Warwick District

Low Carbon Energy Feasibility Report

Warwick District Council

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Issue and Revision Record

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Disclaimer

Contents

Glossary

Acronym	Meaning
AC	Alternating Current
AECB	Association for Environment Conscious Building
AQMA	Air Quality Management Area
ASHP	Air Source Heat Pump
BEIS	(Department for) Business Energy & Industrial Strategy
BGS	British Geological Survey
BREEAM	Building Research Establishment Environmental Assessment Method
CAA	Clean Air Act
CAPEX	Capital Expenditure
CCS	Carbon Capture & Storage
CCUS	Carbon Capture, Utilisation & Storage
CHP	Combined Heat & Power
CO_2	Carbon Dioxide
CoP	Coefficient of Performance
CSH	Code for Sustainable Homes
DC	Direct Current
DH	District Heating
DNO	Distribution Network Operator
DPD	Development Plan Document
EA	Environment Agency
EOR	Enhanced Oil Recovery
EPC	Energy Performance Certificate
EPR	Environmental Permitting Regulations
EV	Electric Vehicle
FHS	Future Homes Standard
FLEQ	Full Load Equivalent
GCCSI	Global Carbon Capture & Storage Institute
GSHP	Ground Source Heat Pump
HNDU	Heat Networks Delivery Unit
HW	Hot Water
ICP	Independent Connections Provider
IRR	Internal Rate of Return
LEP	Local Economic Partnership

Acronym	Meaning
LZC	Low & Zero Carbon
MCS	Microgeneration Certification Scheme
NERS	National Electricity Registration Scheme
NHBC	National House Building Council
NRSWA	New Roads and Street Works Act
O&M	Operation & Maintenance
PEM	Proton Exchange Membrane
PR	Performance Ratio
PV	Photovoltaics
PWLB	Public Works Loan Board
RCV	Refuse Collection Vehicle
REGO	Renewable Energy Guarantee of Origin
RHI	Renewable Heat Incentive
RINA	RINA Tech UK Ltd
SADC	Stratford upon Avon District Council
SCoP	Seasonal Coefficient of Performance
SPG	Supplementary Planning Guidance
SPD	Supplementary Planning Document
STHW	Solar Thermal Hot Water
TA	Technical Advisor
TDCV	Typical Domestic Consumption Values
TER	Target Emissions Rate
WCC	Warwickshire County Council
WDC	Warwick District Council
WPD	Western Power Distribution
WSHP	Water Source Heat Pump

Executive Summary

Warwick District Council ('WDC') has set an ambitious target to reach carbon neutrality for Council estate by 2025, and as close to zero for the district by 2030. This is set against a backdrop of Covid-19 recovery and the proposed merger between WDC and Stratford upon Avon District Council ('SADC'). This study was commissioned to examine four main areas of potential development.

- Renewable electricity generation.
- Hydrogen production for council vehicles.
- District heating for the Myton area.
- Microgeneration opportunities district-wide for Council-owned residential property.

Renewable generation involved a detailed assessment of landholdings to the south of the district near to the M40 at Greys Mallory and further West at the Stratford depot. The ownership of the land is mixed between council ownership, Coventry diocese and local landowners.

Within this study it was identified that there should be grid capacity available to 16 MW which opens up the opportunity for a combination of solar PV, battery storage, wind and hydro development. Wind power on one site has been assessed, however it is considered that obtaining planning consent would be problematic and so the focus has been solar PV and battery storage[1]. Looking at the potentially available landholdings[2] approximately 52 MW to 62.5 MW of solar PV generation was identified – which would far outstrip the available grid capacity.

Standard practice at this stage would be to look at what generation capacity could be delivered within the available grid capacity and develop the most suitable sites to 'shovel ready' status. Alongside this, new developments adjacent to or nearby that could consume power from the generation sites would be considered. If these can be connected to the generation by 'private wire' this could open up the opportunity for further generation capacity (over and above the available grid capacity), which could also be bolstered with battery storage development. For example:

- Private wire to hydrogen hub. Renewable electricity is the largest single cost for the production of green hydrogen so to supply locally generated renewable power via private wire eliminating grid costs could contribute to reducing the cost of hydrogen significantly.
- District heating scheme development at Myton and across Warwick District. With natural gas being gradually phased out it is likely that heat pumps will be used for the provision of heat. These require electricity, and if this is renewable it presents an advantageous case for low carbon heat.

The development of a hydrogen hub is ambitious and forward thinking. Whilst it is noted that the market is in its early stages with offtake and capital costs relatively high at the moment, it is in line with industry calls for more infrastructure to enable the use of hydrogen as a fuel[3]. There is much discussion within the market as to the role (or roles) of hydrogen within the energy transition and whilst the specific applications are unclear it is clear that hydrogen will have a significant role moving forward. Of note are the improving economics for hydrogen fuelled transportation with

[1] The potential for small hydro power generation on the River Avon has also been considered at a high level, however the capacity of these, if feasible, will not be significant.

[2] Including sites over which WDC has limited control.

[3] European Automobile Manufacturers Association, May 2021

capital costs starting to reduce alongside the at scale development of green hydrogen production that will enable the supply of hydrogen at an economic cost.

Key to the success of hydrogen production is a market to supply the hydrogen to and to some degree WDC and SADC are able to control their own destiny through the change of their refuse collection vehicle (‘RCV’) fleet to hydrogen power. This would create a demand for hydrogen that would stimulate the need to develop a refuelling station. However, just the RCV fleet is unlikely to be enough to justify the development of a hydrogen hub so it would be recommended that WDC engages in conversation with alternative ‘customers’ for the hydrogen output which could be from the private sector, academia or indeed other local authorities and public service operators[4].

As already mentioned, the economics of green hydrogen production are significantly influenced by the cost of power which if supplied from a WDC owned facility by private wire could reduce the production cost of hydrogen markedly. Thus, opportunities to explore synergies amongst low carbon projects within the district should be encouraged and developed at an early stage.

The development of district heating for Myton as assessed indicates that a project supplying majority low carbon heat from heat pumps to all existing significant non-domestic buildings and proposed new development included in the current masterplan would be financially viable. The technical details of the project will require further consideration and confirmation through further study work. The current base case as assessed shows a viable system with a combination of heat pumps (80%) and gas boilers (20%) for peak loads and backup. This should be seen as a base case given the usage of natural gas will gradually be phased out. The proposed base case will still provide for significantly reduced CO_2 emissions although the cost of operation (and thus to the consumer) based on current gas and electricity costs is higher compared to gas boilers. Completion of a district heating project will be a few years away and it is expected that during this period gas costs will increase from current low levels as carbon taxes transfer from electricity to gas, reflecting the widening gap in carbon intensity. This will have the effect of raising the cost of gas-based heating and reducing the cost of heat from individual heat pumps and a heat pump-supplied heat network, thereby encouraging essential investment in low carbon heat.

Technology is advancing fast in this area and alternative schemes may be possible for Myton by the time the full development is undertaken, which could reduce capital cost, reduce the cost of operation or reduce / eliminate the need for natural gas at all. Given the potential development of solar PV within WDC there may be the opportunity to leverage a lower cost of power to reduce operating cost and thus reduce the cost to the consumer to par or below par cost against the use of natural gas boilers.

Further consideration could in time be put to the use of hydrogen in a district heating system as the source of heat. Should the hydrogen market pick up and WDC progresses with the development of a hydrogen hub, there could be surplus hydrogen production from that facility that could be deployed to heating in the district[5].

It is important to consider the development of a district heat scheme in Myton as a project within a broader heat decarbonisation strategy that can be rolled out across other developments – such as

[4] Such as Warwickshire County Council, emergency services and bus operators

[5] This will depend on the amount of generation capacity installed, the mix of technologies used and the amount of any battery storage installed.

Kenilworth. If WDC is able to develop a strategy for heat that can be deployed across the district it may help to provide greater certainty and thus reduced risk for housebuilders and the various housing development projects currently underway in WDC.

Microgeneration is a further tool that can be used to decarbonise the building stock of the Council and significant work has been carried out to assess the opportunities for the WDC residential property estate. Interventions that could be carried out across the estate range from insulation type activities through to the deployment of heat pumps, rooftop solar PV, smart controls and behavioural change activities.

The roll out of heat pumps and potentially also other microgeneration technologies across the entire housing portfolio is a significant project in terms of the extent of the works and capital required. CO_2 emissions savings through implementation of an estate-wide project are significant compared to current gas and electric based heating systems, and will increase as the carbon intensity of grid supplied electricity reduces in the future, eventually resulting in close to zero carbon heat.

Energy and O&M related cost savings to the Council are relatively small compared to the capital investment required. The total energy cost savings to tenants are significant when measured against existing electric heating systems, and on average there are no energy cost savings to tenants currently using gas boiler heating systems, as the operating cost of a heat pump is slightly higher compared to a gas boiler.

Financial support for retrofit energy projects is currently available through the Social Housing Decarbonisation Fund, from the Department for Business Energy and Industrial Strategy (‘BEIS’). Tenants / occupiers would benefit from more efficient configurations which in turn may lead to lower fuel bills. Further technology developments to balance grid electricity usage against local generation are being seen emerging in the market regularly so a keen eye needs to be kept on market developments.

1 Introduction

RINA Tech UK Limited together with consortium partners Kingscote Enterprises Limited and Enzygo Limited (collectively known as 'RINA') has been appointed by Warwick District Council (the 'Client', the 'Council' or 'WDC') to provide technical advisory services in respect of a feasibility study of low carbon energy generation within Warwick district.

The scope of work undertaken by RINA is based on the proposal '2021-02-11 Warwick District Council-RINA Renewable Energy Feasibility Study Proposal Rev1' and includes the financial and practical feasibility, costs, potential funding sources and risks, of the following projects.

- Solar PV at 2 sites.
- Hydrogen hub in conjunction with the solar sites.
- District heating at the Myton site.
- Micro-generation applied to the Council's housing stock.

In addition, the report provides support to the development of planning policies which include low carbon energy generation as part of new developments within the emerging Climate Change and Sustainable Buildings Development Plan Document, and with consideration given to applying the findings of the report to the potential opportunities for similar projects within Stratford-on-Avon district.

RINA visited the site and met with representatives from the Council on 11th March. A further site visit was carried out on 27th April. Additional documentation and information has been provided by the Client.

While every effort has been made to check source information, RINA takes no responsibility for the completeness or otherwise of the information provided for the purpose of the study.

2 Renewable Electricity Generation

2.1 Constraints

There are three renewable energy technologies that have the potential for deployment in WDC's area: PV, which represents the largest opportunity, wind power and one small hydropower site (on the River Avon). In each case there are constraints that have to be taken into consideration when assessing the capacity of any particular site and whether or not it is likely to be both viable and capable of winning planning permission.

2.1.1 Grid capacity

In the case of WDC, the largest constraint is the ability of the local grid and/or substation to accept the power generated. The grid consists of a series of circuits at different voltages. Power is transformed from one voltage to another at substations, with each substation typically serving a number of different circuits. There are physical limits to how much power individual circuits and substation equipment can carry. If these limits are exceeded, lines and/or substations will become overloaded and trip out. Consequently, a trip on one circuit can cause outages elsewhere.

Grid operators therefore place limits on any new load (consumption) or new generation that can be connected to any circuit or substation. Consequently, there is currently a maximum of 16 MW of new generation that could be accepted at the electricity sub-station at Greys Mallory.

2.1.2 Grid connection costs

Grid connection costs increase as the length of the power line (between the generator and the connection point) increases. A rough rule of thumb is that an 11 kV overhead power line will cost approximately £100 per metre, and underground cable £300 per metre. This incentivises development of sites as close to the connection point as possible, unless the power can be taken by private wire to replace power bought from the grid[6]. It also incentivises development of as much generation capacity as possible (up to the maximum capacity of the grid to accept the power) to spread development and grid costs over as large a base as possible.

The theoretical land area in the vicinity of Grey Mallory could support a much greater generation capacity than the 16 MW of connection capacity currently available. An area within 1.5 km of the substation was therefore examined, in order to minimise grid connection costs.

2.1.3 Other constraints

Planning policy and legislation impose a number of constraints on where new renewable generation can be located. In carrying out this study, the other key constraints considered were:

- Negative visual impacts on the heritage assets of New Waters and Warwick Castle should be considered unacceptable unless they can be avoided by screening with effective planting.
- Slopes facing towards the new housing developments in the Heathcote and Bishops Tachbrook areas should be avoided unless they are screened.

[6] in this case the power is valued on an import replacement basis, which is higher than the value of power sold into the grid

- Development on the perimeter of the country park and its proposed expansion should be avoided unless it is screened from the (expanded) country park.
- In the case of wind power, proximity to houses and other sensitive receptors (to avoid unacceptable impacts of noise and shadow flicker).

2.2 Potential renewable electricity generation sites

Using the constraints, a filtering exercise resulted in identification of the potential sites described below.

2.2.1 Land east of the A452 at Greys Mallory

Figure 1: Land at Greys Mallory showing the utile area of sites 1 & 2

In the following site descriptions, reference is made to mono-facial and bi-facial PV panels. A mono-facial panel only generates electricity on the face of the panel inclined towards the sun. A bi-facial panel also generates power on the back face, using light that is reflected from the ground.

Site 1

Gross Area[7]:	Approximately 12 ha (29.5 acres)
Utile Area:[8]	Approximately 10.5 ha (26 acres)
Technology:	Solar PV arrays
Peak Capacity:	Approximately 7.4 MW (monofacial panels)
	Approximately 8.9 MW (bifacial panels)
Generation Potential:[9]	6,680,000 kWh per year (monofacial panels)
	8,020,000 kWh per year (bifacial panels)

This is an arable field that overall slopes slightly towards the northwest and the south-west. For the most part it would be shielded from the new housing at Heathcote by topography. The northern boundary of the utile area is a public footpath, and new planting would be required to obscure the security fence. This would in a relatively short time completely obscure any panels or site equipment from the housing.

There are existing trees along the western and southern boundaries that obscure the site, however new planting would be required along the eastern boundary.

Ground conditions appear suitable for mounting frames placed into the soil.

The distance to the substation is 100m across Europa Way, and the power line from the existing solar farm crosses the site.

Based on generic data for insolation levels at Greys Mallory[10], it is estimated that the site would generate between a low of 6,300,000 kWh and 7,050,000 kWh per year with monofacial panels, and between 7,570,000 and 8,460,000 kWh with bifacial panels.

Site 2

Gross Area[11]:	Approximately 10.7 ha (26.4 acres)
Utile Area:[12]	Approximately 9 ha (22.2 acres)
Technology:	Solar PV arrays

[7] Measured in the horizontal plane

[8] After deduction of a margin between the field boundaries and arrays, and avoiding areas that are over-shadowed or subject to rainwater pooling etc.

[9] This is an upper limit for estimation purposes prior to consideration of external constraints. A detailed design may result in higher generation potential

[10] Derived from Meteorological Office data

[11] Measured in the horizontal plane

[12] After deduction of a margin between the field boundaries and arrays, and avoiding areas that are over-shadowed or subject to rainwater pooling etc.

Peak Capacity:	Approximately 6.3 MW (monofacial panels)
	Approximately 7.6 MW (bifacial panels)
Generation Potential:[13]	5,720,000 kWh per year (monofacial panels)
	6,870,000 kWh per year (bifacial panels)

This is an arable field atop a slight plateau with very slight slopes towards the northwest and the south-west. The site would be partially visible from the new housing at Bishops Tachbrook through the mature hedge on the eastern boundary. New planting would be required along the northern southern and western boundaries.

The site is 700m from the substation, across Europa Way.

Ground conditions appear suitable for mounting frames placed into the soil.

Based on generic data for insolation levels at Greys Mallory[14], it is estimated that the site would generate between a low of 5,400,000 kWh and 6,040,000 kWh per year with monofacial panels, and between 6,490,000 and 7,250,000 kWh with bifacial panels.

[13] This is an upper limit for estimation purposes prior to consideration of external constraints. A detailed design may result in higher generation potential

[14] Derived from Meteorological Office data

2.2.2 Land south of the Banbury Road

Figure 2: Land south of the Banbury Road showing the utile areas of potential sites

In preparing this report, it was noted that there may be competing uses for some or all of these sites. However, until such time as a planning application for alternative use is approved for any or all of them, they remain potential energy development sites. RINA notes that in the event an alternative use is approved for sites 1 to 5 and site 7, the field bordering site 6 could be developed along with site 6, particularly if there is an opportunity to supply power to whatever is built north of the M40.

Site 3

Gross Area[15]: Approximately 16 ha (39.5 acres)

[15] Measured in the horizontal plane

Utile Area:[16]	Approximately 13.9 ha (34.4 acres)
Technology:	Solar PV arrays
Peak Capacity:	Approximately 9.8 MW (monofacial panels)
	Approximately 11.8 MW (bifacial panels)
Generation Potential:[17]	8,850,000 kWh per year (monofacial panels)
	10,620,000 kWh per year (bifacial panels)

This is an arable field that is also used for grazing. It slopes gently towards the north-west and is not visible from New Waters, Warwick Castle or the new housing. It would require new planting on its western and eastern boundaries.

This site is the closest to the sub-station at 270 m, but the connection line would have to cross both the A452 and the A425.

Ground conditions appear suitable for mounting frames placed into the soil.

Based on generic data for insolation levels at Greys Mallory[18], it is estimated that the site would generate between a low of 8,360,000 kWh and a high of 9,340,000 kWh per year with monofacial panels, and between 10,030,000 and 11,210,000 kWh with bifacial panels.

Site 4

Gross Area[19]:	Approximately 13 ha (32 acres)
Utile Area:[20]	Approximately 10 ha (24.7 acres)
Technology:	Solar PV arrays
Peak Capacity:	Approximately 7 MW (monofacial panels)
	Approximately 8.4 MW (bifacial panels)
Generation Potential:[21]	6,350,000 kWh per year (monofacial panels)
	7,620,000 kWh per year (bifacial panels)

16 After deduction of a margin between the field boundaries and arrays, and avoiding areas that are over-shadowed or subject to rainwater pooling etc.

17 This is an upper limit for estimation purposes prior to consideration of external constraints. A detailed design may result in higher generation potential

18 Derived from Meteorological Office data

19 Measured in the horizontal plane

20 After deduction of a margin between the field boundaries and arrays, and avoiding areas that are over-shadowed or subject to rainwater pooling etc.

21 This is an upper limit for estimation purposes prior to consideration of external constraints. A detailed design may result in higher generation potential

This site is an arable field located in a shallow hollow, with the land rising to the north-east. It does not appear to be visible to any close sensitive receptors or to the heritage assets. It is screened by mature hedges to the east and west that will require some remedial planting to fill in gaps. Along its northern edge it will require new planting to restore the remains of the hedge, unless the field immediately north is added to this parcel (in which case some remedial planting will be required to that field's northern edge). To the south, this potential site is bounded by the cutting of the M40.

This site is 600 m from the substation and the connecting line would need to cross both the A452 and the A425. If co-developed with site 3 it would be able to share that site's connecting line.

Ground conditions appear suitable for mounting frames placed into the soil.

Based on generic data for insolation levels at Greys Mallory[22], it is estimated that the site would generate between a low of 6,000,000 kWh and 6,700,000 kWh per year with monofacial panels, and between 7,200,000 and 8,040,000 kWh with bifacial panels.

Site 5

Gross Area[23]:	Approximately 11.1 ha (27.4 acres)
Utile Area:[24]	Approximately ha (acres)
Technology:	Solar PV arrays
Peak Capacity:	Approximately 6.8 MW (monofacial panels)
	Approximately 8.1 MW (bifacial panels)
Generation Potential:[25]	6,100,000 kWh per year (monofacial panels)
	7,300,000 kWh per year (bifacial panels)

The site is an arable field gently sloping towards the south-west. It does not appear to be closely visible from any sensitive receptors apart from Red House Farm buildings, and two farms 500m+ on the other side of the M40. It would require screen planting on all boundaries.

Ground conditions appear suitable for mounting frames placed into the soil.

This site is approximately 800 m from the substation and the connecting line would need to cross both Banbury Rd and Europa Way. If it is co-developed with site 3 and/or site 4, it would be able to share that/those site/sites connection line into the substation.

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[22] Derived from Meteorological Office data

[23] Measured in the horizontal plane

[24] After deduction of a margin between the field boundaries and arrays, and avoiding areas that are over-shadowed or subject to rainwater pooling etc.

[25] This is an upper limit for estimation purposes prior to consideration of external constraints. A detailed design may result in higher generation potential

Based on generic data for insolation levels at Greys Mallory[26], it is estimated that the site would generate between a low of 5,400,000 kWh and 6,040,000 kWh per year with monofacial panels, and between 6,490,000 and 7,250,000 kWh with bifacial panels.

Site 6

Gross Area[27]:	Approximately 16 ha (39.5 acres)
Utile Area:[28]	Approximately 14 ha (34.6 acres)
Technology:	Solar PV arrays
Peak Capacity:	Approximately 9.8 MW (monofacial panels)
	Approximately 11.8 MW (bifacial panels)
Generation Potential:[29]	8,890,000 kWh per year (monofacial panels)
	4.9 kWh per year (bifacial panels)

This site is located on a gentle slope downwards from the M40 towards the south-west. It does not appear to be in close visibility to any sensitive receptors apart from Gooseberry Hall Farm immediately to the south, and Red House Farm north of the M40. It would require screen planting along the boundary with the M40 and along its eastern boundary. The southern boundary appears to have a mature hedge, but some remedial planting may be required to fill in gaps.

Ground conditions appear suitable for mounting frames placed into the soil.

Ordinarily this site would not be considered as the M40 sits between it and the substation. However, the farm bridge may provide an opportunity to bring a connecting line over the motorway on this bridge. Using this route, the site is approximately 1,400 m from the substation (it would still need to negotiate Europa Way and the Banbury Road. If it is co-developed with any of sites 3, 4, or 5, it would be able to share those sites' connection lines into the substation.

Based on generic data for insolation levels at Greys Mallory[30], it is estimated that the site would generate between a low of 8,400,000 kWh and 9,380,000 kWh per year with monofacial panels, and between 10,080,000 and 11,260,000 kWh with bifacial panels.

Site 7

Gross Area[31]:	Approximately 8.7 ha (20 acres)

[26] Derived from Meteorological Office data

[27] Measured in the horizontal plane

[28] After deduction of a margin between the field boundaries and arrays, and avoiding areas that are over-shadowed or subject to rainwater pooling etc.

[29] This is an upper limit for estimation purposes prior to consideration of external constraints. A detailed design may result in higher generation potential

[30] Derived from Meteorological Office data

[31] Measured in the horizontal plane

Utile Area:[32]	Approximately 7 ha (17.3 acres)
Technology:	Solar PV arrays
Peak Capacity:	Approximately 4.9 MW (monofacial panels)
	Approximately.5.9 MW (bifacial panels)
Generation Potential:[33]	4,440,000 kWh per year (monofacial panels)
	5,330,000 kWh per year (bifacial panels)

The site is an arable field gently sloping south-west towards the M40. It does not appear to be closely visible from any sensitive receptors apart from Red House Farm buildings, Tachbrook Hill Farm buildings and the two farms 500m+ on the other side of the M40. It would require screen planting on all boundaries.

Ground conditions appear suitable for mounting frames placed into the soil.

This site is approximately 1,300 m from the substation and the connecting line would need to cross both Banbury Rd and Europa Way. If it is co-developed with site 3, 4, 5, or 6 it may be able to share those sites' connection line into the substation.

Based on generic data for insolation levels at Greys Mallory[34], it is estimated that the site would generate between a low of 4,200,000 kWh and 4,700,000 kWh per year with monofacial panels, and between 5,040,000 and 5,630,000 kWh with bifacial panels.

Site 4 - wind power potential

Technology:	Wind
Peak Capacity:	4 MW
Generation Potential[35]:	5,900,000 kWh per year

Wind turbines generate the greater proportion of power in the winter months, when PV generation is at its lowest. Wind turbines also produce power at night. As such, they complement PV generation.

Site 4 was examined for its potential for wind power. However, it is noted that the turbine rotors would be visible above Barford Wood from New Waters and Warwick Castle (at a distance of 3 km) This would make obtaining planning consent problematic.

[32] After deduction of a margin between the field boundaries and arrays, and avoiding areas that are over-shadowed or subject to rainwater pooling etc.

[33] This is an upper limit for estimation purposes prior to consideration of external constraints. A detailed design may result in higher generation potential

[34] Derived from Meteorological Office data

[35] This is an upper limit for estimation purposes prior to site based anemometry and consideration of external constraints..

Notwithstanding the planning considerations, when examining the suitability of any site for wind power, a number of other factors need to be considered. As well as wind speed and impact on birds, it is necessary to consider proximity to dwellings to ensure that noise impact and a phenomenon known as shadow flicker are kept to acceptable levels. In the case of the latter, it is necessary to ensure that turbines are a minimum of ten times the rotor diameter away from any dwelling or sensitive building between the turbine and the sun at times when the sun is low on the horizon.

On this basis, site 4 could accommodate two wind turbines in the order of 2 MW each as well as PV (noting that there would be a reduction in the amount of PV panels that could be installed).

These turbines have 90 m diameter rotors (mounted on a 60m high tower).

Based on past data from the NOABL programme[36], the average wind speed at the site is likely to be in the order of just 6.5 m/s. This would have to be tested by on-site anemometry before any decision to proceed is made.

If planning consent is possible, option of wind power on site 4 should be seriously considered.

[36] NOABL was a database developed for the former Department of Trade and Industry that estimated the average wind speed in every square kilometre in the UK.

2.2.3 Hydropower on the River Avon

There are two weirs on the River Avon at Barford.

Figure 3: River Avon at Barford showing weirs

Publicly available data from the Environment Agency ('EA') suggests that when the river is not in flood, it has an average flow rate of 4.1 cubic metres per second. The hydrostatic head at the weirs is recorded as being approximately 1.2m (4 ft). In theory these weirs could support low head hydro generation of up to 30 kW (25 kW average), giving an output of approximately 170,000 kWh per year. However, the southern bank immediately below the downstream weir is designated at flood risk area, therefore any hydro installation would have to ensure that it does not increase the risk.

The section of the river from Warwick to Barford is used by the Warwick University Boat Club, although clearly they stop before the weirs. Other recreational users include anglers (with one angling forum highlighting the areas below the weirs as offering the opportunity to catch specimen size Barbel) and canoeists, who enjoy 'shooting' the weirs. There have been proposals in the recent past to install new weirs and locks on the Avon to enable pleasure craft to travel from Stratford up to Warwick, including at Barford. Should this proceed, there may be an opportunity to incorporate hydro into the weirs (and any new weirs downstream).

These existing and proposed recreational uses suggest that there would be opposition to any proposal for hydropower at the two weirs as they exist now, unless impact on users could be demonstrated to be minimal. As this stretch of the river has been subject to considerable flooding in the past, the Environment Agency should be consulted first to find out what they would be prepared to accept in Barford before any further feasibility work is undertaken. If the Environment Agency is supportive, preliminary designs could be produced to avoid impacts.

2.2.4 Summary of sites

The sites' production potential is summarised in Table 1 below.

Table 1: Renewable energy sites summary

PV	Peak Capacity (monofacial)	Peak Capacity (bifacial)	Annual Production (monofacial)	Annual Production (bifacial)
Site 1	7.4 MW	8.9 MW	6,680,000 kWh	8,020,000 kWh
Site 2	6.3 MW	7.6 MW	5,720,000 kWh	6,870,000 kWh
Site 3	9.8 MW	11.8 MW	8,850,000 kWh	10,620,000 kWh
Site 4	7.0 MW	8.4 MW	6,350,000 kWh	7,620,000 kWh
Site 5	6.8 MW	8.1 MW	6,100,000 kWh	7,300,000 kWh
Site 6	9.8 MW	11.8 MW	8,890,000 kWh	10,670,000
Site 7	4.9 MW	5.9 MW	4,440,000 kWh	5,330,000 kWh
PV Totals	52.0 MW	62.5 MW	47,030,000 kWh	56,430,000 kWh
Other	**Name Plate Capacity[37]**		**Annual Production**	
Site 4 Wind	4 MW		5,900,000 kWh	
Barford Hydro	30 kW		170,000 kWh	

2.2.5 PV costs

This section only deals with the PV sites; more information is required for wind power and hydro power before a commentary can be given.

PV costs have fallen dramatically over the last 20 years, to the point that PV is now the least cost form of new-build electricity generation in many countries. This has been driven by a number of factors including new PV technology, greater conversion efficiency[38], mass-production using new manufacturing techniques and use of panel mounts that move to track the sun. However, in 2020 panel costs (expressed as the cost per Watt of peak output) increased in real terms. RINA attributes this to a global shortage of semi-conductor materials (in part caused by interruption of production by flooding in China) coinciding with ever-increasing demand for new PV panels.

[37] Wind and hydro power capacities are quoted in terms of the rated capacity stated on the name plate. Their peak outputs can be slightly higher than this for short periods of time

[38] Conversion efficiency, quoted as a percentage, is the proportion of light energy striking the panel that is converted into electricity.

Based on work recently carried out by RINA for other clients, we estimate that the current purchase cost of monofacial panels at the factory gate is in the order of £120,000 per MWp, for purchases of 4 MW or more. To this must be added the cost of inverters, cabling, a control system, mounting frames, fencing and the costs of installation. In the case of the sites examined for this report, all sites are suitable for (relatively low cost) mounting frames sunk into the ground. We have also assumed that panels are fixed (i.e. they do not employ a tracking system). This results in an estimate of £390,000 to £430,000 per MWp installed, before grid connection costs. In general, the larger the site the more it will tend towards the lower cost estimate.

Table 2 PV cost estimate by site

Parameter	Peak capacity (monofacial) (MW)	Low cost estimate (£m)	High cost estimate (£m)
Site 1	7.4	2.9	3.2
Site 2	6.3	2.5	2.7
Site 3	9.8	3.8	4.2
Site 4	7.0	2.7	3.0
Site 5	6.8	2.7	2.9
Site 6	9.8	3.8	4.2
Site 7	4.9	1.9	2.1

2.3 Grid connection

2.3.1 Existing grid at Banbury Road

The proposed locations for solar PV are shown below. The connection point is the 33/11 kV primary substation at the roundabout where Banbury Road and Europa Way intersect. The local Distribution Network Operator ('DNO') in this area is Western Power Distribution ('WPD'). According to WPD, the existing 11 kV grid has an available generation capacity of 16 MW, which is sufficient for the planned generation export of 16 MW. However, some or all of this capacity could become unavailable as other developers are looking to connect into this substation.

Consequently, RINA strongly recommends that the WDC makes a grid connection request to WPD in order to reserve capacity.

Figure 4: Outline grid connection routes (in blue)

Sites 1, 2, 3, 4, 5 and 7 are situated close to Banbury road which is an A road. Therefore, it was considered suitable for the new 11 kV overhead lines from the PV sites to cross the fields on poles to the substation instead of running it adjacent to the road. Site 6 is located south of the M40 therefore it was proposed that an 11 kV cable would be used to cross the farm bridge and subsequently connect to an overhead line which will cross the field to the substation. Table 3 shows the estimated length of the cables for each PV site.

Table 3: Cable lengths for solar site options

PV site	11 kV cable length (km)	11 kV overhead line length (km)
PV site 1	-	0.15
PV site 2	-	0.75
PV site 3	-	0.30
PV site 4	-	0.62

PV site	11 kV cable length (km)	11 kV overhead line length (km)
PV site 5	-	0.88
PV site 6	0.07	1.54
PV site 7		1.38

Table 4 shows the cost of grid connection for each PV site on a standalone basis. It should be noted that these are not definite costs and are subject to change.

Table 4: Grid connection cost

PV site	Cost of connection (£)
PV site 1	99,000
PV site 2	137,000
PV site 3	105,500
PV site 4	125,000
PV site 5	146,000
PV site 6	210,000
PV site 7	175,000

Actual costs will not be determined until a formal grid connection request has been made.

There is insufficient capacity at the substation to develop all of the sites, but different combinations of sites could be co-developed. In this case, the cost of the grid connection for the co-developed sites should be less than the sum of the individual connections. For example, if sites 1 and 2 are co-developed and equipped with bi-facial panels, they would have a combined capacity of 16 MW and a connection cost in the order of the site 2 estimate of £137,000.

2.4 Use of renewable energy

In order to achieve net-zero, it will be necessary for Warwick DC to obtain renewable energy for all demand across the district. This section examines the following options for doing this.

- Purchasing electricity from the grid via a green supplier.
- Generating renewable electricity on land owned or leased by WDC and supplying this to its sites via the grid, using the services of an electricity supplier (known as sleeving or wheeling).
- Use of battery storage.
- Use of Renewable Energy Guarantee of Origin certificates (‘REGOs).
- Generating renewable electricity on land owned or leased by WDC and supplying this by private wire (or other facilities) to an electrolyser for hydrogen production.

It also outlines issues that have to be taken into consideration.

2.4.1 Variability in output and demand

The major generation opportunity in the vicinity of the Greys Mallory substation is solar power. PV peak generation output is in summer, whereas peak consumption is in winter. Depending on how much PV capacity is installed, at different times of the year there will be surpluses and deficits of generation over demand.

In considering this, the value of electricity at different times of day and year needs to be taken into account: high levels of export in summer tend to attract low sales prices, and high levels of import in winter carry high purchase prices.

Permutations of generation capacity therefore need to be considered in order to get the optimum balance between peak demand and peak output, along with the use of battery storage.

2.4.2 Purchasing via green supplier

This is a simple option, used by a number of organisations (including WDC at present). However, electricity purchased this way often attracts a premium to market rates.

Future electricity demand will be higher than is the case now (to meet demand for heat pumps and electric vehicle ('EV') charging) but will be reliant on an ever-increasing share of variable renewable electricity generation. This is likely to result in higher electricity prices in real terms in the future due to greater imbalance charges[39] and the cost of expanding the grid to cope with new demand.

2.4.3 Self-generation supplied via the grid

Where there is no possibility of a private wire, generation at any of the sites will need to be connected to the grid. In this circumstance, generation capacity should ideally be maximised to improve viability. The peak capacity for all the sites except site 7 is greater than 6 MW so they are likely to be financially viable based on current market prices for renewable electricity. Site 7 should also be viable if it is co-developed with one of the other sites.

Combinations of sites up to grid capacity could provide WDC with its annual electricity demand. A sleeving arrangement could be agreed with a Supplier so that all of WDC's demand would be supplied by the Supplier via the grid, and excess power (over demand) would be purchased at an agreed rate. The value of the electricity produced would be an average of the avoided cost of electricity consumed and the sales revenue for the surplus sold.

To Illustrate this, a simple example using sites 1 and 2 is given below:

Assumptions:

- Average cost of power taken from the grid is £0.15 per kWh
- Assumed demand for WDC is 8,700,000 kWh per year
- Under a sleeving arranged, cost of imports would be reduced by 5%
- Under a sleeving agreement, sales of power would be 5.2 p/kWh
- Without a sleeving agreement, sales of power would be between 5.5p and 6.0 p/kWh

[39] Large generators (50 MW+) and suppliers whose predicted and actual generation/consumption does not match in any half hour have to pay imbalance charges. These are nearly always higher than the wholesale price of electricity and ultimately are passed onto consumers. At times when the grid is under stress, imbalance charges can be 20 times more than the wholesale price. As more renewable generation connects to the grid, and as more buildings switch from gas to electricity for heating, the grid is highly likely to come under stress more frequently.

Table 5 Example of sleeving arrangement vs sales to the grid for sites 1 and 2 combined

	Grid electricity only	Sleeving arrangement	PV power sold to grid @ 5.5p/kWh	PV power sold to grid @ 6.0p/kWh
Capital cost, including development costs (£)		5,900,000	5,900,000	5,900,000
Power output (kWh/yr)		12,409,167	12,409,167	12,409,167
Assumed demand (kWh/yr)	8,700,000	8,700,000	8,700,000	8,700,000
Average cost of power from grid (£/kWh)	0.15	0.143	0.15	0.15
Annual cost of grid electricity (£/yr)	1,305,000	1,239,750	1,305,000	1,305,000
Average price of power sold (£/kWh)		0.052	0.055	0.060
Sales revenue (£/yr)		645,277	682,504	744,550
Net cost of electricity consumed (£/yr)	1,305,000	594,473	622,496	560,450
Savings (£/yr)	0	710,527	682,504	744,550

2.4.4 Battery storage

Battery storage allows the storage of power generated during the day to meet demand at night, as well as creating an opportunity to generate income by supplying power from the battery to the grid at peak times and/or grid stabilisation services.

Battery storage would also allow the installation of generation capacity in excess of the grid capacity; power generated in excess of the grid capacity would be transferred to the battery to be released once the level of generation falls below the grid capacity.

Ideally batteries would be installed either at the generation site(s) or at the electrolyser site close to the grid connection.

2.4.5 Renewable Energy Guarantee of Origin certificates

Renewable Energy Guarantee of Origin certificates (‘REGOs’) are issued by the electricity regulator Ofgem to show that electricity from any registered renewable generator is truly renewable. One REGO is issued for each megawatt hour of renewable electricity generated.

There is a growing market for REGOs, and they currently have a value between £0.15 and £1.00. REGOs can be applied to electricity purchased from the grid (from other sources) to demonstrate that energy usage is renewable. In this case organisations buy REGOs equal to their electricity consumption and this enables them legitimately claim that they source their supply from renewable generation. However, a number of organisations own (or are seeking to own) their own renewable energy generation at sites remote from the point(s) of consumption and use their own REGOs to match their consumption.

WDC could use this for its own grid connected generation if it did not enter into a sleeving arrangement; WDC would enter into an electricity supply agreement[40](s) for its buildings and facilities across the district, and a separate agreement(s) for the sale of its generation output into the grid. It would retain REGOs equal to its consumption to demonstrate net-zero.

2.4.6 Direct supply of a hydrogen production hub

Locating an electrolyser for hydrogen production close to the possible generation sites means that it could be directly connected to the generation by private wire i.e. without connecting the generation to the grid. Instead, all output would be bought to the electrolyser. The electrolyser itself would have a (smaller) connection to the grid, to allow export of surpluses, to allow its battery to supply grid services and to allow imports where necessary (such as during winter when PV generation is low). This is discussed in section 3.

Direct wires could in theory be used to supply other loads in the locality, however the viability of each supply has to be examined on a case-by-case basis. This is a balancing act between the cost of the private wire and the value of the electricity (valued on a grid displacement basis). The closer the load is to the generation site, the shorter the cable and the lower its cost, but the load itself has to be large enough justify the cost of the cable. Consequently, larger loads can support longer cables.

For example, EV charging at the park and ride will be close to the PV sites' grid connection and is likely to be viable. In contrast the Heathcote Lane Industrial Estate is 1.7 km from site 1. To justify the cost of the cable (a minimum of £500,000) to here, there would have to be minimum sales of 2 million kWh per year.

[40] These would not have to be with green suppliers

3 Development of Hydrogen Hub

WDC has expressed an interest in leveraging the potential renewable generation for use in green hydrogen which in turn could be utilised as a fuel for buses and refuse trucks. It is understood that Warwickshire County Council ('WCC') is seeking a developer funded (and built) park and ride facility at Greys Mallory, which will be run by WDC. The County Council will commission a bus service operating from the site served by eight buses[41] (each of which are intended to be zero carbon vehicles). Furthermore, WDC and neighbouring Stratford-on-Avon District Council are considering the transition of their thirty refuse collection vehicles to zero carbon. Whilst there are many potential routes to decarbonisation, this study examines the feasibility of developing a hydrogen-based strategy for the fleet.

The main competition to hydrogen in terms of zero carbon is battery electric which can be made to work. However they have some disadvantages when compared with traditional diesel based vehicles which would not be suffered by hydrogen vehicles. The user experience of hydrogen is similar to that of diesel in terms of refuelling. Battery electric will require significant charging infrastructure, power and charging time – which in turn will require capacity in the grid. It is noted that the current intention is for the Park and Ride to be serviced by battery electric buses.

With RCV's, volume is of enormous importance. A battery of the size required would eat into the available space which restricts the amount of time that a RCV could spend on a trip before returning to the depot to empty which means more down time and possibly extra vehicles / operators.

3.1 Hydrogen market

From the numerous commitments and energy strategies published by the leading economies, the world is inextricably on a path to zero carbon over the next few decades. This will mean the demise of fossil hydrocarbon fuels, with electrification using renewable power as the go-to solution. However, most countries have recognised that successful decarbonisation cannot solely rely on renewable electricity and zero carbon hydrogen is required.

The key markets for hydrogen will be the harder to decarbonise sectors, especially the energy intensive industries, heavy duty transport and marine transport, where reliance solely on renewable electricity is not technically viable. Hydrogen also has a role to play in balancing the intermittency of the renewable energy markets.

It is currently difficult for green hydrogen to compete on price against existing fossil fuels but the various energy strategies commit governments and regions to supporting the growth and development of the hydrogen economy, by increasing the scale of production, reducing the cost of production but also levelling the playing field through regulation.

According to analysis for this report, but also backed up by external sources, the current sales price for green hydrogen, to deliver a commercial return, needs to be £5 - £6 per kg, which makes it considerably more expensive than marine oil in terms of usable energy content (although cheaper than UK diesel on the same £/MW comparison). However, a comparison to the current fossil fuel price has limited validity as operators are forced through regulatory, commercial or social responsibility pressures to switch to zero carbon fuels even at higher prices, albeit the detailed timescale for this switch is not yet certain for all markets.

[41] With up to 7 buses operational at any one time.

3.2 Hydrogen production

Hydrogen is the simplest and most abundant element in the universe. It is found within water, fossil fuels, and all living matter, but it rarely exists as a gas so it must be separated from other elements. Hydrogen has about 3 times more energy content by weight than conventional fuels like gasoline and natural gas, which is why it was first selected by NASA for space applications. It also has about 4 times less energy density by volume, so it is challenging to store in a limited space. Hydrogen is an industrial commodity today, mostly used for oil refining, steel production and fertiliser production.

Today, hydrogen represents a small fraction of the global energy mix, and is still largely produced from fossil fuels, mainly from natural gas but also from coal, resulting in the release of 70 to 100 million tonnes CO_2 annually in the EU[42]. For hydrogen to contribute to climate neutrality, it needs to achieve a far greater scale and its production must become fully decarbonised.

There are two main methods to produce hydrogen, steam methane reformation (releasing the hydrogen molecule from a hydrocarbon) and electrolysis (releasing the hydrogen molecule from a bond with oxygen in water). Steam methane reformation is often characterised by the colours grey and blue. Grey hydrogen is a carbon intense but inexpensive production process. Blue hydrogen production differs from grey hydrogen production by incorporating a carbon capture and storage (‘CCS’) or carbon capture, utilisation and storage (‘CCUS’) process. Electrolysis produces hydrogen by passing electricity through water to separate the water into hydrogen and oxygen. When renewable (carbon-free) electricity is used in electrolysis, the resultant hydrogen is referred to as green hydrogen. Grey, blue and green hydrogen are discussed further in the sections below.

For distribution, hydrogen needs to be liquified at very low temperatures, or compressed to very high pressure (350-700 bar) and moved in high pressure (Type 4) vessels, or sent through pipelines at pressures of about 7 bar. Ideally, hydrogen would be distributed through existing gas networks but due to the effect of hydrogen embrittlement, only pipework using non-metallic liners could be utilised. An alternative for distribution is to react hydrogen with another element to form a hydrogen carrier which can be distributed at much lower pressure. Ammonia is one such hydrogen carrier and is formed through the reaction of nitrogen (abundant in air) with hydrogen and acts as a very effective carrier and fuel in its own right.

3.2.1 Grey hydrogen

Globally, world usage of hydrogen exceeded 70 million tonnes in 2018[43], mostly produced from natural gas by steam reformation.

Steam reformation results in a molecule of methane and a molecule of water (steam) being converted into three molecules of hydrogen and one of carbon monoxide.

$$CH_4 + H_2O \Longrightarrow 3H_2 + CO$$

In a second stage (water shift reaction) the molecule of carbon monoxide is reacted with another molecule of water to produce a further molecule of hydrogen and molecule of carbon dioxide.

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[42] EU Hydrogen Strategy 2020

[43] IEA, The Future of Hydrogen, 2019

$$CO + H_2O \Rightarrow H_2 + CO_2$$

Overall, one molecule of methane and two of water will produce four molecules of hydrogen and one of carbon dioxide. As the overall process is endothermic, it requires heat, usually provided by burning additional methane, which in turn results in further emissions of carbon dioxide.

Hydrogen produced in this way therefore has a high carbon emissions factor and is called **Grey Hydrogen.**

3.2.2 Blue hydrogen

Combining Grey Hydrogen production with carbon capture storage and utilisation produces **Blue Hydrogen**.

CCS is the process of capturing and storing carbon dioxide (CO_2) without emitting it into the atmosphere.

Once the CO_2 has been captured, it is compressed and transported by pipeline to sites where it can be pumped underground, usually to depths of 1 km or more and at pressures greater than 74 bar, to be stored in depleted oil and gas reservoirs and other suitable geological structures[44]. There are also proposals to liquify CO_2 for transport by ship or road tanker, however this would appear to add significantly to the cost.

CO_2 could also be used to produce commercially marketable products. This is commonly known as CCUS. The most well-established form of CO_2 utilisation is enhanced oil recovery ('EOR'), where CO_2 is injected into oil and gas reservoirs to increase their extraction. Other forms of CO_2 utilisation are still under investigation. These include using CO_2 in concrete or plastic materials or converting it into biomass[45] – for example, by feeding CO_2 to algae, which are then harvested and processed into biofuel for transport.

The first large-scale CCS project began operating at Sleipner in Norway in 1996. There are now 18 large-scale CCS facilities in operation globally, with five more under construction. According to the independent Global CCS Institute ('GCCSI'), existing installations have the capacity to capture about 31 million tonnes of CO_2 per year[46].

3.2.3 Green hydrogen

Hydrogen can also be produced through an electrolysis process in which a direct current is passed through water between electrodes to split the water molecules into hydrogen and oxygen:

$$2H_2O \Rightarrow 2H_2 + O_2$$

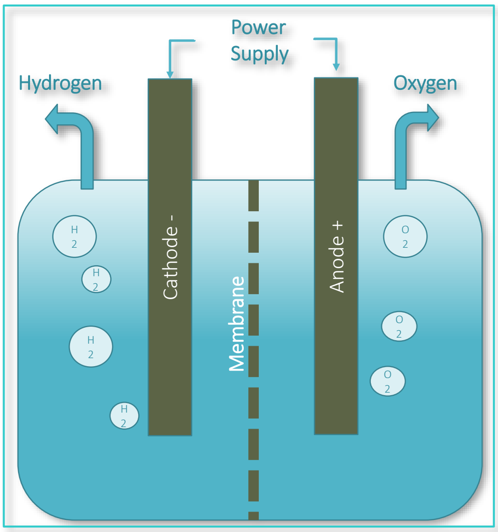
[44] For example, sandstone horizons capped by impermeable shale. Saline aquifers, which are similar to oil and gas reservoirs, are also the subject of research for use as storage sites, but as yet not enough has been invested in exploring them to conclude definitively that they can be used to permanently sequester the CO_2. Unmined coal beds are frequently mentioned for CCS, however this is primarily a technique for extracting coal-bed methane rather than storing CO_2.

[45] https://www.worldcoal.org/reducing-co2-emissions/carbon-capture-use-storage

[46] Source: LSE

Hydrogen gas forms at the negatively charged cathode (a reduction reaction), and oxygen gas at the positively charged anode (an oxidation reaction).

The resistivity of pure water is high, so electrolytes are used to permit the current to flow. Within this general description there are a multitude of processes, most of which either employ a liquid electrolyte or a solid polymer-electrolyte membrane (also called a proton exchange membrane or PEM).



Electrolytes typically contain soluble salts (particularly lithium and sodium salts), acids (frequently sulphuric acid) or alkalis (frequently potassium and sodium hydroxides).

The electrodes used are typically made of catalytic materials, usually platinum group metals or nickel. Other materials can be used for electrodes, depending on the nature of the electrolyte, the required purity of the hydrogen and the acceptability of electrode dissolution.

Production of Hydrogen in this way using power from renewable sources produces no CO_2 and is therefore called **Green Hydrogen**.

High temperature (steam) electrolysis is more efficient than electrolysis at ambient temperature as less electricity is required to break the chemical bonds between hydrogen and oxygen in the water molecule. This is particularly the case where the some or all of the heat supplied is waste heat, for example from steel making. It is reported that electrolysis at high temperature (700-850 degrees Celsius) can utilise as much as 35% less power[47] in the hydrogen production process. However, this requires electrolyser materials that can withstand the higher temperature. Consequently, most development work is focussed on using Solid Oxide Fuel Cells in reverse.

By harnessing process heat and electricity from a nuclear reactor at times when electricity demand is low, hydrogen could be produced through high temperature electrolysis at relatively low cost. Hydrogen produced through nuclear power generation is often referred to as **Yellow hydrogen**.

3.3 Storage and distribution

Hydrogen is relatively difficult to store and transport. It boils at roughly 20.3 K (−252.9°C) and is the smallest molecule of any element, meaning leakage is always an issue. Hydrogen can cause embrittlement of metals in which it is in contact.

There are three methods of storage:

1. **Cryogenic**, where hydrogen is liquefied. This requires highly insulated containers and significant energy input to chill the hydrogen. However, even with the best insulated containers, some ‘boil-off’ will occur resulting in losses;

[47] Shripad T. Revankar, in Storage and Hybridization of Nuclear Energy, 2019

2. **Pressure**, where the gaseous hydrogen is pressurised and stored in a tank, or underground cavern or depleted gas field; and
3. **Chemical**, where the hydrogen is chemically combined with other elements to form stable compounds such as ammonia.

Liquified hydrogen and pressurised hydrogen are primarily used for short to medium term storage and transport over relatively short distances. Such transportation given the temperature or pressures needed require specialised vehicles which leads to a relatively high cost to transport. Thus, localised production of hydrogen at the point of use is generally seen as most appropriate.

Given the commitment of WDC to reaching carbon neutrality, only green hydrogen has been considered for this study as the scale of hydrogen production required could not justify a carbon capture initiative for blue hydrogen and grey hydrogen production is carbon intensive. Thus, an electrolyser solution has been considered for his study only.

3.4 Fuelling vehicles

A heavy duty vehicle such as a bus or a refuse collection vehicle ('RCV') would require approximately 18-20 kg of hydrogen per day to provide a range and capability in line with existing diesel vehicles. Each vehicle would require access to a refuelling facility on a daily basis similarly also to diesel vehicles. There are only a limited number of hydrogen refuelling stations currently active in the UK and given the cost of transporting hydrogen a local facility for producing and refuelling hydrogen vehicles would be recommended.

3.5 Electrolyser location

A tour was made of the area immediately north of the M40, between junctions 13 in the east and 15 in the west, to look for potential locations for an electrolyser to produce hydrogen for vehicle usage. A number of filtering assumptions were made:

- The site should either be close enough to the grid to have an affordable grid connection, or close enough to renewable generation to have a direct wire connection;
- Refuelling would take place at the electrolyser site in order to avoid the use of hydrogen tankers (to a remote refuelling location);
- It should be large enough to accommodate the electrolyser, a battery storage unit and the refuelling infrastructure;
- It should not be closely located to sensitive receptors that could experience material negative impacts from 24-hour operation at the site;
- In the medium term, hydrogen-fuelled vehicles would primarily be long-range heavy goods vehicles, buses, coaches and commercial vehicles such as refuse collection vehicles. As such, the site would have to have dimensions that would enable long vehicles to manoeuvre; and
- ideally the location should be readily accessible from the M40, the A452, the A46, the A429 and the A425, in order to serve vehicles from Warwick District Council, Stratford District Council, the County Council and private HGVs on the motorway network.

Two sites were identified at the roundabout where Edgehill Drive intersects the A429, both of which could be accessed from the roundabout:

- WDC's depot on the south-east of the roundabout (Postcode CV34 6RA, grid reference SP27257 62801);
- The rough ground on the north-east of the roundabout abutting the Longbridge Waste Water Treatment Works (in the ownership of Severn-Trent?).

Both sites appeared to meet the filtering criteria, apart from affordable grid connection/proximity to renewable generation: the Tournament Fields development to the west of the A429 appears to have taken most the available grid capacity. The DNO would have to be consulted to determine what capacity is available or could be made available in the future. In respect of the A429, it is a trunk road that appears to carry high volumes through the village of Longbridge. The County Highways Authority should be consulted to see if the traffic impact of developing either of these two sites would be acceptable before further consideration (of them as suitable sites) is given.

Three more sites that met the filtering criteria were found at the Greys Mallory roundabout where the A452 and the A425 intersect. These are on the north-eastern southern and western sides of the roundabout. The north side is occupied by the police patrol base and the regional grid substation. To north of these, the land is reserved for the Europa Way Park & Ride site. The grid sub-station is also the most likely point to connect renewable electricity generation. Discussion with the County Highways Authority is required to determine how access to any of these sites could be created.

Figure 5: Potential electrolyser sites at Greys Mallory

3.6 Economic case

It is understood that WDC have been in discussion with BOC regarding the provision of hydrogen who have suggested a 2.1MW electrolyser at a cost of £8.4m. If funded by BOC it has been suggested that hydrogen could be supplied at a cost of £9 per kg. Taking a jointly funded solution with WDC providing 40% of the funding the cost of the hydrogen has been suggest at around £6 per kg.

The recent Tyseley Energy Park hydrogen refuelling station development in Birmingham delivered by ITM Power presents varying economics. The 3MW (3.5MW including parasitic load) can deliver 1200 kg of hydrogen per day (i.e. up to 65 buses / RCVs) at a price of £10 + VAT per kg.

Alternative options are available working with Geopura (Siemens), NEL or a number of US based electrolyser manufacturers, all of which will have nuanced business models achieving pricing of similar orders. Ryse hydrogen – owner of Wright bus – have a vertically integrated model of hydrogen production for buses supplied by them and they currently work with a number of public entities across the UK.

The largest single contributor to the cost of hydrogen production is the cost of power. Thus, if the cost of power can be reduced through – for example – local renewable generation it is possible to dramatically reduce the cost of hydrogen. For example, a recent study by University of Birmingham[48] showed that through leveraging private wire opportunities (in that case, power purchase from a neighbouring energy from waste plant), a hydrogen price of £5 per kg was possible if power could be purchased at £75 per MWh[49]. Further studies for the IFC by Kingscote Enterprises showed similar results – that at a power cost of US$69 per MWh, hydrogen could be produced at under US$5 per kg. The business models that emerge from the electrolyser manufacturers and associated development and delivery companies will all focus around these economics. Shared ownership and public private investment approaches are likely to de-risk and unlock potential developments

At £5 - £6 per kg of hydrogen – a total fill cost of £100-£120 per bus or truck it is considered broadly similar to the refuelling cost of an equivalent diesel vehicle. Thus, if the suggested solar developments that have been evaluated as part of this study are taken forward, it could be entirely feasible that the cost of hydrogen could be kept to £5-£6 to operate at parity with diesel from a fuel perspective.

However, the cost of hydrogen fuel cell vehicles is currently very high and universally require public subsidy in order for them to be viable in the market today. Thus, any development of hydrogen in WDC would likely also require some form of public subsidy. Thus early conversations with UK Gov't would be recommended in order to identify and source suitable subsidy funds to assist with development. It should be noted that UK Gov't hydrogen strategy is due for publication in the coming months which should be monitored closely for subsidy or grant support for hydrogen development.

3.7 Planning & environmental considerations

WDC has declared a climate emergency to become net-zero carbon as an organisation by 2025, and by 2030 to ensure total emissions in Warwick District as a whole are as close to zero as possible.

With transport now accounting for approximately 28% of the UK's greenhouse gas emissions, and the majority of these coming from road transport, the UK government's announcement to ban the selling of new petrol, diesel and hybrid cars in the UK from 2040 to 2035, highlights the urgent need to carbonise all forms of transport as a step towards net-zero carbon by 2050.

[48] Hydrogen as a Component of City Development, University of Birmingham / Kingscote Enterprises, October 2019

[49] There is an non-linear interaction between the cost of power and the electrolyser utilisation rate, but generally the higher the utilisation rate, the higher the power price that can be tolerated

In December 2020, the UK government published its Energy White Paper, outlining the broad energy strategy for the next decade. The white paper sets out support for the hydrogen sector, including plans to develop 5 GW per annum low carbon hydrogen production by 2030. An independent hydrogen strategy is expected to be published by central government in 2021 to outline further plans to support the hydrogen sector.

Hydrogen is an energy carrier that can be used to store, move, and deliver energy produced from other sources.

Utilising hydrogen power in a variety of areas, from transport to industry to heating can provide a clean fuel that, when consumed in a fuel cell, produces only water as a by-product. Hydrogen can be produced from a variety of domestic resources, such as natural gas, nuclear power, biomass, and renewable power like solar and wind. This range of production methods serve to make hydrogen an engaging low carbon alternative for transportation and electricity generation applications.

The impediments presently facing hydrogen usage are similar to those of battery powered electric vehicles, being the lack of a comprehensive refuelling infrastructure and higher vehicle costs.

Hydrogen 'hubs' may offer solutions to these issues, with multiple users sharing a hydrogen refuelling facility, as additional stakeholders create increasing and regular demand for hydrogen.

Hydrogen is a particularly suitable fuel for larger vehicles, such as buses and HGVs, due to the provision of an improved vehicle power-to-weight ratio than batteries, which enable long distances to be travelled without significant increased vehicle weight.

Hydrogen supply is paramount, which can either be delivered to site from an offsite production plant or produced onsite.

To produce hydrogen on-site, an electrolyser is required to extract hydrogen from water. A compressor unit takes the extracted hydrogen and compresses it for efficient storage.

Sufficient land would be required to store the hydrogen produced under pressure, and a dispenser for pumping the hydrogen gas to the vehicle under pressure.

Hubs can produce green hydrogen on-site by using renewable energy to power the electrolysis process, either from local renewable energy sources or by using an energy company that offers a green tariff.

Hydrogen hubs, and their associated infrastructure, must be constructed in locations that will not lead to detrimental impacts on the environment, landscape, or residential receptors. As such, location is key, in terms of accessibility, connectivity and sufficient land to build the facilities and accommodate the users. A site should be close enough to the national grid to have an affordable connection or be in proximity to renewable generation to have a direct wire connection.

With the significant strategic highway network comprising the M40, A452, A46, A429 and A425, a location within close proximity to this network and the proposed end users from WDC, Stratford District Council, WCC and other stakeholders, is highly recommended.

Due to the operational hours and the anticipated high levels of transportation, a suitable site should be located away from sensitive receptors, such as high-density residential areas and ecological and landscape designations. A suitable access is also required.

The identified sites for the proposed hydrogen hub would offer convenient access onto the M40, A452, A46, A429 and A425; however, depending on the scale of development, key environmental considerations will need to be considered.

As with the majority of development taking place in south Warwick, the impact on Warwick Castle and Warwick Castle Grade I Listed park and garden is a key consideration. Whilst a small electrolyser can easily be assimilated into the urban area of Longbridge, consideration should be given to the associated infrastructure, such as battery storage and refuelling infrastructure. At its closest point, the Warwick Castle Park and Garden is only 200m away, on the opposite side of the river Avon. As such early engagement with the Heritage and Landscape Officer at WDC is encouraged to determine whether the electrolyser and associated infrastructure would impact the setting of the heritage asset. It is vital to determine the scale of electrolyser (and infrastructure) proposed on-site prior to engagement with statutory consultees to properly assess the potential impact of the proposed development.

The site identified as Longbridge is identified within the local plan as an employment allocation for ‘B’ uses. It is likely that a hydrogen electrolyser hub would be considered a ‘sui generis’ use class, so engagement with the planning policy team at WDC is encouraged to determine whether the development would conflict with the overall strategy of the area. However, it is considered that allocated employment land is a suitable location. Assuming that the proposal is suitable for its location, it is envisaged that the economic benefit, in addition to the employment opportunities, would outweigh the loss of employment land in the ‘B’ use class.

As the proposal also includes a battery storage, the impact on noise would need to be fully considered to nearby receptors, such as Longbridge village, a predominantly residential area which includes office space and hotels.

If the land surrounding Greys Mallory is determined to be a preferrable location for the proposal, the vast majority of the recommendations remain the same; however, the requirement to determine the impact on residential receptors is conflated as a result of housing allocation to the south of Warwick. Notwithstanding this, to determine the full extent of impacts resulting from the proposal, it is recommended that WDC engage in internal consultation with officers to determine whether the proposal would impact the Warwick Castle park and garden, or nearby residential receptors. As noted within previous sections, it is likely that WCC will need to be consulted to determine the impacts on the local highway network resulting from the construction and operation of a hydrogen hub.

3.8 Conclusions

The general rule of thumb for green hydrogen production is that economies are achieved through scale. Thus, should WDC decide to proceed with the development of a hydrogen hub it would be important to search beyond the scope of WDC and SADC RCV fleet. The bus fleet for the park and ride would be ideal although given the timescales for delivery and the likely cost of hydrogen fuelled vehicles it may be challenging (although perhaps not impossible) to include them. Even with the buses it would be advisable to consider looking further afield – exploring opportunities with industry, academia and the private sector in addition to further exploration with other neighbouring authorities or the County Council.

At face value, working with BOC to deliver a hydrogen hub that can dispense hydrogen at £6 per kg may seem interesting and would be close to allowing an economic comparison with diesel or battery electric powered buses were capital costs excluded. Capital costs for hydrogen vehicles present a significant impediment in the market currently as they remain capital intensive. Particularly given the relative simplicity of hydrogen fuel cell vehicles when compared to diesel it is expected the capital costs will reduce once the market takes hold.

The delivery of a hydrogen hub on the basis of an assumption that capital costs for the vehicles that will create the market may not be advisable. However, it is noted that the location of Warwick is advantageous as there are limited hydrogen refuelling stations in the Midlands with close access to the road networks. The UKH2Mobility organisation identifies hydrogen refuelling stations in the map below.

Figure 6: Locations of hydrogen refuelling stations – Thames valley & midlands

Thus, given the expected increase in hydrogen demand over the coming years it may be advisable at the least to prepare for that market with the development of a hydrogen hub to 'shovel ready' status – that is a development ready to build once the market enables the economics to stand up.

3.9 Recommendations / next steps

- Identify suitable location, ideally co-located with renewable power generation.
  - The most suitable location has been identified as the East site near to Greys Mallory.
  - Up to 16 MW of grid connection is available and a similar volume of renewable power generation.
- Identify the current and future demand requirements of a hydrogen refuelling station.
  - A 2.1 MW electrolyser as put forward by BOC would produce around 840 kg[50] of hydrogen per day – enough for 42 vehicles[51].
  - Once providing the hydrogen for the bus and RCV fleet there would be limited production capacity for any further vehicles. In the case that the park and ride bus fleet is battery electric as planned, this would point to either a smaller electrolyser or surplus for supply to market.

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[50] This assumes that approximately 42 MWh of power would be required per day, or 50 kWh per kg of hydrogen

[51] This assumes 20 kg of hydrogen per vehicle per day. For a 12m long bus, this translates into a distance travelled of approximately 240 km per day.

  - Should there be scope for further expansion by WDC or SDC then a larger facility may be suitable.
  - Given the likely increase in hydrogen usage for large vehicle transportation WDC may wish to consider allowing private company access to a developed hydrogen refuelling hub for private fuel sales, thus opening the possibility for larger facilities.
  - Taking a modular approach with a view to expansion may be suitable to enable growing demand. The electrolyser manufacturers have recognised the need for such an approach and the electrolyser and balance of plant equipment could be expanded over time to match demand. This enables a start small strategy although economy of scale opportunities would not benefit the development in the short term.
- Consider the access requirements and road modifications that would be required in order to allow refuelling to suit the operating conditions of the buses and RCVs that would be intended to operate from there.
- Develop detailed financial model to set out the full case for the deployment of hydrogen fuel cell vehicles.
  - The high-level economics are understood and set out in this document but an appraisal versus battery electric would be recommended considering all the permutations and constraints.
- Enter discussions with UK Government to identify and access any available funds to assist with hydrogen market development.
- Open partnership discussions with potential refuelling station technology suppliers.
- Develop a planning position on the development of the site through a pre-application discussion with WDC planners.

4 District Heating - Myton

The following section assesses the feasibility of district heating ('DH') to supply existing and new build development within the Myton area.

DH in this context includes provision of low and zero carbon ('LZC') energy supplies to provide heating and cooling to individual buildings.

4.1 Introduction

Decarbonising heat is key to achieving Net Zero locally and nationally. Currently, heating in the UK is one of the highest sources of carbon emissions and is dominated by fossil fuels, with 85% or about 24.5 million homes and over two million businesses supplied directly by the mains gas grid. Converting them to low carbon heating by 2050 is a huge task. According to the 2011 census there were 60,427 dwellings in Warwick district, and in 2016 there were 7,535 businesses. Considering that the vast majority of homes and businesses will be located in the urban centres it is expected that a similar percentage as for the whole of the UK will be supplied by mains gas.

While the electricity grid will need to become zero carbon by 2050, to decarbonise heating at the pace and scale required, according to the Energy System Catapult there are three main options that will likely be rolled out to homes and buildings in different parts of the UK.

4.1.1 Hydrogen boilers

Hydrogen boilers operate in a similar way to traditional natural gas boilers. Hydrogen-ready boilers are already available, although hydrogen gas production needs to grow from virtually zero to supply industry and heavy transport as well as heat. Without substantial subsidy, the cost of heating via a pure hydrogen boiler is likely to be significantly higher than the current cost of heating via natural gas.

4.1.2 Heat pumps

The Energy White paper published in December 2020 stated intent for the installation up to 600,000 heat pumps by 2028, up from c30,000 today, and therefore a clear aim that heat pumps will be the low carbon solution of choice for many of the 25m homes currently heated using a gas boiler, with the majority in urban areas potentially connecting to district heating schemes using large centralised heat pumps. It is also assumed that heat pumps will replace the heating systems in the majority of gas heated commercial buildings.

Heat pumps have significant efficiency advantages over hydrogen and given the energy required to replace gas heating, are considered to be a much more realistic option for mass decarbonisation of heat. However, heat pumps often require both internal and external space and work best in thermally efficient buildings. Consequently, heat pumps will not be suitable as a retrofit for all buildings. A recent report by the Energy and Utilities Alliance stated, 'Up to 54% of UK homes using gas for heating will not be suitable for a heat pump'. If more homes were better insulated this figure would be higher.

4.1.3 District heating

A heat network is a distribution system of insulated pipes that takes heat from a central source (energy centre) or several sources and delivers it to domestic or non-domestic buildings. Heat network infrastructure is energy agnostic and can accommodate a range of heat sources. Compared to a heat pump, the space requirements to connect buildings is less. They are easily configurable to cater for future development and can be retrofitted. DH technology is proven and common across Europe with an established UK supply chain.

DH schemes can supply heat at the same conditions as existing individual boilers, allowing internal heating systems to remain unchanged, however DH networks operating at lower temperatures and a wider delta T (temperature difference between supply and return) compared to individual boilers translates to lower energy consumption, both in terms of heat loss and pumping energy. Building thermal efficiency improvements will also help with enabling lower temperature heat supply.

4.2 Myton area

The Myton DH study area is shown in Figure 7 below.

Figure 7: Myton district heating study area

The south-eastern and eastern sections of the site are currently being developed for housing by a number of commercial housebuilders, to include a total of 1,160[52] residential units and community buildings. This area is shown in Figure 8 below.

Figure 8: New build housing area

The properties within this development are understood to include gas boiler-based heating systems and therefore are unable to be considered for LZC technologies at this time. In the medium term it is likely that the gas system will be replaced with a suitable LZC solution, in line with zero carbon requirements.

The middle portion of the site is the subject of a Masterplan which comprises proposed development of the greenspace as mixed-use including education, social care, sports facilities, retail, leisure, and a small amount of residential. This area is shown in Figure 9 below.

[52] Based on Encraft study report

Figure 9: Masterplan area

Within the Masterplan area a number of existing developments will remain, including Myton School and John Atkinson Sports Centre to the north, and the Grade II Listed farmhouse and barn building towards the southern end of the site, which will be renovated.

The remaining areas of the study area include Warwick Technology Park in the southwest, Warwick School, The Bridge Sports Centre, Bridge House Theatre and Warwick Hall towards the northwest, Coten End Primary School and St. Nicholas Park Leisure Centre in the northwest, Round Oak School / Evergreen School towards the north, and mixed majority low-rise residential development across the north and north-eastern boundary. These developments are shown in Figure 10 below.

Figure 10: Existing development

4.2.1 Building details

The following section includes details of all significant buildings located within the study area, to be included in the assessment of LZC technologies.

The details of existing development outside of the Masterplan area are shown in Table 6 below.

Table 6: Details of existing development

Buildings	Existing heating & cooling system	Internal floor area (m^2)[53]
Warwick Technology Park:		
National Grid	Gas boilers and central air conditioning	27,340
Wireless House	Mixed-mode with mechanical ventilation. Includes some gas heating	5,322
1 Kingmaker Court (IRESS)	Gas boilers and air conditioning	3,843

[53] Estimated figures based on aerial images and external survey

Buildings	Existing heating & cooling system	Internal floor area (m²)[53]
2 Kingmaker Court (Wolseley)	Mixed-mode with natural ventilation	3,741
3 Kingmaker Court	Gas boilers and air conditioning	1,988
Mid Counties Co-operative	All electric	4,001
Neville House (Warwickshire Police)	Gas boilers and air conditioning	2,585
Seton House (Tulip)	Gas boilers and air conditioning	2,340
Innovation Centre Warwick (University of Warwick)	Air conditioning	5,140
Iceni Centre	Gas boilers and air conditioning	8,941
IBM UK, Globe House	Gas boilers and air conditioning	5,060
Other non-residential buildings:		
Warwick School (including The Bridge sports centre, Bridge House theatre, Warwick Hall - accommodation for 60 students)	Gas boilers	TBC
Coten End Primary School	Gas boilers	3,200
St. Nicholas Park Leisure Centre	Gas boilers	TBC
Round Oak School / Evergreen School (support service & sports college)	Gas boilers	2,805
Myton School & sports centre	Gas boilers	TBC
Residential:		
Myton Gardens	Individual gas boilers	150 each (estimated average)
Myton Crescent	Individual gas boilers	150 each (estimated average)
Field Head Lane	Individual gas boilers	150 each (estimated average)
Brittain Lane	Individual gas boilers	150 each (estimated average)
The Malins	Individual gas boilers	150 each (estimated average)
Myton Road	Individual gas boilers	150 each (estimated average)

The description of existing heating & cooling systems for buildings in Warwick Technology Park are taken from energy performance certificates ('EPCs').

The details of proposed new development as part of the Masterplan area are shown in Table 7 below. Information is based on the document '210218 SK01RevC MASTERPLAN COLOUR 1.1000 Overall and Schools' provided by the Client, and RINA assumptions.

Table 7: Details of proposed new development within Masterplan area

Buildings	Details	Internal floor area (m^2)[54]
Care Home (60 bed)	Two / three storey	3,825
Myton School Sixth Form Centre	Assumed two storey	2,400
Primary School	Assumed single storey	2,000
SEN School	Assumed single storey	1,500
Athletics Facility	Assumed single storey	1,200
Community Football Stadium		1,500
Local Centre: Farmhouse & barn[55]		425
Local Centre: Residential		300
Local Centre: Retail		1,200
Local Centre: Convenience store		100
Residential development (28 units)	3 & 4 bed houses	3,360
Residential Care Home (70 bed)	2/3 storey	4,463
Car showroom	BMW	4,000
Hotel (80 bed)	Travel Lodge	3,800
Total		**30,073**

4.3 Energy demand assessment

Based on the information provided Table 8 below shows the buildings assumed to connect, together with the estimated annual heat demand and heat connection capacity.

Table 8: Buildings to connect to district heating scheme

Connection	Heat demand (kWh/yr)	Heat capacity (kW)	Existing / new
National Grid	8,200,000	2,187	Existing
Wireless House	212,880	149	Existing
1 Kingmaker Court	153,720	108	Existing
2 Kingmaker Court	0	0	Existing

[54] Estimated figures based on information in Masterplan document

[55] Existing – to be renovated

Connection	Heat demand (kWh/yr)	Heat capacity (kW)	Existing / new
3 Kingmaker Court	79,520	56	Existing
Mid Counties Co-operative	0	0	Existing
Neville House	103,380	72	Existing
Seton House	93,600	66	Existing
Innovation Centre Warwick	0	0	Existing
Iceni Centre	402,345	282	Existing
IBM UK, Globe House	202,400	142	Existing
Warwick School	13,500,000	11,250	Existing
Coten End Primary School	155,000	194	Existing
St. Nicholas Park Leisure Centre	1,070,000	594	Existing
Round Oak School / Evergreen School	264,350	330	Existing
Myton School (incl sports centre)	1,777,600	1,778	Existing
Care Home	497,250	191	New
Myton School Sixth Form Centre	115,200	120	New
Primary School	96,000	100	New
SEN School	72,000	75	New
Athletics Facility	78,000	60	New
Community Football Stadium	97,500	75	New
Local Centre: Farmhouse & barn	57,600	34	Existing
Local Centre: Residential	31,000	15	New
Local Centre: Retail	69,600	60	New
Local Centre: Convenience store	5,800	5	New
Residential development	319,200	168	New
Residential Care Home	580,125	223	New
Car showroom	212,000	200	New
Hotel	494,000	190	New
Totals	**28,940,070**	**18,723**	

The existing residential development at the northern / north-eastern edge of the study boundary (streets listed under ‘residential’ in Table 6) are excluded from the analysis of a DH scheme due to the practical challenges and cost of introducing a heat network and making connections to existing individual domestic properties, as evidenced in previous studies and projects of this type. Decarbonisation of heat provision for these properties is likely to involve retrofitting individual heat pumps on a piecemeal basis.

4.4 Energy solution

A high-level commercial model has been produced based on the heat demands and heat capacities above. The model assumes a central heat pump solution providing 80% of the heat demand with 20% provided via gas boilers for peak heat loads and as back up plant. It may be possible to incorporate existing boiler plant into the network to reduce initial capital expenditure. Over time the gas back up boilers will need to be replaced with appropriate zero carbon technology (e.g. hydrogen or electric boiler plant).

There are a number of heat pump technologies that could be suitable ranging from air source, ground source, water source or potentially sewer source, and the suitability of each option will need to be assessed during a detailed feasibility phase. However, for the purposes of this commercial assessment a generic heat pump with a seasonal coefficient of performance ('SCoP') of 3.0 has been assumed. SCoP is analogous to efficiency, a value of 3.0 being equivalent to an efficiency of 300%, where one unit (kWh) of electricity powering the heat pump produces 3 units of heat.

Assuming a CO_2 emissions factor for grid supplied electricity of 0.136 kgCO_2/kWh and a CO_2 emissions factor for natural gas of 0.210 kgCO_2/kWh the average carbon content of heat supplied would be 0.100 kgCO_2/kWh which should allow the project to receive funding via the Green Heat Networks Fund. This carbon factor will track the carbon intensity of grid supplied electricity downward over time and when gas boilers are replaced as described above the district heat supply should be able to achieve zero carbon when the electricity grid does. Powering of the heat pumps via onsite or sleeved renewables could allow zero carbon heat supply to be achieved earlier.

No location for the energy centre has been identified as this will depend on the detailed assessment of the technology options although it has been assumed in the assessment that there will be a 5.0 km network operating at less than 80°C, the majority of pipework requiring hard dig for trenches. It may be possible to operate the heat network at less than 60°C but this will depend on the compatibility of the existing buildings in terms of their thermal efficiency and existing heating systems. The lower the network temperature the more efficient the operations can be.

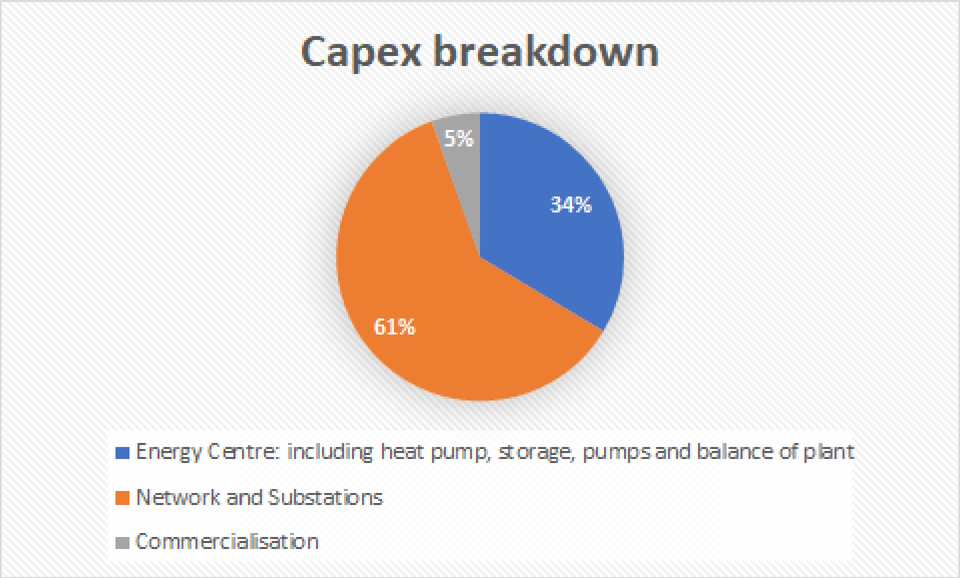
The DH solution would need to include thermal storage for intraday energy balancing (enable energy and economic efficiency in heat production) and peak demand management (enabling the capacity of heating plant to be reduced). There may also be potential for introducing seasonal energy storage arrangements to manage seasonal demand. This could be particularly of interest if a cooling network is also included. A cooling network has not been modelled at this time.

4.5 Costs and funding

The assumed capital cost of the DH energy system, based on the connections included in Table 6, has been calculated at £18.3m. This is a high-level estimate and will be subject to verification as part of the detailed feasibility work.

The capex is broken down between energy centre costs (including all utility connections, heat storage, pumps etc), heat network including substations, and commercialisation.

Figure 11: Capex breakdown



It has been assumed the DH scheme can be funded via a combination of connection fees from heat customers and grant funding (via the Green Heat Networks fund) with the balance via either Public Works Loan Board ('PWLB') Council borrowing or private sector investment. This will be subject to strategic decision on the appropriate commercial structure for Warwick District Council.

4.6 Customer proposition

The high-level commercial assessment has been developed on the basis that heat provision from the district heating scheme should ensure no disadvantage to heat customers compared against a zero-carbon counterfactual heating solution. The assumed zero-carbon counterfactual is an individual air source heat pump.

It is assumed that all existing buildings will need to replace their own heating systems with low carbon heating plant (most likely a heat pump) in the next 20 years and therefore connecting to the heat network avoids that future replacement cost. A connection charge for each heat customer is proposed, but at a significant discount compared to the cost of an individual heat pump solution.

Heat customers will be charged a fixed fee that covers the full maintenance and replacement cost of the heat substation, and a variable heat charge on a p/kWh basis. The heat substation (including heat exchangers and associated equipment) is the interface at the connection point between the heat network and each building's heating system.

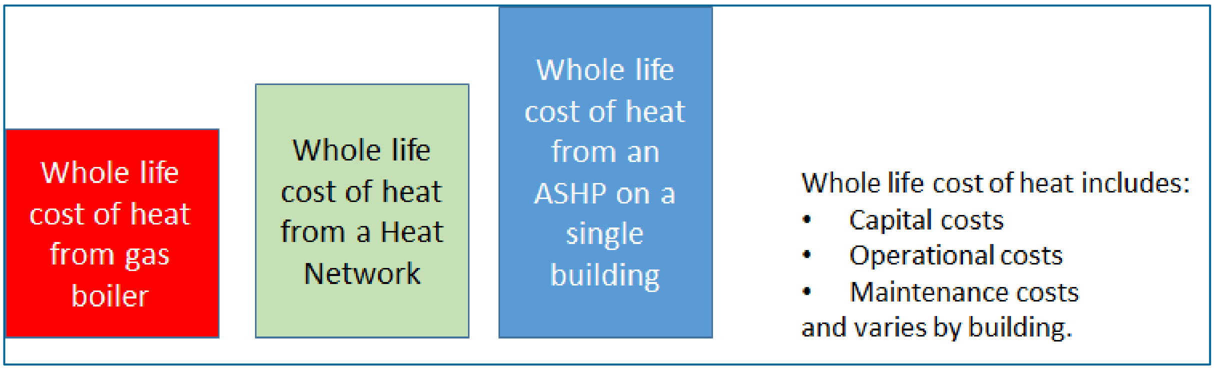
The ultimate charge to the customer will need to be determined once the full details of the scheme are known, but providing heating via a heat pump system will, unless subsidised, be higher than gas heating based on current prices for gas and electricity.

The energy related prices used in the commercial model are consistent with other city projects that are operational or in development, and where savings against counterfactuals (otherwise installed heating plant) have been demonstrated.

It should be noted that the whole life cost of heating via a DH system will, unless subsidised or the cost of gas increases, be more expensive than the current cost of gas heating. Based on the assumed commercial model however, it should be lower than the whole life cost of heating via an individual ASHP.

The proposed base case will provide for significantly decreased CO_2 emissions although the cost of operation (and thus to the consumer) based on current gas and electricity costs is likely to be slightly higher compared to gas boilers in each home. It is anticipated that completion of the DH scheme project will be a few years away and it is expected that during this period gas costs will increase from current low levels as carbon taxes transfer from electricity to gas, having the effect of raising the cost of gas based heating and reducing the cost of heat from both an individual heat pump and from a heat pump powered heat network.

Figure 12: Whole life cost comparisons

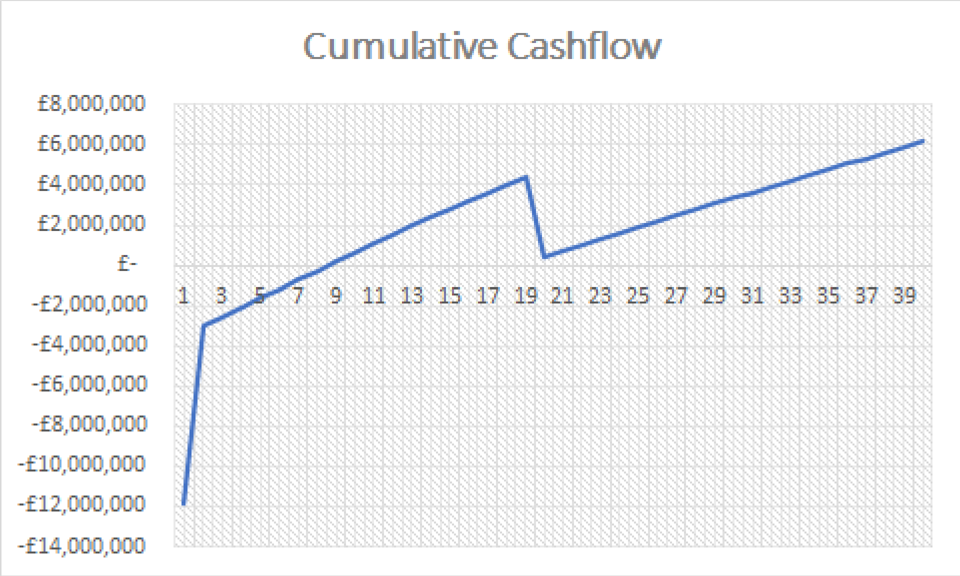


The commercial assessment does not include the costs associated with changes to existing secondary or tertiary heating systems in each building which are assumed to require modification to accommodate a local building level heat pump in any case.

4.7 Commercial summary

The commercial assessment of the project including the connections shown in Table 8 (total heat demand 28.9 GWh/yr) indicates a 40 year real, pre-tax internal rate of return ('IRR') of 7.5%, with non-discounted positive cashflows of £6.1m.

Figure 13: Project cumulative cashflow



4.8 Risks

The significant potential risks associated with the roll out of a DH scheme include the following.

- Capital programme risk – this can be mitigated via the contractual process.
- Demand risk – this can be mitigated via charging for both capacity and demand to reduce exposure plus ensuring upfront demand assessment is properly carried out.
- Connection risk – likely to be the biggest risk at the outset of the project. WDC can mitigate this through planning policy requiring new developments to connect, heat zoning, upfront contracting, and competitive pricing or via concession arrangements.
- Capability risk – undertaking this type of project will require expertise and appropriate technical support, which can be part-funded by BEIS through the Heat Networks Delivery Unit ('HNDU').

4.9 Growth

DH networks are easily expandable and generally work best at scale. Therefore, the Myton development area can be seen as a catalyst for a Warwick wide DH scheme.

Cities such as Bristol, Birmingham, Exeter etc have already embraced DH and are developing several networks as part of their decarbonisation plans.

4.10 Planning & environmental considerations

DH comprising a network of subterranean insulated pipes distributes heating and/or cooling in the form of hot or chilled water from a local energy centre, which may include for example heat pumps, bioenergy or combined heat & power ('CHP') plant, and delivers this heating and cooling directly to homes and businesses.

The construction and installation of a DH network usually meets the definition of 'development' under the Town and Country Planning Act 1990, requiring planning permission. There are, however, some instances where planning permission for such works is not required, such as:

- Permission as part of a wider development;
- Local authority permitted development rights;
- Electricity undertaker permitted development rights;
- De minimis treatment of DH works; and
- Adoption of a Local Development Order.

New development will be required to adhere to policy requirements to connect to DH networks, or include future proofing measures, unless it has been demonstrated that it is not feasible and viable to do so. A commitment to connection may be secured via a legal agreement (Section 106).

Planning considerations in relation to DH would include:

- The size of the development and the heat load and energy demands;
- The distance of the proposal from DH network;
- The presence of physical constraints, such as main roads and railway lines;
- The cost of connection and the impact this has on financial viability;
- What efforts the applicant has made to secure agreements to create a new network through connection with nearby buildings or estates;
- The distance from the development of planned DH networks;
- The proximity of any public sector buildings with communal heating systems especially uses such as swimming pools, hospitals and large housing estates;
- Land use mix of proposed development;
- Land use mix and density of surrounding built environment.

In addition to securing planning permission there may be other consents which must be in place before work can commence. These include the need for permits under the Environmental Permitting Regulations ('EPR') should these be required. Any works undertaken in Air Quality Management Areas ('AQMA') may also require additional approval under the Clean Air Act 1993 ('CAA'). In order to implement elements of a scheme that fall within the highway, it may also be necessary to secure a Street Works Licence under Section 50 of the New Roads and Street Works Act ('NRSWA') 1991.

4.10.1 Myton study area

A significant barrier to the provision of a heat network is the density required to facilitate it. The area surrounding the Myton study area features two major housing allocations, HO1 and H46A, which are allocated to deliver 1,840 dwellings across the plan period. If considered early in the design process, the associated infrastructure for the network can be provided early in the construction of the development. The provision of a heat network itself is not a planning consideration; however, the location of the energy centre would need to be considered within the overall masterplan, and would be permitted subject to environmental constraints and impacts on nearby receptors.

The impacts of the energy plant will need to be fully considered throughout the detailed design of the Myton area Masterplan. Their impact is dependent on the scale of the development, in addition to associated noise from operation of the plant. Given the urban environment of the Myton study area it is likely that these structures can be incorporated into the overall design of the scheme; however, potential impacts on designated heritage assets such as Warwick Castle nearby should be fully considered.

Once the method for powering the heat pumps has been determined, pre-engagement with WDC statutory consultees is recommended to determine whether the method of heating is suitable for the location. For instance, in the case of combustion (whether renewable or fossil fuel power) this is likely to require full consideration from WDC, including air quality and noise from the Environmental Health Officer. Where an alternative source of heat can be found, such as low grade heat or external industrial processes to provide the energy to the scheme, it is unlikely that the proposal will face significant constraints to planning permission.

4.11 Next steps

This high-level assessment will need a more detailed feasibility study and business case development. This work can usually be part funded by HNDU funding.

This next step should undertaking a detailed compatibility review, demand assessment, network routing, heat source options assessment, stakeholder and customer engagement, technical economic modelling and commercial structuring optioneering.

4.12 Conclusions

Having reviewed the available documentation, met with Officers of the Council and undertaken a review of potential solutions it is the conclusion of this section that a DH scheme as set out should be viable for delivery. This report should be considered with the following points in mind:

1. This sets out a base case for delivery and as such presents a worst case (which has been found to be feasible. It would be recommended at the next stage to search for mitigants – such as technology advancements – to improve the business case.
2. In section 2 of this study, significant opportunities for solar PV development have been identified. Private wire of such generation could be used to significantly improve the economics for heat pump-based heating systems. Thus it would be recommended to consider how other low carbon developments could be utilised to further WDC’s net zero ambitions.
3. Should WDC progress to deliver a hydrogen hub as identified in section 3, there is the potential for use of over-produced hydrogen as a fuel for DH schemes. Thus, in line with exploring the use of solar PV for heat pump systems it would be recommended that hydrogen-based systems are also explored.

Finally, as set out in the general conclusions to this study, it is recommended that the delivery of a DH scheme for Myton should be undertaken alongside a broader heat decarbonisation strategy for the district and beyond as there is the potential for economies of scale and benefiting from the latest technologies.

5 Micro-generation

5.1 Introduction

The following section assesses the opportunities for micro-generation renewable energy technologies for Council-owned housing stock within Warwick, Leamington and the wider district, principally from the viewpoint of replacing existing gas and electric heating systems. The analysis focusses on heat, as this is traditionally the more difficult area to address, and also where significant reductions in carbon emissions can be made. Building roof mounted solar PV is also considered, in the context of synergy with heat pumps.

Site visits carried out included an outline examination of the majority of medium and high-rise residential buildings identified by the Council as typical of the types of buildings and sites included within the housing portfolio, as well as a sample of low rise semi-detached and terraced property.

Energy demand, energy supply, CO_2 emissions and financial aspects are assessed in the following sections.

5.2 Building details

The following section provides details of Council-owned residential buildings to be included in the assessment of microgeneration technologies.

The Client has provided the following maps showing locations (in purple) of the majority of Council-owned residential property in Warwick, Leamington and Kenilworth. It is noted that there is additional Council-owned property present in other areas of the district, and therefore not all properties are shown on these maps.

Figure 14: Locations of Council-owned residential property in Warwick

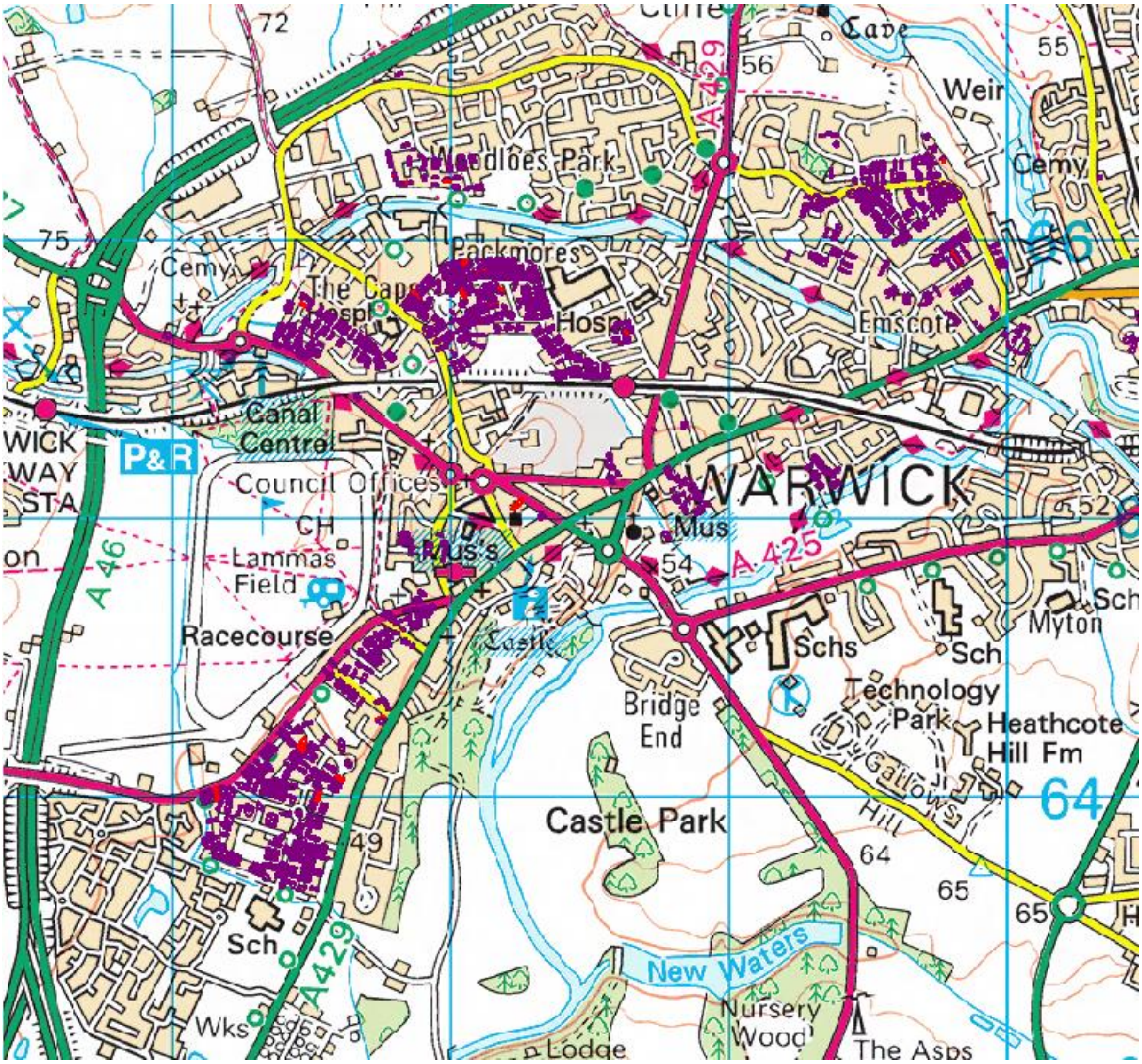


Figure 15: Locations of Council-owned residential property in north Leamington

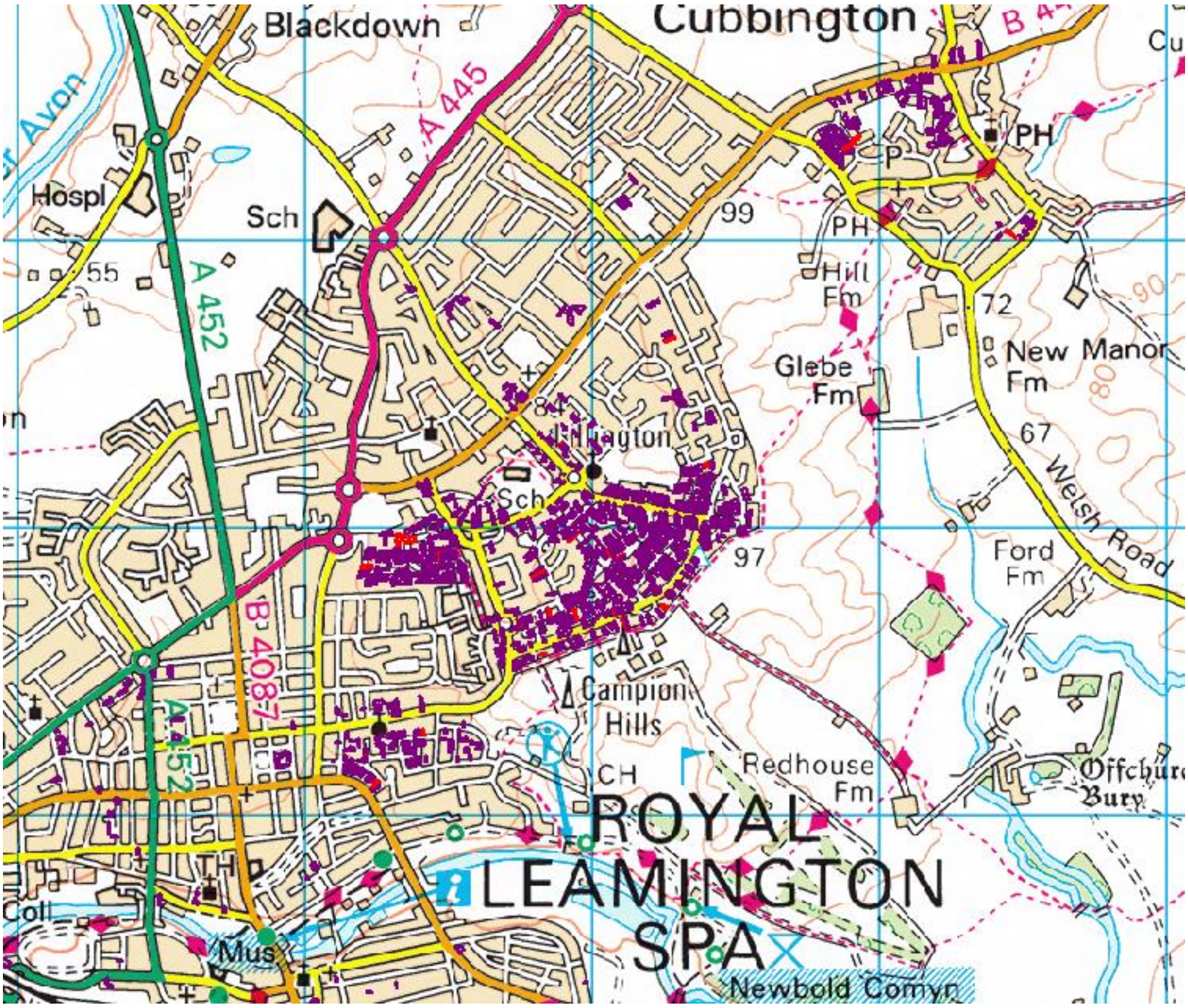


Figure 16: Locations of Council-owned residential property in south Leamington

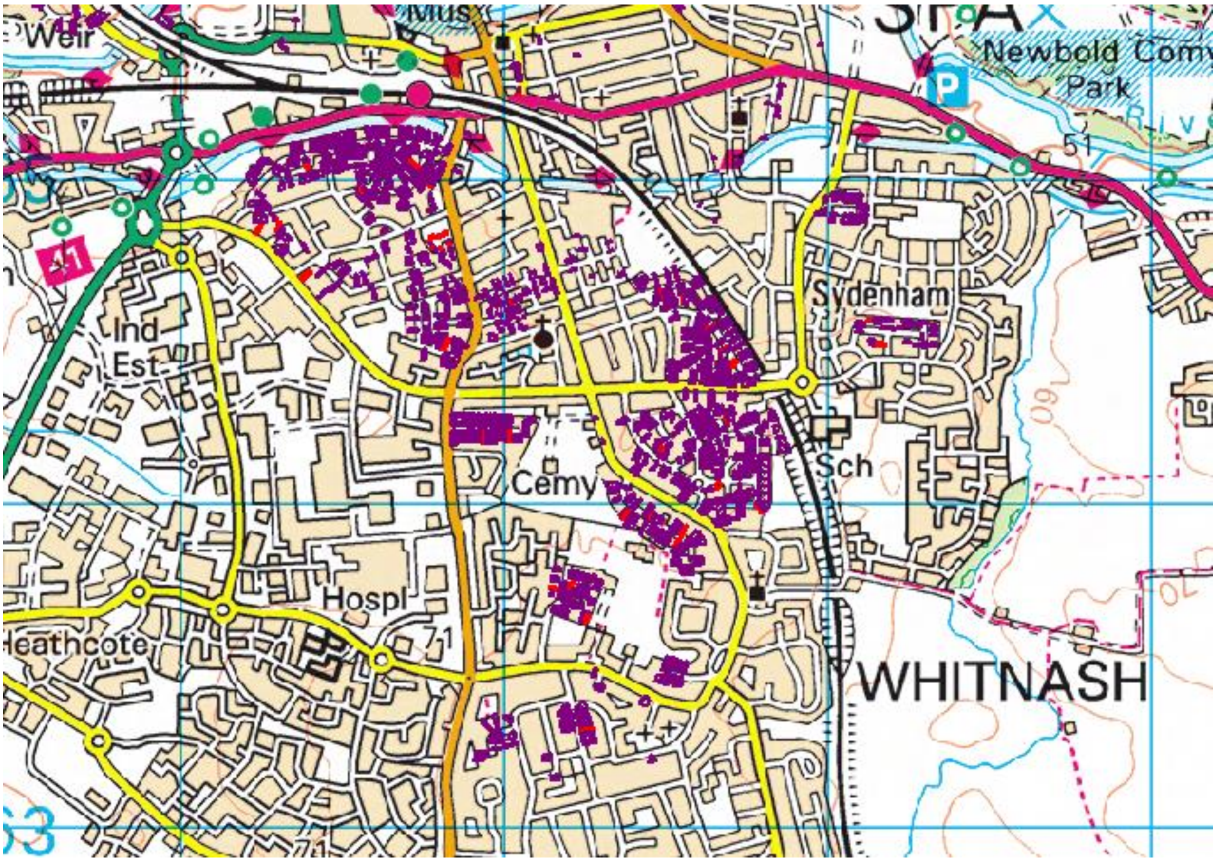
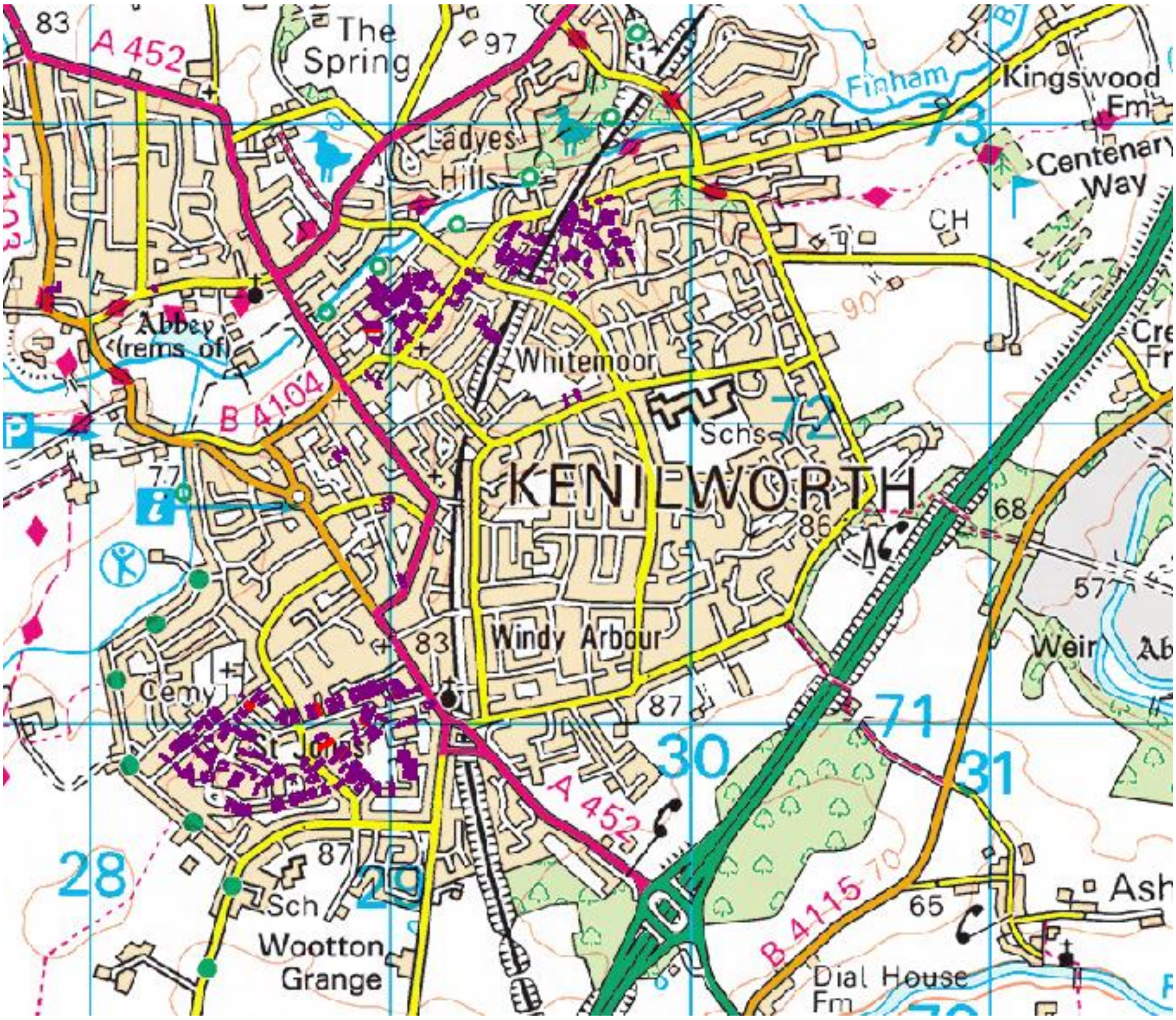


Figure 17: Locations of Council-owned residential property in Kenilworth



Council-owned residential property is dispersed throughout Warwick district, and includes blocks containing multiple individual residential units, sheltered housing, and low rise individual semi-detached and terraced property. The locations and numbers of individual dwellings in each area, and including additional properties planned in the future, are shown in Table 9 below.

Table 9: Council-owned residential property

Location	No. of residential properties - existing	No. of residential properties - planned
Warwick:		
All Saints & Woodloes	578	
Aylesford	449	
Myton & Heathcote	41	54
Saltisford	615	

Location	No. of residential properties - existing	No. of residential properties - planned
Leamington:		
Brunswick	1044	6
Clarenden	412	
Lillington	1194	
Milverton	177	
Willes	220	
Kenilworth:		
Abbey & Arden	106	
Park Hill	287	
St John's	291	
Other areas:		
Whitnash	202	
Bishop's Tachbrook	90	63
Budbrooke	95	
Radford Semele	87	26
Cubbington & Leek Wootton	199	
Totals	**6,087**	**149**

Details of blocks of residential property, including standard and sheltered housing type, are shown in Table 10 below. All standard residential blocks are located in Leamington.

Table 10: Blocks of residential property

Buildings	Details	No. of residential units
Standard residential – high rise		
Southorn Court	Constructed 1970s, 8 storey, electric heating in each flat	46
Eden Court	Constructed 1960s, 15 storey, electric heating in each flat	90
Ashton Court	Constructed 1970s, 8 storey, electric heating in each flat	46
Stamford Gardens	Constructed 1960s, 7/9 storey, electric heating in each flat	74
Westbrook House	Constructed 1970s, 11 storey, electric heating in each flat	33
Radcliffe Gardens	Constructed 1960s, 5/11 storey, 4x central gas boilers in basement boiler room	66

Buildings	Details	No. of residential units
Christine Ledger Square	Constructed 1960s, 11 storey, majority individual gas boilers, some electric heating	66
Standard residential – medium / low rise		
Oakfield House	Constructed TBC, 4 storey, heating system TBC	16
Kennedy Square	Constructed TBC, 4 storey, heating system TBC	82
St. Paul's Square	Constructed TBC, 4 storey, heating system TBC	43
Sheltered housing		
Acorn Court (Leamington)	Constructed 1980s, 1/2/3 storey, central gas boilers & CHP[56] plant (5.5kWe 12kWth)	46
James Court (Warwick)	Constructed 1987, 1/2/3 storey, central gas boilers (2x 100kW - 2010)	28
Yeomanry Close (Warwick)	Constructed 1983, 2/3 storey, central gas boilers (2x 164kW - 1983)	42
Charles Gardner Road (Leamington)	Constructed 1960s, 2 & 5 storey, individual gas boilers	60
Chandos Court (Leamington)	Constructed 1991, 2/3 storey, 4x central gas boilers & CHP plant (5.5kWe 12kWth)	48

For low rise semi-detached and terraced property we have assumed that the majority are heated using individual gas boilers, with the remainder heated using electric night storage heaters and immersions.

We note from the site survey that the CHP units located at Acorn Court and Chandos Court appeared to be out of service.

A summary of all Council-owned residential property, split by type, is shown in Table 11 below.

Table 11: Summary of Council-owned residential property - split by type

Type	No. of blocks	Total no. of residential units
Multi-residential blocks – high rise	7	421
Multi-residential blocks – medium / low rise	3	141
Sheltered housing blocks	5	224
Low rise semi-detached and terraced houses & flats	-	5,301
Total		**6,087**

[56] Combined Heat & Power

5.3 Energy demand assessment

A high-level energy demand analysis has been carried out considering individual residential properties and communal areas within each property type described in the section above.

Estimates of heat loads and heat demands for all property types are shown in Table 12 below.

Table 12: Heat demand analysis

Buildings	Estimated average peak space heat load per unit (kW)	Total peak space heat load (kW)	Average annual heat demand per unit (kWh/yr)	Total annual heat demand (kWh/yr)
Standard residential blocks – high rise				
Southorn Court	3.0	138	6,200	285,200
Eden Court	3.0	270	6,200	558,000
Ashton Court	3.0	138	6,200	285,200
Stamford Gardens	3.0	222	6,200	458,800
Westbrook House	3.0	99	6,200	204,600
Radcliffe Gardens	3.0	198	6,200	409,200
Christine Ledger Sq.	3.0	198	6,200	409,200
Standard residential blocks – medium / low rise				
Oakfield House	3.6	58	7,040	112,640
Kennedy Square	3.6	295	7,040	577,280
St. Paul's Square	3.6	155	7,040	302,720
Sheltered housing				
Acorn Court	3.0	179	7,000	388,240
James Court	3.0	109	7,000	236,320
Yeomanry Close	3.0	164	7,000	354,480
Charles Gardner Road	3.0	234	7,000	506,400
Chandos Court	3.0	187	7,000	405,120
Low rise individual houses & flats				
Houses & flats	5.3	27,830	9,550	50,624,550
All property				
Totals	**-**	**30,474**	**-**	**56,117,950**

The total peak heat load of all Council owned domestic property, following implementation of energy efficiency measures to achieve specific maximum peak heat loss, is approximately **30.5 MW**, equivalent to an annual space heating and HW demand of around **56.1 GWh.**

Estimates of peak space heat loads are based on an assumption that all properties will have undergone a 'medium' level intervention of energy efficiency measures, as appropriate to each property, including application of the following where required.

- Installation of 300mm thick mineral wool loft insulation.
- Installation of cavity wall insulation (it is anticipated that this has already been carried out).
- Replacement PVC-framed double glazed windows and doors.
- Draughtproofing to reduce uncontrolled outside air infiltration.
- Any additional measures as required resulting from a thermography test to detect specific areas of high heat loss in the building envelope (e.g. issues identified with wall insulation and thermal bridges).

It is noted from the survey of an empty property in Ashton Court that all windows were double glazed, appear to have been recently fitted, and are in generally good condition.

In addition, the figures in the table above and further analysis includes the following assumptions.

- Living (heated) floor area:
  - Standard residential blocks - high rise: 60m^2 per unit.
  - Standard residential blocks – medium / low rise: 60m^2 per unit.
  - Sheltered housing: 50m^2 per unit plus 30% of residential floor area for communal areas.
  - Low rise individual houses & flats: 75m^2 per unit.
- Estimated average peak space heat load:
  - Standard residential blocks - high rise: 50 W/m^2.
  - Standard residential blocks – medium / low rise: 60 W/m^2.
  - Sheltered housing: 60 W/m^2.
  - Low rise individual houses & flats – 70 W/m^2.
- Space heat demand estimate for all property except sheltered housing based on 1,400 peak load equivalent heating hours per year.
- Space heat demand estimate for sheltered housing based on 1,600 peak load equivalent heating hours per year.
- Estimated average domestic hot water ('HW') demand, per residential unit:
  - Standard residential blocks - high rise: 2,000 kWh/yr.
  - Standard residential blocks – medium / low rise: 2,000 kWh/yr.
  - Sheltered housing: 2,200 kWh/yr.
  - Low rise individual houses & flats: 2,200 kWh/yr.

Estimated electricity demand per unit is based on Ofgem Typical Domestic Consumption Values[57] ('TDCV') for electricity under Electricity Profile Class 1 (no electric heating):

- Standard residential blocks – high rise - average of 'Low' and 'Medium': 2,350 kWh/yr.
- Standard residential blocks – medium / low rise – average of 'Low' and 'Medium': 2,350 kWh/yr.
- Sheltered housing - 'Low': 1,800 kWh/yr.
- Low rise individual houses & flats – 'Medium': 2,900 kWh/yr.

[57] https://www.ofgem.gov.uk/gas/retail-market/monitoring-data-and-statistics/typical-domestic-consumption-values

5.4 Microgeneration technology assessment

5.4.1 Technology

The assessment of building-integrated microgeneration technology options is based on the characteristics of each type of property, and opportunities and constraints associated with the surrounding site.

Renewable heating technologies considered include ground source heat pumps (‘GSHPs’) and air source heat pumps (‘ASHPs’) to provide space heating and domestic HW, both as domestic scale equipment supplying heat to individual residential properties, and at larger scale supplying heat to buildings containing multiple residential units as part of a communal heating system. Within the urban environment GSHPs typically include vertical closed loop borehole heat collectors, due to land area restrictions, and these can be connected to each heat pump as an individual system, or alternatively can be sized to serve a number of heat pumps and therefore a number of individual properties, from a ‘shared heat collector’.

For heat pumps to operate at their highest year-round efficiency, heat supply temperatures should be as low as possible, usually lower than those typically delivered from a gas boiler and standard radiator heating system. Where standard heat pumps are supplying heat via radiators the maximum supply temperature is typically 50°C, and this dictates that radiators need to be larger compared to those receiving heat from boilers with supply temperatures typically between 60 - 80°C, to deliver the same kW output to each room. High temperature heat pumps can supply heat at temperatures close to standard radiator temperatures, and this option is useful in the case of heat pump retrofit in smaller dwellings currently heated using gas boilers. Heat pump operating efficiency is defined by its seasonal coefficient of performance (‘SCoP’).

Electrically driven heat pumps require a minimum electrical supply capacity, of a size dependent upon the heat output capacity and coefficient of performance (‘CoP’) of the heat pump, and also the internal design, and operation on start-up (ref. direct or inverter driven compressor). Individual domestic scale heat pumps deployed in a piecemeal fashion within an urban environment are not likely to cause issues on the local electricity network, assuming that the electrical capacity of the heat pump can be accommodated within the individual property’s existing supply, taking account of its capacity and the maximum existing electrical load. A large-scale uptake of heat pumps within a defined area however may cause capacity and operational issues on the local network supply, with limits being potentially reached on the existing capacity of transformers, switchgear and cables, and proposals for a project of this type will require a network assessment to be carried out by the local distribution network operator (‘DNO’), the cost of which may be covered through the public service obligation, however for a study covering a large area as in this case would need to be confirmed through discussion with the DNO, given the extent of the network analysis work required.

Based on information available from the British Geological Survey (‘BGS’) the local bedrock conditions in the Warwick and Leamington area comprise sedimentary formations, and these include Mercia Mudstone Group (mudstone – and according to local borehole data includes alternating layers of mostly mudstone, sandstone and siltstone), Tarporley Siltstone Formation (siltstone, mudstone and sandstone) and Helsby Sandstone Formation (sandstone). This mix of bedrock conditions extends across Warwick and Leamington, and would not be detrimental to the viability of GSHPs connected to closed loop heat collectors.

Both GSHPs and ASHPs can operate in combination with solar thermal hot water (‘STHW’) systems where suitable unshaded roof space is available, either flat or pitched with orientation between due east and due west (180°). Solar collectors provide pre-heat to domestic HW storage thereby reducing the annual heat required to be delivered by the heat pump.

Biomass boilers are not considered in the assessment due to environmental and health issues associated with boiler flue emissions in the urban environment, and increased traffic movements from fuel deliveries.

Roof mounted solar PV panels can be installed where suitable unshaded roof space is available, including flat roofs, and pitched roofs with an orientation generally south or up to 90° to the east or west. The viability of solar PV is specific to each individual building, and an initial desktop survey of all Council-owned property would be required to determine the number of properties potentially suitable, and the approximate roof area available in order to estimate PV array size, kWp capacity and electricity generation. Where suitable conditions exist an appropriately sized PV system when combined with a heat pump is likely to enable around 75% of annual electricity generation to offset otherwise imported electricity, where suitable controls prioritise HW production by the heat pump where possible during periods of high PV generation.

5.4.1.1 Multi-residential buildings

Multi-residential buildings are assessed for individual GSHPs installed in each flat and connected to shared borehole heat collectors located in the available land area in close proximity to each building. This concept has been applied to a number of similar types of property in recent years, notably by Enfield Council which has converted 8 tower blocks containing a total of 400 flats, replacing electric heating systems. It is noted that these projects were able to take advantage of the non-domestic Renewable Heat Incentive (‘RHI’) which provided 20 years of index-linked payments against the capital cost of the installation, based on deemed heat demand from the EPC of each property. This financial support measure is no longer available, having ended to new projects in March 2021. There is currently no similar replacement financial support scheme for connected residential properties. The domestic RHI which supports the installation of renewable heating equipment for individual properties (not connected via a heat network) is due to end to new applications in March 2022, is expected to be replaced by a Clean Heat Grant, worth £4,000 per property.

The individual GSHPs and shared heat collector project as applied to Southorn Court or Ashton Court is assessed below. The buildings are understood to be similar in terms of design and size, each containing 46 flats, and therefore the analysis can be applied to either. The GSHPs would supply 100% of space heating and HW demand in place of existing electric storage heaters and HW cylinder immersions, which are understood to operate predominantly on cheaper night-rate electricity.

A summary of the energy analysis for Southorn Court or Ashton Court is provided in Table 13 below.

Table 13: Ground source heat pump analysis summary - Southorn Court / Ashton Court

Parameter	Value
Heat pumps	
Estimated heat supply temperature from heat pumps for space heating (°C)	50
Estimated heat supply temperature from heat pumps for HW (°C)	65
Peak space heat load of areas to be heated by heat pumps (kW)	138.0
Estimated space heat demand of areas to be heated by heat pumps (kWh/yr)	193,200
Estimated percentage of peak space heat load provided by heat pumps	100%
Estimated percentage of space heat demand provided by heat pumps	100%
Estimated space heat generated by heat pumps (kWh/yr)	193,200
Estimated HW generated by heat pumps - (kWh/yr)	92,000
Total heat generated by heat pumps (kWh/yr)	285,200
Heat pump provisional heat output capacity at design conditions (kW)	3.0
Heat pumps total heat output capacity at design conditions (kW)	138.0
Heat pumps estimated SCoP	3.00
Maximum power extracted from ground (heat pumps evap. capacity) (kW)	92.0
Heat pumps electrical capacity (kW)	46.0
Heat pumps electricity consumption (kWh/yr)	95,067
Heat extracted from ground (kWh/yr)	190,133
Electrical supply capacity requirement (A)	212.0
Heat collector circulation pumps energy (kWh/yr)	5,704
Total electricity consumption of heat pump system (kWh/yr)	100,771
Heat pumps FLEQ run hours (hours/yr)	2,067
Heat collector	
Estimated average ground temperature - undisturbed condition (°C)	9.7
Estimated ground thermal conductivity (W/m/K)	2.2
Maximum power to be extracted per unit length of heat collector (W/m)	33
Total length of ground collector (m)	2,788
Initial estimated depth of boreholes (m)	200
Number of boreholes at approximate estimated borehole depth	14
Estimated spacing between boreholes (m)	8.0
Number of boreholes - length	7
Number of boreholes - width	2
Borehole array length (m)	48
Borehole array width (m)	8
Borehole array area (m^2)	384

Each heat pump and new HW cylinder would be installed in the airing cupboard in each flat, which based on an inspection of a vacant property in Ashton Court is considered to be of sufficient size, with the existing HW cylinder removed. Uninsulated polymer flow and return pipework allowing circulation of water and glycol mix at low temperature would route from each heat pump through to communal areas on each floor of the building, down through existing risers and outside the building, connecting to the manifold at the borehole array below ground. The existing storage heaters in each room would be removed, and a new radiator system installed, with radiators sized to provide the kW heat output required in each room based on a supply temperature of 50°C, and return temperature around 41°C, in order to provide a high SCoP and lowest running costs for tenants.

Heat pump SCoP relates to the heat supply temperature (and in this case ground temperature) and assumes a heat pump supply temperature of 50-55°C, which would be possible where oversized radiators are fitted. The analysis assumes that a certain minimum level of building energy efficiency is implemented prior to implementation of the GSHP project.

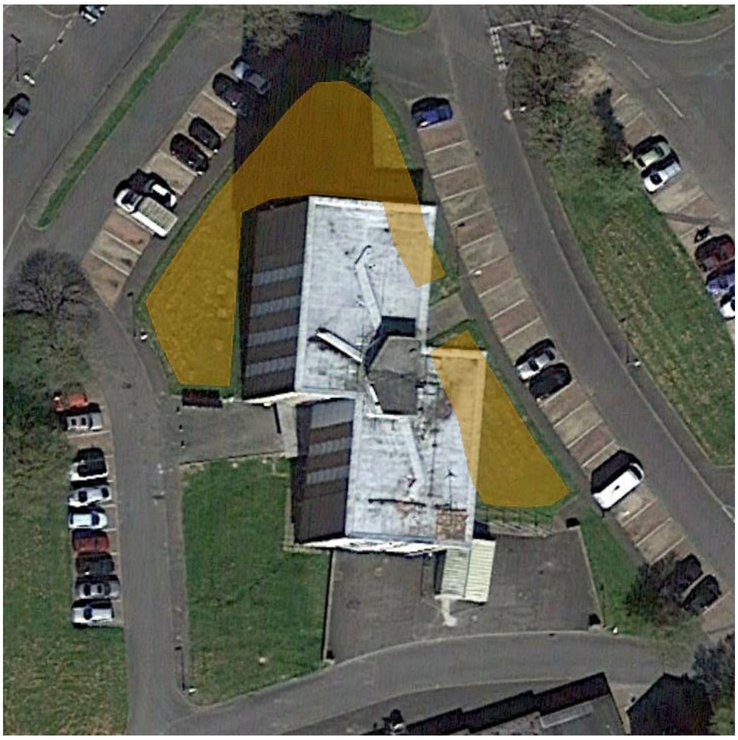
Space available on the building roof could provide an opportunity to include solar energy systems, either STHW system or solar PV, or potentially both as separate systems or combined as a PVT system. A solar thermal system could provide heat to HW cylinders, reducing the heat required to be generated by the heat pumps. Insulated flow and return pipework would route from the roof mounted collector panels through the risers and inside each property, to an additional heating coil at the base of each HW cylinder. A suitably sized STHW system to supply heat to all properties, assuming sufficient space is available on the building roof for the quantity of collector panels required, discounting existing obstructions, would typically supply around 50% of HW demand, around 1,000 kWh/yr per property, or 16% of total heat demand (space heating & HW). CO_2 emissions savings would be relatively small, reducing over time reflecting the reduction in the CO_2 emissions intensity of grid as an increasing number of renewable and low carbon energy generators provide electricity to the grid, in place of fossil fuelled plant. The installation of this system is likely to be complex due to restricted access to install insulated pipework, compared to installation of plain plastic pipework.

An example location of a suitably sized borehole array within land area available to the east of Southorn Court is shown in Figure 18 below.

Figure 18: Southorn Court showing example location of borehole array

An example location of a suitably sized borehole array within land area available to the east, north and west of Ashton Court is shown in Figure 19 below.

Figure 19: Ashton Court showing example location of borehole array



Based on the analysis and site survey, and an estimate of the available land area required for boreholes based on peak heat loads and annual heat demands of each building, we consider that in addition to Southorn Court and Ashton Court, the above design concept can in principle be applied to the following buildings:

- Eden Court
- Stamford Gardens
- Westbrook House
- Christine Ledger Square
- Kennedy Square
- St. Paul's Square

In the case of Radcliffe Gardens the central gas boilers could be replaced by heat pumps, connecting to the existing communal system supplying heat to each flat, or alternatively individual heat pumps could be installed in each flat as described for Southorn Court / Ashton Court above, space and access permitting, allowing all central boiler plant and equipment to be removed.

It should be noted that further detailed assessment of the project will be required in order to confirm feasibility and costs, including proposed energy efficiency measures, confirmation of peak heat loads and annual heat demands, determination of suitability of ground conditions and confirmation of heat collector sizing, available space within each property for the heat pump and HW cylinder, radiator requirements, sufficient electrical capacity for the heat pump equipment, access within risers for water/glycol pipework, existing utilities in the area proposed for boreholes and connecting pipework etc.

It is noted that existing radiator systems in Radcliffe Gardens and Christine Ledger Square will likely require replacement with larger units, to match existing units' kW output based on lower operating temperatures.

5.4.1.2 Sheltered housing

Based on an assessment of open land area in close proximity, we consider Acorn Court and James Court buildings to be potentially suitable for a central GSHP system. Heat pumps would be installed in place of existing gas boiler plant (and CHP plant in the case of Acorn Court), supplying the communal heating system to all apartments and communal areas, depending on the availability of the land identified nearby for borehole heat collectors.

A summary of the analysis for Acorn Court is provided in Table 9 below. The analysis for James Court is similar, with peak heat load and heat demand around two-thirds those of Acorn Court, based on a comparison of the number of individual residential units and building floor area. Alternatively James Court could be connected to a district heat network serving the Myton area, should a scheme be implemented, as the building is located a short distance to the north of the Myton area boundary, and close to St. Nicholas Park Leisure Centre and Coten End Primary School, both of which are included as connections to a potential heat network.

A summary of the energy analysis for Acorn Court is provided in Table 14 below.

Table 14: Ground source heat pump system analysis summary - Acorn Court

Parameter	Value
Heat pumps	
Estimated heat supply temperature from heat pumps for space heating (°C)	50
Estimated heat supply temperature from heat pumps for HW (°C)	65
Peak space heat load of areas to be heated by heat pumps (kW)	179.4
Estimated space heat demand of areas to be heated by heat pumps (kWh/yr)	220,800
Estimated percentage of peak space heat load provided by heat pumps	100%
Estimated percentage of space heat demand provided by heat pumps	100%
Estimated space heat generated by heat pumps (kWh/yr)	220,800
Estimated HW generated by heat pumps - (kWh/yr)	101,200
Total heat generated by heat pumps (kWh/yr)	322,000
Space heating heat pumps output capacity at design conditions (kW)	180.0
HW heat pump output capacity at design conditions (kW)	30.0
Heat pumps total heat output capacity at design conditions (kW)	210.0
Heat pumps estimated SCoP	3.75
Maximum power extracted from ground (heat pumps evap. capacity) (kW)	153.6
Heat pumps electrical capacity (kW)	55.8
Heat pumps electricity consumption (kWh/yr)	85,867
Heat extracted from ground (kWh/yr)	236,133

Parameter	Value
Electrical supply capacity requirement (A)	83.5
Heat collector circulation pumps energy (kWh/yr)	6,440
Total electricity consumption of heat pump system (kWh/yr)	92,307
Heat pumps FLEQ run hours (hours/yr)	1,538
Heat collector	
Estimated average ground temperature - undisturbed condition (°C)	9.7
Estimated ground thermal conductivity (W/m/K)	2.2
Maximum power to be extracted per unit length of heat collector (W/m)	38
Total length of ground collector (m)	4,041
Initial estimated depth of boreholes (m)	200
Number of boreholes at approximate estimated borehole depth	20.2
Estimated spacing between boreholes (m)	8.0
Number of boreholes - length	7
Number of boreholes - width	3
Borehole array length (m)	48
Borehole array width (m)	16
Borehole array area (m^2)	768

Two heat pumps providing space heating and one high temperature heat pump providing HW, plus a new HW storage tank would be installed in the existing boiler room, in place of the existing boilers and CHP plant. Flow and return pipework circulating water and glycol mix at low temperature would connect the heat pumps from the plant room to the manifold at the borehole array, with pipework buried below ground. Existing radiators and convector units would be assessed for suitability for lower heating temperatures, and likely replaced with larger units, sized to provide the kW heat output required in each room based on a supply temperature of 50°C, and return temperature around 41°C.

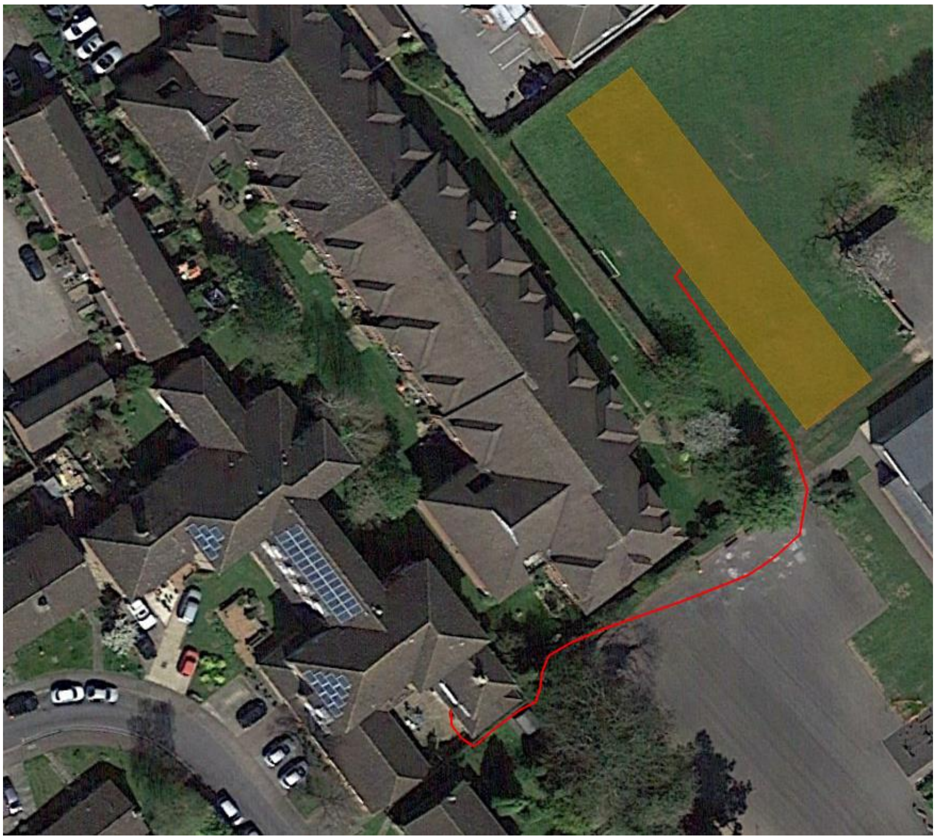
The central section of the building features an unobstructed section of south facing roof with a slope of approximately 20° from horizontal, which is reasonably short distance from the boiler room. STHW collectors or a PVT system installed on this roof area could provide additional heat to the new HW storage tank, reducing the heat required to be generated by the heat pumps. Insulated flow and return pipework would route from the collector panels through the roofspace and drop down into the boiler room to connect to an additional heating coil at the base of the HW tank. Based on a desktop analysis and visual inspection, around 40m^2 of roof area is available for STHW collectors, translating to an estimated HW generation of approximately 15,000 kWh/yr assuming 30m^2 area of collector panels and a sufficiently large HW storage tank can be accommodated, equal to 15% of estimated total annual HW demand. The associated CO_2 emissions savings would be relatively small, and reducing over time reflecting the reduction in the CO_2 emissions intensity of the electricity grid as an increasing number of renewable and low carbon energy generators replace of fossil fuelled generating plant.

A provisional location of a suitably sized borehole array within land area available to the north of Acorn Court building is shown in Figure 20 below. We understand that this land is owned by Warwickshire County Council, and would require a partnership approach for use for the heat collector.

Figure 20: Acorn Court showing example location of borehole array and connecting pipework route

An example location of a suitably sized borehole array within the playing field of Coten End Primary School, to the northeast of James Court is shown in Figure 21 below.

Figure 21: James Court showing example location of borehole array and connecting pipework route



The installation of boreholes, manifold and interconnecting pipework could be carried out outside of term time, ideally over the summer holiday period. Following completion of the installation all excavations would be backfilled and grassed over, allowing continuation of current use.

It should be noted that further detailed assessment of each project will be required in order to confirm feasibility and costs, including proposed energy efficiency measures, confirmation of peak heat loads and annual heat demands, determination of suitability of ground conditions and confirmation of heat collector sizing, land agreements, available space within the boiler room for new heat pumps and HW storage, space heating system requirements, sufficient electrical capacity for heat pump equipment, existing utilities in the area proposed for boreholes and connecting pipework etc.

Other sheltered housing developments including Yeomanry Close and Chandos Court are not close to land of suitable area for the required quantities of borehole heat collectors for GSHPs, and therefore these buildings are assessed for central ASHPs to replace existing gas boilers, and existing gas CHP plant in the case of Chandos Court. The design and operation principles for retrofit of ASHPs are as described for GSHPs above, however with the additional considerations of suitable locations for external evaporator units, in respect of available space and noise, and lower operating efficiency compared to GSHPs.

5.4.1.3 Low rise residential

Low rise residential property is assumed to include a mix of houses and flats, semi-detached and terraced, with each individual dwelling including either a gas boiler (system or combi type) supplying a conventional radiator system, plus a HW storage cylinder in the case of a system boiler, or electric night storage heaters and an electrically heated HW storage cylinder. It is anticipated that the majority of these properties include gas boiler heating systems. The split between the numbers of gas and electric heating systems in unknown, but for the purposes of the analysis it is assumed that 80% of properties are currently heated using a gas boiler and radiator system, and 20% electric storage heaters and immersions.

Where low carbon heat supply via district heating is not feasible, the decarbonising of heat for existing domestic properties will be reliant on the large scale roll out of retrofit heat pumps. The type of heat pump will depend on the local conditions, with the typical urban environment dictating the use of individual ASHPs as available land will be limited. Where there is access to suitable open land areas or water sources, GSHPs or water source heat pumps (‘WSHPs’) may be possible, however the opportunities for these alternatives are likely to be limited in the majority of situations.

Given the total number of Council-owned properties, and excluding other types of property examined above, decarbonisation through elimination of gas consumption and reduction of electricity consumption will require the retrofit of around 5,300 domestic heat pumps into individual properties across the district. Properties will require installation of an outdoor heat pump evaporator unit, indoor unit and likely also a new HW cylinder, including interconnecting pipework and controls. It is expected that building energy efficiency upgrades to reduce heat demand would be included as part of the project. Properties with electric heating will require new radiator systems and HW cylinders, properties with gas boilers will either retain existing radiators where high temperature heat pumps are installed, or will otherwise require larger radiators in the case of standard heat pumps supplying heat at around 50°C, along with new HW cylinders. Electricity supplies to each property, and the local network, will require assessment and upgrades as needed, with a comprehensive network study carried out by the DNO.

Switching all Council-owned residential properties from individual gas and electric heating systems to heat pumps is a significant undertaking in terms of investment, management and resources, and will require substantial capital funds, careful planning and engagement with tenants in order to successfully make the change.

The assessment which follows assumes that all properties are generally suitable for retrofit of high temperature ASHPs supplying heat to standard radiator systems, and the analysis of energy, CO_2 emissions and costs / benefits is carried out on that basis.

A summary of the energy analysis considering an average domestic property is provided in Table 15 below.

Table 15: Air source heat pump analysis summary - average low rise domestic property

Parameter	Value
Estimated heat supply temperature from heat pump for space heating (°C)	65
Estimated heat supply temperature from heat pump for HW (°C)	65
Peak space heat load of areas to be heated by heat pump (kW)	5.3
Estimated space heat demand of areas to be heated by heat pump (kWh/yr)	7,350
Estimated percentage of peak space heat load provided by heat pump	100%
Estimated percentage of space heat demand provided by heat pump	100%
Estimated space heat generated by heat pump (kWh/yr)	7,350
Estimated HW generated by heat pump - (kWh/yr)	2,200
Total heat generated by heat pump (kWh/yr)	9,550
Heat pump total heat output capacity at design conditions (kW)	6.0
Heat pump estimated seasonal coefficient of performance ('SCoP')	2.75
Maximum power extracted from air (heat pump evap. capacity) (kW)	3.8
Heat pump electrical capacity (kW)	2.2
Heat pump electricity consumption (kWh/yr)	3,473
Heat extracted from air (kWh/yr)	6,077
Electrical supply capacity requirement (A)	10.0
Total electricity consumption of heat pump system (kWh/yr)	3,473
Heat pumps FLEQ run hours (hours/yr)	1,592

As for other types of building included in the assessment, heat provision could be supplemented by a roof mounted STHW system, where sufficient unobstructed building roof space at suitable orientation is available. The system design and benefits would be as for high rise residential property described above.

5.5 CO_2 emissions

An assessment of CO_2 emissions associated with deployment of heat pumps in all properties in place of existing electric and gas heating systems considering each housing type is provided in the following section.

A CO_2 emissions summary considering all Council owned property is provided in Table 16 below.

Table 16: CO_2 emissions summary

Buildings	Existing heating fuels consumption (kWh/yr)	CO2 emissions - existing (tonnes/yr)	Electricity demand assoc. with heat pumps (kWh/yr)	CO2 emissions – heat pumps (tonnes/yr)	CO2 emissions savings (tonnes/yr)
Standard residential blocks – high rise					

Buildings	Existing heating fuels consumption (kWh/yr)	CO2 emissions - existing (tonnes/yr)	Electricity demand assoc. with heat pumps (kWh/yr)	CO2 emissions – heat pumps (tonnes/yr)	CO2 emissions savings (tonnes/yr)
Southorn Court	285,200 (elec)	72.2	95,067	24.1	48.1
Eden Court	558,000 (elec)	141.3	186,000	47.1	94.2
Ashton Court	285,200 (elec)	72.2	95,067	24.1	48.1
Stamford Gardens	458,800 (elec)	116.2	152,933	38.7	77.4
Westbrook House	204,600 (elec)	51.8	68,200	17.3	34.5
Radcliffe Gardens	584,571 (gas)	107.5	136,400	34.5	73.0
Christine Ledger Sq	511,500 (gas)	94.0	136,400	34.5	59.5
Standard residential blocks – medium / low rise					
Oakfield House	140,800 (gas)	25.9	40,960	10.4	15.5
Kennedy Square	721,600 (gas)	132.7	192,427	48.7	84.0
St. Paul's Square	378,400 (gas)	69.6	100,907	25.5	44.0
Sheltered housing					
Acorn Court	554,629 (gas)	102.0	103,531	26.2	75.8
James Court	337,600 (gas)	62.1	63,019	16.0	46.1
Yeomanry Close	506,400 (gas)	93.1	118,160	29.9	63.2
Charles Gardner Rd	633,000 (gas)	116.4	184,145	46.6	69.8
Chandos Court	578,743 (gas)	106.4	135,040	34.2	72.2
Low rise individual houses & flats					
Houses & flats (gas boilers)	50,624,550 (gas)	9,308.3	14,727,142	3,728.8	5,579.6
Houses & flats (electric heating)	10,124,910 (elec)	2,563.5	3,681,785	932.2	1,631.3
All property					
Totals	**67,488,503**	**13,235**	**20,274,607**	**5,133**	**8,102**

The percentage CO_2 emissions savings for each housing category is as follows:

- Standard residential blocks – high rise: 66.4%.
- Standard residential blocks – medium / low rise: 62.9%.
- Sheltered housing: 68.1%.
- Low rise individual houses & flats (gas boiler systems): 59.9%.
- Low rise individual houses & flats (electric systems): 63.6%.

The total CO_2 emissions savings for the entire housing stock is **8,102 tonnes/yr**, equivalent to a saving compared to existing heating systems of **61.3%**.

It is noted that CO_2 emissions savings will increase over time, reflecting the reduction in the CO_2 emissions intensity of the electricity grid as an increasing number of renewable and low carbon energy generators replace fossil fuelled plant, with the continuing trend resulting in close to zero carbon electricity supply, and in the case of heat pumps, close to zero carbon heat supply.

Where suitable roofspace exists to install solar PV panels, electricity supply from the grid to operate heat pumps will be reduced, and overall CO_2 emissions savings will be higher. Depending on the size of system, solar PV supplying a property which includes a heat pump should enable around 75% of PV generation to offset otherwise imported demand.

The analysis includes the following assumptions.

80% of low-rise individual houses & flats are heated using individual gas boilers, the remaining 20% are heated using electric storage heaters and immersions. The actual numbers of each type are not known, but could be confirmed by the Council to enable a more accurate assessment to be carried out.

Existing heating fuels consumption figures are based on the following heating system efficiencies:

- Electric heating: 100%.
- Communal gas boilers: 70%.
- Individual gas boilers: 80%.

Heat pump electricity demand is based on the following heat pump SCoPs:

- Individual GSHPs serving residential units (multi-unit residential building): 3.0.
- GSHPs as part of communal heating system (Acorn Court, James Court): 3.75.
- ASHPs as part of communal heating system (Yeomanry Close, Chandos Court): 3.00.
- Individual ASHPs serving residential units (Oakfield House, Charles Garner Road, all low-rise individual houses & flats): 2.75.

CO_2 emissions figures are based on the following UK CO_2-equivalent emissions factors for 2020[58]:

- Grid supplied electricity: 0.25319 $kgCO_2/kWh$.
- Natural gas: 0.18387 $kgCO_2/kWh$.

It is noted that the CO_2 emissions factor for grid-supplied electricity is an annual average and includes transmission and distribution losses. In practice the carbon intensity of electricity supply is variable, and depends on the weather and time of day, reflecting the percentage of low and zero carbon electricity generation available and included in the overall electricity supply mix.

5.6 Financial appraisal

The following section provides an outline financial appraisal of each type of property assessed.

An outline financial appraisal of the installation of heat pumps in place of existing heating systems in multi-residential buildings is shown in Table 17 below.

[58] UK Government GHG Conversion Factors for Company Reporting

Table 17: Heat pump project outline financial appraisal - multi-residential buildings

Parameter	Multi-unit residential building (Southorn Court - 46 flats)	Sheltered accommodation (Acorn Court – 46 living units)	Sheltered accommodation (Yeomanry Close – 42 living units)
Technology	Multiple GSHPs	Communal GSHPs	Communal ASHPs
Project capex			
Equipment & installation cost (£k)	828	350	200
Modification / provision of heating systems (£k)	Included above	Included above	Included above
Professional fees (£k)	83	35	20
Total project capex (£k)	**911**	**385**	**220**
Project heating fuel consumption & costs			
Electricity consumption (kWh/yr)	2,067 (per dwelling)	92,307	98,000
Electricity cost (£/yr)	331 (cost to tenant - per dwelling)	12,000	12,740
Heat pumps & infrastructure O&M cost (£/yr)	1,771 (cost to Council – whole building)	563	400
Total operating cost (£/yr)	Split between tenant & Council	12,562	13,140
Current heating fuel consumption & costs			
Gas consumption (kWh/yr)	-	554,629	506,400
Gas cost (£/yr)	-	15,530	14,179
Gas boilers O&M cost (£/yr)	-	500	500
Electricity consumption (kWh/yr)	6,200 (per dwelling)	-	-
Electricity cost (£/yr)	608 (cost to tenant - per dwelling)	-	-
Electricity system O&M cost (£/yr)	1,150 (cost to Council – whole building)	-	-
Total operating cost (£/yr)	Split between tenant & Council	16,030	14,679
Project savings			
Resident (£/yr)	**277**	**-**	**-**

Parameter	Multi-unit residential building (Southorn Court - 46 flats)	Sheltered accommodation (Acorn Court – 46 living units)	Sheltered accommodation (Yeomanry Close – 42 living units)
Council (£/yr)	**-621**	**3,467**	**1,539**

An outline financial appraisal of the installation of ASHPs in place of existing gas and electric heating systems in individual residential properties is shown in Table 18Table 17 below.

Table 18: Heat pump project outline financial appraisal – individual properties

Parameter	Individual property – existing gas heating	Individual property – existing electric heating
Technology	Individual ASHP	Individual ASHP
Project CAPEX		
Equipment & installation cost (£k)	9	9
Modification / provision of radiator systems (£k)	N/A	3
Professional fees (£k)	Included above	Included above
Total project CAPEX (£k)	**9**	**12**
Project heating fuel consumption & costs		
Electricity consumption (kWh/yr)	3,473	3,473
Electricity cost to tenant (£/yr)	556	556
Heat pumps O&M cost to Council (£/yr)	50	50
Current heating fuel consumption & costs		
Gas consumption (kWh/yr)	11,938	-
Gas cost to tenant (£/yr)	537	-
Gas boilers O&M cost to Council (£/yr)	100	-
Electricity consumption (kWh/yr)	-	9,550
Electricity cost to tenant (£/yr)	-	936
Electricity system O&M cost to Council (£/yr)	-	25
Project savings		
Resident (£/yr)	**-£18**	**£380**
Council (£/yr)	**£50**	**-£25**

Applying the above results to all Council-owned property provides the following figures:

- Capital investment **£63.5m** (excluding building energy efficiency measures).
- Energy and O&M cost savings to the Council **£191k per year** (based on current costs).
- Energy cost savings to tenants **£475k per year** (based on current costs).

The analysis includes the following assumptions.

Energy costs:

- Tenant:
  - Electricity - single rate: 16.0 p/kWh.
  - Electricity – dual rate day: 17.0 p/kWh.
  - Electricity – due rate night: 9.0 p/kWh.
  - Gas: 4.5 p/kWh (includes standing charges, based on an average per-property gas consumption of 12,000 kWh/yr).
- Council:
  - Electricity - single rate: 13.0 p/kWh.
  - Gas: 2.8 p/kWh (includes standing charges).

Energy costs to tenants include VAT. All other costs exclude VAT.

For existing electric heating systems designed to operate on night-rate electricity, current energy costs assume 90% of electricity consumption is at the night-rate tariff, and 10% is at the day-rate tariff.

Heat pump operating cost is based on heat pump operation at a single standard electricity rate. In practice the Council and tenants should be able to take advantage of recently introduced smart variable tariffs whereby a suitably configured control system can minimise or avoid operation of the heat pump during high tariff periods, thereby taking advantage of lower tariffs (lower than the single standard electricity rate) at other times, in theory leading to lower overall heating costs.

GSHP O&M cost includes an amount for overall maintenance and insurance of the infrastructure (heat collector, manifold and connection/distribution pipework).

Individual properties capex figures are based on a large scale roll out of heat pump installations, where it is assumed the Council will be able to benefit from discounts through bulk purchasing of equipment and installation contracts, as well as standardisation of overall design. In addition, for existing gas boiler systems, project capex assumes the installation of high temperature heat pumps suitable to supply heat to existing radiator systems without modification.

Project capex excludes any upgrades required to individual power supplies or the wider electricity network, as this is currently unknown. In the case of individual properties, based on heat pump electrical capacity it is expected that the capacity of existing individual electricity supplies to each property will be sufficient without modification, however the DNO will need to carry out an area wide network study which includes for the installation of multiple heat pumps, and potentially also increased electric vehicle charging, in order to determine the details and costs of required network upgrades.

5.7 Planning & environmental considerations

The microgeneration renewable energy technologies considered for Council-owned housing stock within Warwick, Leamington and the wider district, include ASHPs, GSHPs and roof mounted solar (PV and thermal).

The vast majority of microgeneration technologies can be installed using permitted development rights. If planning permission is required key considerations are sympathetic materials, positioning of infrastructure, noise, and impact on local character.

5.7.1 Air source heat pumps

From 1st December 2011 the installation of an ASHP on domestic premises is considered permitted development, not requiring an application for planning permission.

These permitted development rights apply to the installation, alteration, or replacement of an ASHP on a house or block of flats, or within the curtilage (garden or grounds) of a house or block of flats, including on a building within that curtilage. A block of flats must consist wholly of flats (e.g. should not also contain commercial premises).

Development is permitted only if the ASHP installation complies with the Microgeneration Certification Scheme ('MCS') planning standards (MCS 020) or equivalent standards.

The volume of an ASHP outdoor compressor unit (including housing) must not exceed 0.6 m^3.

Only the first installation of an ASHP would be permitted development, and only if there is no existing wind turbine on a building or within the curtilage of that property. Additional wind turbines or ASHPs at the same property requires an application for planning permission.

All parts of the ASHP must be at least one metre from the property boundary.

Installations on pitched roofs are not permitted development. If installed on a flat roof all parts of the ASHP must be at least one metre from the external edge of that roof.

Permitted development rights do not apply for installations within the curtilage of a Listed Building or within a site designated as a Scheduled Monument.

On land within a Conservation Area or World Heritage Site the ASHP must not be installed on a wall or roof which fronts a highway or be nearer to any highway which bounds the property than any part of the building.

On land that is not within a Conservation Area or World Heritage Site, the ASHP must not be installed on a wall if that wall fronts a highway, and any part of that wall is above the level of the ground storey.

The ASHP must be used solely for heating purposes, removed as soon as reasonably practicable when it is no longer needed for microgeneration, and sited, so far as is practicable, to minimise its effect on the external appearance of the building and its effect on the amenity of the area.

5.7.2 Ground and water source heat pumps

GSHPs and WSHPs can be used for space and water heating. These systems operate by drawing heat from the ground or a body of water and upgrading the heat via a heat pump to temperatures suitable for space heating and hot water. There are two types of WSHP; closed loop and open loop.

Planning permission for GSHPs and WSHPs is not required for the installation of a heat pump within the curtilage of a dwelling. Other considerations are the same as set out for ASHPs i.e. there are no heat pumps or wind turbines on site, the technology is at least 1m away from the property boundary, and the installation is not on a pitched roof.

However, if the property is a Listed building, and works directly affect the fabric of the building, listed building consent may be required. Furthermore, works within the curtilage of the Listed building may adversely affect its setting, therefore planning permission will be required.

5.7.3 Solar

Solar equipment mounted on a house or a block of flats or on a building within the curtilage is one of the most common types of microgeneration, and the installation of solar panels and equipment on residential buildings may be permitted development, not requiring planning permission, providing the equipment on a building is sited, so far as is practicable, to minimise the effect on the external appearance of the building and the amenity of the area.

When no longer needed equipment should be removed as soon as reasonably practicable.

Furthermore, to be permitted development, the panels should not be installed above the highest part of the roof (excluding the chimney) and should project no more than 200mm from the roof slope or wall surface.

The solar panels must not be installed on a building that is within the grounds of a Listed building or on a site designated as a scheduled monument.

If the property is in a conservation area, or within a world heritage site, panels must not be fitted to a wall which fronts a highway.

5.8 Conclusions

The analysis indicates that implementation of retrofit heat pumps and potentially also other microgeneration technologies across the entire Council housing portfolio is a significant project in terms of the extent of the works and capital required. The project could potentially be financially supported through the BEIS Social Housing Decarbonisation Fund, similar to current projects being undertaken by the Council.

CO_2 emissions savings as a result of implementation of the project are significant, and will increase as the carbon intensity of grid supplied electricity reduces in the future, eventually resulting in close to zero carbon heat.

Energy and O&M related cost savings to the Council are relatively small compared to the capital investment required. The total energy cost savings to tenants are significant when measured against existing electric heating systems, and on average there are no energy cost savings to tenants currently using gas boiler heating systems, as the operating cost of a heat pump is slightly higher compared to a gas boiler.

It is noted that, when including energy efficiency measures, operating costs will be lower for all systems, gas or ASHP, reflecting the lower demand for heat. For ASHPs, inclusion of energy efficiency measures will mean lower running costs compared to existing building condition heated via gas boilers. For a given set of energy efficiency measures, heat demand will be the same for any heating system, but greater energy efficiency measures means that heat pumps can supply heat at lower temperatures, which improves heat pump operating efficiency and therefore reduces running cost.

6 Recommendations & Next Steps

Through this report there have been a number of conclusions and recommendations, summarised in this section.

- Grid Connection – of priority is to secure the grid capacity for any generation facilities to be developed at the Greys Mallory location. This will enable any solar PV, wind or battery storage and also provide capacity to support a hydrogen refuelling station.
- Identify and secure land – some of the land evaluated is not under the ownership of WDC so should be progressed to secure options at the earliest opportunity.
- Business cases – the feasibility work carried out in this report has identified a number of potential options for each of the areas of study. Once these have been prioritised it is recommended that they are progressed to business case to enable decisioning on progression and access to market and funds.
- Develop case for hydrogen – the development of a hydrogen hub will be reliant on there being a market to supply to. WDC have taken some steps in this regard by considering the RCV fleet. It is recommended that WDC also engage with other interested parties that may be able to supplement demand for hydrogen and thus enhance the business case.
- Engage with UK Government – the net zero agenda is expanding rapidly across the country so engagement with UK Gov't to participate in funding competitions and allocations is recommended. Such access to funds may prove the key to unlocking potential developments identified.
- Develop net zero planning policy – delivering net zero will require stringent and enforced planning policy which all interventions and developments within the district will need to adhere to. Such policy will need to be robust and enforceable but practical and deliverable.
- Engage with local and national developers – WDC has a relationship with a number of local developers. Alongside the development of planning policy for net zero it will be critical to engage with the developers to ensure their participation and compliance with policy.
- Strategic heat decarbonisation – whilst this report examines the Myton area and the potential for a low carbon heat network it is recommended that a more comprehensive heat decarbonisation study be undertaken to identify policy and interventions that will enable the heat based path to net zero.
- Decarbonising through microgeneration – a policy and framework for delivery is recommended for the delivery of interventions that will drive housing stock towards net zero. Whilst initially focused on council owned properties it is recommended that a policy be established that is effective across the district.
- Explore energy market innovations – the energy market is undergoing significant transformation which may open up opportunities for WDC to create offers that benefit its citizens. Examples of this could include innovative deployment of solar and battery storage facilities to derive income.
- Develop decision-making framework – it is likely that many interventions and developments will be required to achieve net zero. With time running relatively short it will be critical to have a framework for decisions to allow progression at pace.

7 Planning Policy Development

7.1 Introduction

As part of Warwick District's overall aim to become net-zero carbon, or as close as possible, by 2030, the authority began preliminary works to prepare a Sustainability and Climate Change Development Plan Document ('DPD') which would form part of the development plan and expand upon the climate change and sustainability policies introduced within the 2017 Local Plan. It will focus on ensuring that development across the district will consider sustainability and the impact on the environment throughout the construction and life of the building.

RINA, in partnership with Enzygo, carried out a review and evaluation of the initial draft Climate Change and Sustainable Buildings DPD. The review did not seek to identify a preferred approach to development control, nor did it recommend a different policy approach. Instead, it aimed to scrutinise the proposed policy, mechanisms, and targets outlined in the existing document, and offer recommendations for the refinement of them.

7.2 Methodology

To appropriately frame the review of the DPD, Enzygo carried out a robust review of the document which sought to determine Warwick District's current preferred direction of planning policy in respect of sustainability and climate change. The review identified several topic areas for further analysis:

- Overall structure and policy approach;
- Application of the energy hierarchy across all development;
- The credibility, accessibility, and practicality of the Association for Environment Conscious Building ('AECB') standard;
- The requirement for all development to demonstrate compliance through a Sustainability Statement;
- The thresholds, standards, and measurements of policy requirements;
- Potential for alternative standards and measurements.

To inform the review of Warwick's draft DPD, Enzygo evaluated all climate change, sustainability, and climate change planning documents currently adopted across England. They also conducted interviews with built-environment professionals to seek their views on the proposed policies, standards, and requirements of the draft DPD to best inform their analysis of the DPD and how it might be viewed by the built environment sector if the DPD progressed to Examination in Public.

In total, Enzygo reviewed 42 planning documents across 343 local authorities to gain an understanding on existing climate change guidance across England. We also approached 30 industry specialists and received pre-consultation responses from 11.

7.3 Overall Strategy and Approach

The overall strategy of the draft Climate Change and Sustainability DPD follows a three-stage sequential strategy:

1. Reduce energy demand. Use less energy, use fewer resources, generate fewer carbon emissions.

a) Adjust human behaviour – largely beyond the scope of the DPD.

b) Maximise energy efficiency – requiring less energy to achieve similar outcomes.

2. Energy sources. Ensure that any energy requirements which remain after stage 1 are acquired from the 'cleanest' and most sustainable sources.

3. Carbon offsetting. Any carbon emissions still resulting after the first two-stages of the strategy, should be subject to offsetting measures to bring the total emissions to net zero, or as close as possible.

The document goes on to outline the remaining policies and under which stage of the document they relate to. Concerns were raised over the clarity of this approach, with Enzygo stating that the proposed format could be complicated and not accessible to all users of the document. Further concerns were raised over the placement of the energy hierarchy inside the overall strategy.

A review of sustainability planning documents across England found that the overall strategy outlined within the Warwick DPD was restrictive and narrow in comparison. The draft Cornwall Climate Emergency DPD took a broader approach to the topic areas the policies would relate to. For instance, the Cornwall DPD offers policy and guidance on transport management, natural and historic environmental protection, and improvements for the maintenance of coastal and river processes. It was noted that each district features varying environmental constraints; however, Cornwall's overarching approach took a broader approach to the effects of climate change.

Similarly, it was found the Greater Cambridge Sustainable Design and Construction Supplementary Planning Document ('SPD') (2020) and Herefordshire Sustainability SPD (2021) provide sustainability guidance on a wider set out topic areas, including biodiversity and sustainable design.

The overarching response from built environment professionals was the lack of clear and concise targets. Some noted that Warwick District's overall target was to become as close to net-zero carbon by 2030; however, the reading of the policies found that the aim of the document was to maximise opportunities to eliminate or reduce carbon emissions, which did not offer hard targets for the document.

A common response was the ambitious nature of the document. Many of the developers interviewed were familiar with working to high standards in London and the southeast; however, they believed that the standards were extremely high for the midlands, where the viability of development is more constrained due to end values such as house prices compared to London and the southeast.

Nearly all responses questioned whether compliance with the policies was achievable, particularly for large-scale house builders. It was noted that the current direction of national planning policy is to deliver housing, and ambitious climate targets may interrupt housing delivery across Warwick District if the standards are too high for most housebuilders. Numerous references were also made to the role of Building Regulations (soon to be updated) and the aim to increase sustainability through the construction process and if the emerging planning policy document was overlapping.

7.4 Application of energy hierarchy

The draft DPD outlines an energy hierarchy for development across the district. The four-step hierarchy is:

- Reducing the need for energy (Stage 1);
- Energy efficiency (Stage 1);
- Maximising the potential for energy supply from decentralised, low carbon and renewable energy sources, including community led initiatives (Stage 2);
- Efficiently using fossil fuels from clean technologies (Stage 2).

It was believed that the use of an energy hierarchy within the overarching strategy could present confusion for the average user of the document, particularly when the energy hierarchy steps are referring to which step of the strategy it is responding to.

During the nation-wide review of planning documents, it was found that the provision of an energy hierarchy was commonplace. Several authorities utilised a ‘be lean, be clean, be green’ approach; however other authorities took a tailored approach to each hierarchy. For instance, Woking Borough Council set out an additional step which required proposals to demonstrate the *need* for energy. The Greater London Authority Sustainable Design and Construction Supplementary Planning Guidance (‘SPG’) (2014) features an additional step that outlines the need to adjust human behaviour and maximise energy efficiency within the first step.

The London Plan (2021) adopted a revised hierarchy which needs to be demonstrated through an energy strategy. This includes the addition step to ‘be seen’, which involves the monitoring, verification, and reporting of energy performances.

During interviews with built environment professionals, several responses highlighted the additional burden on developers and housebuilders in following the hierarchy for larger scale developments. For instance, the third step of the hierarchy states proposals must *maximise the potential for energy to be supplied from decentralised, low carbon and renewable energy sources,* which is a large burden to place on the developer if the infrastructure to support low energy generation is not already in place.

7.5 Policy thresholds and figures

When WDC unanimously agreed to declare a Climate Emergency, the Council set two ambitious targets; to become a carbon neutral organisation by 2025, and supporting the district to become as close to carbon neutral as possible by 2030.

To help facilitate this, Warwick District is proposing compliance with the AECB standard. The DPD states that the benefit of demonstrating the compliance with this standard is the reduction of approximately 70% of CO_2 emissions to the average UK housing type. The associated embodied carbon standard requires applicants to provide details of embodied carbon within the materials and construction method of the project.

Research of the standard found that Passivhaus certifiers can certify proposals as AECB compliant. It is also recommended that only Passivhaus architects prepare plans for proposals that seek to meet the standard.

Many authorities across England require commercial development to abide by the Building Research Establishment Environmental Assessment Method ('BREEAM') standard of either 'very good' or 'excellent'. This standard is recognised as a uniform standard by most developers, and as such it is seen as a standard certification for commercial developments aiming to meet carbon reduction measures.

Several planning documents refer to the Code for Sustainable Homes ('CSH') standard; however, since its removal, it cannot be enforced by planning authorities. Many documents reference the Passivhaus standard; however, this is typically perceived as best practice approach, rather than being actively enforced by Councils. Many progressive districts in the UK use the Passivhaus standard to demonstrate compliance with planning policy. For instance, development across Bristol City must demonstrate a 10% reduction in regulated CO_2 emissions through efficiency measures and a minimum of 35% in regulated CO_2 emissions through a combination of onsite renewable energy generation. If a building is constructed to Passivhaus standard, the reduction targets relating to energy efficiency measures, on-site renewables and allowable solutions will not need to be met.

Similarly, Glasgow City Council planning policy states that residential development must meet Gold Level Compliance from September 2018 onwards. A Passivhaus certification is an acceptable route to achieving Gold Level Compliance. The alternative is demonstrating a 27% reduction in the Target Emissions Rate ('TER') plus a minimum 20% abatement in emissions from low and zero carbon renewables.

Three separate responses raised concern over the independence of the AECB organisation, and whether they were a suitable organisation to set out the building standards across a whole district. One response compared it to the National House Building Council ('NHBC') standard, who they believed worked on behalf of housebuilders, as opposed to the people living within the dwelling. Other responses highlighted concern over a perceived bias towards the AECB, a relatively unknown organisation. They believed the Council should be more transparent and set out the rationale for deciding to utilise this standard.

Several responses questioned the rationale for using such an obscure organisation for setting out standards across the district. They questioned why the district would not use a better known, larger organisation. They questioned whether there are enough certified consultants in the west midlands to certify developments. There was concern that compliance with this standard may create issues with prolonging timeframes of development if a suitable certifier cannot be located.

One response, from a volume housebuilder, questioned whether similar organisations could utilise pre-existing internal standards. They raised concern that districts setting out different standards would interrupt delivery of housing across wider areas. The time, costs, and expertise associated with complying with an entirely different standard may jeopardise delivery of large-scale sites, which are typically built-out by organisations which utilise internal standards.

7.6 Sustainability statement

Under Strategic Policy 2, WDC would require the submission of a sustainability statement with all applications except householder development. The policy states that the statement must address the three stages of the sequential approach set out in policy SP1.

The requirement for planning applications to be supported by a sustainability statement is becoming widespread across England. Typically, the role of the sustainability statement is to demonstrate compliance with the overall aims of local policy (or corresponding Supporting Planning Guidance).

The supporting text for the policy SP2 states that the requirement for a sustainability statement has been *'introduced to enable all policies in this document to be addressed in one document which will accompany planning applications'*.

Preliminary concerns were raised over the information that would be required to complete the sustainability statement in its entirety. Several of the requirements do not appear to correlate to existing draft policy, for instance part e). For the information required as part of the sustainability statement, the DPD should offer guidance to the applicant on how to meet the standards required.

Enzygo raised concern that draft Policy SP2 requires (nearly) all development to provide a sustainability statement; however, not all development will meet the stipulations of SP2 by virtue of the type of development (e.g. infrastructure, agricultural, telecommunications).

There was also concern that small-scale housebuilders, tradespeople and some architects may not have the specialism to respond to all steps of the sustainability statement, for instance the requirement to demonstrate compliance with the heat hierarchy. Superficially, an applicant may be able to prepare a sustainability statement to meet the stipulations of policy SP2, but without adequate guidance, or targets, it is unlikely that the statement will provide the information desired.

Many authorities utilise sustainability statements for major development to demonstrate compliance with planning policy and guidance. Several authorities, such as Derbyshire Dales and Lewes District, have prepared a planning checklist to demonstrate compliance with sustainability measures. Whilst there still may be concerns with technical understanding, the provision of a checklist provides the information that the applicant will require to achieve a valid application.

The main concern raised through interviews was the technical information required to fill out the sustainability statement. Smaller developers noted that large-scale housebuilders will have independent sustainability teams that will have the technical knowledge to fill out the statements, but smaller developers may struggle to fill out the statement to a satisfactory standard.

Nearly all responses raised concern over the timescales and building costs associated with meeting the standards set out within the statements. The specialist information (energy demand, utilisation of renewable energy, design specifications and water consumption) will increase the build costs for most developments. Consideration must be given to the impact on both viability and timeframes of development.

7.7 District heating and combined heat & power

The draft DPD (ESG1) currently states that for all residential development of one or more dwellings, or 1,000m^2 or more of non-residential floorspace, the council will require 10% of energy requirements to be from decentralised and renewable or low carbon sources.

Policy ESG2 goes on to provide in-depth guidance on the provision of infrastructure for new decentralised energy production and expansion of existing networks.

Enzygo noted that this policy was influenced by London Borough of Enfield's Development Management Plan (2014). Enzygo noted that Enfield had been proactive in helping design, implement and create these energy networks. The authority had created an SPD in 2015 solely aimed at providing information on how to connect to decentralised energy networks which set out clear technical guidance.

Enfield created a company in 2011 tasked with the provision of an energy network. The network was brought into operational use in 2017, and currently has 517 homes connected to it. There is the potential to supply an additional 1,500 additional homes to the network.

A review of planning documents across England found that the provision of district heating and local energy networks was stronger in London. Several authorities' SPDs noted the requirement to utilise local heat maps to identify locations for networks. Enfield's Development Management Document features a policy which states "*the council will support, and in some cases facilitate, the provision of infrastructure to support new and expanding networks",* demonstrating clear support for the provision of networks in the district.

Enzygo found that developers were, for the most part, supportive of the provision of heat networks, but noted that the responsibility for organising and setting them up would be best placed on local authorities, public bodies and energy companies, and not developers. Some responses noted that the policy should not be considered until the Council has committed to the delivery of such networks across the district.

Most responses stated that they would expect the local authority to do the bulk of the work in creating such networks. This would include heat mapping, researching and eventually master planning. The infrastructure would then need to be constructed, with support from the local authority. The academic responses noted that no energy company would set up a district heat network without the support and collaboration of the local authority, as they need the reliance that development will connect to it. WDC would need to leverage investment, such as through Local Economic Partnerships ('LEP') and use time and resources to investigate the feasibility of the networks before relying on developers to connect and invest in them.

7.8 Carbon offsetting

Policy OS1 states that where a proposal cannot meet the Council's required carbon reduction percentage on-site as calculated at the point of determination of planning application, it should make up the shortfall by:

- A cash payment in lieu contribution to the Council's carbon offsetting fund, and/or
- An off-site offsetting scheme provided that such a proposal is properly research/quantified and, where relevant, will be referred to Warwickshire County Council's Ecology team for verification. Its delivery must be guaranteed.

The Council set a proposed a payment of £95 per tonne for offsetting.

Enzygo noted that the Council's carbon reduction target is to achieve 'as close to net zero carbon as possible'; however, there is no clear target to assess the carbon reduction targets against. A clear carbon reduction target should be outlined within the overarching strategy of the document. At present, there is a carbon reduction target for the district as a whole by 2030 but the DPD does not set out targets for individual development proposals.

Enzygo found that the majority of carbon offsetting payments are made through Section 106 payments. Notably, this is only achievable for major development, and should smaller proposals need to pay into the fund, there appears to be no instrument to achieve this.

Research found that for many building types, achieving zero emissions was not possible on-site without significant design amendments. The ability for developments to utilise off-site carbon offsetting can help mitigate the impacts of development that cannot meet reduction targets on-site.

Reviewing the price per tonne for other authorities, it was found that the London Authority and Bristol City both have a proposed £95 per tonne, but only on major applications.

The London Plan sets out a clear formula for calculating the tonnage required to offset a development. It requires development to meet at least 35% reduction beyond building regulations for major development (residential should achieve 10% and non-domestic 15%). Only when it is demonstrated that the net zero target cannot be fully achieved on site can offsetting be considered.

Enzygo's review of recently adopted or emerging planning documents found that several authorities outside the southeast have adopted sustainability planning documents, but made no provision for carbon offsetting.

The most common response from built environment professions was the requirement for WDC to ensure that offsetting does not become a preferable approach to meeting carbon targets across the district.

Some responses noted the lack of clear carbon reduction targets. Without these, there is no carbon tonnage to offset against.

WDC need to ensure they have the resources to offer advice and guidance to ongoing applications. As the carbon target is calculated at the point of determination, WDC need to be satisfied that they have the resources to keep applicants up to date on the potential carbon offsetting fee they are required to pay to meet the overall target.

In addition to the identified topics, Enzygo also sought the professional opinions of the interviewees regarding Policy W1 and Policy EV1.

7.9 Policy W1 - conserving water

All responses noted that the requirement for 105 litres per person per day was fully achievable and reasonable for the majority of developments. One volume housebuilder response noted that they already work to this standard.

The requirement for greywater harvesting could be easily adapted too, if required by policy. A housebuilder response noted that the Council could require all residential and commercial development to install a water metre to minimise water use and identify leaks.

The explanatory text of policy W1 references green and brown roofs. A chartered architect raised concern over the maintenance and expertise required to facilitate, and for upkeep.

7.10 Policy EV1 - electric vehicles

Several authorities outside the southeast of England have adopted policies which require the provision for EV charging points, as opposed to the charging ports themselves. A smaller developer noted that electric vehicle charging points can cost up to £700 per unit; however, a volume housebuilder noted that the requirement for EV charging points is not a consideration for determining whether to agree a land deal.

Some responses stated that the onus for EV charging points should be on the developer, not authority. As the market for EVs evolves, the demand for dwellings with EV charging points will increase, leading to housebuilders evolving their building practices to facilitate this demand. They argued that a developer would not undersupply the number of charging points required by a development, as it will soon become an important element for a newbuild property to ensure the dwelling is attractive to the market. It is very much about the private sector adopting quickly to the change in people's behaviour rather than a specific planning policy.

7.11 Recommendations and comments

The high-level review of the document has established several key actions and areas of focus. As noted within the introduction, Enzygo's review did not aim to resolve issues with the document, rather it sought to highlight areas of concern and establish the direction other authorities have taken across England.

Notwithstanding that, Enzygo make the following recommendations and comments.

7.11.1 Overall direction

WDC need to determine what the overall aim of the document is. The overarching strategy of the document states that the authority is aiming to become net-zero carbon, or as close as possible, by 2030. Notwithstanding this, it does not set out any targets for development in the short term. Reference is made to the London Plan's carbon reduction aims, notably a 35% carbon reduction beyond building regulations. If WDC want all new development to meet a certain standard, a hard target needs to be set out early in the document.

Some responses believed that the implementation of a net-zero carbon target by 2030 was ambitious, and the burden fell mainly on the housebuilders and developers. Several responses proposed a phased approach to carbon reduction between 2021-2025 and 2025-2030. This grace period would allow local developers to react to the changes and prepare for them.

7.11.2 Layout and format of the document

Enzygo raised concern over the format and arrangement of the document. As noted, the way in which the overarching strategy and the energy hierarchy interact may confuse the user of the document. The way in which the document sets out the policies under the 'stage' of the overall approach is unclear, with one response noting it appeared 'over engineered'.

The majority of sustainability planning documents in England are supplementary planning documents, as opposed to a development management document. Once WDC confirm the direction of their climate change and sustainability policies, they should determine whether the additional guidance can be published as an SPD, as opposed to a DPD, which will shorten the examination process and allow the authority the opportunity to adopt the policy much quicker and so use it as material planning consideration when determining applications at the earliest opportunity.

7.11.3 Standardisation vs. building regulations

Enzygo found that only 2 out of 12 consultee responses had heard of the AECB standard, and none of them experience using it. Some had concerns with the impartibility of the organisation, whilst others noted that it would require sufficient certifiers within the west midlands to not interrupt delivery of development.

Many of the housebuilder responses questioned the requirement for an independent accreditation when the UK government is proposing alterations to the Building Regulations Part L. By 2025, the UK Government anticipate that residential development will feature 80% of the carbon emissions compared to the 2013 building regulation standards. They will also require new development to be 'net-zero ready'. Crucially, prior to the October 2019 consultation on the Future Homes Standard ('FHS'), central Government was proposing to abolish the ability for local authorities to create their own carbon reduction targets. Whilst the Government did not introduce this, it is still questioned whether the introduction of an independent accreditation is practical if central government are looking to expand Part L of the building regulations.

Notwithstanding this, if WDC is going to introduce the AECB standard, they need evidence that the introduction of such standards would not affect the delivery of new dwellings. This evidence would be required at the examination in public and enable a DPD to be formally adopted.

7.11.4 Closing the loop

A recurring response from the consultees was the necessity for the authority to monitor developments after consent to ensure compliance with carbon reduction measures, commonly called 'closing the loop'.

The London Plan introduced an additional step to the energy hierarchy called 'be seen' which requires developments to monitor and report on operational energy performance. The policy seeks to understand the performance gap between consent and operation and identify ways of closing the gap and achieving the desired carbon target.

If WDC decide on a carbon reduction measure, it may wish to monitor major proposals to ensure that they are meeting the consented carbon reduction measure. Guidance has been published as part of the draft London Plan on this issue.

7.11.5 Checklist requirement for development

The criteria for the sustainability statement need to be re-examined to ensure that they meet the policies across the rest of the document. At present, there appears to be some disparity between the proposed documents in the DPD, and what information is required within the sustainability statement.

Instead of requiring a sustainability statement, WDC could create several checklists for different scales of development. This may decrease the level of expertise required to demonstrate compliance to new sustainability policies. This approach ensures that the applicant only needs to provide information relevant to that proposal, slimming down upfront costs when submitting a planning application and minimising timeframes for applications to be determined to enable development to continue to come forward across the district.

Some responses suggested the creation of a sustainability officer to offer guidance on the DPD policies.

7.11.6 Carbon offsetting

Carbon offset funds are becoming more commonplace across England; however, they are concentrated with in London and the southeast.

The Council need to implement a carbon reduction target that development is required to meet upon adoption of the document. Developers cannot offset carbon if there is not a pre-existing carbon reduction target that development needs to meet in the first instance.

As the requirement for carbon offsetting is made at the planning permission stage of the project, it may create an unexpected cost for some developers. As such, it may be necessary for the Council to create an additional Section 106 Practitioner/Officer post who can advise applicants on the offsetting cost for their development throughout the determination process, in order to minimise unexpected costs at the tail end of a proposal.

7.11.7 District heat

Several Councils across England offer guidance on community and district heat networks through adopted SPDs and other planning documents; however, many of these districts do not feature such networks. In order for the proposed policy to have substantial worth, the Council need to invest and instruct preliminary work to examine the feasibility of creating community heat networks across the district. This will most likely involve a preliminary heat mapping exercise, followed by master planning of strategic sites.

Due to the function of the networks, energy providers need assurance that development will connect to the network. This is typically achieved through collaboration between energy providers and local authorities. WDC may need to instruct the services of an energy consultant to examine the feasibility of networks across the district prior to opening dialogue with local service providers.

WDC need to ensure that the heat density of Warwick is suitable for heat networks. If the pre-existing heat density of Warwick is too low to facilitate networks, it may be more beneficial to create site-specific policies for strategic land allocations to feature heat networks. This has the additional benefit of enshrining the provision of a heat network at the inception of a strategic land allocation, as opposed to retrofitting at a later time. Once these networks are adopted within local policy, the supporting policy map could designate areas as having to connect to nearby networks, putting the onus of connection on development proposals within the identified sites unless a specific reason and evidence is provided as to why new development cannot connect to them.

8 Stratford-on-Avon Synergy

It is widely recognised that taking a broader energy systems-based approach to development across boundaries can yield greater efficiency.

Stratford upon Avon District Council ('SADC') neighbours Warwick district to the south and covers some three times the geographical area with approximately 90% of the population. As a more rural area, SADC may offer complementary opportunities for renewable energy generation that could potentially be blended together with the activities of WDC for mutual benefit. Whilst the area within WDC is comparatively constrained it may be possible to secure further land for solar PV or wind generation which could provide power for green hydrogen production which could be deployed as a transportation fuel across the two districts.

Indeed, recent announcements that WDC and SADC are to be combined to form South Warwickshire Council play very much to the narrative that Warwick could benefit from working with the more rural Stratford area. This in turn should allow for a much broader and more ambitious plan towards net zero, opening up renewable energy generation opportunities which could be leveraged across the broader combined council area. This could also significantly benefit the urban centres of Warwick and Leamington Spa with renewable generation and decarbonised heat schemes.

Whilst this overall report identifies potentially significant renewable generation opportunities, combining with Stratford could dramatically improve this picture. It is therefore recommended that the scope of this study be changed to include the geographies that will become the combined South Warwickshire Council. This should include:

- Expansion to consider all Council owned land within the combined authority for potential renewable generation
- Broader consideration of hydrogen market opportunities
- Identification of all Council owned or influenced properties as potential off-takers
- Development of a combined council-wide decarbonised heat strategy – taking a systems based approach to identify opportunities to target net zero
- Explore opportunities to collaborate with further neighbouring local authorities, industry and the private sector

It is understood that the council intends to be carbon neutral as a council by 2025. This is a challenging target that will require significant time and financial investment to achieve. Working together with Stratford as a combined council certainly presents greater opportunities to deliver a bold net zero strategy although careful planning will be required to do so alongside an integration exercise.

A. Appendix - Grid connection application process

Connection offer application

RINA recommends that the Client submits an application to Western Power Distribution (‘WPD’) as soon as possible as the available capacity left in the network may be acquired by others. Before submitting a formal connection application, the Client can discuss the proposed connection with WPD by requesting a connection surgery appointment. WPD will make contact within 2 days of request to arrange an appointment to discuss the connection such as application process, timescales, constraints etc.

Budget estimate

The Client can also request a budget estimate before entering a formal agreement. The budget estimate provides the estimate of the likely cost of connection. However, this cost estimate is based on a desktop exercise and will not include detailed network analysis, technical studies, or a site visit. According to the Statement of Methodology and Charges for Connection to Western Power Distribution (East Midlands) PLC’s Electricity Distribution System published in April 2021, there will be no charge for thebudget estimate.

Connection offer

The application generally follows this process below with the possible timescales suggested.

The Connection Application Timeline

Month 1	**Project Planning Phase:** Consult published information to identify connection opportunities (see Section C of this Guide for more information)	Planning
Months 2 - 3	**Hold Preliminary Discussions with the DNO:** Hold preliminary discussions with DNO to identify connection options and potential issues	Information Phase
Months 4 - 5	**Request Information about the Network:** Submit a request for details of the circuit capacity, flows and loads in the vicinity of your site (This stage is optional)	Information Phase
Month 6	**Review this information** and consider the size and configuration of your project accordingly Complete and submit the **standard application form**	Design Phase
Month 7	DNO prepares Use of System offer — **Months 7 - 9** DNO prepares Connection Offer	Design Phase
Month 10	**Receive a Connection Offer** and review, with external advice/ assistance if necessary, noting the elements for Contestable and Non-contestable work.	Design Phase
Months 10-12	**Negotiate final connection terms** with the DNO, and appoint an Independent Connections Provider if appropriate. You commence discussions with the DNO about a Connection Agreement, to be negotiated whilst the connection is under construction.	Design Phase

If an application is correctly made, WPD will provide a connection offer which is valid for 90 days after which it will automatically expire. In some cases, the Client can request for an extension of further 90 days period. WPD can validate the request provided there are no detrimental impacts on other customers who want to connect on the same network. The request for an extension must be submitted in writing, no more than 10 days before the expiry date of the original connection offer. If the Client accepts the connection offer, it will be a binding contract between WPD and the Client.

The connection offer presents a description of non-contestable and contestable works to provide the Client with the required connections, and the associated cost for these works. The connection offer will be presented to the Client as two options:

- Option 1 – WPD will undertake all identified contestable and non-contestable works.
- Option 2 – WPD will undertake only the non-contestable works and the Client may appoint a suitably accredited Independent Connection Provider (‘ICP’) to undertake the contestable works.

If the Client wishes to appoint an ICP to undertake contestable works, they will need to request a Point of Connection offer. This will leave WPD to carry out non-contestable works only and the Client needs to appoint a suitable accredited ICP. Further information and a list of ICPs are available from accredited body Lloyds Register website, https://www.lr.org/ which is under the National Electricity Registration Scheme ('NERS'). More information is also available in section 2 and 3 of the Statement of Methodology and Charges.

Non-contestable work includes construction of WPD owned equipment, typically equipment at the connection point of the infrastructure, and works which can only be carried out by WPD – this estimate includes the capital cost of the equipment, labour and construction costs and an element of maintenance costs. The contestable element of the offer from WPD includes a cost for any of the infrastructure that would typically be owned and operated by the developer and can either be undertaken by the developer (or their approved ICP), or by WPD. Generally, option 1 is more expensive, however it is preferred to request the cost for the contestable work (as well as the non-contestable), so that comparisons can be made. A list of non-contestable and contestable works is available in WPD website https://www.westernpower.co.uk/connections-landing/competition-in-connections/information-for-customers

Minimum requirement

WPD will require a minimum level of information along with the formal application which will depend on the type of connection. The table below presents a list of required items for metered connections for the connection offer and budget estimate. Further information is available at their website: https://www.westernpower.co.uk/connections-landing/connection-offers-and-agreements/types-of-connection-offer

Required Items for metered connections

Connection offers	Budget estimates
Applicant's name, correspondence address, contact details and the site address.	Applicant's name, correspondence address, contact details and the site address.
Proposed location of each metering point.	Site plan at an appropriate scale to indicate the site boundary.
Date when the customer requires the connection(s) to be made.	Indicative date when the customer requires the connection(s) to be made.
Site plan at an appropriate scale to indicate the site boundary, the layout of buildings and roads and where the customer expects a substation(s) to be required, the proposed location of the substation(s). The plan should be free of unnecessary details and suitable for use as a background layer for the proposal drawing.	Total maximum capacity (kVA) requirement and interim capacity requirements for phased developments.
Technical details of any customer owned equipment that is likely to cause disturbance	Summary technical details of any customer owned equipment that is likely to cause disturbance to the electricity supply stating

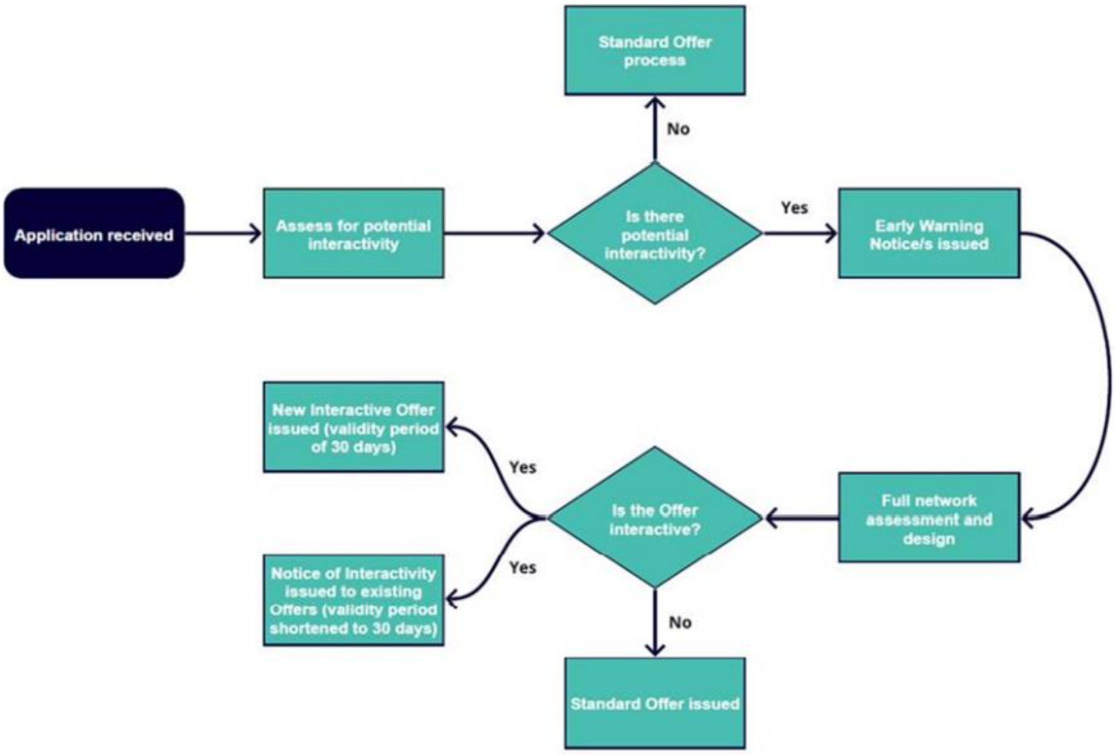
Connection offers	Budget estimates
to the electricity supply (e.g., large motors, heat pumps, generators, EV charge points).	as a minimum the number, type (e.g. large motors) and rating (starting current and frequency of operation) for each different item of equipment.
Maximum capacity (kVA) at each metering point to be connected (for domestic premises whether electric space and water heating is to be installed) and interim capacity requirements for phased developments.	Summary technical details of any electricity generator that is required to operate in parallel with the supply stating as a minimum the number, type (e.g. PV) and size (rating and number of phases) for each different generator unit.
The extent of any contestable works to be carried out by the customer (or their nominated ICP).	The extend of any contestable works to be carried out by the customer (or their nominated ICP).
Technical details of any electricity generator that is required to operate in parallel with the supply (i.e. the G99 standard application form).	-

Interactivity

When WPD receive two or more applications for a connection which make use of the same network or network assets, the connection offers become an interactive connection offer for which the Client will receive a notice that they have shorter period to accept the offer. The interactive connection offer is a queue based on the date of application and are either unconditional connection offers or conditional connection offers. An unconditional connection offer is not reliant on the acceptance of any offers in the queue. Conversely, a condition connection offer is dependent on the result of the offers ahead of them. The conditional offer may contain constraints, for instance lower capacity, or an un-firm capacity. In both cases, the client has 30 days to accept the offer.

The process of the interactive offers is shown below and was taken from WPD published Interactivity Process Guide document.

WPD Process for interactive offers and notices of interactivity



Connection offer expense

When making an application WPD may charge a connection offer expense in accordance with the Electricity (Connection Offer Expenses) Regulations 2018. WPD will request charges irrespective of whether the Client accepts the connection offer. The amount will vary and depends on the complexity based upon the requested capacity and the assets required to facilitate the connection, and will need to be paid within 28 days of issue. If WPD conducts all contestable and non-contestable works, the minimum offer expense is £2,566. Conversely, if an ICP undertakes the contestable work while WPD undertakes the non-contestable work the minimum connection offer expense is £756 and £1,777, respectively. The minimum connection expense offer presented above is for generation greater than 1 MVA at HV (i.e. 11 kV). Section 7 of the Statement of Methodology and Charges provides the cost for the works.

If the Client does not wish to pursue the application, they have 10 working days to cancel their application starting from the date they receive the offer to notify WPD in writing. Further information can be found in their website: https://www.westernpower.co.uk/connections-landing

B. Appendix – Planning Background

Land south of Banbury Road

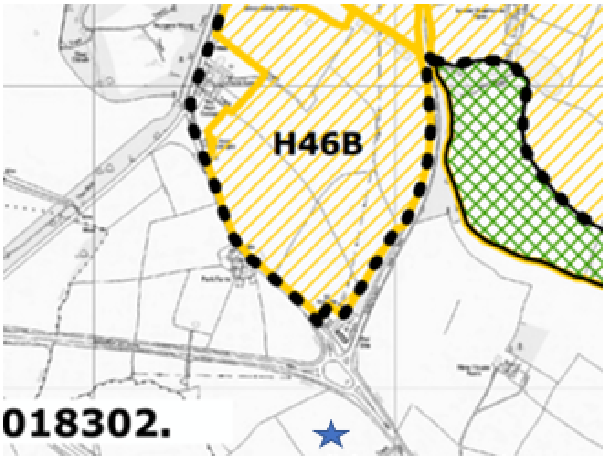
Check	Comment
Site address Inc. post code	Land south of Banbury Road
Co-ordinates	X 429748 Y261888 SP297618
Area	78.8 hectares
Statutory designations (map below)	The site has no formal designation within the Local Plan.  **Figure 1: Policy map (Site donated by star)** The most northernly point of the site sits approximately 200m south of housing allocation H46B, with only the round-about for the A452 and A425 separating the two sites. Approximately 600m to the east is a major housing commitment to the south of Bishop's Tachbrook.
Existing use. Brownfield/ Greenfield	The land south of Banbury Road is made up of 5 separate land parcels, with a total area of approximately 78.8ha. They are all arable fields, some of which are also used for grazing. Accordingly it is a greenfield site.
Distance from other sensitive sites	There are no statutory or non-statutory designations on site.

	 **Figure 2: Ecology Map** Whilst not included within the site area's boundary, Half Moon Plantation may require consideration if a planning application is to be submitted on site. It is identified within the Priority Habitat Inventory as deciduous woodland and Traditional Orchard. It is also in the National Forest Inventory as broadleaved woodland. A review of species designations across the site has identified the site as featuring tree sparrow. Renewable schemes, such as solar farms, offer opportunities for biodiversity net gain through on site biodiversity improvements. Any proposed development on site would need to be supported by an Ecological Assessment. A biodiversity net gain can be demonstrated through the Biodiversity Metric 2.0 tool.
Local Authority	Warwick District Council
Key Planning Policies	Regarding how the Government intends to meet the challenge of climate change, the National Planning Policy Framework states at Paragraph 148 *'The planning system should support the transition to a low carbon future in a changing climate, taking full account of flood risk and coastal change. It should help to: shape places in ways that contribute to radical reductions in greenhouse gas emissions, minimise vulnerability and improve resilience; encourage the reuse of existing resources, including the conversion of existing buildings; and support renewable and low carbon energy and associated infrastructure.'* Additionally, Paragraph 154 states *'When determining planning applications for renewable and low carbon development, local planning authorities should:* *a) not require applicants to demonstrate the overall need for renewable or low carbon energy, and recognise that even small-scale projects provide a valuable contribution to cutting greenhouse gas emissions; and* *b) approve the application if its impacts are (or can be made) acceptable. Once suitable areas for renewable and low carbon energy have been identified in plans, local planning authorities should expect subsequent applications for commercial scale projects outside*

	these areas to demonstrate that the proposed location meets the criteria used in identifying suitable areas'. The Development Plan for Warwick District Council consists of: **CC2 Planning for Renewable Energy and Low Carbon Generation** – Proposals for new carbon and renewable energy technologies (including associated infrastructure) will be supported in principle subject to all of the following criteria being demonstrate: a) The proposal has been designed to minimise any adverse impacts on adjacent land uses b) The proposal has been designed to minimise impact on natural environment in terms of landscape, ecology and visual impact c) The design will ensure heritage assets are conserved in a manner appropriate to their significance d) Where appropriate, the scheme can link with proposals being brought forward through the Council's Low Carbon Action Plan and any other future climate strategies e) The scheme maximises appropriate opportunities to address the energy needs of neighbouring uses f) For biomass, it should be demonstrated the fuel can be obtained from sustainable sources g) For proposals for hydropower the application should normally be accompanied by a flood risk assessment. Also, for wind energy proposals, planning permission will only be granted if: h) The development is in an area identified in either the Local Plan or a Neighbourhood Plan as being suitable for wind energy; and, i) Following consultation, it can be demonstrated that the planning impacts identified by local communities affected by the proposal have been fully addressed and that the proposal has the backing of those communities. **HE1 Designated Heritage Assets and their setting** – Development will not be permitted if it would lead to substantial harm to, or total loss of, the significance of a designated heritage asset, unless it is demonstrated that the substantial harm or loss is necessary to achieve substantial public benefits that outweigh the harm, or it is demonstrated the following apply: a) The nature of the heritage asset presents all reasonable uses of the site; and b) No viable use of the heritage asset itself can be found that will enable its conservation, and c) Conservation by grant funding or charitable public ownership is not possible; and d) The harm or loss is outweighed by the public benefit of bringing the site back into use.

	Where development would lead to less than substantial harm to the significance of a designated heritage asset, this harm will be weighed against the public benefits of the proposal, including securing its optimum viable use. **HE4 Archaeology** – Development will not be permitted that results in substantial harm to Scheduled Monuments or other archaeological remains of national importance, and their settings unless in wholly exceptional circumstances. **NE3 Biodiversity** – New development will be permitted if it protects, enhances and/or restores habitat biodiversity. Development proposals will be expected to ensure that they: a) Lead to no net loss of biodiversity, and where possible a net gain b) Protect or enhance biodiversity assets and secure their long term management and maintenance, and; c) Avoid negative impacts on existing biodiversity. Where this is not possible, mitigation measures must be identified. If mitigation measures are not possible, then compensatory measures involving biodiversity offsetting will be required. **NE 4 Landscape** – New development will be permitted that positively contributes to landscape character. Development proposals will be required to demonstrate they: a) Integrate landscape planning into the design of the development at early stages b) Consider its landscape context, including local distinctiveness of the different natural and historic landscapes and character, including tranquillity c) Relate well to local topography, and built form and enhance key landscape features, ensuring their long term management and maintenance d) Identify likely visual impacts on the local landscape and its immediate setting and undertake appropriate landscaping to reduce these impacts e) Aim to either conserve, enhance and restore important landscape features in accordance with the latest local and national guidance f) Avoid detrimental effects on features which make a significance contribution to the character, history and setting of an asset, settlement or area g) Address the importance of habitat biodiversity features, including aged and veteran trees, woodland and hedges and their contribution to landscape character, and where possible, enhancing these features through means such as buffering and reconnecting fragmented areas h) Maintain the existence of viable agricultural units i) Are sensitive to an areas capacity to change, acknowledge cumulative effects and guard against coalescence between existing settlements. **NE8 Protection of Natural Resources** – Development proposals will be permitted provided they ensure that the district's natural resources remain safe, protected and prudently used. Development proposals will be expected to demonstrate they: • Avoid the best and most versatile agricultural land unless the benefits of the proposal outweigh the need to protect the land for agricultural purposes.

	Onshore wind farms are currently challenging to navigate successfully through the planning process. The Written Ministerial Statement (HCWS42, 2015) stated that local planning authorities should only grant permission for wind energy development if: • The development site is an area identified as suitable for wind energy development in a Local or Neighbourhood Plan • 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.
Distance from residential	The nearest residential properties are the isolated farms on Banbury Road, including Spinney Farm, Red House Farm, and Greys Mallory. The northern portion of the site is approximately 200m south of housing allocation H46B. The site is approximately 500m west of Bishop's Tachbrook. Any proposed development will need to consider the residential amenity of nearby dwellings, in addition to the other isolated dwellings surrounding the site. A landscape mitigation plan should consider how best new planting can be introduced to further screen the site.
Landscape	The appraisal site is located within the Feldon Parklands landscape character area of Warwickshire. The site does not benefit from an individual appraisal of the landscape character; however, Warwickshire County Council describes the overall character of the Feldon Parklands as: • A large scale rolling topography with occasional steep scarp slopes • Large woodlands, often associated with rising ground. • Many coverts and belts of trees • Mature hedgerow and roadside oaks • Large country houses set in mature parkland • A nucleated settlement pattern of small estate villages • Large, isolated brick farmsteads. Warwickshire County Council identify the conservation and enhancement of the overall structure and well wooded character of the landscape as the most suitable management strategy. From a desktop review of the surrounding landscape area, the site does not appear to feature many of the identified character features. The field parcels feature hedgerows; however, these do not appear to be of substantial nature. Similarly, the only identified piece of woodland near the site is the Half Moon Plantation. Directly to the north of the appraisal site is Warwick Castle Listed Park and Garden, which does feature many of the characteristics identified by Warwickshire County Council

	appraisal. To the west of the site is Sherbourne Park, a Georgian manner set within landscaped Warwickshire gardens. Whilst the landscape may feature some sensitivities, the M40 runs adjacent to the development site and is a detractive feature on the local landscape.
PRoWs	There are no public rights of way which cross the site. There are some footpaths close to the appraisal site. Users of the PRoWs are sensitive receptors when considering landscape and visual impacts and need careful consideration when developing the development proposal.  **Figure 3: Public rights of way map**
Heritage constraints	There are no designated heritage assets on site. Within a 500m buffer (from centre of site), there are two designated heritage assets: • Greys Mallory (Including Forecourt Walls to East and Southeast) • West Lodge, East Lodge and Archway (106 yards to east of Greys Mallory)  **Figure 4: Heritage Mapping with 500m Buffer**

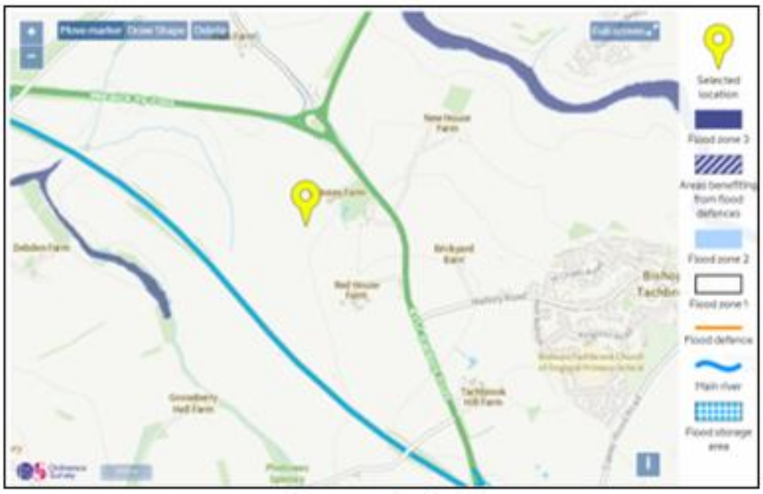
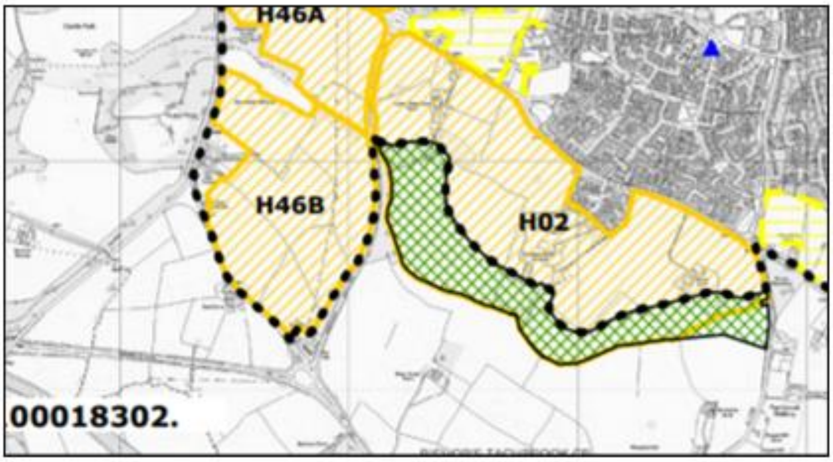
	In addition to these close receptors, there are additional heritage assets outside the 500m which will also require consideration. These include a cluster of Grade II listed structures in Bishop's Tachbrook and its associated Conservation Area, but more importantly, Warwick Castle, Warwick Castle Grade I Park and Garden and their associated assets. At their nearest point, the appraisal site and Warwick Castle Park and Garden is only 500m away.
Air Quality Management Area	The site not within an AQMA.
Flood zone	The site is in Flood Zone 1, indicating a low risk of flooding.  **Figure 5: Flood risk** The site has a very low risk of surface water flooding; however, there are small areas of low and medium risk. As the site is above 1ha, it will require an accompanying Flood Risk Assessment. 

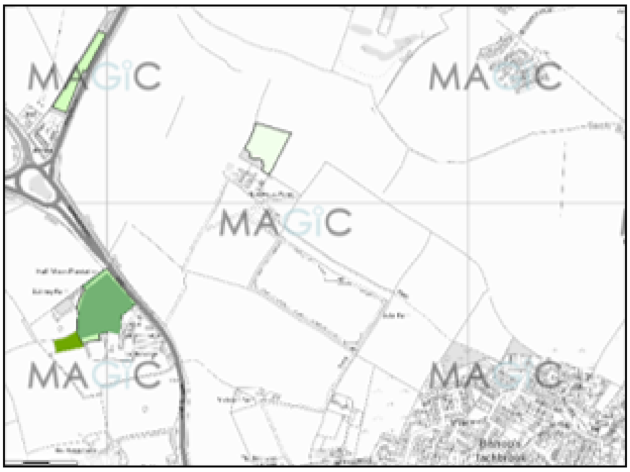
	Figure 6: Surface water
Coal mining	The site is not within an area affected by historic coal mining activities.
Access	Farm access from Banbury Road.
ALC	Within plans available through Natural England, the appraisal site is identified as being Grade 3 (good to moderate). As such, the appraisal site will require a ALC survey to determine whether the land is considered the best and most versatile. If the land is found to be Grade 3a, any application on site will be required to demonstrate why the benefits of the proposal outweigh the loss of best & most versatile agricultural land.  **Figure 7: Agricultural Land Classification**
Planning Documents	• Planning Statement • Design and Access Statement • Landscaping Visual and Impact Assessment • Landscape Mitigation Plan • Phase 1 Preliminary Risk Assessment • Flood risk assessment with drainage strategy • Heritage and Archaeology Desk based assessment • Glint & Glare Assessment • Noise assessment (if battery storage is proposed) • Ecological Assessment and biodiversity management plan • Transport Assessment • Construction Management Plan The requirement for supporting documents can be confirmed through the pre-application process.
Recommendations and Next Steps Actions	
Recommendations	The proposed renewable energy facility can use the renewable energy policy aspirations of Policy CC2. Renewable energy projects to benefit from planning policy support (if the

	identified harm is acceptable in the overall planning balance) and the Council's ambition to become net-zero carbon by 2030. The site is not allocated for a specific use within the Warwick District Local Plan and is considered open countryside. The local landscape is not protected; however, the Warwick Castle Park and Garden is approximately 500m to the north. As such, it is likely that the proposal will require an initial landscape appraisal to determine whether the development proposed would detract from the setting of the Park and Garden. Similarly, Greys Mallory and West Lodge, East Lodge and Archway are in proximity and will require consideration through a Heritage Impact Assessment. Given the sensitivities of some of the receptors (Warwick Castle, listed buildings), the proposal will require a landscape and planting strategy to assist in screening the development. This strategy should respond to the recommendations of Warwickshire County Council Assessment and Strategies. Complete an agricultural land classification survey to confirm the land quality and if it is best and most versatile land agricultural land. As noted above, achieving planning permission for onshore wind turbines is challenging. It requires as site allocation within a Local or Neighbourhood Plan and backing from the local community following consultation. Section 2.2.2 of this report recommends a 60m column. It is unlikely this will achieve planning permission due to the high levels of intervisibility associated with structures of this height. It will have an impact on Warwick Castle and Warwick Castle Park and Garden. Hydrogen production can be built to various scales; however, the delivery of fuel is a key consideration when determining whether the site is suitable. As noted within the report, directly to the north of the Junction is a proposed park and ride, which could provide a key anchor to the provision of a hydrogen hub. As the report noted, the largest single contributor to the cost of hydrogen production is the cost of power, so the ability to provide a private wire from a neighbouring energy from waste plant would provide extensive opportunities for the site. Feasibility studies should be undertaken to determine whether a hub in this location is feasible or practical.
Next steps	• Consider the best technology for the site • Undertake a survey to determine the quality of the agricultural land • Undertake initial landscape assessment work • Undertake initial heritage assessment work particularly in respect of the Castle • Engage in consultation with statutory consultees.
Conclusion	The sites represents an opportunity to progress a renewable energy generating facility in the form of PV solar. Depending on the delivery of power and impact on nearby land users, part of the site could be used for a hydrogen hub.

	The development site has no formal designation and is classed as countryside. The M40 forms part of the strategic highway network and is a detractive feature on the landscape. Notwithstanding this, the wider landscape may be sensitive to change. If solar is proposed a landscape visual impact assessment should be undertaken. For smaller scale development landscape impacts will still need to considered though a robust planting mitigation strategy to screen sensitive receptors should be formulated. It is critical to demonstrate that a proposed solar farm would not have a significant impact on the surrounding landscape (and nearby residential dwellings and heritage assets). An agricultural land classification survey is required to confirm the land quality and if it is higher grade (best & most versatile) agricultural land. Should the impact on nearby receptors be acceptable (or made to be acceptable), there are no policy restrictions as to why a solar farm or hydrogen hub would not be permitted in this location.

Land east of A452 at Greys Mallory

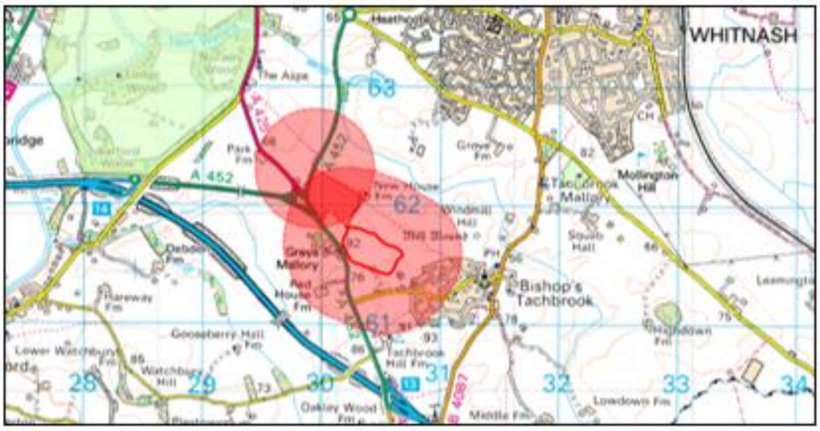
Check	Comment
Site address Inc. post code	Land east of A452 at Greys Mallory
Co-ordinates	X 320078 Y 262080 SPD: 300620
Area	22.7 hectares
Statutory designations (map below)	The development site is located outside of a settlement boundary and would constitute a countryside location. The site has no formal designation within the Local Plan.  **Figure 1: Policy map (Site donated by red line)** The appraisal sites are situated close to land designated for housing allocations within the Warwick District Local Plan (H46B). At its closest point, only Europa Way (A452) separates the appraisal site and the housing development. To the north of the site is land designated for the Tachbrook Country Park to provide open space for the future and existing residents of South Leamington Spa. At its closest point, the land designated for this use is approximately 400m to the north of the appraisal site
Existing use. Brownfield/ Greenfield	Both sites are arable agricultural land parcels. Greenfield.
Distance from other sensitive sites	There are no statutory or non-statutory designations on site. There are several isolated pockets of woodland surrounding the appraisal site, including a 0.98 conifer woodland identified within the National Forest Inventory just north of the farmstead in between the two sites. On the opposite side of the A452 south of the site is the Half Moon Plantation, which is identified within the Priority Habitat Inventory as

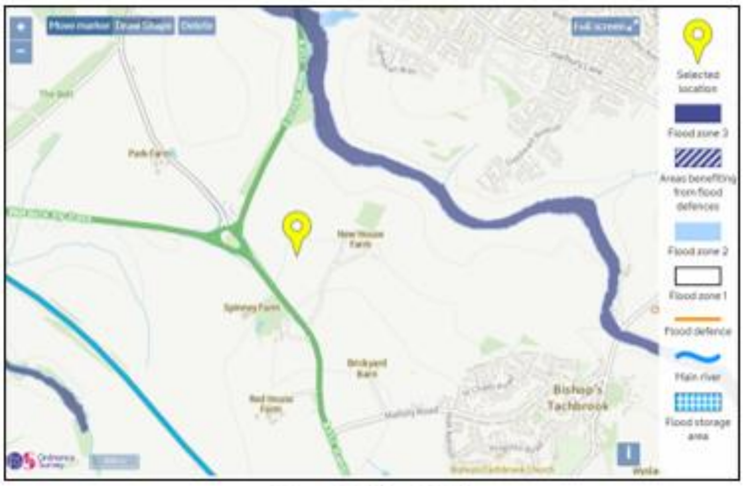
	deciduous woodland and Traditional Orchard. It is also in the National Forest Inventory as broadleaved woodland.  **Figure 2: Ecology Map** A review of species designations across the site has identified the site as featuring tree sparrows. Renewable schemes, such as solar farms, offer opportunities for biodiversity net gain through on site improvements. Any proposed development on site would need to be supported by an Ecological Assessment and a biodiversity net gain can be demonstrated through the Biodiversity Metric 2.0 tool.
Local Authority	Warwick District Council
Key Planning Policies	Regarding how the Government intends to meet the challenge of climate change, the National Planning Policy Framework states at Paragraph 148 *'The planning system should support the transition to a low carbon future in a changing climate, taking full account of flood risk and coastal change. It should help to: shape places in ways that contribute to radical reductions in greenhouse gas emissions, minimise vulnerability and improve resilience; encourage the reuse of existing resources, including the conversion of existing buildings; and support renewable and low carbon energy and associated infrastructure.'* Additionally, Paragraph 154 states *'When determining planning applications for renewable and low carbon development, local planning authorities should:* *a) not require applicants to demonstrate the overall need for renewable or low carbon energy, and recognise that even small-scale projects provide a valuable contribution to cutting greenhouse gas emissions; and* *b) approve the application if its impacts are (or can be made) acceptable. Once suitable areas for renewable and low carbon energy have been identified in plans, local planning authorities should expect subsequent applications for commercial scale projects outside these areas to demonstrate that the proposed location meets the criteria used in identifying suitable areas'.*

	The Development Plan for Warwick District Council consists of: **CC2 Planning for Renewable Energy and Low Carbon Generation** – Proposals for new carbon and renewable energy technologies (including associated infrastructure) will be supported in principle subject to all of the following criteria being demonstrate: a) The proposal has been designed to minimise any adverse impacts on adjacent land uses b) The proposal has been designed to minimise impact on natural environment in terms of landscape, ecology and visual impact c) The design will ensure heritage assets are conserved in a manner appropriate to their significance d) Where appropriate, the scheme can link with proposals being brought forward through the Council's Low Carbon Action Plan and any other future climate strategies e) The scheme maximises appropriate opportunities to address the energy needs of neighbouring uses f) For biomass, it should be demonstrated the fuel can be obtained from sustainable sources g) For proposals for hydropower the application should normally be accompanied by a flood risk assessment. Also, for wind energy proposals, planning permission will only be granted if: h) The development is in an area identified in either the Local Plan or a Neighbourhood Plan as being suitable for wind energy; and, i) Following consultation, it can be demonstrated that the planning impacts identified by local communities affected by the proposal have been fully addressed and that the proposal has the backing of those communities. **HE1 Designated Heritage Assets and their setting** – Development will not be permitted if it would lead to substantial harm to, or total loss of, the significance of a designated heritage asset, unless it is demonstrated that the substantial harm or loss is necessary to achieve substantial public benefits that outweigh the harm, or it is demonstrated the following apply: a) The nature of the heritage asset presents all reasonable uses of the site; and b) No viable use of the heritage asset itself can be found that will enable its conservation, and c) Conservation by grant funding or charitable public ownership is not possible; and d) The harm or loss is outweighed by the public benefit of bringing the site back into use.

	Where development would lead to less than substantial harm to the significance of a designated heritage asset, this harm will be weighed against the public benefits of the proposal, including securing its optimum viable use. **HE4 Archaeology** – Development will not be permitted that results in substantial harm to Scheduled Monuments or other archaeological remains of national importance, and their settings unless in wholly exceptional circumstances. **NE3 Biodiversity** – New development will be permitted if it protects, enhances and/or restores habitat biodiversity. Development proposals will be expected to ensure that they: a) Lead to no net loss of biodiversity, and where possible a net gain b) Protect or enhance biodiversity assets and secure their long term management and maintenance, and; c) Avoid negative impacts on existing biodiversity. Where this is not possible, mitigation measures must be identified. If mitigation measures are not possible, then compensatory measures involving biodiversity offsetting will be required. **NE 4 Landscape** – New development will be permitted that positively contributes to landscape character. Development proposals will be required to demonstrate they: a) Integrate landscape planning into the design of the development at early stages b) Consider its landscape context, including local distinctiveness of the different natural and historic landscapes and character, including tranquillity c) Relate well to local topography, and built form and enhance key landscape features, ensuring their long term management and maintenance d) Identify likely visual impacts on the local landscape and its immediate setting and undertake appropriate landscaping to reduce these impacts e) Aim to either conserve, enhance and restore important landscape features in accordance with the latest local and national guidance f) Avoid detrimental effects on features which make a significance contribution to the character, history and setting of an asset, settlement or area g) Address the importance of habitat biodiversity features, including aged and veteran trees, woodland and hedges and their contribution to landscape character, and where possible, enhancing these features through means such as buffering and reconnecting fragmented areas h) Maintain the existence of viable agricultural units i) Are sensitive to an areas capacity to change, acknowledge cumulative effects and guard against coalescence between existing settlements. **NE8 Protection of Natural Resources** – Development proposals will be permitted provided they ensure that the district's natural resources remain safe, protected and prudently used. Development proposals will be expected to demonstrate they: d) Avoid the best and most versatile agricultural land unless the benefits of the proposal outweigh the need to protect the land for agricultural purposes.

Planning history	
Distance from residential	The nearest residential properties neighbouring the site are the isolated farm buildings off the A452, including New House Farm, Greys Mallory, and Red House Farm. As noted, the allocated residential development to the south of Heathcote will be in proximity to the site. The site is approximately 220m north of Bishop's Tachbrook. Any proposed development will need to consider the residential amenity of nearby dwellings, in addition to the other isolated dwellings surrounding the site. A landscape mitigation plan should consider how best new planting can be introduced to further screen the site.
Landscape	Policy NE4 requires development to positively contribute to landscape character. The appraisal site lies within the Feldon Parkland Landscape Character Area. It is made up of farmland which provides an important buffer separating it from Heathcote and Whitnash. The area comprises open, medium to large scale, mainly arable landscape. Hedgerows are largely redundant, with many having gaps. Some have been trimmed, whereas others have been left to grow. The associated Landscape Sensitivity and Ecological & Geological Study states that the visual sensitivity is moderate, whilst the landscape has high intervisibility. The study identifies key receptors as rural and urban residents and public rights of way users. The study identifies the potential to replace hedgerows oaks and plant coverts and belts of trees to restore Feldon Parklands character. Due to the nature of the development and the high intervisibility across the landscape area, the proposal will require a Landscape Visual Impact Assessment and landscaping plan to demonstrate that the proposal can be suitably assimilated into the landscape without impacting on the character of the landscape.
PRoWs	A desktop review of the site has identified a public right of way within proximity to the development site. It is likely that any proposal on site will require a landscape and planting strategy to effectively screen users of the local PRoW network from the proposed development. Users of the PRoWs are sensitive receptors when considering landscape and visual impacts and need careful consideration when developing the proposal. It is not unusual for solar farms to be dissected by a pubic right of way as a countryside location are usually required for solar farms due to developable area required.

	 **Figure 3: Public rights of way map**
Heritage constraints	Within a 500m buffer of each site, there is a total of 3 designated heritage assets that would require specific consideration if this site progressed to a planning application. These are: • Greys Mallory (including Forecourt Walls to East and Southeast) • Barn approximately 30 metres northwest of Newhouse Farmhouse West Lodge, East Lode and Archway 106 yards to  **Figure 4: Heritage Mapping with 500m Buffer** In addition to these heritage assets, there are additional assets outside the 500m buffer which will also require consideration. These include a cluster of Grade II listed structures in Bishop's Tachbrook and its associated Conservation Area, but more importantly, Warwick Castle, Warwick Castle Grade I Park and Garden and their associated assets. The border of the Warwick Castle Park and Garden is approximately 1km to the west. Critically, during the determination process for the solar PV scheme adjacent to the appraisal site, English Heritage noted that the *proposal will not have an impact upon the setting of the Castle and Park*, which was further established through additional heritage

	work which found the scheme only had a low impact on the significance of designated heritage assets. It should be noted this was only for a modest sized solar farm and cumulative impacts will need to be considered.
Air Quality Management Area	The site not within an AQMA.
Flood zone	The site is in Flood Zone 1, indicating a low probability of flooding.  **Figure 5: Flood risk** The site has a low risk of surface water flooding.  **Figure 6: Surface water**
Coal mining	The site is not within an area affected by historic coal mining activities.
Access	The site has access onto Banbury Road
ALC	Within plans available through Natural England, the appraisal site is identified as being Grade 3 (good to moderate). The National Planning Policy Framework (NPPF) designates grades 1,2 and 3a as being the Best and Most Versatile Land (BMVAL). National and local

<table>
<tr><td></td><td>policy protects BMVAL from development. As such, the appraisal site will required a ALC survey to determine whether the land is considered the best and most versatile.

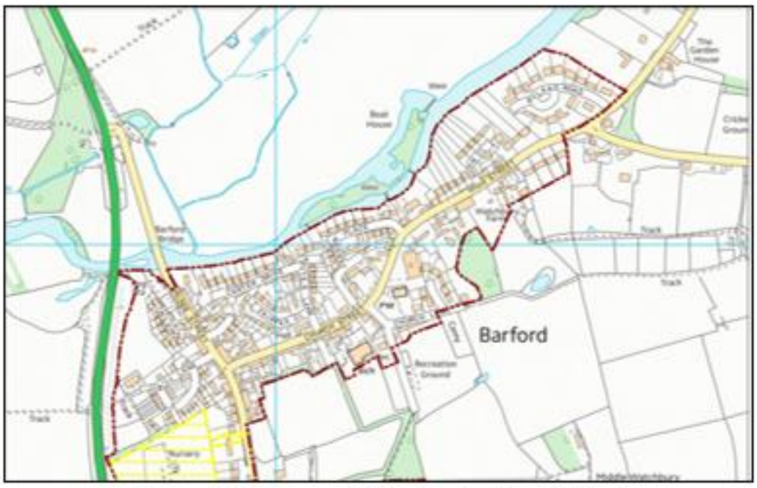
If the land is found to be Grade 3a, any application on site will be required to demonstrate that the benefits outweigh the loss of best & most versatile agricultural land.

Figure 7: Agricultural Land Classification</td></tr>
<tr><td>Planning Documents</td><td>• Planning Statement
• Design and Access Statement
• Landscaping Visual and Impact Assessment
• Landscape Mitigation Plan
• Phase 1 Preliminary Risk Assessment
• Flood risk assessment with drainage strategy
• Heritage and Archaeology Desk based assessment
• Glint & Glare Assessment
• Noise assessment (if battery storage is proposed)
• Ecological Assessment and biodiversity management plan
• Transport Assessment
• Construction Management Plan
The requirement for supporting documents can be confirmed through the pre-application process.</td></tr>
<tr><td colspan="2">Recommendations and Next Steps Actions</td></tr>
<tr><td>Recommendations</td><td>The proposed renewable energy facility can use the renewable energy policy aspirations of Policy CC2. Renewable energy projects to benefit from planning policy support (if the identified harm is acceptable in the overall planning balance), and the Council's aspirations to net-zero carbon by 2030.

Complete an agricultural land classification survey to confirm the land quality and if it is best and most versatile land agricultural land.</td></tr>
</table>

	An initial landscape assessment should be undertaken to assess the impact of the development on the local landscaping, with reference to the housing allocation and proposed Country Park to the north, and Warwick Castle and Warwick Castle Park and Garden to the northwest. Determine the cumulative impact of proposed development and the existing solar farm adjacent to the appraisal site.
Next steps	• Consider the best technology for the site • Undertake a survey to determine the quality of the agricultural land • Undertake initial landscape assessment work • Undertake initial heritage assessment work
Conclusion	The sites represents an opportunity to progress a renewable energy generating facility The development site has no formal designation and is classed as open countryside. The wider landscape undulates. As such, it is vital to demonstrate that the proposed solar farm would not have a significant impact on the surrounding landscape (and nearby residential dwellings and heritage assets). An agricultural land classification survey is required to confirm the agricultural land grade. Should the impact on nearby receptors be acceptable (or made to be acceptable), there are no policy restrictions as to why a solar farm or alternative energy proposal would not be permitted in this location.

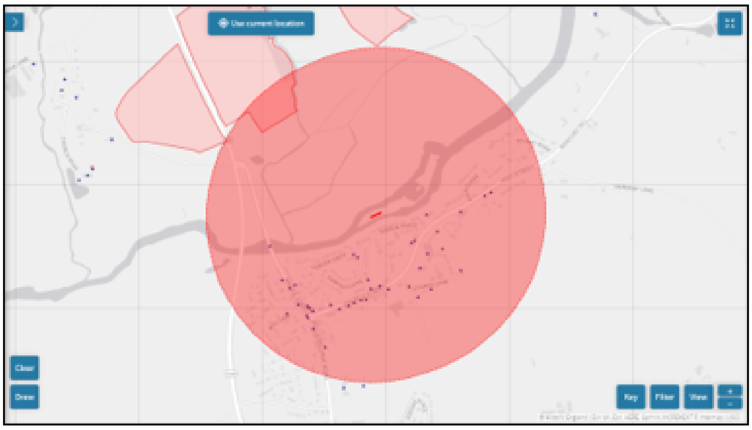
Hydro on River Avon

Check	Comment
Site address Inc. post code	Hydropower on the River Avon
Co-ordinates	X 427079 Y261068 SP270610
Area	n/a
Statutory designations (map below)	The development site is located outside of a settlement boundary and would constitute a countryside location. The site has no formal designation within the Warwick District Local Plan:  **Figure 1: Policy map (Site donated by red line)**
Existing use. Brownfield/ Greenfield	Section of river used by Warwick University Boat Club, anglers, canoeists.
Distance from other sensitive sites	 **Figure 2: Ecology Map**

	There are no statutory designations on site. A review of sensitive receptors on, or adjacent to the site found the following land-based designations: • Priority Habitat Inventory – Deciduous Woodland • National Forest Inventory – Broadleaved Woodland • Network Expansion Zone • Priority Habitat Inventory – Coastal and Floodplain Grazing Marsh • SSSI Impact Risk Zones. In terms of ecology, the main considerations would be an assessment of the proposals in accordance with the Water Framework Directive (i.e., do the proposals help contribute to the WFD ecology objectives for the watercourse if there are any), is there potential for associated protected species, e.g. Otter, Water Vole, White-clawed Crayfish, protected fish species, Kingfisher, foraging bats etc. and how may they be impacted during construction and operation. Further consideration should be given to the potential for impacts on downstream habitats, which may be impacted.
Local Authority	Warwick District Council
Key Planning Policies	Regarding how the Government intends to meet the challenge of climate change, the National Planning Policy Framework states at Paragraph 148 *'The planning system should support the transition to a low carbon future in a changing climate, taking full account of flood risk and coastal change. It should help to: shape places in ways that contribute to radical reductions in greenhouse gas emissions, minimise vulnerability and improve resilience; encourage the reuse of existing resources, including the conversion of existing buildings; and support renewable and low carbon energy and associated infrastructure.'* Additionally, Paragraph 154 states *'When determining planning applications for renewable and low carbon development, local planning authorities should:* *a) not require applicants to demonstrate the overall need for renewable or low carbon energy, and recognise that even small-scale projects provide a valuable contribution to cutting greenhouse gas emissions; and* *b) approve the application if its impacts are (or can be made) acceptable. Once suitable areas for renewable and low carbon energy have been identified in plans, local planning authorities should expect subsequent applications for commercial scale projects outside these areas to demonstrate that the proposed location meets the criteria used in identifying suitable areas'*. The Development Plan for Warwick District Council consists of:

	CC2 Planning for Renewable Energy and Low Carbon Generation – Proposals for new carbon and renewable energy technologies (including associated infrastructure) will be supported in principle subject to all of the following criteria being demonstrate: a) The proposal has been designed to minimise any adverse impacts on adjacent land uses b) The proposal has been designed to minimise impact on natural environment in terms of landscape, ecology and visual impact c) The design will ensure heritage assets are conserved in a manner appropriate to their significance d) Where appropriate, the scheme can link with proposals being brought forward through the Council's Low Carbon Action Plan and any other future climate strategies e) The scheme maximises appropriate opportunities to address the energy needs of neighbouring uses f) For biomass, it should be demonstrated the fuel can be obtained from sustainable sources g) For proposals for hydropower the application should normally be accompanied by a flood risk assessment. Also, for wind energy proposals, planning permission will only be granted if: h) The development is in an area identified in either the Local Plan or a Neighbourhood Plan as being suitable for wind energy; and, i) Following consultation, it can be demonstrated that the planning impacts identified by local communities affected by the proposal have been fully addressed and that the proposal has the backing of those communities. **HE1 Designated Heritage Assets and their setting** – Development will not be permitted if it would lead to substantial harm to, or total loss of, the significance of a designated heritage asset, unless it is demonstrated that the substantial harm or loss is necessary to achieve substantial public benefits that outweigh the harm, or it is demonstrated the following apply: a) The nature of the heritage asset presents all reasonable uses of the site; and b) No viable use of the heritage asset itself can be found that will enable its conservation, and c) Conservation by grant funding or charitable public ownership is not possible; and d) The harm or loss is outweighed by the public benefit of bringing the site back into use. Where development would lead to less than substantial harm to the significance of a designated heritage asset, this harm will be weighed against the public benefits of the proposal, including securing its optimum viable use.

	HE4 Archaeology – Development will not be permitted that results in substantial harm to Scheduled Monuments or other archaeological remains of national importance, and their settings unless in wholly exceptional circumstances. **NE3 Biodiversity** – New development will be permitted if it protects, enhances and/or restores habitat biodiversity. Development proposals will be expected to ensure that they: a) Lead to no net loss of biodiversity, and where possible a net gain b) Protect or enhance biodiversity assets and secure their long term management and maintenance, and; c) Avoid negative impacts on existing biodiversity. Where this is not possible, mitigation measures must be identified. If mitigation measures are not possible, then compensatory measures involving biodiversity offsetting will be required. **NE 4 Landscape** – New development will be permitted that positively contributes to landscape character. Development proposals will be required to demonstrate they: a) Integrate landscape planning into the design of the development at early stages b) Consider its landscape context, including local distinctiveness of the different natural and historic landscapes and character, including tranquillity c) Relate well to local topography, and built form and enhance key landscape features, ensuring their long term management and maintenance d) Identify likely visual impacts on the local landscape and its immediate setting and undertake appropriate landscaping to reduce these impacts e) Aim to either conserve, enhance and restore important landscape features in accordance with the latest local and national guidance f) Avoid detrimental effects on features which make a significance contribution to the character, history and setting of an asset, settlement or area g) Address the importance of habitat biodiversity features, including aged and veteran trees, woodland and hedges and their contribution to landscape character, and where possible, enhancing these features through means such as buffering and reconnecting fragmented areas h) Maintain the existence of viable agricultural units i) Are sensitive to an areas capacity to change, acknowledge cumulative effects and guard against coalescence between existing settlements. **NE8 Protection of Natural Resources** – Development proposals will be permitted provided they ensure that the district's natural resources remain safe, protected and prudently used. Development proposals will be expected to demonstrate they: • Avoid the best and most versatile agricultural land unless the benefits of the proposal outweigh the need to protect the land for agricultural purposes.
Distance from residential	The nearest residential receptors are dwellinghouses on Vernon Place. The rear gardens of these dwellings abut directly onto the River Avon.

	A noise assessment may be required to determine the impact of hydropower development on these receptors.
Landscape	The appraisal site lies on the border between the Feldon Parklands and the Terrace Farmlands character areas. The characteristics of Feldon Parklands have been outlined in previous chapters. The Terrace Farmland landscape character area is defined by: • Broad, flat gravel terraces • A large scale geometric field pattern • Small arable plots growing a wide variety of vegetable crops • Well wooded streamlines • Glasshouses and other associated horticultural buildings • Small, nucleated villages with many brick and timber buildings. Whilst a hydropower station would be isolated within the wider landscape, it is likely that landscaping works would be required to demonstrate that it will not have a detrimental impact on the landscape character of the area.
PRoWs	No public right of way dissect the site.
Heritage constraints	There are no heritage assets on site.  **Figure 3: Heritage Mapping with 500m Buffer** Within a 500m buffer surrounding the development site, there are 41 identified heritage assets. These include 39 Grade II listed structures, clustered predominantly in Barford, and 2 historic enclosures that are scheduled monuments. Further out from the 500m buffer there is an additional designated historic enclosure. 1.5km northeast of the appraisal site is Warwick Castle Park and Garden. The site is located within the Barford Conservation Area.
Air Quality Management Area	The site not within an AQMA.

Flood zone	Given the weirs location in the River Avon, the site is in Flood Zone 3, indicating a high risk of flooding.  **Figure 4: Flood risk** Similarly, and as expected the surrounding area is susceptible to surface water flooding.  **Figure 5: Surface water** Policy CC2 requires applications for hydropower to be accompanied by a Flood Risk Assessment.
Coal mining	The site is not within an area affected by historic coal mining activities.
Access	There is no clear defined access onto the site; however, it is anticipated there is suitable vehicular access to the site to service the weirs could be identfied.
Planning Documents	• Planning Statement • Design and Access Statement • Landscaping Assessment • Landscape Mitigation Plan • Flood risk assessment with drainage strategy

	• Heritage Assessment • Noise assessment • Ecological Assessment and biodiversity management plan • Construction Management Plan The requirement for supporting documents can be confirmed through the pre-application process.
Recommendations and Next Steps Actions	
Recommendations	The proposed renewable energy facility can use the renewable energy policy aspirations of Policy CC2. Renewable energy projects benefit from planning policy support (if the identified harm is acceptable in the overall planning balance) and the Council's ambition to become net-zero carbon by 2030. Planning permission would be required for: • any new structures: including a small turbine house (circa 3m x 3m), • any engineering works required to enable the weir to be used for hydro generation (such as raising the northern spillway, repairing the walls). The site is not allocated for a specific land use within the Warwick District Local Plan and is considered open countryside though is actually watercourse. The local landscape is not protected; however, there are two scheduled monuments within 500m of the site, and there is a listed Park and Garden 1.5km northeast. The site is located within the Barford Conservation Area and any new structures and infrastructure will need to be sympathetically designed so adverse impacts on the heritage assets are minimised. All small hydro and micro hydro systems must have a hydro license issued by the Environment Agency (EA) in England and is a separate permitting regime to planning permission. The process to obtain the licenses takes on average circa nine months for a typical site. Planning permission will be required for any new structures/ engineering works proposed. A Preliminary Ecological Appraisal would be utilised to inform whether there are any specific ecology constraints and opportunities due to the sensitivities associated with development in, or adjacent to, watercourses.
Next steps	• Confirm the quantum of development required to generate hydro energy • Undertake initial heritage assessment work • Undertake preliminary ecology surveys • Undertake preliminary discussions with the Environment Agency
Conclusion	The sites represents a good opportunity to progress a renewable energy generating facility; however, the proximity to residential development and historic designations may be constraints to development. The proposal will require a Flood Risk Assessment, as dictated through the Local Plan.

	Consideration should be given to the construction methods and noise of the development, both during construction and during operation. Development in Warwick District should provide biodiversity net-gains, and consideration to how this can be achieved should be given. Should the impact on nearby receptors be acceptable (or made to be acceptable), there are no policy restrictions as to why a solar farm would not be permitted in this location.

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