issue - nearer the ground, turbulence becomes much greater than at height. Operational issues also become a significant factor - a wind turbine of any size needs regular maintenance and parts replacement. For smaller units the cost of callouts becomes prohibitive and parts availability is poor. Finally, the cost per kW of capacity is much higher than for larger turbines: a 1MW class turbine might cost £2m installed or £2/kW, whereas a 10kW class turbine might cost £40,000 installed or £4/kW.

So, a small turbine is roughly twice as expensive, produces less than half the power, and is very hard to keep running for the same period of time. Even the fact that a small-scale turbine might produce energy that could be used directly by a home or a business rather than go into the grid is not great enough to offset these disadvantages. Of course, small-scale wind turbines still have their place in off-grid applications.

Rooftop-mounted wind turbines were briefly popularised in the UK some years ago but have fallen out of favour for good reason. These suffer from all the disadvantages of smaller turbines which are compounded by even greater turbulence issues. A landmark study of this approach was carried out in the Warwick Wind Trials[6] which reported in 2008. This study showed very poor real-world performance of every turbine they tested despite the fact that several of the models installed were well-established and high-quality units, showing that the rooftop location was the problem.

It's worth noting that modern large-scale wind turbines achieve efficiencies approaching the limit in physics -the Betz limit of 59%[7]. Innovations in design are therefore incremental and no huge breakthroughs are likely or indeed possible given our current understanding of physics. Novel designs featured in the media offering substantial improvements in efficiency are unfortunately either wishful thinking or scams in our experience.

In December 2020 WPD confirmed that the generation constraints would apply to an application for a wind turbine. However a 66kV line may become available to Hereford in 2023, this would only be feasible for a larger wind turbine which would not currently be acceptable, but this option could be explored in the future.

Wind Recommendation

Wind turbines are theoretically viable in the study area, and Western Power Distribution have indicated that a sub 1MW turbine might be acceptable despite current grid constraints*, but they are very restricted by current planning policy. The HEAT group may wish to campaign for inclusion of wind power in local plans but at the current time there is no clear route to installing wind turbines locally.

**See email from Ben Godfrey, 22.12.2020 pg 36*

[6] https://warwickwindtrials.org.uk/

[7] https://www.linkedin.com/pulse/betz-everything-you-need-know-wind-turbines-written-1927-paul-gipe/

sharenergy

Hydropower

The river resource in the study area consists of three linked catchments - the Pool Brook, the Mere Brook and the Severn. The Mere Brook flows into the Pool Brook which in turn flows into the Severn. The catchments of the two brooks are shown below -the Pool Brook in green, the Mere brook in yellow, with the parish boundary shown as a red dotted line:

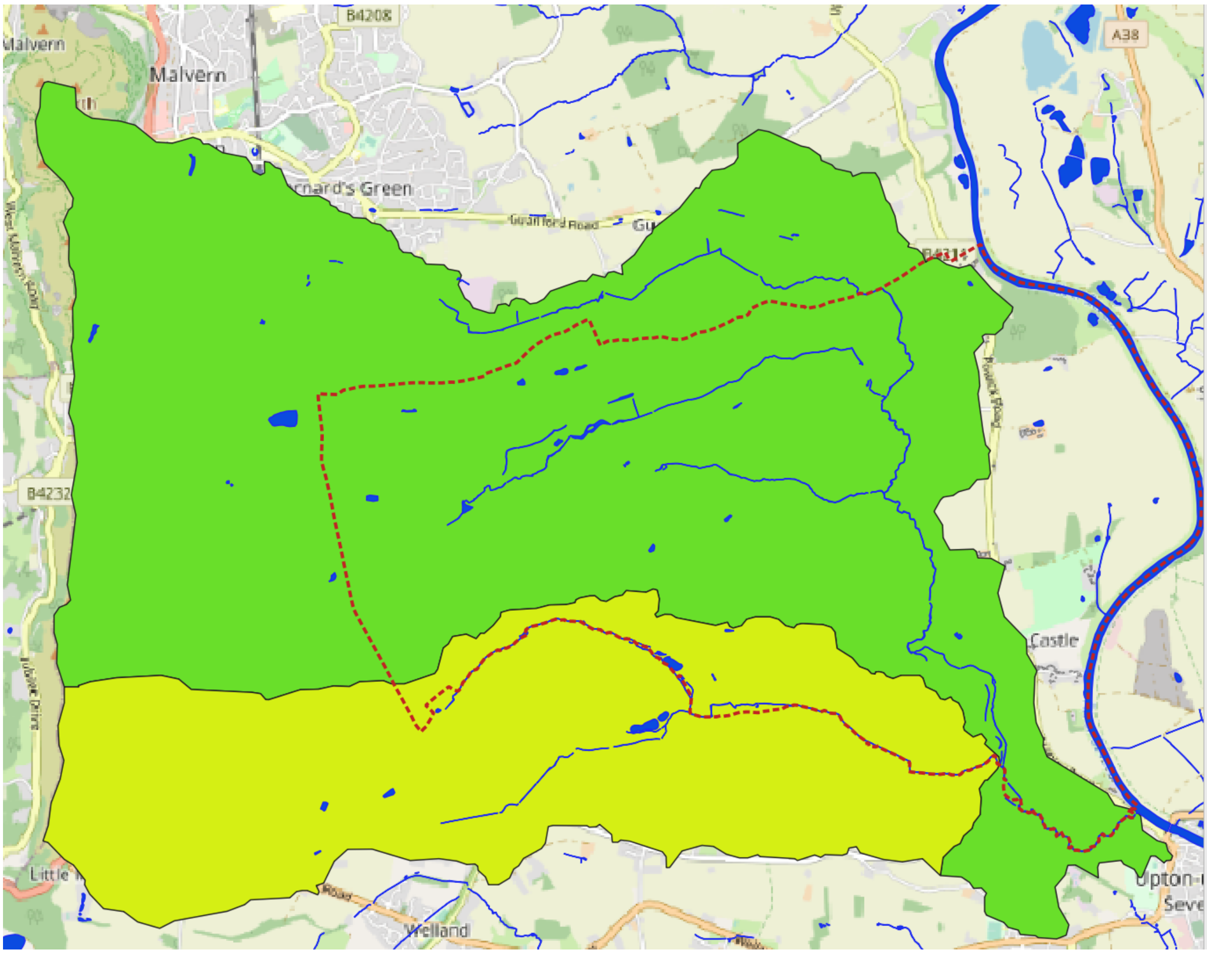


Figure 7.

8

In order to estimate practical hydropower potential, we need to consider two factors at any site: head and flow. Head is the change in water levels between the hydro intake and the hydro discharge point, measured in metres. Flow is measured in cubic meters/second.

In areas with very steep ground, hydro schemes normally operate by diverting water into a pipe and dropping it down the hillside to a turbine. This is not feasible on shallower gradients (where the cost of the pipe soon becomes prohibitive). Lower head schemes therefore tend to operate where there is an existing weir (as it is generally too expensive to build new weirs and these are unlikely to receive the necessary Environment Agency permissions). We have been unable to determine whether there are any existing weirs on either Pool or Mere Brooks. However, it is unlikely that there is a weir above 2m in height.

[8] data source: https://environment.data.gov.uk/

We can calculate approximate flow from the catchment data. In the best case, a hydro scheme could be situated downstream from the confluence of Mere and Pool brooks so as to maximise flow. The combined catchments measure 36 km^2 and mean flow in m^3/s is given by the equation[9]:

Mean flow = rainfall*catchment_area/seconds in year

Rainfall in the region is around 0.6 m/yr[10] giving a mean flow of around 0.7 m^3/s. In practice this will be reduced by evaporation and is not all available for hydro generation so we can use a figure of 0.5 m^3/s.

The standard calculation for hydro power is

power = head * flow * efficiency * g (gravitational constant).

with head of 2m, flow of 0.5 m^3/s, efficiency of 70% and g being approximately 10, the power generated would be 7kW.

That corresponds to an annual energy production of approximately 30 MWh/yr. This would be a very small hydropower plant. Under current conditions with no subsidy available, pretty well all UK hydropower schemes are not financially viable and development of lowland hydro has come to a complete standstill. It is hard to imagine any circumstances under which a scheme this small would be viable.

We do know that Hanley Castle did at one point have a functional watermill at Castle Mill[11] with a waterwheel, and a painting of the Mill Pool by Edward Archer is in the collection of
Malvern Library.

[12] 

Figure 8.

[9] see useful resource here: http://www.engineering.lancs.ac.uk/lureg/nwhrm/resource/map_flow1.php

[10] https://en.climate-data.org/europe/united-kingdom/england/hanley-swan-176547/

[11] https://britishlistedbuildings.co.uk/101098802-castle-mill-hanley-castle

[12] https://artuk.org/discover/artworks/the-old-mill-pool-hanley-castle-worcestershire-53792

The existence of a mill pond normally suggests that the mill did not have enough flow to operate without one.

By far the largest watercourse in the study area is the Severn, which adjoins the parish. We do know that there are no weirs on the Severn in this area or any likelihood of being able to build one. In this case the only feasible way to generate energy from the river is to use kinetic energy alone (so-called zero-head hydro). Such devices vary in design and output although the fundamental physics means they have low output for their size.

The formula for power generation from flow machines is:

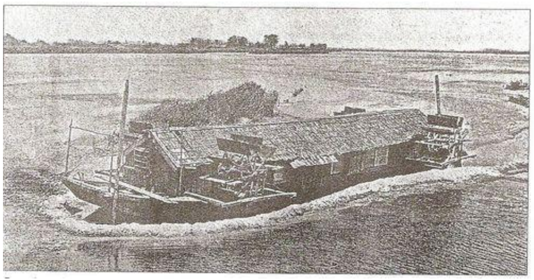
Power = (1/2)(Turbine Efficiency) (Water Density) (Turbine Flow Area) (Water Velocity)^3

Mean flow in the Severn at this point is 95 m^3/s[13] and its cross-sectional area is around $50m^2$ giving a water velocity of around 2 m/s. So, to get 10kW power, a turbine flow area of around $8m^2$ is needed. Such a large device brings problems of capital cost, installation, servicing and screening to avoid damage to fish and other elements of the river ecology. These problems are not limited to this site and for these reasons we are not aware of any operational zero-head hydro schemes in the UK.

The project team drew two devices to our attention. The Turbulent design[14] solution would only operate on a site with a weir. We note that it does not appear to offer any great advantages, having similar head and flow requirements to an Archimedes Screw which are well-known, robust, cost-effective, and approved by the Environment Agency as having low impact on fish.

The other device mentioned was the Waterrotor[15]. This is a zero-head hydro turbine which sits on the river bed. Technically this could be deployed in the Severn, but we note that it is a prototype device. There is no guarantee that it would be possible to obtain EA licencing for a novel device and there would be significant operational risks - we note that despite the manufacturers claims that the device is designed for 20 years of operation they are only prepared to offer a 1-year warranty. In our view this is not an avenue worth pursuing for a limited benefit - even if the rotor were to work constantly, it would only deliver 87 MWh/yr (assuming a 10kW output is possible).

It is worth noting that novel devices are frequently proposed for zero-head energy generation. We are not sure that any significantly outperform medieval solutions such as the ship mill.[16]



Hydro at Severn End

[13] https://nrfa.ceh.ac.uk/data/station/meanflow/54043
[14] www.turbulent.be
[15] https://waterotor.com/our-solution/
[16] https://www.lowtechmagazine.com/2010/11/boat-mills-bridge-mills-and-hanging-mills.html

We have investigated the possibility of a hydro scheme using the open drain that runs through property owned by Severn End. The drain runs for around 2km from near the wood just below Malvern View and ending just southeast of Severn End.

There is no appreciable drop on the River Severn from the top of the loop by the Rhydd to the bottom of the loop by Severn End, so it's not possible to get a natural run of water down the drain, therefore a continuous flow is not possible, leaving a hydro that runs from floodwater and heavy rains, or a hydro used as a storage facility.

We estimate the average width of the drain at the top to be around 1.5m. The drain is 3m deep at the southern end, about 1m deep at the north. If we allow 1m for the water we can use* and 2m for the drop, which gives 3,000m^3 *(or 3M kg)* of water available on a 2m drop.

**We cannot use all the water as we have to allow for the drop at the southern end. However, because the drain narrows significantly in the lower half and is only 1m deep at the north end, this is a significant proportion of all the water held in the drain.*

Looking at the potential energy of that water, allowing for an average drop of 2.5m, this gives a figure of 3M x 9.8 x 2.5 = 73M Joules. This is equivalent to roughly 20kWh. There will however be losses in the turbine, allowing for 80% efficiency that is 16kWh delivered,

At 15p/kWh, emptying the drain once would deliver electricity worth around £2.40.

We have also run the figures through a hydro calculator, which produced very similar results.

This clearly does not work as a system filled by flood water and seasonal heavy rain.

We have also considered whether it could work as a storage device. For this to work, Severn End would need to be on a variable time of day tariff (such as Octopus Agile) and use a significant amount of electricity during the peak charging times of 4pm to 7pm (and this peak use should not be easily shifted to other times of day).

If these conditions are met, then the drain could be filled during times of the day when electricity costs under 5p/kWh, let's assume an average price of 2.5p/kWh. If the drain was emptied at peak times when the agile tariff averages 22.5p and allowing for 80% efficiency in the system, then there is a saving of £3.10 per fill and discharge. If this was done every day for 11 months of the year (allowing one month for flooding or river levels too low to extract) that would produce a saving of £1,000/annum. However, it is highly unlikely that all this electricity would be used in the house and the system would be run every day, therefore actual savings are more likely to be around £700/a.

This system would only be storing slightly more electricity potential than a Tesla Powerwall 13kW battery.

The output of the hydro would not be constant unless the flow could be adjusted. There would be significantly more power when the gate is first opened and then it would gradually slow. Therefore, rather than a 5.5kW turbine, something like a 10kW turbine would be needed, with maximum power only used for around 30 minutes/day.

It might also be possible to include this system into a flexible trading contract with the Distribution Network Operator but we consider that the sums raised would be of a similar order or less. WPD have been offering £50/annum to domestic customers with a battery of a similar size to this hydro scheme to participate in their flexibility market.

We have not costed the hydro equipment needed but even a 10kW hydro is a considerable undertaking. We therefore do not consider this project is worth further investigation.

One alternative project would be to look at replacing the current diesel pumps used to irrigate this land, with pumps driven by small wind turbines or solar panels. We understand that the Severn End estate however do not farm this land directly.

Another alternative would be to fit photovoltaic panels at Severn End itself. There is some land just south of the walled garden that would be suitable for this. The wall would screen the panels from the house and garden and a hedge could be provided to screen them from the drive. PV panels now require a good proportion of the energy generated to be used directly for the finances to work, but Severn End is a very large property and hence is likely to fulfill this requirement, especially if any electric vehicles are purchased.

Hydropower Recommendation

We do not recommend any further work is done on investigating possibilities for hydro power in the area.

Solar Photovoltaics (PV) and Battery Storage

Overall solar resource

The underlying solar resource is known as insolation - the amount of energy available from the sun in the parish, given as kWh/m2/year. This is mainly a function of latitude and weather. Hanley Castle is in the sunniest third of the UK:

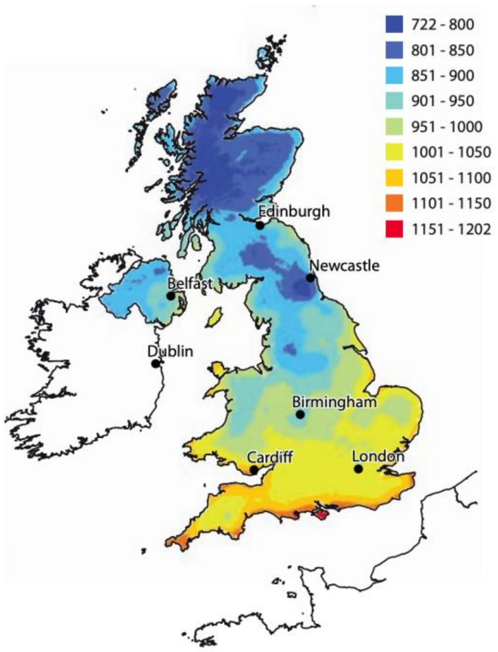


Figure 1 UK Solar irradiation map. Yearly total of global irradiation in kWh/m². Averaging period: 1997-2003. Map data courtesy of the Met Office ©

Figure 9.

Using the PVGIS[17] database we can estimate annual production as 1,020 kWh/m2/yr on a horizontal surface and 1,205 kWh/m2/yr on a surface which is optimally angled towards the sun – in this location that would be at a slope of 39 degrees and a heading of -2 degrees (due South). The amount of insolation varies throughout the year:
This gives us a rough metric of the total energy received by the parish. The Parish area is 17.92 square kilometres so the horizontal energy received from the sun is around 18,000 GWh/year - to put that in context, it's a huge amount of energy roughly equivalent to half of the electricity use of the West Midlands[18]. Of course, only a small fraction of this energy can practically be harvested by solar panels.

Rooftop solar

Solar photovoltaic panels are often best sited close to electricity users. Rooftop arrays use existing structures and with some exceptions tend not to compete with other uses of the space. We have carried out a broad-brush study looking at total insolation on rooftops in the parish.

Our analysis shows insolation figures per square metre on rooftops in the parish. A sample of the output is shown here.

17 https://ec.europa.eu/jrc/en/PVGIS

18 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/527628/Sub-national_electricity_and_gas_consumption_summary_report_2014.pdf

Figure 10.

In this image, areas of highest insolation are shown in red and orange, lower insolation is shown in blue. The analysis takes into account the aspect (compass direction facing) and slope of each rooftop together with the impact of shading from nearby buildings. On each individual building this can provide a rough idea of where best to site panels (subject to more detailed design for chosen buildings). We can analyse this further to give an estimate of the total energy theoretically available from rooftop solar in the parish of around 6 GWh/yr.

Key assumptions in arriving at this figure:

Lowest output areas discarded (in practice this mostly removes north or partially north-facing roof slopes)
Clear Skies Factor of 65% (accounting for cloud cover)
Solar panel efficiency: 15% (how good panels are at turning light into electricity)
Solar panel system losses: 14% (power losses in the system from panel to grid)
Panel cover factor: 75% (accounting for panel setback from roof edges, angles etc)

The figure is a realistic maximum for the output using current solar technology. Some rooftops will be unsuitable due to roof strength, planning issues or other constraints so the realisable value will be somewhat lower. Nevertheless, this is a significant resource.

Financial viability

The removal of all subsidy for renewable energy generation has hit solar viability hard. As a rule of thumb, rooftop solar needs to be sited either on top of, or near to, a user of power which will take at least half the generated energy.

Sample figures are given here for a 50kW array:

Installed cost	£33,000	assuming easy install
Annual production	47.5 MWh	
Income - electricity exported	£1,188	
Income - electricity used on site	£2,138	
Total income	**£3,326**	
Operations cost	-£1,273	maintenance, insurance etc
Depreciation	-£1,320	25 years
Operating surplus yr1	**£733**	

This yields a reasonable rate of return (IRR) of around 4%.

For rooftop solar recommendations see split into domestic and commercial below.

Ground-mounted solar

The approach taken to identify rooftop solar potential will not work as well for solar panels sited elsewhere. While the majority of roofs are potentially suitable sites, most land will not prove suitable for solar panel installation because of competing uses. Some land uses are obviously not compatible with solar - in the case of roads or private gardens for example. Others may or may not be suitable. For example, a car park could be covered with a solar roof; whether that is acceptable or not will be highly site-specific.

In practice, most standalone solar is sited on land that was previously used for agriculture. That can also be contentious, as the production of energy is often seen as less important than the production of food. This debate cannot be boiled down to a set of easy answers and reflects a wider debate about land use in the UK. Land covered in solar panels may still be suitable for grazing of livestock, or for the planting of meadows which increase biodiversity.

A common assumption is that it is better to use lower grade agricultural land for solar parks. Most of the parish (red dotted line below) is designated Grade 3 agricultural land, with a smaller parcel of Grade 2 around Hanley Castle centre (light blue area below)

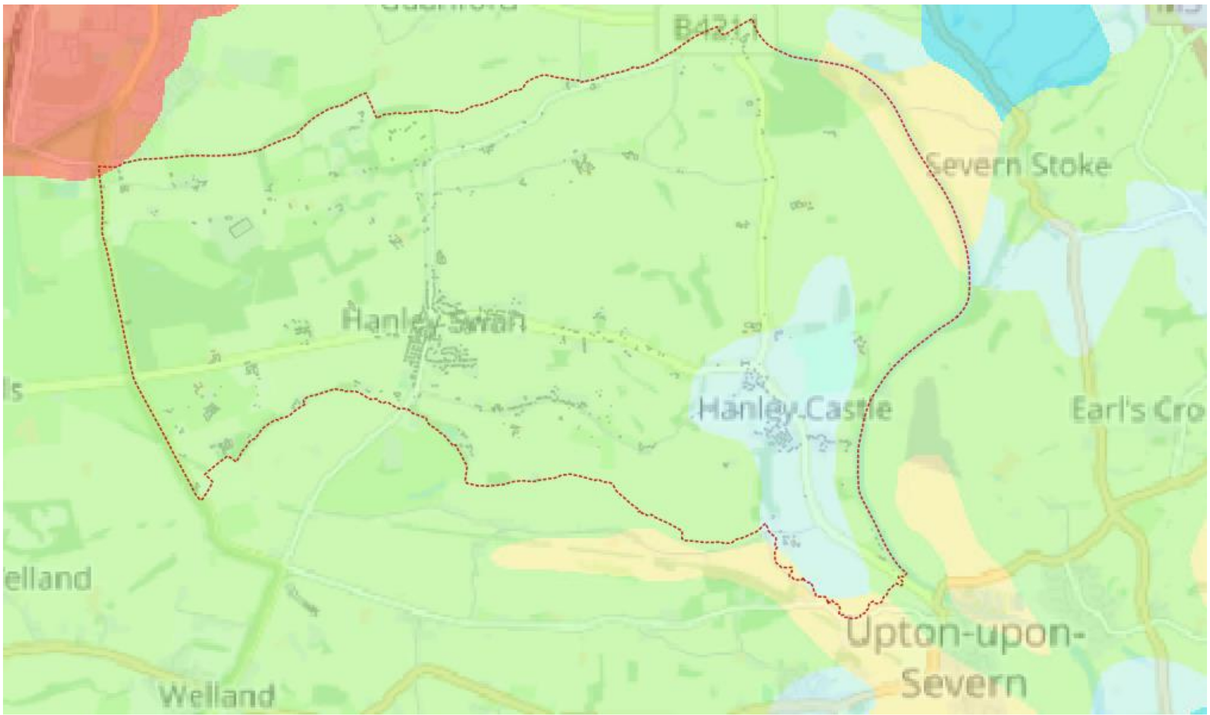


Figure 11

As an estimate, perhaps a quarter of the area of the parish could conceivably be used for a solar park. This corresponds to a theoretical energy output of around 225 GWh/yr.

Development of field-scale solar energy is likely to be technically constrained, less by availability of suitable land than by grid capacity. There are likely to be suitable sites for an array of 4MW, but further investigations with WPD have revealed that even this size of array would not be currently acceptable to them.

Financial viability

Sample figures are given for a 4MW array:

Installed cost	£2,000,000	assuming grid connection and other costs not excessive
Annual production	3,821 MWh	
Income	**£168,000**	All exported to grid
Operations cost	-£50,000	maintenance, insurance, admin, rent etc
Depreciation	-£67,000	30 years
Operating surplus yr 1	**£51,000**	

Modelling shows a 5.86% project return (IRR). This is below the hurdle rate for most commercial projects but may be realistic for a community-based project (which may, for example, be able to raise community share and bond capital at lower rates).

A 4MW solar array will take up approximately 4 hectares of land (ie an area of 400 x 100m). This is the largest project that is likely to be able to get a grid connection locally, and at the same time around the smallest viable grid-connected project. A smaller solar field would still have similar grid connection costs and administration and management overheads, and is therefore unlikely to be viable unless it can be connected to a sufficiently large energy user to use a large proportion of its generated power. To our knowledge there is no such user in the parish apart from ESP.

Standalone Solar Recommendation

In September 2020 we recommended that more study is conducted into specific sites in the parish to establish viability of a solar field sized to maximum grid export capacity, and to examine possible routes to delivery. This work uncovered three potential sites but work on these was halted when WPD confirmed the grid constraint.

Domestic Rooftop PV

Without the Feed in Tariff or similar subsidy, domestic PV installations are only financially viable if there is a large direct use of the electricity generated. With increased electrification of heating and transport however, this will become more common.

A domestic PV system would cost in the region of £900/kWp, so a 3kW system (9 panels at 330W ea) would cost £2.7k. This system would generate around 2,700kWh/a. If 50% of these units are used directly at a saving of 15p/kWh and half are exported at an export price of 5p the average saving would be 10p/kWh or £270/a. It would therefore take 10 years for a simple payback on the system. However, it is unusual for a domestic property to use 50% of their electricity generated by PV, unless they have particular high daytime usage, such as EV charging

Domestic Rooftop PV Recommendation

We do not recommend any further work is carried out on Domestic PV in this project. However, HEAT could play an important role in promotion of PV to those who are likely to use enough daytime electricity, spreading good local examples and arranging bulk discounts.

Domestic Batteries

Domestic batteries are currently expensive and with current electricity prices have a long payback period. If a battery holds 12kWh of electricity worth 15p/kWh that is £1.80 for a full load and discharge, even if the electricity used to fill the battery is free. If this is done every day of the year that would be worth £657 but this is highly unlikely. Savings are likely to be under £500/annum on a system costing at least £6,000. As battery prices fall and electricity prices rise or move to variable time if day tariffs then batteries will become a viable option, but not just yet.

There is a scheme operating in London using a network of domestic batteries as a virtual power plant. This however probably benefited from capital grants towards the battery install costs. Spirit Energy provide an analysis of Powervault batteries and Gridflex on their website: https://www.spiritenergy.co.uk/powervault. Their conclusion is that the risks outweigh the benefits.

Domestic Batteries Recommendation

We do not consider this option to be worthy of further investigation at this stage. However, it could be viable in future years as the economics of battery storage change.

Non Domestic Rooftop PV

Non domestic buildings are generally more suited for applying PV panels because the direct use is likely to be higher than for dwellings. This particularly applies to offices with air conditioning as they have high summer electricity loads. Factories, Care Homes and Schools can also provide viable rooftop space for PV.

We have looked at a number of possible sites in the Parish and consider that the best possibilities are:

1. Willow End Business Park
2. Merebrook Business Park
3. Hanley Workshops
4. Options College, Malvern View
5. Albion Lodge Care Home
6. Hanley Castle High School

The High School already has 30kW of PV but this only provides 7% of their overall electricity consumption, not including the new buildings recently added.

We have looked at the Willow End Business Park as an indicator of how this could work elsewhere.

We have used Open Solar software to create an initial design for the site which indicates a potential for around 110kW of PV at Willow End over seven panel groups, giving a combined output of 98,300kWh/annum. This is not using the most efficient panels, therefore if a scheme was thought to be viable, this figure could easily be increased (although at additional cost)

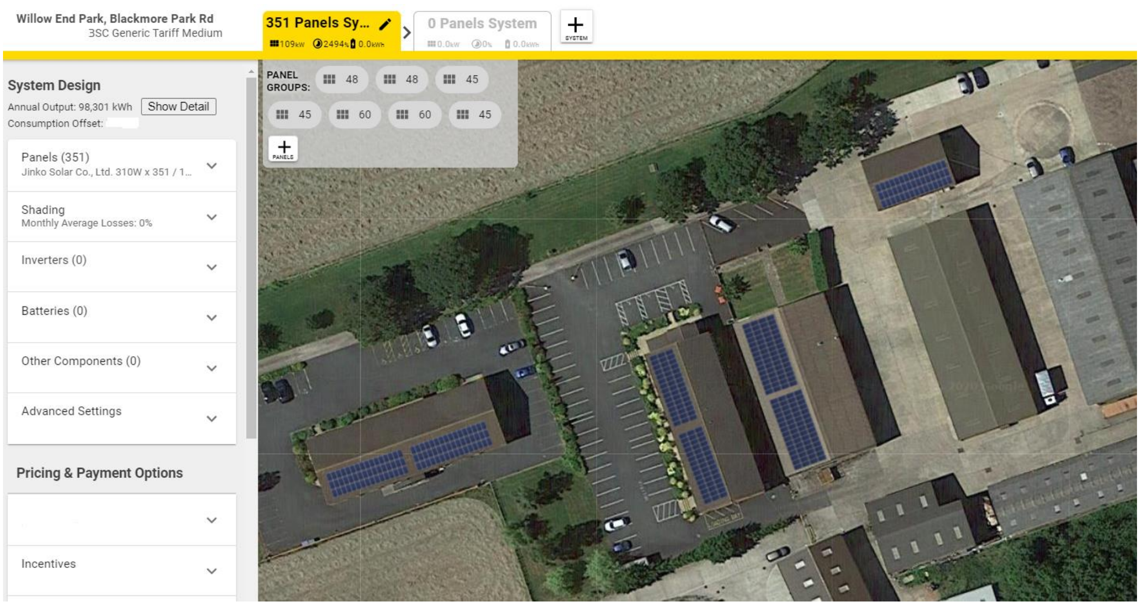


Figure 11.

However, as we understand the buildings at Willow End are all rented, the owners are unlikely to be interested in investing in PV as they do not occupy the buildings, and the tenants are unlikely to be interested in installing PV as they do not own the buildings. The tenants could use the BEEP or LOCOP grants to provide 40% of the finance, but would still have to find the remaining 60%.

An alternative is that a third party installs the panels and sells the electricity to the tenants. This would reduce the annual income as the tenants would want to see some savings. If we allow a 20% discount on the electricity price, the payback period extends to around 8 years. Adding on the cost of capital and administration costs, this would result in a payback of around 12 years. Very few commercial operators will be interested at that payback period but it could suit a Community Energy scheme which has a longer perspective.

One issue however, is that there is no guarantee that any of these buildings will remain occupied for the 12 years needed to pay back the investment. If one or two of the buildings are unused for short periods, that would not have a drastic effect on the returns seen, with maybe a year or two added to the payback period. However, if any of them were to remain empty for long periods that could have a bigger effect. The risk is already shared on this site as we have seven different occupiers. The risk could be further shared by extending the scheme to cover other local sites, or it could be shared further by integrating with a larger co-op such as the Big Solar. See www.bigsolar.coop

For the scheme to work, any developer would need to enter into arrangements with the tenants and owners of the properties and would need to assess whether each individual business would use enough of the electricity directly to make a scheme viable. An assessment of the risk to each installation from future changes would also be needed.

Non-Domestic Rooftop Solar Recommendation

In September 2020 Sharenergy recommended this option to be worthy of further consideration and for it to be pursued in the next phase of this project.

Whilst some interest was found no definite sites were identified. This work is to be carried on in 2021 by HEAT in partnership with the Big Solar Co-op.

Heat

Heat Introduction

Hanley Castle has a high proportion of dwellings using oil or LPG gas as a fuel source- at least 66%, and probably more. In order for the Parish to become zero carbon, alternative heating systems need to be found for these properties. the area is considered unsuitable for a larger heat network due to the scattered nature of development.

Individual ground source heat pumps or biomass boilers are probably the best solution for larger properties. Air source heat pumps could be viable in smaller newer properties, but many of the properties are smaller older buildings where an air source heat pump would struggle in very cold weather, unless radical insulation works were undertaken. However, the heat demand is not sufficient to justify an individual ground source heat pump or biomass boiler. An alternative for these properties is to use a shared loop ground source heat pump system. These shared loop systems have been pioneered in the UK by Kensa, see https://www.kensaheatpumps.com/district-heating.

Individual dwellings are eligible for the Domestic Renewable Heat Incentive (RHI) which runs until the end of March 2022. Commercial properties and any system feeding more than one dwelling come under the Non-Domestic RHI, which ends at end of March 2021. It is possible to apply to register a larger non domestic system (over 100kWt) by end of March 2021 and have another year to commission it, but planning permission needs to be in place along with evidence of funds available to complete the install.

Individual Domestic Heat Pumps or Biomass Boilers

Heat pumps work by tapping heat from an external heat source by use of a compression cycle, in the same way that fridges extract heat from their interior. Ground source pumps are more efficient in colder weather than air source, as the ground temperature is less variable than the air temperature. The ground source can be either through slinky pipes laid under a lawn or by boreholes. Care should be taken that the loop area is sufficient to provide the heat that is needed, otherwise the ground can freeze.

Heat pumps are measured by a Coefficient of Performance (COP). A COP of 3 means that 3 kWh of heat is produced for every kWh of electricity put into the system. An average COP of around 3 would be expected for an air source pump, nearer 4 for ground source. If electricity costs 16p/kWh, a COP of 4 means the heat is costing 4p/kWh which is cheaper than mains gas.

Heat pumps work well with a better insulated building, with underfloor heating or larger radiators (as they distribute lower temperature water than a standard boiler does), with a wood stove to top up the heat in the coldest weather and with Photovoltaic panels which can produce some of the electricity to run the pump in spring and autumn.

Domestic RHI payments are made every quarter for seven years with the payments linked to inflation, provided the house is lived in for at least 6 months of the year. If the heat pump is the only main heating system, payments are made on the deemed heat load of the property, with a maximum of 30,000kWh/a for ground source or 20,000kWh for air source. An Energy Performance Certificate that's under two years old is needed, and it should not include any recommendations for loft insulation or cavity fill, unless a registered surveyor can provide evidence that the cavity should not be filled.

The payments are based on the COP of the system. A COP of 4 means that 25% of the heat is in effect coming from grid electricity, and payments are paid on the renewable 75%. So, at 30,000kWh x 0.75 times the current rate for ground source pumps of 21.16p/kWh gives annual payments of up to £4,760. Additionally, fuel savings on 39,000kWh usage would be in the region of £500/a, depending on current fuel. Over seven years this could potentially pay back all of the installation cost. The fuel savings will increase with inflation and carry on for the life of the pump.

An air source heat pump would give a lower eligible heat demand figure of around 12,000kWh and 10.85p/kWh, or roughly £1,300/a and lower fuel savings, but are much cheaper to install. Air source heat pumps must feed a radiator system to be eligible for the RHI.

Electricity is rapidly becoming a low carbon fuel as the UK grid decarbonises, and a heat pump is a good way of further reducing carbon impact by extracting much of the energy needed from the surrounding environment.

For larger less well-insulated properties, a biomass boiler might be preferred. These can be either pellet, chip or log fired. Pellet is the most convenient but the fuel is more expensive. Chips are only really applicable to very large houses or district heating schemes. Logs are cheaper, especially if the owner has their own woodland, but require manual labour to fill the boiler, although this is done on a daily or every other day, not continuously like a wood stove.

Biomass boilers also benefit from RHI payments. The current rates are 6.97p/kWh. There is no reduction in the heat demand figure for efficiency as there is for heat pumps; there is a 25,000kWh heat demand maximum. This gives a total maximum from the RHI of £1,740/annum.

All systems must be installed by MCS accredited companies to be eligible for the RHI. The domestic RHI does not apply to new build properties unless they are individual custom built.

For more information on the RHI see the website:

https://www.ofgem.gov.uk/environmental-programmes/domestic-rhi

It is expected that the domestic RHI will be replaced with an upfront grant but this is likely to provide considerably less overall than the current arrangement. Upfront payments are also currently available of up to £5k through the Green Homes voucher scheme, although this has to be spent by the end of March 2021 and if accepted it would affect RHI payments.

Individual Domestic Heat Pumps or Biomass Boilers Recommendation

A Community Energy scheme is not seen as a viable option for individual heat pumps or biomass boilers. HEAT could however play a useful role in;

A. Publicising the availability of the RHI

B. Encouraging residents with existing systems to engage with those interested

C. Arranging bulk ordering to reduce costs

Individual Commercial Heat Pumps or Biomass Boilers

Owners of commercial property can claim the Non-Domestic RHI for fitting heat pumps or biomass boilers. Payments would be based on metered heat used on a two-tier basis, over 20 years and they are linked with inflation. Air source heat pumps would have to feed a radiator system in order to qualify. This is a reasonably generous system but it still requires the owner to raise all the installation cost up-front, and schemes under 100kWt need to be completed by the end of March 2021 as detailed in the heat introduction. This timescale is very tight.

An alternative to the NDRHI is to use upfront grants, but it is one or the other; no scheme is eligible for both.

There are two grant schemes available to SME (Small to Medium Enterprise) businesses in Worcestershire currently, BEEP (Business Energy Efficiency Programme) and LOCOP (Low Carbon Opportunities programme). These also apply to tenants, providing they have at least a 5-year lease and permission from the landlord.

BEEP offers free advice and grants of up to £20,000 (up to 40% of the cost of a project) to local SMEs with an energy spend of at least £2,000/a. This money could be spent on LED lights, new heating or insulation, heat recovery, variable speed drives, renewables and energy storage plus waste and water reduction, and recycling projects. BEEP runs till March 2022.

See the website: https://www.business-central.co.uk/beep/

LOCOP is similar but only covers low carbon energy generation. LOCOP offers 40% up to £100,000 for capital projects and £50,000 for revenue projects. The scheme currently runs to the end of August 2022.

See the website: https://www.business-central.co.uk/locop/

Worcestershire Council are also launching a Public Sector Energy Efficiency Programme (PEEP) on October 1st. Free energy advice will be available plus capital grants of up to £200k to cover 40% of total cost, though other match funding might be available. PEEP applies to any building that gets more than 50% of its funding from Central or Local Government, including the NHS, Fire, police & ambulance, council buildings, grant-maintained schools and village halls. Unfortunately, academies are not eligible so it does not apply for the High school or Primary school. The obvious building in Hanley parish is the village hall but the finances of this will need to be checked.

Non-Domestic Heat Pumps & Biomass Boilers Recommendation

Whilst the grant programmes are not accessible for Community Energy Schemes, we consider that HEAT could play a valuable role in promoting these schemes to local businesses and organisations and in spreading good practice and experience.

Domestic Shared Loop Ground Source Heat Pumps Existing Properties

In the Kensa system, a shared ground loop system supplies refrigerant to a shoebox heat pump in each dwelling. By sharing the ground loop and by fitting out multiple properties at the same time, significant cost savings can be made over individual installations for each property. In addition, by installing a shared heating system, the heat pumps become eligible for the Non-Domestic Renewable Heat Incentive (NDRHI), rather than the Domestic version. The Non-Domestic RHI pays out less per kWh of heat provided but pays it out over 20 years instead of 7, thus making it attractive for a Community Energy model. The NDRHI payments are based on the deemed heat demand of each property, as found on the Energy Performance Certificate (EPC) and are index linked so there is a reasonably high degree of confidence in the income stream.

The NDRHI is also applicable to all new build properties, whereas the Domestic RHI only applies to new properties that are self-built.

The NDRHI is due to end at the of March 2021, and registration for an extension is difficult, as previously noted. It is therefore highly unlikely any shared loop scheme in existing properties in the Hanleys could be installed using the NDRHI.

It is quite likely that further support for shared loop schemes will be forthcoming, but we have no way of knowing how this will work or whether it will be suitable for a Community Energy approach, therefore we are presenting some possible schemes in case future support is available.

We have identified three possible areas for shared loop systems within the Hanleys:

1. Winnington Gardens, a circle of 1950s mostly semi-detached ex council houses
2. The Walnuts, a 1970s terrace of Housing Association properties
3. Coverfield, a mix of 1950s semi-detached, some with large extensions and some smaller terraced houses built in the last 20 years

We have chosen Winnington Gardens for appraisal; lessons learnt here can be applied to the other sites. These sites are used for indicative purposes, the conclusions drawn could be used elsewhere and for any scheme to proceed the residents, and a Housing Association or developer would need to be in full agreement. If a scheme were to proceed it is possible that neighbouring properties could also be included.

Winnington Gardens.

There are 38 properties in Winnington Gardens, 18 of these have EPCs. 7 of these show oil boilers, 2 have storage heaters, 1 has electric room heaters, 6 have air source heat pumps and 2 have dual fuel boilers. It is likely that the other 20 properties are a mix of oil and electric heating. 6 of the properties are bungalows, one is a new build, the rest are all 1950s two storey semi-detached or terraced houses.

Taking out the properties with air source heat pumps, the bungalows and the new build, the average heat demand figure is 8,530kWh plus hot water demand of 2,710kWh, totalling 11,240kWh/a. This figure is consistent with the calculations we carried out for the No 20 Winnington Gardens case study.

As at September 2020, the current NDRHI rate for schemes over 100kWth is 6.98p/kWh. Up until July 2020 it was 8.72p,and it is expected to fall further over the next six months. This gives a current annual income of £785/property, or £15,690 over 20 years, plus an allowance for inflation. The installation costs would be at least £12,000 per property, so there is unlikely to be sufficient income to repay any share capital raised, the interest accruing and the costs of running a Community Benefit Society.

The rate for schemes under 100kWth is still 9.68p/kWhm and that is not expected to drop, so if the NDRHI had been fully extended to 2022 we could have worked on a smaller scheme with an income of

£1,088/a/property or £21,760 over 20 years, which is likely to have been viable. We do not consider that either of the other sites would give a better result.

Domestic Shared Loop Ground Source Heat Pumps, Existing Properties, Recommendation
We do not recommend any further work is done on shared loop schemes for existing properties at this point, but the idea should be reconsidered when the replacement for the NDRHI is launched or other funding is found.

Domestic Shared Loop Ground Source Heat Pumps - New Properties

The Non-Domestic RHI can apply to new build properties, unlike the domestic version. Therefore, a new build estate fitting a shared loop ground source system would gain RHI payments whereas a system for each house would not. Additionally, the developer will already have costs associated with providing heating for these properties so not all the costs will be additional.

There is a development of 12 houses at Picken End that is due to go to planning shortly where a shared loop system could be considered. At the moment we don't have full details of the properties involved and they might not reach the 100kWt threshold, though several of the properties are quite large. If the developer was interested, a scheme involving some of the neighbouring properties could be put together that could reach the 100kWt threshold. The shared loop system could easily be added to the planning application and the developer could show evidence of finance in place.

Once the scheme is registered for the NDRHI there would then be time available in which to decide:
A, whether to proceed with the shared loop scheme,
B, whether the developer owns and runs the shared loop system or whether a Community Benefit Society (CBS) is set up to do this.
C, what the ongoing arrangements would be between the owners of the shared loop scheme and the owners of the houses.

This could work well as a CBS scheme with the opportunity for the owners of the houses to become members of the CBS alongside other members of the community, and people further afield. There is not an existing CBS that we know of that would be in a position to take this scheme on, but a CBS could be formed with the intention of doing further projects if and when opportunities arise.

A CBS can raise money through share or bond issues. Bonds have fixed rates of interest and normally shorter repayment times. Shares have a variable rate of interest and are normally a longer-term investment, though the capital is normally repaid gradually over the 20-year RHI period. Investments in CBSs normally range from £100 to £100,000. CBS members have one vote regardless of the size of their investment. Conventional loans could also be considered alongside the shares and bonds; this is often done to raise capital quickly and then repaid once a share or bond issue has been completed.

If a CBS will be owning at least 51% of the project, then further funds could be raised through Phase 2 of RCEF, up to £100,000, for legal and development work.

Domestic Shared Loop Heat Pumps, New Properties Recommendation

In September we recommended that this option was considered further in the next phase of this project. Unfortunately, these investigations were ended due to funding and planning issues *(see final section)*

Waste Heat

It appears that the Haylers End Energy from Waste (EfW) facility does not have surplus heat available. However, we made some calculations before this became apparent and we are including these here for completeness. This information might also be useful if it is found at a later date that heat is available after all.

The Haylers End plant is sited away from the main population areas of the Parish, heat pipes are expensive, and any recipient of the heat would need back up heating for times when the plant is not running. For similar reasons very few EfWs make use of their heat output.

Options for using this heat include,
1, building greenhouses close to the EfW plant
2, drying firewood
3, developing other commercial buildings, for industries needing heat, near to the EfW site,
4, use of phase change heat batteries. See www.sunamp.com

We consider the first two options are worthy of consideration either as commercial or community/social enterprises but are probably outside the scope of this piece of work.

Sunamp batteries have been used in a trial taking heat by barge from a power station by the River Avon into Bristol City Centre to put the heat into a district heating scheme. We presume this scheme may be feasible as they can transport the heat in bulk with low labour and transport costs.

According to SunAmp their batteries can contain 60kW of heat on a pallet load. For comparison, a dwelling with 10,000kWh/a heat demand would require an average of 54kWh/day during the heating season, so a pallet load of SunAmp batteries would heat one medium house for one day. If this heat were to replace electric heating it would be worth 60 x 15p = £9, if replacing oil, it would be worth under half that. It therefore appears to be unlikely that a community scheme could be set up to make use of this heat using SunAmp batteries, as the costs of transporting this heat would almost certainly outweigh its value.

Waste Heat Recommendation

We recommend that no further work is carried out on waste heat as part of this project but HEAT could consider other options for developing or encouraging social enterprises to make use of waste heat from Haylers End if in future it is found that there is some available after all.

Anaerobic Digestion

Anaerobic Digestion (AD) is ideally suited for the treatment of crop wastes and residues. These are treated in smaller farm scale units, because the transportation of wastes between farms can lead to regulatory problems. No sizeable supplies of these have been identified in the Parish. In addition, Sharenergy are not aware of any Community Energy organisation that has managed to set up an Anaerobic Digestion scheme; it appears to be more suited to ownership by individual farms.

Hydrogen

There is considerable debate about the future role of hydrogen in helping us to transition to a Net Zero carbon economy. Hydrogen can be used as a transport and heating fuel but it is not a direct replacement for the natural gas, petrol and diesel we currently use. Some work is being undertaken to develop hydrogen cars (see www.Riversimple.com) but these efforts are hampered by the lack of hydrogen refuelling infrastructure and at the amount it appears that battery powered vehicles are cornering the low carbon transport market. It also takes considerable energy to generate hydrogen.

It is possible to create hydrogen by splitting fossil fuels, unfortunately this gives off CO2 so is not recommended unless carbon capture and storage is carried out, this adds to the complexity and costs involved.

Hydrogen can also be created by splitting water using electrolysis. This is known as Green hydrogen as the process does not emit CO2. However Green hydrogen is only around 70 to 80% efficient so is currently only feasible where large amounts of surplus energy are available. This is the case on some Scottish islands where the grid connection to the mainland often cannot cope with the output from the local wind turbines. Here hydrogen is being produced when the turbines would otherwise be switched off, so efficiency is not a consideration. This hydrogen is mostly being used for transport and work is underway to utilise it for the ferries that are currently fuelled by heavy diesel.

No surplus of electricity has been identified in the Hanley Castle Parish, and it is difficult to imagine surpluses in the near future. It has been considered to develop a stand-alone solar array that only produces hydrogen, due to the grid constraint. However, this is highly unlikely to be economic. The solar array would need an income of at least 4.5p/kWh to make it viable, and this would make the hydrogen too expensive.

We are therefore not recommending that any further work is carried out on hydrogen production at this point but it is possible that there may be future opportunities for HEAT to investigate innovative hydrogen projects.

Progress on the Three Major Schemes, Dec 2020

Non Domestic Rooftop Solar

Contact was made with a representative of the pension fund that owns two buildings occupied by SPARC on the Merebrook estate. This person was very interested and he thought that the Directors of SPARC would also be keen. However, when he was informed that the financial benefit from a Co-operative Energy rooftop solar scheme would fall to the tenants rather than the owners of the building, he was apparently disappointed. It was pointed out that the owners would be helping the tenant and the local community initiative and contributing to a reduction in carbon emissions. It was decided that a HEAT representative would take further action on this, but no progress appears to have been made.

Other attempts to contact owners of the industrial estates have not been fruitful.

It was suggested that we should also contact ESP, the large factory in the NW corner of the Parish. We were informed in the summer of 2020 that a commercial PV developer was looking into a scheme at this site but there does not appear to have been any progress made. It is considered that early 2021 would be a good time to approach the company.

HEAT have decided to investigate taking this work forward in partnership with the Big Solar Co-op (BSC). Working with BSC would enable the HEAT volunteers to push a project forward without having to set up and run a Co-operative Benefit Society (CBS). BSC have tools available to produce PV proposals, using the same software as was used for looking at Willow End as part of this project *(see pg 22)* and are developing materials, leases and relationships with installers.

New Build Shared Loop Ground Source Heat Pumps.

Contact was made with the developers of the site at Picken End who were very interested in the possibility of a shared loop ground source heat pump scheme. The developers stated their intention of starting on site as early as possible in 2021 with an aim of completing early 2022 which fitted with the timetable for claiming the Non Domestic Renewable Heat Incentive (NDRHI) using the extension for schemes over 100kW thermal.

However, issues were then raised over the planning permission for this site. The Neighbourhood Plan clearly sets out a maximum of 10 dwellings per site, but the developer's outline proposal included 12 dwellings. It was felt that this could mean a protracted planning situation and could result in a scheme that was too late and too small for the NDRHI. It was also discovered that the larger heat pump funding of the NDRHI has already been committed, and a confirmation letter from BEIS stated that they had no plans to extend the NDRHI.

It was therefore decided to halt work on this proposal.

Ground Mounted Solar

A site visit was arranged with the owner of Severn End, Sir Nick Letchmere who is very interested in the possibility of a ground mounted solar array on his land. Three possible fields were identified though one was slightly shaded, one would be fairly visible from other properties and the third has some flooding issues. It was decided to verify the grid capacity before undertaking any design work on these fields. A Community

Energy interview application was made to Western Power Distribution (WPD) and an email was received from WPD's 11kV planner in response to this on Nov 20th.

The email stated,

"Dear Mr Green,

My Colleague Victoria Silvester has asked that I contact you with regard to your enquiry about the potential PV site near to our Primary Substation at Brotheridge Green. I have chosen to make this initial contact with you via email in order that we all have a record of events for your enquiry. Please feel free to contact me by telephone if you wish to discuss this further.

As far as Brotheridge Green Substation itself is concerned I believe there **is** potentially capacity available for your proposed 5MW connection. However, the Grid supply point for the 66kV network which Brotheridge Green forms a part is at Feckenham, near Redditch. The National Grid network at Feckenham is at capacity with regard to generation connections. Because of this a straight forward connection onto the Feckenham network in this area will not be possible as the WPD Active Network Management (ANM) scheme is already fully committed. This means that some conventional reinforcement would be required between either Feckenham and Evesham Substation or Feckenham and Strensham Substation and the site would probably still need to be in the ANM scheme after the reinforcement. I cannot give an accurate estimate of the cost of this reinforcement as a detailed network analysis is required to determine its extent. Any connection on to Feckenham would also need to be part of a Transmission ANM scheme. My understanding is that as part of the TANM or WPD ANM scheme curtailment of generation when required is in the order of 30 % to 50% and is managed on a last in, first out basis.

At the moment there are no other real options. In the future it may be possible to get a 66kV connection via the Hereford network but this would require significant network reconfiguration at Brotheridge Green and also work on the 66kv network in the Hereford area would also need to be completed (current estimate would be 2022 but this may move). We would need to confirm this would work via studies.

I hope you find this information helpful, although it is not very positive. Once again, please feel free to contact me if you wish to discuss this further.

Kind Regards

Mark Hardman
11kV Planner, Worcester City"

It has since been verified that Brotheridge Green Substation is currently connected to Hereford and Feckenham, therefore connecting to Hereford would be quite possible once the improvement works were carried out. However, it was confirmed by WPD in a phone call on December 15th 2020 that this would mean connecting directly to the 66kV network. This is much more expensive than connecting to the 11kV network, which would imply that the scheme would have to be larger than previously envisaged to spread this extra cost over a greater capacity. This was felt to be unacceptable locally.

The WPD call also verified that there are no plans to ease the congestion at Feckenham, indeed work has been undertaken there fairly recently, but it is already at full capacity again. WPD's Active Network Management scheme is also fully committed. The problem appears to arise from a large number of renewable installations elsewhere in the region, including the 44MW solar array at Croome which received planning approval in July 2020. Whilst some of these schemes may not come to fruition, they all seem to have planning permission or are in the process of being commissioned, so this is considered unlikely.

It was also stated by WPD that larger rooftop solar applications could also fall foul of the constraint situation but a definite reply on that would only be made once an application was submitted.

A further email was received from Ben Godfrey, WPDs Network Strategy Manager on 22nd Dec 2020:

"I can confirm that the situation is as described by our planners, Feckenham is an area of limited capacity, both for additional generation and demand.

There are three meshed areas out of Feckenham which are limited for additional generation connection, across these we have connected 232MW to date (125MW PV) and we have a further 214MW accepted in the process of connecting (200MV PV).

This has required us to implement an active network management area in Feckenham, which allows more generation to connect in return for us being able to curtail the power when it is in excess of what can be accommodated. We have reached the limit of this ANM system as it becomes the limiting factor in maintaining a secure and resilient system as a single potential point of failure.

There are no plans for generation related reinforcement; as you'll have experienced, the costs associated with triggering generation related reinforcement fall to the connecting parties as per the Ofgem connections charging methodology, so DER projects is this area are less financially viable than other areas due to the higher connection costs – hence less likely to go ahead.

There is some reinforcement planned next year for Feckenham; adding new capacity for demand which is limited due to voltage restrictions, this involves establishing a new Bulk Supply Point at Banbury.
For the 2023-2028 period, we are also planning on new demand capacity around the Evesham area to resolve some of the constraints. These schemes may release some generation capacity, but it is not their primary aim. This new capacity is also subject to being allowed in our next price control.

We are also procuring generation turn up/demand turn down in the Hereford-Ledbury 66kV area via flexibility services (www.flexiblepower.co.uk/our-schemes) to ensure we can connect more demand.

As more demand comes on the network, this should allow more generation to connect, and there may be some handing back of allocated capacity by schemes in progress which may fall by the wayside.

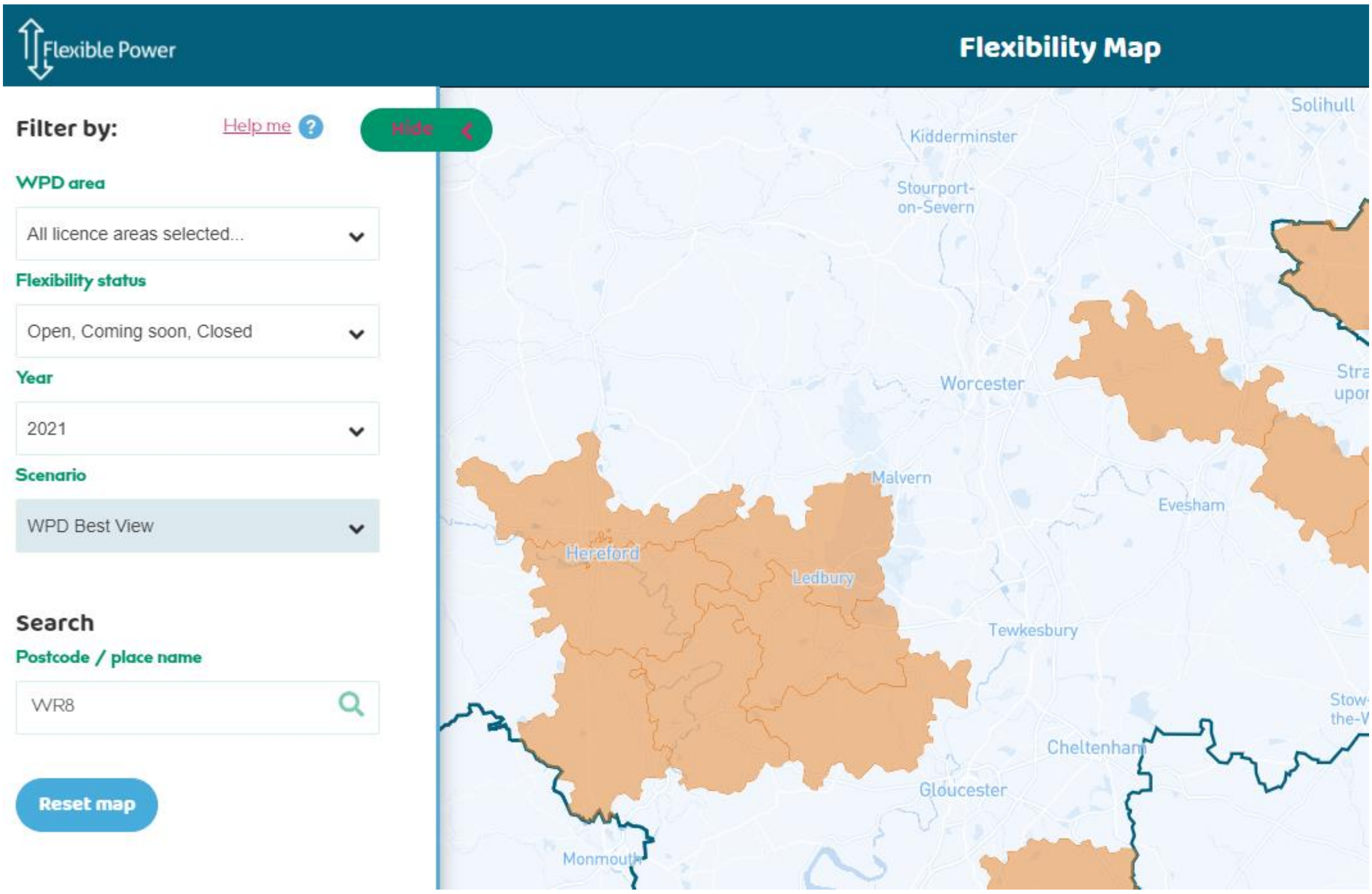
However, at the moment, the lowest cost connection for you to progress the 4MW connection is a 66kV connection at Brotheridge Green which we can accommodate by refeeding it from Hereford. This would require us to make other modifications on the system to accommodate the transfers away from Feckenham, but wouldn't attract additional cost on your side.

The other option would be a sub-1MW alternative connection for a wind-turbine, which would be limited in terms of output around the peak PV window, resulting in around 11% curtailment across the year.

Hopefully this goes some way to explain the issues and options we've tried – and the pathways that are available now or might be in the future.

Ben Godfrey
Network Strategy Manager

The flexibility map was consulted, this does not include Hanley Castle as an area where flexibility schemes are currently encouraged.



It is therefore proposed that HEAT do not pursue the ground mounted scheme at this point, although the situation should be monitored for when the constraints are lifted, or when space on an Active Network Management or Flexibility scheme becomes available.

Appendix 1 Hanleys Renewables Matrix. (As drawn up Sept 2020)

Technology	Technically Feasible	Financially Feasible	Any other constraints*	CO2 saving	Suitable for RCEF project (sept 2020)	Suitable for other HEAT input	Comments
Non Dom Rooftop PV	Y	Y	N	Y	Y		Very suited to a CE model, a number of potential sites have been identified
Ground Mounted PV	Y	Y	?[1]	Y	Y		Very suited to a CE model, Suitable sites not yet identified, Severn End estate interested.
Shared loop, domestic new build	Y	N[2]	?[2]	Y	Y		Very suited to a CE model, suitable site identified, developer not yet approached
Large Scale Battery storage	Y	?	N	?[3]	Y		Should be considered alongside ground mounted PV if a suitable site can be found.
Domestic Rooftop PV	Y	?	N	Y	N	Y	HEAT could promote to homeowners with high enough direct usage to make it viable
Shared loop existing properties	Y	N	Y	Y	Not unless the NDRHI is extended	Not at this point	Removal of the NDRHI has taken away the support this technology needs,
Individual heat pumps & biomass boilers	Y	Y	Y	Y	N	Y	HEAT could promote to business & homeowners and publicise the domestic RHI & voucher scheme, BEEP & LOCOP programmes
Domestic Batteries	Y	Not at this point	N	?[3]	N	Y	HEAT could monitor situation to see when battery storage becomes viable.
Waste Heat	N		N	Y	N	Y	
Wind	Y	Y	Y	Y	Not at this point	Y	Currently constrained by planning, HEAT could work towards easing of planning restrictions or prepare for when these restrictions are lifted.
Hydro	N	N	Y	n/a	N	N	Not suitable in this area.

Anaerobic Digestion	Y	Y	N	Y	N	?	Suited to waste streams rather than crops grown specifically, not suited for a CE model? HEAT could promote to farmers?
Hydrogen	Y	?[4]	Y	Y	N	N	

Notes,

1. There appears to be capacity at Brotheridge Green sub-station but this needs to be checked. There may be constraints on individual sites due to lack of opportunities to connect to the substation or the 66kV line leading to it.
2. Non-domestic RHI could have made this attractive to a developer and CE group, but the scheme is due for withdrawal in March 2021
3. Batteries do not save CO2 directly but help the grid to make better use of renewables.
4. Hydrogen can be a useful means of storing renewable energy where there is a surfeit that the grid cannot absorb. That is not the case in this area.