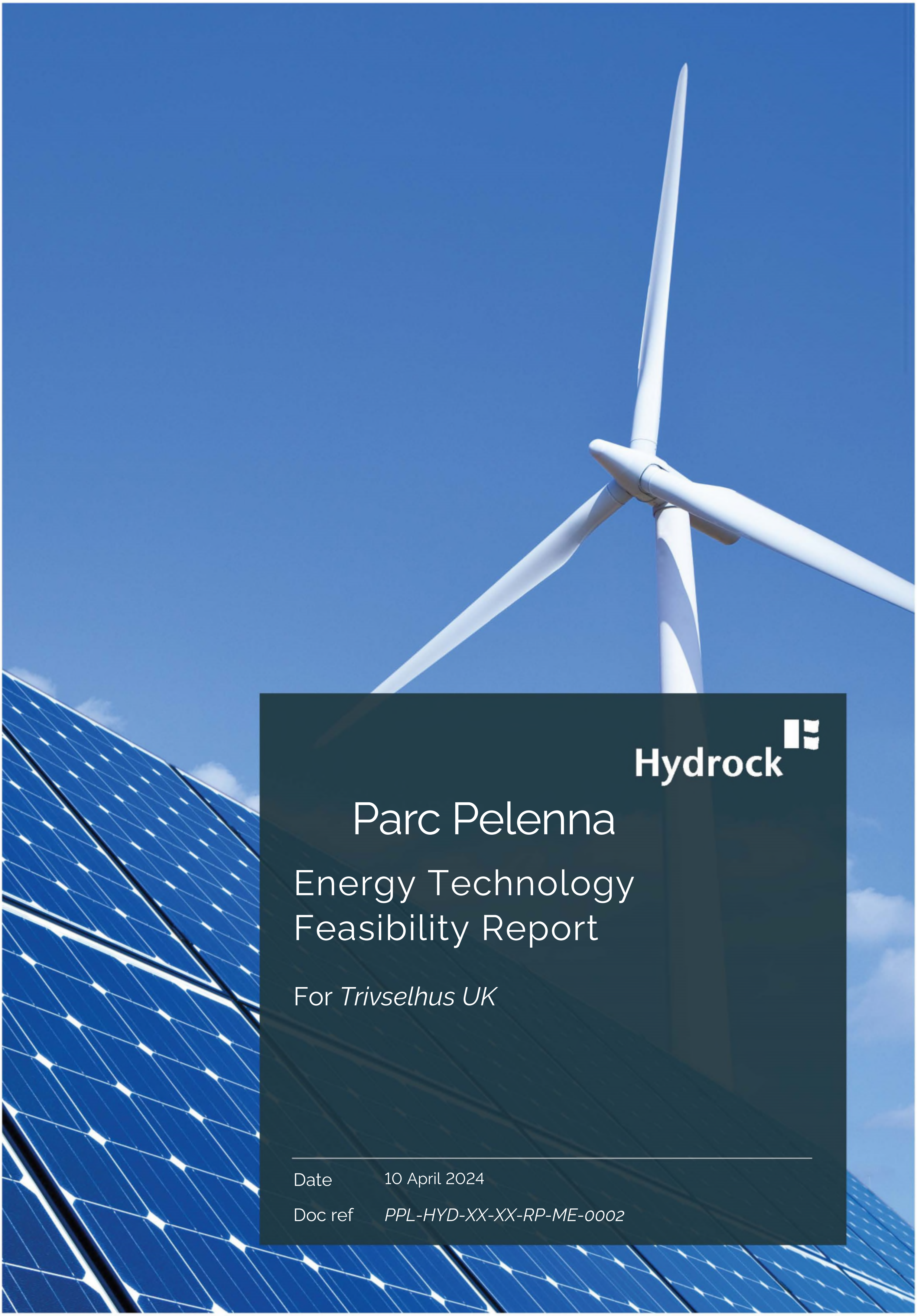

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Parc Pelenna

Energy Technology Feasibility Report

For *Trivselhus UK*

Date 10 April 2024

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1. Introduction

1.1 Study Context

This feasibility report examines the viability of implementing various energy technologies at Parc Pelenna to identify the optimal solution when considering the need to improve energy efficiency, reduce costs, and minimize environmental impact. The report assesses the technical features of each proposed technology, providing recommendations whether each solution is viable for the proposed site. While this report covers economic factors, it does not provide breakdowns of the costs of incorporating each technology and the savings produced. This report does not seek to demonstrate Building Regulations Wales Part L 2022 compliance, however some information on the regulation is provided. As design develops, a full Part L compliance assessment will need to be carried out.

2. Site Details and Energy Demand

2.1 Site Details

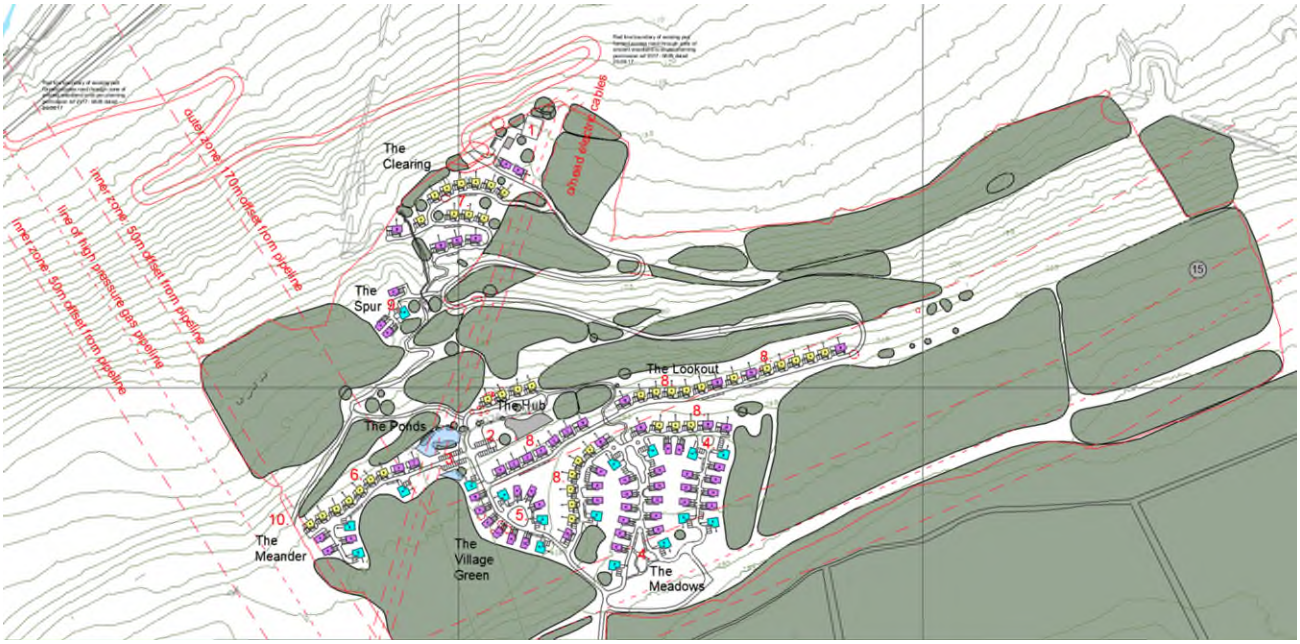

Figure 1: 2D Plan of the proposed Parc Pelenna site.

The Parc Pelenna site is located north-east of Neath, residing on the side of a nearby hill, surrounded by woodland. The proposed site shall consist of a number of lodges, with a leisure complex located in the centre.

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3. Policy Context

3.1 National Policy

This section sets out a summary of current national guidance and policy in relation to sustainable development.

3.2 National Planning Policy Framework

The National Planning Policy Framework (NPPF) for Wales includes the following documents: Planning Policy Wales (PPW), Technical Advice Notes (TANs), Minerals Technical Advice Notes (MTANs) and Policy Clarification Letters (PCLs). The primary objective of these documents is to ensure that the planning system contributes towards the delivery of sustainable development and improves the social, economic, environmental and cultural well-being of Wales, as required by the Planning (Wales) Act 2015, the Well-being of Future Generations (Wales) Act 2015 and other key legislation and resultant duties such as the Socio-economic Duty.

All planning decisions must align with the above documents and decisions must seek to promote sustainable development and support the well-being of people and communities across Wales.

Planning Policy Wales defines five Key Planning Principles:

- Growing our economy in a sustainable manner
- Making best use of resources
- Facilitating accessible and healthy environments
- Creating & sustaining communities
- Maximising environmental protection and limiting environmental impact

Every development plan must take forward the national sustainable placemaking outcomes and use them to develop an overarching set of outcomes. Each development plan will consider the scale at which they will contribute, through policies and allocations, to achieving an outcome. Collectively, the focus on achieving these outcomes across all development plans will ensure the planning system plays its role in delivering sustainable places.

Ideally all developments in Wales should have the following outcomes: meet appropriate development densities, generate their own renewable energy, promote clean air and reduce overall pollution, promote physical and mental health and well-being.

3.3 Practice Guidance (Planning for Sustainable Buildings)

Planning Practice Guidance (PPG) provides further advice on various planning issues associated with development, including those linked to sustainability and renewable energy and underpins the policies within the NPPF.

PPG is a material consideration in planning decisions and should generally be followed unless there are clear reasons not to. It sets out how local authorities should include polices that protect the local environment and strategies to mitigate and adapt to climate change and supports developments that are functional and adaptable for the future.

PPW (4.4.3, 4.7, and 4.12) sets out the Welsh Government's land use planning policies in respect of planning for sustainable buildings in development plans and development management. It does not establish a higher national building standard than Building Regulations, but encourages local planning authorities (LPAs) to seek opportunities to do so on strategic sites. TAN 12: Design, is the primary guide to achieving good quality sustainable design.

3.3.1 Technical Advice Note 12 – Objectives of Good Design

TAN 12 defines five key Objectives of Good Design: Access, Character, Community Safety, Environmental Sustainability, Movement. Environmental Sustainability is defined as "achieving efficient use and protection of natural resources; enhancing biodiversity; designing for change". To achieve Environmental Sustainability in design TAN 12 suggests that developments seek to minimise energy demand and carbon emissions through the implementation of energy hierarchy and zero carbon standards.

3.3.2 Recent Changes to Part L

A new Part L regulation for use in Wales was released in 2022.

Wales is also adopting the SAP 10 methodology which greatly benefits fully electrified sites. However, new buildings such as student accommodation have to cut emissions by an average of 27% when compared to the previous version.

The Government's aim is to reduce building carbon emissions by 75-80% compared to 2014 baselines by 2025. The first step towards this goal has come into effect since 2022 when the required 37% CO2 emissions decrease constitutes the halfway point on the road map to 2025.

This can be met through a combination of low carbon heating, on-site low / zero carbon energy technology with higher levels of passive design solutions (e.g. double glazing).

3.4 Local Planning Policies

3.4.1 Neath Port Talbot's Local Development Plan (2011-2026) - Policy RE2

Policy RE2 states that for developments that possess on-site renewable and low carbon energy generation, an Energy Assessment should be carried out to determine the feasibility of incorporating such technologies. This is the case for developments with a total floor area of 1000m^2 or greater.

3.5 Planning Policy Summary

Both local and national policy aims to ensure the delivery of sustainable and well-designed homes and other buildings which mitigate and adapt to the impacts of climate change.

The Local Development Plan confirms the Council's commitment to the creation of sustainable new developments.

The latest national planning policy and guidance confirm the Government's approach to sustainable development which is being driven through the updates to the Building Regulations to ensure new buildings are well designed and reduce emissions in line with the UK's national carbon targets.

4. Grant Funding initiatives

A number of financial incentives or low capital procurement solutions could be considered applicable for this development, from Government funding, local Government funding and private grant funding streams. Traditional grant funding for capital investment is limited but some competition schemes and private schemes are available. Examples of funding opportunities available at the present time include.

- Smart Export Guarantee (SEG)
- Energy Service Company (ESCo) or Energy Supply Contract
- Competition/Award Funding from Private Institutions
- Enhanced Capital Allowances (ECA)

4.1 Smart Export Guarantee (SEG)

The SEG is a government initiative for licensed electricity suppliers which can offer a tariff and make payment to small-scale low-carbon generators for electricity exported to the National Grid. Low-Carbon Technologies eligible for SEG include:

- Solar photovoltaic (solar PV)
- Wind
- Micro combined heat and power (micro-CHP)
- Hydro
- Anaerobic digestion (AD)

4.2 Energy Service Company (ESCo) or Energy Supply Contract

These are finance models where an energy supply contract is in place for low carbon technology and the building user purchases delivered energy at a rate lower than grid supplied energy. The supplier retains ownership of the technology and receives any beneficial tariff payments.

4.3 Competition/Award Funding from Private Institutions

Award schemes such as the Ashden Awards for Sustainable Energy and the Energy Globe Award competition where financial and prestigious awards honouring outstanding projects and initiatives worldwide in the field of sustainable development, including energy efficiency, renewable energy, water and the protection of the atmosphere. This is open to companies, private/ public institutions and individuals.

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5. Initial Review of Energy Technology Options

The following is a list of potential LZC technologies utilised in similar schemes within the UK and abroad. An initial high-level review has identified which technologies are worthy of further consideration within this report; those that are deemed currently unsuitable are struck through.

- ~~Wind~~ (reason: considerable planning constraints with local area, as well as visual concern for site, in addition, the site is within a valley and therefore will likely suffer from poor wind speeds and reliability)
- Solar
  - Hot Water
  - Photovoltaics
- Energy Storage
- Water
  - ~~Small Scale Hydro Power~~ (reason: no suitable water sources in the vicinity)
  - Rainwater Harvesting
- Biomass
  - ~~Biomass single room heaters/stoves~~ (reason: not suitable due to safety concerns)
  - Biomass boilers
  - ~~Biomass community heating schemes~~ (reason: no existing or planned community schemes at the time of writing)
- Combined Heat and Power (CHP) for use with the following fuels:
  - Natural Gas
  - Biomass
  - ~~Sewerage gas and other biogases~~ (reason: overly complex fuel procurement and storage)
- Heat Pumps
  - Ground source Heat Pumps
  - Air Source Heat Pumps
  - ~~Water source heat pumps~~ (reason: no suitable water sources in vicinity)
  - ~~Geothermal heating systems~~ (reason: no suitable geothermal sources in vicinity)

5.1 Non-Applicable Community Based Technologies

Some additional community-based technologies have had to be disregarded for the following reasons:

- Local community CHP system: Not applicable due to no community CHP system being present in the area.
- Community waste heat or power: Not applicable due to no community waste heat / power system being present in the area.

As a result of local community CHP or waste heat / power infrastructure systems not being present nearby, the proposed development cannot export excess heat or power.

The following sections within this report will investigate the remaining LZC technologies in greater detail.

Table 1: A table showing the breakdown of energy technologies potentially available for this site

Technology	Building Characteristics	Uses	Scale	Considerations	Viability
Photovoltaic Panels	Roof or façade mounted panels.	Suitable where there is a large electrical load, opportunity for export or battery storage.	To maximise potential, it is important to consider orientation. Pairs well with electric heating and/or hot water.	To maximise potential, it is important to consider orientation. Pairs well with electric heating and/or hot water, as well as electric vehicle charging.	Viable
Energy Storage	Space allowance for internal or external facility.	Paired with electrical renewable generation methods, such as wind or PV.	All scales	Significant capital Maintenace Space allowance	Viable
Solar Thermal	Additional hot water tank(s) required.	All uses.	Smaller scales, typically.	Needs a demand for hot water – domestic or canteens, showers, washrooms.	Not viable, discussed in 6.1.
Air Source Heat Pumps	Sited on external walls, within ground or rooftop enclosures or well-ventilated plant rooms.	All uses	All scales.	Careful siting needed to reduce aesthetic impact. Potential noise impact. Powered by electricity, so lower carbon reduction than other technologies. Can also be used to provide cooling, especially in building with no openable windows.	Viable
Ground Source Heat Pumps	External space for horizontal trench or vertical boreholes.	All uses.	Medium to large.	Archaeology. More effective if cooling and heating used in the building to balance the ground Typically, large capital outlay	Viable
Biomass Boiler	Space needed for plant, fuel storage and deliveries.	Mixed use, colleges, offices, commercial, residential- especially multi-residential – best where constant energy demand.	Medium to large, viable where heat demand is above 15 kW, can be combined with gas for summer / backup use.	Air quality impact. Impact of deliveries on operation of site Fuel source (security of supply) Distance transported.	Potentially viable, discussed in 9.1
Combined Heat and Power	Space needed for plant.	Applications with consistent heat and electricity demand, i.e. leisure centres, hotels, student accommodation	All scales	Ideally requires near constant heat demand to maximise benefit/minimise maintenance	Potentially unviable, discussed in 10.1
Rainwater Harvesting	Space for pumps, filtering and a storage tank (either above or below ground).	All uses	All scales	Demand for non-potable water (ie WC or external taps). Additional pipework may be required for separate systems. Water capture volume dependant on roof sizing.	Potentially unviable, discussed in 8.1

6. Solar

6.1 Solar Hot Water

6.1.1 Description

Solar Water Heating (SHW) systems use energy from the sun to heat water that is stored in either a separate hot water storage vessel or a twin coil hot water storage inside the building. The systems use heat collectors, generally mounted on the roof in which a fluid is heated by the sun. The anticipated life span of a SHW system is 30 years.

Solar energy technology comes in two distinct forms; solar tubes or solar flat plates, both of which act as solar collectors. When a fluid is passed through the solar collector, the temperature of the fluid will increase. The most common fluid used is currently water, although refrigerant can also be used.

Evacuated tube collectors are the best performing commercially available collectors and are considered most appropriate for commercial installations. Evacuated tube collectors consist of highly efficient heat conductors within evacuated glass tubes that are designed to maximise the energy collected from solar radiation and minimise radiation losses.

The solar collectors are connected to a pumped circuit. The heat transfer fluid is circulated from the collector into a hot water cylinder where it pre-heats the secondary water. This in turn then reduces the required load for the boiler, therefore reducing the energy demand to heat water to the required temperature for the project.

Figure 2 Example Solar Thermal Panels

6.1.2 Design Issues

A SHW system would only ever supplement the main heat source and the viability of a SHW system depends heavily on which primary heat source has been chosen. If CHP, Biomass or a heat pump is used as the primary heat source for example, then SHW would negatively affect viability because these systems operate most effectively when supplying as much of the demand as possible.

In addition, the following considerations should be made:

- To maximise the benefits and efficiencies of the SHW, the collectors should be orientated south and be installed at a 30˚ to 40˚ pitch.
- A relatively large hot water cylinder is required within a plantroom.
- The system provides for domestic hot water only and not space heating.
- The system will not deliver hot water throughout the full year, fully weather permitting.
- The system may be visible depending on the installation height relative to the surrounding building context. Planning permission will be required for solar collectors.
- Competes with photovoltaic panels for suitable roof space.

6.1.3 Suitability

With regards to this scheme, a SHW system has been found to be unviable, with the key point being the competition for space with PV. With water heating conventionally being achieved via gas boilers, the application of a solar thermal system could reduce the potential incoming gas supply. With gas being approximately 3 times cheaper than electricity, economically it would be more beneficial to employ PV on the available roof space.

6.2 Solar Photovoltaic Cells (PV)

6.2.1 Description

Photovoltaic (PV) systems convert energy from the sun into electricity through semi-conductor cells. PV systems are considered ecologically beneficial as they are non-polluting and produce no harmful residues.

PV cells are manufactured and sold as photovoltaic panels, and there are currently three options of panel available; mono-crystalline (approx. 20% efficient), polycrystalline (approx. 15% efficient), and amorphous thin film (approx. 10% efficient).

The positioning and orientation of the PV panels are crucial to their performance, ideally, they will be orientated due South with unobscured direct sunlight for maximum electrical output.

Systems consist of semi-conductor cells connected together and mounted into modules. Modules are connected to an inverter to turn their direct current (DC) into alternating current (AC), which is usable in buildings.

The anticipated life span of a PV cell is 30 years. Studies have shown that PV systems in the UK will generate an amount of energy equal to that used in their manufacture (energy payback), within approximately 4 to 5 years depending on the PV cell used and site conditions.

Roof mounted PV systems are visually discrete and operate with a negligible noise level, and as a result have been granted 'permitted planning' by the UK Government.

Figure 3 Example PV Array

6.2.2 Design Issues

PV can supply electricity either to the buildings they are attached to, or when the building demand is insufficient either used to charge energy storage systems (see Section 7) or electricity can be exported to the electricity grid.

The following considerations should be made regarding PV:

- To maximise the benefits of an installation solar modules (PV cells) should be south facing and installed with a 30˚ - 40˚ pitch in un-obscured sunlight.
- Solar panels installed at a pitch can cause higher stresses on the roof, and therefore often need to be offset with ballast weights.
- By offsetting electricity from the grid, PV can make the building cheaper to run

6.2.3 Suitability

From the considerations outlined above, no significant obstacles to utilising PV have been found. This technology has been deemed potentially suitable for the scheme. The PV will be sized based on the amount of available space for panels. Site conditions may hinder performance of the PV, with properties having possible issues with shading from trees or height relevant to the surrounding area.

7. Energy Storage System (ESS)

7.1 Battery Storage

7.1.1 Description

Batteries are devices used to store and provide electrical energy through chemical reactions. They come in various shapes, sizes, and compositions, catering to different needs and applications. For energy storage systems, batteries can store excess energy generated from renewable sources, such as solar panels and wind turbines, for later use when demand is higher or when renewable energy production is low. They can also aid in reducing electricity bills by storing energy during off-peak hours when rates are lower and supplying it during peak demand periods when rates are higher.

With any size storage system, space allowance must be considered, where the required sizing will be directly correlated to the capacity of the system, Battery storage can be internal or external depending on the application

Figure 4 An example battery storage facility.

7.1.2 Design Issues

As battery technology is an evolving market, there are constant improvements in battery performance, life cycle and maintenance. Alongside these factors, larger manufacturing scales are likely to bring costs down over time. However, these factors are still significant when considering the application of an ESS. These factors are discussed below:

- Life expectancy has stated potential ranges from 10-30 years, although these numbers can vary significantly and there is likely to be a degree of uncertainty.
- Maintenance and upkeep of the system is likely to incur further costs, adding to the significant capital investment required from this technology.
- The capital investment of a battery storage will be significant.
- The size of a system will be a considerable factor, with a potentially large space allowance needed to house the system.

7.1.3 Suitability

An ESS has been deemed as viable for this site. While capital investment and potential payback should be considered further by a specialist, space allowance on the site is suitable for this type of system. The ESS system would improve the effectiveness of renewable generation, for example PV, and could reduce energy bills for the site.

8. WATER

8.1 Rainwater Harvesting

8.1.1 Description

While not strictly a low or zero carbon technology for the building, a rainwater harvesting system does help reduce the carbon footprint of our water industry through minimising water usage. At present a significant amount of energy is consumed in collecting, treating and distributing potable water, which is then used for WC flushing, and does not require water to be purified to drinking standards. Therefore, rainwater harvesting technologies can help reduce the building's overall carbon footprint.

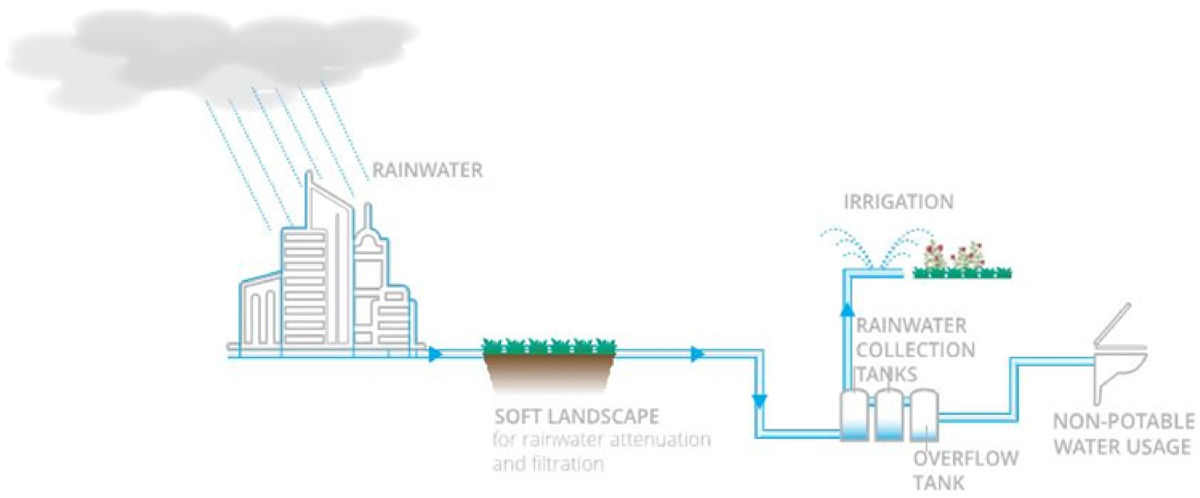

Figure 5 Typical Rainwater Harvesting System

A rainwater recovery system captures rainfall which lands on the roof of the building where it is stored in a tank for future use, typically WC and urinal flushing. This replaces water which would have been drawn from the mains water connection and hence reduces the demand and reliance on the mains water system.

It is also possible to recycle greywater from wash hand basins and showers. This can be utilised for toilet flushing or cleaning. Greywater can be collected, treated and stored along with rainwater, which means the two systems can be effectively combined.

For complete self-sufficiency, systems would need to treat the harvested rainwater to potable water standards. Foul water would be collected and treated to non-potable standard for toilet flushing. However, this is costly and has safety considerations that are likely to make it impractical.

8.1.2 Design Issues

The following considerations should be made:

- The unpredictable nature of rainfall means that a development should not be wholly dependent on rainwater, however it can be beneficial in reducing bills and demand. Especially so, when the development in question is located in an area with a reasonable amount of expected rainfall
- The volume of water captured is directly liked to this size of the catchment area, (roof area in most instances), as well as the annual rainfall in the area. Therefore, site evaluations must be made to assess the suitability for a specific site.

- The requirement of a large storage tank, whether underground or above, requires significant space which must be considered for the site. Space allocations must also be allowed for pumps and filters where necessary.
- Rainwater harvesting system would only be most cost effective if used to serve external taps and WC toilets, alongside any irrigation systems if applicable.

8.1.3 Suitability

Summary: This technology has been deemed potentially unsuitable for this scheme. The requirement of a significantly sized storage tank for the system would be incompatible with the layout of the properties on the site. As the water demand of each property would be considered low, the tanks would aim to serve multiple properties. Due to the limited applications of captured rain water, the reductions in water usage would be low, while creating additional infrastructure costs and complexity. Should a leisure complex be established with usage requirements that suit rainwater harvesting systems (external taps, WC toilets and irrigation systems), then this type of system could be reconsidered at a later stage.

9. BIOMASS

9.1 Biomass Heating

9.1.1 Description

The term 'Biomass' refers to an energy resource derived from organic matter, such as wood from forests, urban tree pruning, farmed coppices, energy crops or farm and industrial waste. As a tree grows it absorbs carbon dioxide, and when it is burnt the same amount of carbon dioxide is released. Biomass therefore has a very low net CO2 factor when used as fuel. In this report, we refer only to the type of biomass which can be made into wood chips or wood pellets and can be burnt in a standard biomass boiler.

Wood pellets are products from untreated wood waste such as sawdust, pulverised pallets or reclaimed timber. Wood chips are produced from a range of sources such as forestry timber, short rotation coppice and reclaimed timber.

Figure 6 Wood Pellet Spectrum

Wood fuelled boilers can directly replace conventional heating gas boilers however for performance reasons they are often used in parallel. In addition, biomass boilers are generally larger in terms of physical size than gas boilers, need additional equipment and often considerable fuel storage space.

Modern biomass boilers offer smoke free operation; however, a small amount of visible smoke can be emitted on cold start of the combustion system. As a result, planning consultation should be sought before installing biomass appliances.

Fuel particle size and moisture content have a significant impact on the efficiency of the boiler and maintenance regime required. As well as the storage that needs to be provided, the delivery of the fuel must also be taken into consideration. Table 2 provides an indication of the size of the fuel store required for three different indicative boiler sizes.

Table 2. Fuel Store Sizes

Boiler Output	18kW	80kW	350kW
Fuel Input	6.25kg/hr (25kW)	25kg/hr (100kW)	200kg/hr (400kW)
1 m3 Storage	24 hrs	6 hrs	Too small
4 m3 Storage	4 days	24 hrs	6 hrs
16 m3 Storage	Too big	4 days	24 hrs
48 m3 Storage	Too big	Too big	3 days

9.1.2 Design Issues

The following design considerations have been identified:

- Fuel storage facilities often account for a significant proportion of the overall capital cost of a biomass heating project, require a significant amount of space for fuel storage, as well as access for regular fuel deliveries. Fuel delivery areas require fire suppression systems and frequent maintenance due to the number of moving parts and tendency for fuel to build up within the mechanism.
- Biomass boilers require a consistent loading in order to achieve reasonable operating efficiencies.
- Biomass produces other greenhouse gas emissions. Including high nitrogen oxide (NOx) emissions, nitrogen dioxide (NO2), particulates (PM) and sulphur dioxide (SO2).

9.1.3 Suitability

Biomass systems have been deemed potentially suitable, as there would be sufficient space for the fuel storage facilities, as well access for transportation. There could be potential for a centralised biomass heating system, or biomass heating for communal areas. The maintenance of the boiler and the required constant loading system could be recognised as a potential issue, with a dedicated member of staff or on call engineer being a likely necessity. Air quality from the burning process may also be a concern, with potential greenhouse gasses listed above. However, biomass is typically required to be supplemented by gas-fired systems, and as such the strategy as a whole performs unfavourably against Part L 2022 compliance.

10. Combined Heat and Power (CHP)

10.1 Natural-Gas CHP

10.1.1 Description

Combined heat and power (CHP) - also known as co-generation - is a very efficient way of producing electricity and producing heat simultaneously from a single fuel, therefore reducing energy costs and the amount of carbon dioxide emitted into the atmosphere. Depending on application, it can present itself as an economical and sustainable alternative for meeting the demands of both the electrical and heating demand.

A CHP unit is a small gas-fired engine linked to an electric generator. The heat from the engine is available for space-heating or domestic hot water heating, and the output from the generator is linked directly into the buildings electrical distribution system.

Compared with grid-supplied electricity, CHP-supplied electricity is more carbon efficient by utilizing the heat energy that would normally be wasted at the power station.

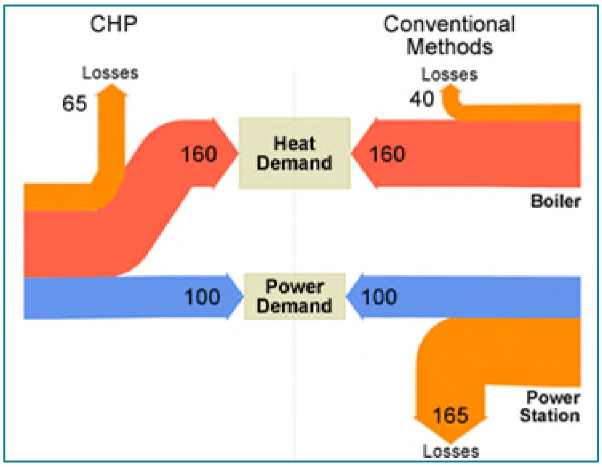

Figure 7 Sankey diagram highlighting reduced losses from CHP when compared to conventional boiler and power station

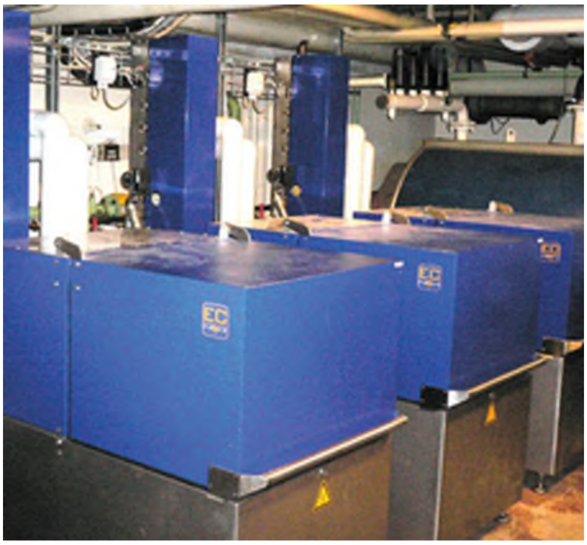

Figure 8 Example CHP Units

10.1.2 Design Issues &

- CHP is generally feasible when it is used to provide heat and electricity for over 4,000 hours a year and is therefore ideally suited to a demand profile which is predictable and relatively constant. For this reason, buildings such as hotels, leisure centres and high-density housing such as student accommodation are typically suited to CHP power generation.

10.1.3 Suitability

CHP has been deemed potentially unviable, as the uncertainty of heating load of the properties would not be suited to the constant heat demand required for a CHP system. It is worth noting, should a leisure complex with features such as a swimming pool be considered at a later stage, CHP could be re-considered for this application. However, as with the biomass system, because CHP is (typically) fuelled by fossil-fuels and shall require a gas-fired boiler to offer top-up and/or redundancy, these systems perform poorly when considered for Part L 2022 compliance.

11. HEAT PUMPS

11.1 Ground Source Heat Pump

11.1.1 Description

A heat pump is defined as "a device which takes up heat at a certain temperature and releases it at a higher temperature" (BS EN 255-1, 1997). A few metres below the earth's surface, the ground is maintained at a constant temperature all year round between 10°C and 12°C. Ground source heat pumps (GSHP) can extract this energy to provide a carbon-efficient form of space heating and/or cooling for the buildings. A GSHP cannot be considered completely 'renewable' however since it uses mains electricity to drive the compressor.

A GSHP is made up from 3 key components; a ground loop for heat extraction/rejection, the heat pump itself and the distribution system within a building.

The ground loop comprises lengths of plastic pipe buried in the ground, either in a vertical borehole or a horizontal trench. The pipe is a closed circuit and is filled with a mixture of water and antifreeze, which is pumped around the loop, absorbing heat from or rejecting heat to the ground.

A borehole is typically drilled to a depth of between 15 to 100 metres and will benefit from more stable ground temperatures than a horizontal trench.

Horizontal trenches are typically excavated to a depth of one or two metres. The heat transfer performance can be enhanced by laying coiled piping in trench rather than straight piping. As a rule of thumb, a coiled loop layered in a trench of about 10 metres in length will provide sufficient energy for a 1kW heating load.

The heat pump itself works by using the evaporation and condensing cycle of a refrigerant to move heat from one place to another. In this case, the evaporator takes heat from the water in the ground loop and the condenser gives up heat to a hot water tank, which feeds the building's heat distribution system.

Almost all heat pumps currently in operation are based on a vapour compression cycle or an absorption cycle. The vapour compression cycle is by far the most common cycle for commercial heat pump equipment.

GSHPs are well suited to a low temperature heating system (E.g. underfloor heating/air conditioning systems) with a flow temperature of 30 - 35°C. If heat pumps are used with conventional hydronic heating systems with circulation temperatures of 60°C or higher, they have a poor coefficient of performance (CoP). Table 1 shows how the CoP of a water-to-water heat pump varies with the distribution/return temperature.

Table 3. Variation of CoP of Heat Pumps

Heat distribution system (Supply/Return temperature)	CoP
Floor heating (30°C/35°C)	5.0
Modern radiators (35°C/45°C)	3.5
Conventional radiators (50°C/60°C)	2.5

Figure 9 Typical horizontal ground loop

11.1.2 Design Issues

The following design considerations need to be factored in when considering GSHP suitable for the Parc Pelenn development:

- Maximising the efficiency of any GSHP requires a good understanding of the local geology, which will likely require further studies and could affect the project program.
- If vertical boreholes are not viable, horizontal loops would require a large amount of space, which may not be feasible due to the location of the building
- If the heat required from the GSHP by the building exceeds that available within the ground, equipment efficiency drops drastically and can affect the ground temperature.
- At lower efficiencies, a GSHP does not contribute particularly favourably to Part L2 compliance.
- Due to the complexity of the system and extensive groundworks required, GSHPs tend to have a high capital cost.
- Efficiency is highly dependent upon many factors and can vary wildly, adversely effecting operating costs.

11.1.3 Suitability

Taking into account these factors, a GSHP system could be a viable technology for this project. The available space on the site could likely allow for either a borehole or horizontal loop type system. A centralised system would be the most applicable, as the capital investment for smaller individual properties would likely be high compared with an ASHP system. A centralised system would possibly also need a form of booster due to GSHP operating at lower water temperatures.

11.2 Air Source Heat Pump

11.2.1 Description

Air Source Heat Pumps (ASHP) utilise energy in the air to generate useful heat. Heat from the air is absorbed into a fluid which is pumped through a heat exchanger in the heat pump. Low grade heat is then extracted by the refrigeration system and, after passing through the heat pump compressor, is concentrated into a higher temperature for use within a building.

This useful heat can then be transferred into a more conventional wet distribution system serving underfloor heating or radiators (air-to-water), or can remain within a refrigerant distribution system for use in fan coils (air-to-air).

By being capable of operating both as above and in a reverse cycle, ASHPs can simultaneously heat and cool different areas of a building.

ASHPs run at lower temperatures than conventional boilers, and so are well suited to under-floor heating systems and air conditioning rather than the perimeter radiators.

Figure 10 Typical ASHP external unit, paired with internal units (not shown)

11.2.2 Design Issues

The following design issues should be considered when assessing the suitability of an ASHP system:

- ASHP's require outdoor space or well-ventilated plantrooms (with openings as required), this can be roof mounted or wall mounted depending on site limitations. The use of acoustic louvres can be considered to minimise noise disruption. The systems will generally only run during occupied hours which will minimise noise disruption to surrounding residential areas.
- ASHP's are generally used as part of the heating arrangement or areas of the development which require air conditioning, such as laboratories or innovation spaces. They can be utilised in the form of VRF systems which can provide simultaneous heating and cooling, using heat recovery to further reduce CO2 emissions.
- Due to the high efficiencies achievable in modern ASHPs, they are capable of contributing significantly to Part L 2022 compliance.
- ASHP's have a lower capital cost than a GSHP.

11.2.3 Suitability

Based upon the considerations above, no significant obstacles to using ASHPs have been found. ASHP systems could be factored in for the properties, with the availability for heating and comfort cooling being desirable for occupant comfort. It would be possible for the operation as individual units, or act as a centralised system as a part of a district heating network.

12. Conclusion

This report has covered potential energy technologies that could be available for the Parc Pelenna site, with recommendations as follows:

Technologies that have currently been found viable for the site:

- Photovoltaic panels: (PV)
- Energy storage systems (ESS)
- Air source heat pumps
- Ground source heat pumps

These technologies have been currently found potentially viable, with drawbacks as to their potential unsuitability stated in the report:

- Biomass Boilers

These technologies have been found potentially unviable, with reasoning stated in the reports.

- Combined Heat and Power
- Rainwater Harvesting

Further assessment of feasibility, alongside Part L 2022 compliance, should be considered at the next design stage.