Twickenham Riverside
LZC Feasibility

LONDON BOROUGH OF
RICHMOND UPON THAMES

July 2021

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2.0	11/06/2021	Planning	LW	NA	-
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4.0	15/07/2021	Planning	LW	NA	Site plan updated

EXECUTIVE SUMMARY

This report has been prepared by Skelly and Couch on behalf of London Borough of Richmond upon Thames ('the Applicant'), in support of a full planning application for the following description of development (hereinafter referred to as the 'Proposed Development'):

Demolition of existing buildings and structures and redevelopment of the site comprising residential (Use Class C3), ground floor commercial/retail/cafe (Use Class E), and public house (Sui Generis), boathouse locker storage and floating pontoon with associated landscaping, restoration of Diamond Jubilee Gardens and other relevant works.

It is also intended to be submitted as evidence for the requirements of BREEAM credit ENE 04 - Low Carbon Design.

The Proposed Development is at 1, 1A, 1B and 1C King Street; 2-4 Water Lane; the site of the former swimming pool and associated buildings, The Embankment; the Diamond Jubilee Gardens, Twickenham ('the Site').

A brief overview of relevant local and regional planning policy is provided, in the context of Low and Zero Carbon (LZC) technologies. The London Plan Policy SI2 and LBRuT Local Plan Policy LP22(B) require that the Proposed Development should achieve a ‘zero carbon’ standard, with a minimum carbon reduction of 35%, relative to UK building Regulations 2013.

LZC technologies are presented and discussed on merit and dis-merit, and their suitability to the Proposed Development.

The study determines that the most suitable LZC technologies for the Proposed Development are:

1. Air source heat pump
2. Photovoltaic panels

Heat pumps are a viable option and would contribute to providing the improvement in air quality on the site, as per the requirements of the London Plan, as well as significantly reducing carbon emissions relative to a gas boiler system.

Air-source heat pumps are concluded to be the most suitable LZC technologies for space and water heating, whilst photovoltaic (PV) panels are favourable for electricity generation, which complements a heat pump installation well by providing energy at the point of use. The predicted payback period for the proposed PV array is 18 years.

OVERVIEW

Introduction

The Proposed Development will deliver 45 apartments ranging from studios to three-bed apartments over two separate buildings, and the proposed description of development is as follows:

Demolition of existing buildings and structures and redevelopment of the site comprising residential (Use Class C3), ground floor commercial/retail/cafe (Use Class E), and public house (Sui Generis) boathouse locker storage and floating pontoon with associated landscaping, restoration of Diamond Jubilee Gardens and other relevant works.

The Proposed Development will provide a number of accessible car parking spaces. Cycle parking shall be provided for the use of occupants' use and for users of the commercial buildings and recreation ground.

This report should be read in conjunction with the Energy Statement and Stage 3 Report.

The Site

The Site occupies a space on the northern bank of the River Thames, close to the centre of Twickenham in the London Borough of Richmond-upon-Thames (LBRuT). The majority of the Site is currently occupied by Diamond Jubilee Gardens, and incorporates a number of car parking spaces for Eel Pie Island residents.

It is bounded by retail units on King Street to the North; Water Lane to the east; Wharf Lane to the west and the River Thames to the south.

Figure 1: Site aerial view and local points of interest

Figure 3: Site aerial view (plan)

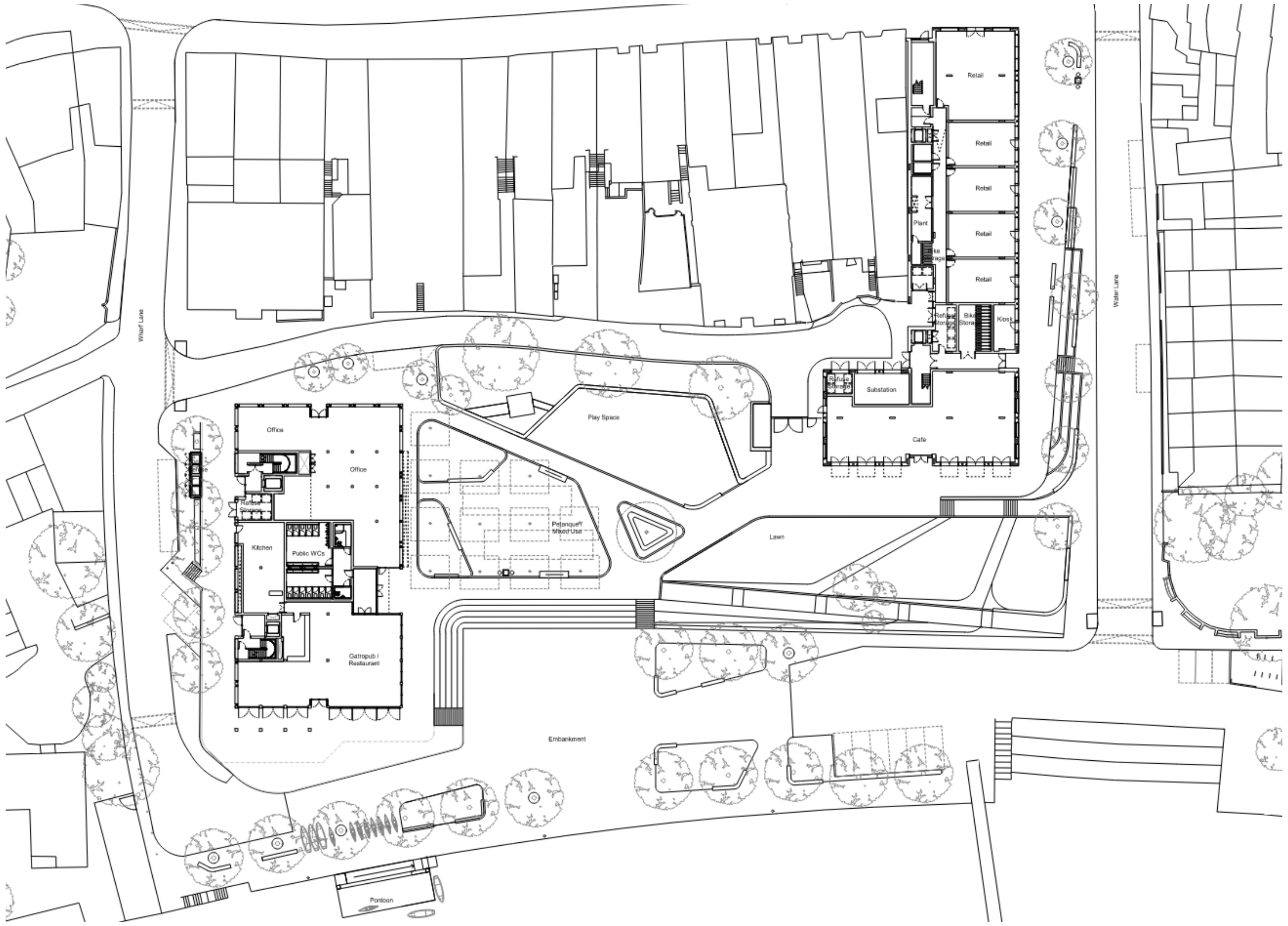


Figure 2: Proposed Site layout

Incentives for LZC Energy Production

Renewable Heat Incentive (RHI)

The Renewable Heat Incentive scheme provides financial incentives for heat production by renewable or low-carbon sources. Eligible installations receive quarterly payments for 7 years based on the amount of heat generated. The payments are adjusted annually in line with the relevant price index.

Heat metering is required on all renewable heat installations.

Technology	Tariff (p/kWh)	Duration (Years)
Biomass	6.74	7
Solar Thermal	21.09	7
ASHP	10.71	7
GSHP	20.89	7

Table 1: Domestic RHI tariff from 1st August 2019

Planning Requirements

The Proposed Development is required to comply with the LBRuT Local Plan and the Greater London Authority (GLA) London Plan (2021). The London Plan and LBRuT Local Plan are aligned in their requirements for developments to achieve a ’zero carbon’ standard. In effect, this requires a minimum carbon reduction of 35%, relative to UK building regulations 2013, with the remaining carbon to be offset, either:

1. *through a cash in lieu contribution to the borough’s carbon offset fund, or*
2. *off-site provided that an alternative proposal is identified and delivery is certain.*

It is further stipulated that developments must achieve a carbon reduction attributed to fabric efficiency measures alone of at least 10% for residential, and 15% for non-residential developments. This is in accordance with the ‘be lean, be clean, be green, be seen’ approach, set out within the New London Plan.

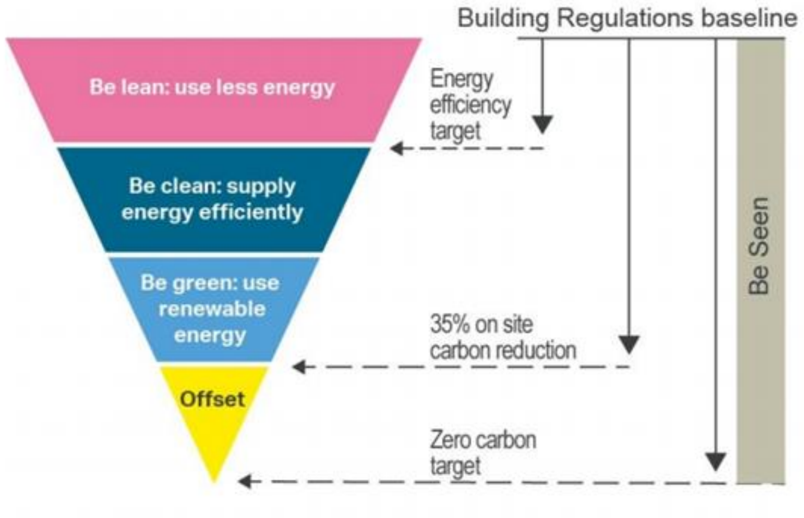


Figure 4: The New London Plan energy hierarchy

LOW AND ZERO CARBON TECHNOLOGIES

Introduction

The following section provides a feasibility analysis of Low or Zero Carbon (LZC) technologies for use on the Twickenham Riverside development. There are various options when it comes to LZC technology, but a combination of project constraints rules out a number of these. The considerations are:

- Capital expenditure
- Return on Investment
- Carbon savings potential
- Clean energy output potential
- Spatial requirements
- Operation and maintenance requirements
- Logistical implications
- Planning requirements

The analysis compared all of the factors outlined above to arrive at a solution that is most viable for the Twickenham Riverside development.

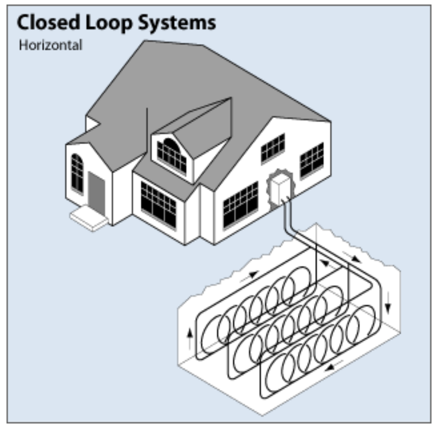
Out of all the technologies considered, the following were discounted for one or more of the reasons outlined above:

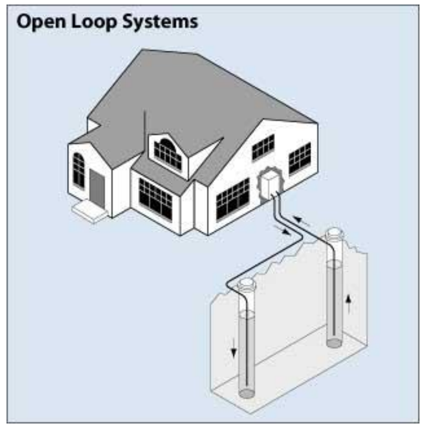
- **Hydroelectric:** although the Site is immediately adjacent to the Thames, hydroelectric energy schemes require a large height difference to convert energy to electricity, which is not a feature of the site.
- **Hydrogen:** generation and storage are still in the experimental stage at this scale and no systems are currently commercially available.
- **Biomass:** Large number of deliveries required to maintain constant supply of fuel, and large storage area required. Emissions may also be an issue with close proximity of apartments, therefore deemed unsuitable for the Site.
- **CHP:** would require a large, constant heat load to be viable, which is not typical of residential properties which have large diurnal fluctuations. The net carbon footprint of CHP systems is becoming less favourable when compared with alternative electrical energy sources as the National Grid decarbonises with an increasing renewable energy contribution. Past analysis on similar schemes has highlighted CHP is a less viable LZC than, for example electric heat pumps.
- **Biomass CHP:** as above.
- **Wind Turbines:** Wind turbine technology is not suitable for high density areas and those within close proximity to residential properties so has been discounted

The feasibility study therefore reviewed the use of the following technologies to offset CO_2 emissions:

- Ground Source Heat Pumps
- Air Source Heat Pumps
- Photovoltaics (PVs)
- Solar Thermal Panels

Ground and Water Source Heat Pumps





Ground source heating involves extracting heat from the ground to heat the building, by circulating water through buried pipes. The length of the pipe depends on the building's energy requirements.

The low-grade heat extracted from the ground is passed through a heat pump, which provides high grade heat (in the form of hot water) to the building. The system can also be used in reverse to provide cooling in summer. By coupling the heat pump with the ground, a much higher Coefficient of Performance (COP) is achieved than the air coupled heat pumps commonly used in cooling systems.

The ground's temperature at around 2m deep remains steady throughout the year at approximately 11°C. In the winter, this relatively high temperature can be taken advantage of as a heat source.

Heat pumps can be a very efficient way of obtaining heat. A heat pump's efficiency is quantified by its coefficient of performance (COP), which is a measure of useful energy produced (heat) against energy used (electricity). A seasonal coefficient of performance (SCOP) is calculated signifies average performance over a typical annual profile, and this value should be used to compare systems. A typical GSHP may have a SCOP of 4, which means for every unit of electricity used in the heat pump 4 units of heat will be delivered to the building. For reference, direct electric or gas heating systems cannot exceed a SCOP of 1. The system must be designed to optimise the heat pump; high efficiencies for heat pumps are achieved where the difference in temperature between the heated water and the ground are lowest. Therefore, heat pump technology is especially suited to low temperature heating systems such as under floor heating. A high SCOP value can be achieved where the required temperature is 35 degrees, but this drops significantly where the required temperature is 55 degrees.

There are four basic types of ground loop systems:

- Horizontal
- Vertical
- Pond/Lake/River
- Open Loop

Three of these—horizontal, vertical, and pond/lake—are closed-loop systems. The fourth type of system is the open-loop option. Their suitability depends on the climate, soil conditions, available land, and local installation costs at the site. All these approaches can be used for residential and commercial building applications.

Where heating and cooling are demanded simultaneously, a heat recovery heat pump provides the opportunity to recover and redistribute energy between the heating and cooling systems, thereby providing heating and cooling for very little energy input.

Within the context of the Twickenham Riverside development, a heat recovery heat pump would provide the opportunity to recover heat between residential apartments, which would have a heating-dominated or heating only load throughout the year, and the commercial units, which will have a high annual cooling load. in conjunction with a site-wide heating and cooling network. Commercial units would likely have a cooling-dominated load profile, whereas the residential apartments; residential heat energy consumption in new building being dominated by the requirement for hot water. By simultaneous providing both heating and cooling through a heat recovery heat pump, the heating and cooling loads This would improve the system efficiencies significantly and is a strong driver for adopting a heat recovery ground source heat pump.

Advantages

The advantages of ground source heat pumps include:

- Very high efficiency source of heat energy
- No local emissions
- No gas supply/infrastructure required
- Do not contribute to local increases of air temperature in summer
- Can provide heating and cooling independently or simultaneously (heat recovery type only)
- Opportunity for heat recovery between heating and cooling streams provides heat/coolth for very little input
- No external plant space required

Disadvantages

The disadvantages include:

- Low-grade heat is produced which means that heat emitters must be larger and hot water generation can be difficult
- High capital expenditure and rising electrical costs affect paybacks
- Relatively high running costs compared with gas boilers
- Storage vessels are required to prevent the heat pump cycling too often
- They are complex pieces of machinery and maintenance engineers are not as readily available as with alternative technologies
- Maintenance costs are higher compared to boilers
- A large area would be required for the ground-coupled heat exchanger arrays, with extensive ground works
- Water in closed loop circuits need to contain glycol which is a hazardous substance
- They can be noisy

Summary

The efficiency and potential for ground source heat pumps to provide significant carbon reductions are attractive for the Twickenham Riverside development. The opportunity to offset heating and cooling loads between domestic and non-domestic buildings provide further justification for adopting GSHPs. However the limited space on site would mean that GSHPs alone would not be able to meet the peak heating demand.

It has been estimated that a GSHP of a capacity equivalent to 30% of the peak heating demand would provide approximately 70% of the annual heating energy, and therefore a bivalent heating system, using supplementary gas boilers, would have a negative impact on overall system efficiencies and increase the associated carbon emissions.

Air-Source Heat Pumps

An air-source heat pump (ASHP) extracts heat from external air to provide useful heat within a building. ASHPs are classified as either air-to-air or air-to-water depending on whether the heat distribution system in the building uses air or water.

The efficiency of an ASHP is heavily dependent upon the ambient external temperature, with a higher ambient temperature increasing efficiency. Figure 5 below shows how a typical ASHP's COP varies with temperature. This shows at typical UK minimum temperatures of around -5°C, an ASHP achieves a COP of 2 at 55°C water temperature.

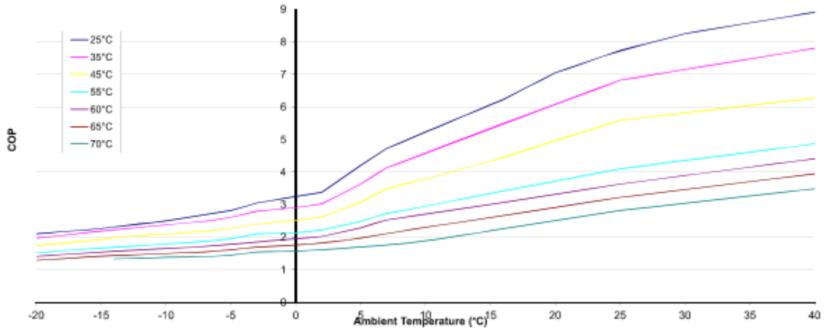


Figure 5: Typical ASHP SCOP (efficiency) vs ambient temperature

Heat pumps have some impact on the environment as they need electricity to run, but the heat they extract from the air is constantly being renewed naturally.

Unlike gas boilers, heat pumps deliver heat at lower temperatures over much longer periods. This means that during the winter they may need to be left on longer to work efficiently.

There are two main types of air source heat pump system:

- An air-to-water system distributes heat via the wet central heating system. Heat pumps work much more efficiently at a lower temperature than a standard boiler system would. So, they are more suitable for underfloor heating systems or larger radiators, which give out heat at lower temperatures over longer periods of time.
- An air-to-air system produces warm air which is circulated by fans to heat. They will not provide hot water as well.

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 useful heat capable of heating water for the heating and hot water circuits. For cooling, this cycle works in reverse.

Advantages

The advantages of air source heat pumps include:

- High efficiency source of heat energy
- Lower capital expenditure and maintenance costs compared to GSHPs (but still relatively high infrastructure compared to electric heating or gas boilers)
- Can provide heating and cooling independently or simultaneously (heat recovery type only)
- Opportunity for heat recovery between heating and cooling streams provides heat/coolth for very little input
- No gas supply/infrastructure required
- No ground works required
- No local emissions
- Relatively long life

Disadvantages

The disadvantages include:

- Relatively high capital cost
- Relatively high running costs compared with gas boilers
- Low-grade heat is produced which means that heat emitters must be larger and hot water generation can be difficult
- Storage vessels are required to prevent the heat pump cycling too often
- They are complex pieces of machinery and maintenance engineers are not as readily available as with alternative technologies
- Maintenance costs are higher compared to boilers
- Water in closed loop circuits need to contain glycol which is a hazardous substance
- They can be noisy if not attenuated

Summary

Air-source heat pumps present an efficient, technically feasible solution for the Twickenham Riverside development. Carbon dioxide reductions have been estimated to be well in excess of the necessary reduction for planning purposes.

Air-source heat pumps typically achieve lower seasonal efficiencies than ground-source heat pumps, so annual running costs and carbon emissions would typically be higher as a result. However this technology could be used for the whole developments heating and domestic hot water needs, without any boiler back-up.

An air-source heat pump installation could be procured at a significantly lower cost than a comparable ground-source heat pump installation and may therefore be the best viable option for the development. This should be determined following a costing exercise considering the two options.

Overleaf is a comparison table of options for air source heat pump and ground source heat pump, utilising boreholes and energy piles.

	ASHP	GSHP Closed loop	GSHP Closed loop + energy piles
	General		
Plant Space	50m2 (per building)	45m2 (serves whole site) significant ground area required for vertical pipework loops	45m2 (serves whole site) Less ground area required as piles are used
Location	Roof/loft space	GF or Basement + additional buffer vessels and pipework	
Ventilation	High +	Minimal	
Noise	External/louvred plant space. Increased noise break-out could impact roof lights in close proximity	Contained within internal plant space	
Groundworks	None required	Coordination needed between civil works and specialist contractor. Increased time on site. Below ground heating (and cooling) pipework across site	Significant coordination needed between civil works and specialist contractor. Increased time on site. Below ground heating (and cooling) pipework across site
Maintenance	Medium	Down time would need to be carefully managed to ensure continuity of supply for commercial units if supplied with cooling. A single system would serve the whole development which means ownership, maintenance and billing need to be considered	
Metering	Individual residential heat meters, commercial units on standalone VRF	Heat meters on both residential and commercial units, site wide billing	
Future Proofing	Individual buildings to facilitate connection to future DHN	Enhanced provision for site-wide connection to future DHN. Potential for cooling to apartments and commercial units	
	Carbon/Energy Performance		
Capital Cost	Med-High	High	Very high
Service Life	20	20	20
Annual Running Costs	Medium	Low	Low
LZC and Carbon offset	Good	Very good	Very good
Annual RHI payment (p/kWh) **1 Bed** **2-3 Bed**	10.85 ~£900 ~£1300	21.16 ~£1700 ~£2500	
Annual RHI Heat Demand limit (kWh)	20,000	30,000	
Capital Cost Efficiency (£/kgCO2/yr)	Best	Medium +£400k	Worst +£500k

Photovoltaic Panels

Photovoltaic (PV) technologies generate electrical energy from sunlight that can be used to not only reduce user reliance on the national grid, but in some instances can provide enough energy to allow electrical grid independent developments.

Advantages

The advantages of PV panels include:

- Produces clean renewable electrical energy
- High visibility, therefore excellent educational and PR value
- Once built the energy is virtually free
- Mechanically simple, no moving parts, therefore low maintenance requirements and operating costs and long life
- High public acceptance
- May offset the cost of roof or cladding
- Modular in nature so easy to size appropriately and extend
- Easy to integrate with battery storage
- Good safety record
- Can be integrated into new or existing buildings
- Low cost

Disadvantages

The disadvantages include:

- Solar energy is not a reliable energy source, output is reduced in overcast conditions and produces no energy at night
- Risk of future overshadowing (this is a reasonably low risk for the site as it is not overlooked from the south)
- PV cells produce DC electricity which must be converted to AC
- Efficiency drops as temperature rises
- Low-voltage output can be difficult to transmit
- Poor reliability of auxiliary (balance of system) components and storage devices.
- Feed-in tariffs ended in April 2019

To assess the feasibility of PV technology a high-level quantitate analysis was undertaken to estimate energy contribution and associated carbon savings, as well as the area required for the necessary PV array.

The site is orientated with buildings on a north-west / south-east axis so there are opportunities for PV panels to be installed on south-west facing roofs. The roof construction shall be pitched at an angle of approximately 40° from horizontal, which provides a favourable surface for PV panels to be installed. Figure 6 below shows a cross section through the Wharf Lane building roof construction.

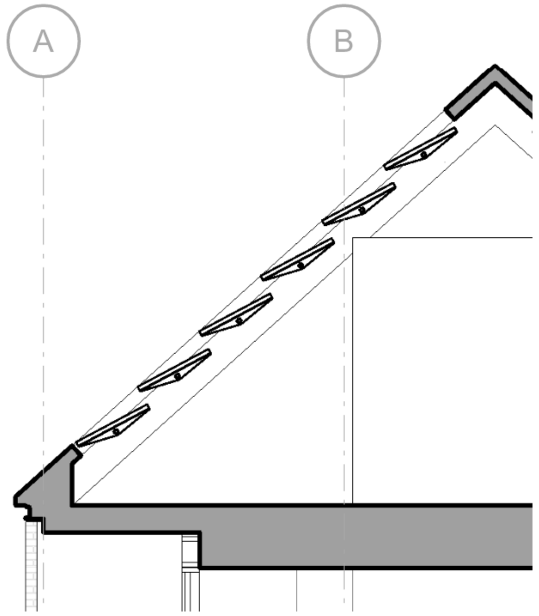


Figure 6: Cross-section through Wharf Lane building showing pitched roof

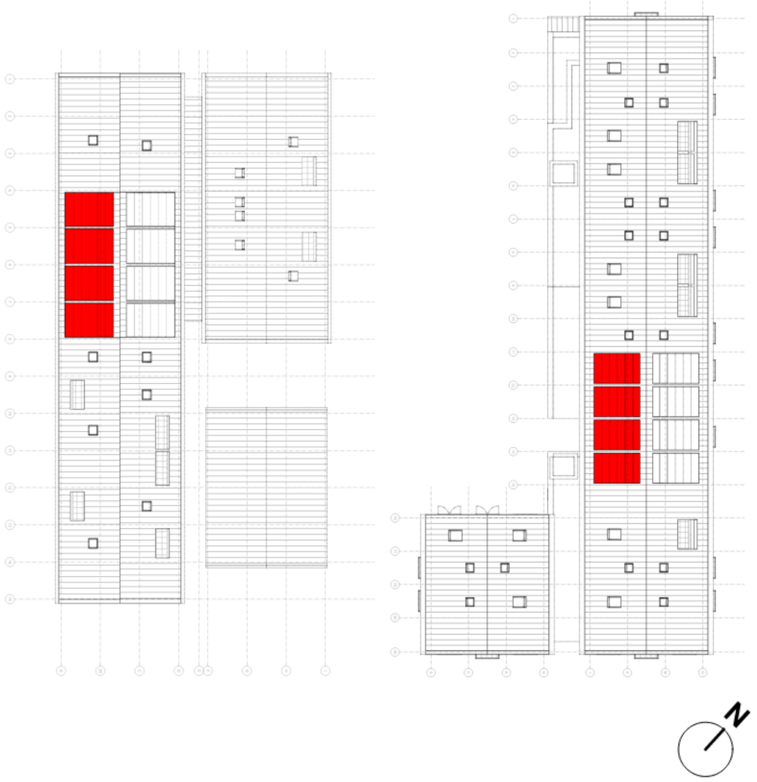


Figure 7: Roof plans of Wharf Lane (left) and Water Lane (right) building showing south-west facing roof space available for PVs

Figure 7 above shows the viable roof area for installation of PV panels, equating to 58 m^2 on Wharf Lane and 58 m^2 on Water Lane, a total of 116m^2.

Summary

PVs are a cost-effective and reliable means to reduce a building's dependence on grid-supplied electricity and reduce Part L carbon emissions and would be an appropriate technology to employ for the Twickenham Riverside development.

The Wharf Lane and Water Lane buildings have pitched roofs facing south-west, which provide a large area suitable for the installation of PV panels.

Solar Thermal Panels

Solar thermal panels use heat from the sun to warm up water, thus helping provide hot water for the building. A conventional system uses a mains powered circulation pump that couples the solar panels to a hot water storage tank.

There are two main types of solar thermal panels:

- Evacuated tube collectors consist of rows of parallel transparent glass tubes, each of which contains an absorber tube. The tubes are covered with a special light-modulating coating, and sunlight passing through the outer glass tube heats the absorber tube contained within it. Evacuated tube panels are generally more expensive but suffer less with heat loses and are less effected by some parts of the panel being shaded
- Flat plate collectors consist of a thin absorber plate (of thermally stable polymers, aluminium, steel or copper, to which a black or selective coating is applied) backed by a grid or coil of fluid tubing and placed in an insulated casing with a glass or polycarbonate cover.

Advantages

The advantages of solar thermal collectors include:

- Produces clean renewable heat energy
- High visibility, therefore excellent educational and PR value
- Once built the energy is virtually free
- Low maintenance and operating costs
- High public acceptance
- Unobtrusive plumbing
- May offset the cost of roof or cladding
- Modular in nature so easy to size appropriately and extend
- Good safety record
- Can be integrated into new or existing buildings

Disadvantages

The disadvantages include:

- Solar energy is not a reliable energy source, output is reduced in overcast conditions and produces no energy at night
- Risk of future overshadowing
- Low-grade heat is produced which means that heat emitters must be larger and hot water generation can be difficult
- Water may require softening
- Storage is required, as solar source does not often match hot water requirement
- Panel array requires a large area compared to other technologies

Summary

The space for a solar thermal panel installation is limited by the roof area and will not be sufficient to meet the full domestic hot water loads of the building.

Solar thermal technology has been rejected due to the fact that priority has been given to PVs to generate clean electricity and the carbon savings associated with this renewable heat source would be less than for PVs. PVs are also favourable as they can generate electrical energy to power the heat pump, thus reducing reliance on the national grid infrastructure.

Solar thermal panels appear to be a suitable technology to employ for the Twickenham Riverside development on first consideration, however, under cross-comparison with PV panels, which are the closest alternative technology, solar thermal generation is a much less favourable energy source for a number of reasons, as presented below:

- Disconnect between generation of heat energy and consumption for largely residential development
- Large water storage requirement
- Electricity generation coupled with heat pump is a more effective and efficient means of generating heat than solar thermal

CHOSEN TECHNOLOGIES

From the qualitative analysis, it has been determined that the most appropriate technologies to be implemented are:

- Air-source heat pump (ASHP)
- Solar photovoltaic (PV)

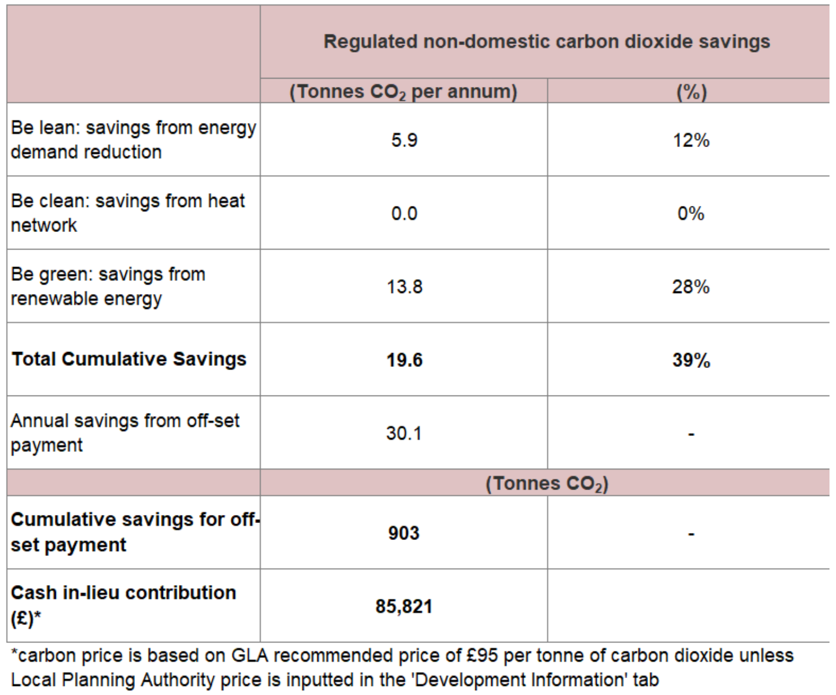
The primary reasons for selecting a GSHP are to realise the benefits of high seasonal efficiencies and to enable maximum system efficiency through recovery of energy between heating and cooling.

The following sections will present analysis of the energy production and carbon savings attributable to a GSHP installation.

Air-source heat pump

Quantitative analysis

An analysis of the heat pump system has been carried out in order to quantify the anticipated energy production and CO_2 reductions realisable through the installation of air-source heat pump. The results, are reported in **Table 2** below, in terms of Part L regulated CO_2 emissions, using SAP10 carbon intensity figures.



	Regulated non-domestic carbon dioxide savings	
	(Tonnes CO_2 per annum)	(%)
Be lean: savings from energy demand reduction	5.9	12%
Be clean: savings from heat network	0.0	0%
Be green: savings from renewable energy	13.8	28%
Total Cumulative Savings	**19.6**	**39%**
Annual savings from off-set payment	30.1	-
	(Tonnes CO_2)	
Cumulative savings for off-set payment	**903**	-
Cash in-lieu contribution (£)*	**85,821**	

*carbon price is based on GLA recommended price of £95 per tonne of carbon dioxide unless Local Planning Authority price is inputted in the 'Development Information' tab

Table 2: Part L carbon emissions reduction achieved through installation of a ASHP, SAP10 figures from GLA carbon reporting spreadsheet.

These figures demonstrate the anticipated CO_2 reduction of 28% attributable to the GSHP system.

Solar photovoltaic

Quantitative analysis

To assess the feasibility of PV panels, a quantitative analysis has been carried out to estimate the potential carbon dioxide reduction, for installation, payback (energy costs avoided) and offset costs (carbon offset fund payments).

This analysis assumes that the roofs of Wharf Lane and Water Lane may be covered with a 58m² PV panel array.

An overview of this analysis is presented in Table 3 below.

	Wharf Lane & Water Lane
Required carbon saving (tCO_2)	n/a
Proposed PV panel area (m^2)	116
Capacity of Installation (kWp)	38
Annual energy generation (kWh)	11,361
Estimated capital cost (ex. VAT)^2	*~ £18k ^{1}*
Estimated CO_2 saving (tCO_2)	**2.65**
Service Life	25 years
Annual maintenance (estimated)	£500^2
Capital cost / yr (over 25 yr life)	£600
Annual energy cost saving	£1230.10^3
Annual carbon offset saving (@ £95/tonne)	£252
Annual Saving	£982
Payback	18 years
Net Income over Life	£24550

(1) Estimated from comparable scheme

(2) Estimated, to include routine cleaning and maintenance requirements.

(3) Assumes 61% energy consumed @ 14.4p/kWh UK average tariff & 39% exported @ 5.24 p/KWh, excludes maintenance costs

Table 3: Summary of PV analysis

CONCLUSION

This feasibility study report outlines the approach undertaken to date in selecting an appropriate low and zero carbon (LZC) technology for adoption on the Twickenham Riverside development.

The study has determined that the most suitable LZC technologies for the development are:

1. Air-source heat pump
2. Photovoltaic panels

A quantitative analysis has been presented which presents the energy generation and carbon savings that may be directly attributed to each technology. CO_2 reductions of 13.8 and 2.65 tCO_2 are estimated for the air-source heat pump PVs, respectively.