# The London Resort Development Consent Order

BC080001

## Environmental Statement
## **Volume 2: Appendices**

## Appendix 20.3 – Energy Strategy

Document reference: 6.2.20.3
Revision: 00

December 2020

Planning Act 2008
The Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009
Regulation 5(2)(a)
The Infrastructure Planning (Environmental Impact Assessment) Regulations 2017
Regulation 12(1)

[This page is intentionally left blank]

# Revisions

| Revision | Description | Issued by | Date | Approved by |
| --- | --- | --- | --- | --- |
| 00 | Issue for DCO Submission | AA/JE | 24/12/20 | BUR/LRCH |

**Buro Happold Ltd**
Camden Mill,
Lower Bristol Road,
Bath,
BA2 3DQ

[This page is intentionally left blank]

# Executive Summary

Sustainability and low carbon principles are at the heart of the London Resort's vision and are the basis for the overarching energy strategy objective of targeting net zero carbon in its operations. Given the significant carbon impact from the built environment on the UK's total emissions, London Resort Company Holdings Limited (LRCH or the Applicant) recognises the unique impact the London Resort can have on driving down carbon emissions and setting the standard as a sustainable, next generation entertainment resort. Grid decarbonisation, along with regulatory and policy changes targeting the decarbonisation of the heat sector is driving an ongoing industry shift towards the electrification of heat. As such, a key objective in the development of the energy strategy was to assess a range of heat pump configurations for the Resort including decentralised/building level heat pumps and more centralised, large scale heat pumps as part of a site-wide district heating system.

A range of site-wide cooling configurations have also been defined and appraised. As with the review of heating configurations, both decentralised strategies and centralised district cooling systems have been considered and, in all cases, using electric chillers. Both river water cooled chillers and cooling-tower based systems have been assessed.

Through energy modelling, the peak and annual energy demands for heating, cooling and power (including electric vehicle charging) were calculated and a range of heating and cooling technologies were assessed. A summary of the London Resort annual and peak energy demands at the 2038 maturity year is presented below.

| 2038 Energy Demands | Peak Energy Demand (MW) | Annual Energy Consumption (GWh/a) |
|---|---|---|
| Heating (Thermal) - undiversified | 29.4 | 46.9 |
| Cooling (thermal) - undiversified | 35.0 | 31.8 |
| Power | 59.9 | 267.6 |
| Gas | 30.0 | 4.1 |

Compliant strategies have been developed for both centralised and decentralised heating strategies. A centralised heating strategy would be based on a 12 MW air source heat pump district heating system with back-up/top-up gas boilers sized and district heating. The heat pump and gas boiler plant will be located within a centralised energy centre building, with gas boilers sized for full peak heat demands. A decentralised heating strategy would involve the use of heat pumps located on individual buildings.

The proposed cooling strategy for the London Resort is based on the use of water cooled electric chillers (with cooling towers) supplying cooling via district cooling network. All chillers and cooling towers are to be located within the same centralised energy centre building as heating plant. As with the heating strategy, an equivalent decentralised cooling strategy would be feasible, whereby air cooled chillers are located on individual buildings.

The energy strategy includes the deployment of 13.3 MW of solar power capacity across the Kent Project Site, with an estimated power generation of 13.9 GWh/yr. The use of on-site solar results in a total reduction in lifetime carbon emissions of around 44,800 tonnes of $CO_2$ equivalent ($tCO_2e$), resulting in an overall lifetime carbon impact of 522,270 $tCO_2e$.

The notably lower energy demands of the Tilbury have been assessed and an energy strategy developed based on the use of building level air source heat pumps, air cooled chillers and provision of electric vehicle charging.

Based on this performance, the current strategy for heating allows comfortable compliance with the Building Regulations Part L 2013 carbon reduction target of 35% (compared with the Part L 2013 baseline scenario). However, with the imminent update of Building Regulations and the Standard Assessment Procedure (SAP) carbon emission factors referenced by the regulations, the proposed energy strategy should be reviewed to determine performance against any future regulations as building designs come forward.

[This page is intentionally left blank]

# Contents

[This page is intentionally left blank]

# List of Tables

[This page is intentionally left blank]

# List of Figures

[This page is intentionally left blank]

# Glossary

| Term | Definition |
|---|---|
| ACC | Air Cooled Chiller |
| ASHP | Air Source Heat Pump |
| CHP | Combined Heat and Power |
| COP | Coefficient of Performance |
| CP | Charge Point |
| CT | Cooling Tower |
| DC | District Cooling |
| DCO | Development Consent Order |
| DH | District Heating |
| DHW | Domestic Hot Water |
| EV | Electric Vehicle |
| GIA | Gross internal area |
| GLA | Greater London Authority |
| NSIP | Nationally Significant Infrastructure Project |
| RW | River Water |
| SCOP | Seasonal Coefficient of Performance |
| SH | Space Heating |
| UKGBC | United Kingdom Green Building Council |
| WCC | Water Cooled Chiller |
| WSHP | Water Source Heat Pump |

[This page is intentionally left blank]

# Chapter One ◆ Introduction

## Site Description

1.1 The Project Site lies approximately 30 km east-south-east of central London on the south and north banks of the River Thames, in the ceremonial counties of Kent and Essex. For clarity, the section of the Project Site to the south of the River Thames is referred to as the 'Kent Project Site' and that to the north of the river is identified as the 'Essex Project Site'. The term 'Project Site' refers to both the Kent and Essex Project Sites collectively. The 'Order Limits' within which the proposed DCO would apply are shown on the Location Plan (document reference 2.1).

1.2 The Kent Project Site occupies much of the Swanscombe Peninsula, formed by a meander in the River Thames, and includes a corridor for transport connections extending generally southwards to the A2(T). It also includes a section of the A2(T) corridor approximately 3.5 km in length between the existing Bean junction to the west (A2(T) / B255) and Pepper Hill (A2(T) / B262) to the east. The Kent Project Site occupies 387.53ha of land in a complex shape.

1.3 The Kent Project Site includes land falling within the jurisdiction of Dartford Borough Council (DBC) to the west and Gravesham Borough Council (GBC) to the east. The majority of the Kent Project Site also falls within the Ebbsfleet Garden City, established in April 2015, for which Ebbsfleet Development Corporation (EDC) is the Local Planning Authority.

1.4 The High Speed 1 (HS1) line crosses the Kent Project Site along an approximate north-west to south-east axis. The urban areas of Stone, Greenhithe, Ingress Park and Swanscombe lie to the west and south. These are largely residential in character, with commercial uses concentrated on Stone's river frontage. Beyond Greenhithe to the south-west of the Kent Project Site lies Bluewater shopping centre, a significant regional retail destination. To the east of the Kent Project Site lies Northfleet, a neighbourhood of mixed residential and commercial uses.

1.5 Across the southern and south-eastern parts of the Swanscombe Peninsula is an extensive industrial area concentrated around Manor Way, Galley Hill and London Road. To the south of the A2(T) the land is more open and rural in character, with small settlements amid farmland and woodland blocks. Most of this area lies in the Metropolitan Green Belt.

1.6 The Essex Project Site includes areas of land east of the A1089 Ferry Road and the Tilbury Ferry Terminal, incorporating the London International Cruise Terminal and non-contiguous the Asda roundabout at the junction of the A1089 St Andrews Road / Dock Road, Windrush Road and Thurrock Park Way. The Essex Project Site is 25.54 hectares in area.

1.7 The Essex Project Site falls within the jurisdiction of Thurrock Council, a unitary authority. The Essex Project Site lies immediately to the east of the existing port of Tilbury and to the west of Tilbury2, a new port currently under construction. At the south-east corner of the Port lies the Tilbury Ferry Terminal incorporating the London International Cruise Terminal (a grade II* listed building featuring a floating landing stage and series of bridge structures). The Asda roundabout is located to the north of the port of Tilbury and incorporates highway land.

## Project Description

1.8 The Resort will be a nationally significant visitor attraction and leisure resort, built largely on brownfield land at Swanscombe Peninsula in Kent on the south bank of the River Thames and with supporting transport and visitor reception facilities on the northern side of the river in Essex.

1.9 A detailed description of the Proposed Development is provided in chapter three of the Project ES. The focus of the Resort will be a 'Leisure Core' containing a range of events spaces, themed rides and attractions, entertainment venues, theatres and cinemas, developed in landscaped settings in two phases known as Gate One and Gate Two ('the Gates'). Outside the Gates will be a range of ancillary retail, dining and entertainment facilities in an area known as the Market.

1.10 The Resort will also include hotels, a water park connected to one of the hotels, a conference and convention centre known as a 'conferention centre', a Coliseum (capable of hosting e-Sports events), creative spaces, a transport interchange including car parking, 'back of house' service buildings, an energy centre, a wastewater treatment works and utilities required to operate the Resort. Related housing is also proposed to accommodate some of the Resort's employees.

1.11 Substantial improvements are proposed to transport infrastructure. This will include a new direct road connection from the A2(T) and a dedicated transport link between Ebbsfleet International Station, the Resort and a passenger ferry terminal beyond. The ferry terminal would serve visitors arriving by ferry on the River Thames from central London and Tilbury. A coach station is also proposed. On the northern side of the Thames to the east of the Port of Tilbury, additional coach and car parking and a passenger ferry terminal are proposed to serve the Resort.

1.12 The Proposed Development would involve an extensive restoration of land used in the past for mineral extraction, waste disposal and industrial activities including cement and paper production, with a comprehensive landscape strategy proposed incorporating the retention and enhancement of wildlife habitats.

## Energy Strategy

1.13 The provision of an appropriate and robust energy strategy for meeting the London Resort power, cooling and heat demands is important to ensuring compliance with energy and carbon emission reduction requirements, as per national, regional and local policy (refer to Policy Review).

1.14 Notably the London Resort is targeting a net-zero carbon emissions goal in operations, which is further than minimum policy requirements, to which the development of a robust and realistic energy strategy is key. The ongoing decarbonisation of the UK's electricity grid and the large-scale deployment of renewable power generation will play a critical role in reducing the Project Site's overall carbon emissions. Such trends provide an intrinsic carbon benefit to site-wide electricity consumption and electrically driven cooling systems; however, challenge the appropriateness of fossil fuelled heat generating technologies, in particular natural gas combined heat and power (CHP).

1.15 Grid decarbonisation, along with regulatory and policy changes targeting the decarbonisation of the heat sector is driving an ongoing industry shift towards the electrification of heat. This is primarily occurring through the use of heat pumps, a key technology that can be deployed at a range of different scales that uses electricity to generate heat for space heating and hot water with a lower carbon impact than conventional systems such as gas CHP.

1.16 As such, a key objective in the development of the energy strategy was to assess a range of heat pump configurations for the Kent Project Site including decentralised/building level heat pumps and more centralised, large scale heat pumps as part of a site-wide district heating system. Both air and river water source heat pumps have been reviewed as part of a detailed options appraisal considering not only the carbon and cost impact of these systems but also visual impacts, environmental influences and delivery risks.

1.17 A range of site-wide cooling configurations for the Kent Project Site have also been defined and appraised as part of this study. As with the review of heating configurations, both decentralised strategies and centralised district cooling systems have been considered and, in all cases, using electric chillers. Both river water cooled chillers and cooling-tower based systems have been assessed.

1.18 Given virtually all of the London Resort energy demands are within the Kent Project Site, the technology appraisal of heating and cooling configurations has been limited to these loads. As the comparatively low heating and cooling requirements of the Essex Project Site are limited to the Ferry Terminal and Logistics Centre, building level air source heating and cooling plant is proposed.

1.19 This Energy Strategy presents the approach taken in estimating site-wide energy demands to provide a basis against which the above configurations can be assessed and the carbon impact quantified, along with the outcomes of this options appraisal study and the resulting proposed strategy. The wider implications of the selected strategy relating to energy utility connections (gas and power), on site renewable generation and off-site carbon offsetting measures are also presented.

1.20 Broader aspects relating to the supply of new utilities to the Resort (as determined through this work), along with coordination of any existing utilities on site is described further within the Utilities Statement (document reference 7.6). Further assessment of the energy strategy environmental impact is presented within the Outline Sustainability Statement (document reference 7.7) and Environmental Statement Chapter 16 – Air Quality and Chapter 20 – Greenhouse gas and climate change.

# Chapter Two ◆ Net zero carbon

2.1 Sustainability and low carbon principles are at the heart of the London Resort vision and as is the basis for the overarching energy strategy objective of targeting net zero carbon in operations. Given the significant carbon impact from the built environment on the UK's total emissions, LRCH recognises the unique impact the London Resort can have on driving down carbon emissions and setting the standard as a sustainable, next generation entertainment resort.

2.2 The UK Green Building Council (UKGBC) provides a framework of guiding principles and definitions against which project developers can assess the carbon impact of different on-site energy demand and supply measures and therefore quantify additional measures required to achieve net zero carbon.

2.3 The London Resort is targeting net zero carbon in its operational energy and has adopted the UKGBC scope, principles and definitions within the energy strategy. The UKGBC defines net zero carbon operational energy as:

*'When the amount of carbon emissions associated with the building's operational energy on an annual basis is zero or negative. A net zero carbon building is highly energy efficient and powered from on-site and/or off-site renewable energy sources, with any remaining carbon balance offset.'*[1]

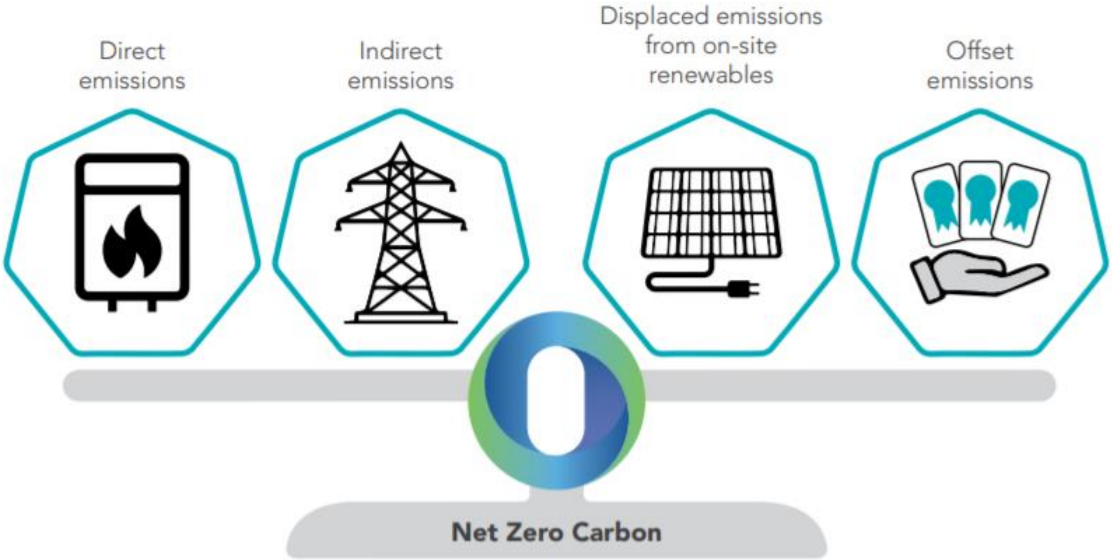
2.4 The following steps (in order of priority) are set out by the UKGBC:

- ***Establish a net zero scope*** by targeting either net zero carbon in either construction or in operational energy. This sets the boundaries for an analysis of carbon emissions and provides guidance on which carbon emissions need to be considered.
- ***Reduce operational energy use*** (demand and consumption) as a priority and before all other measures. In-use energy consumption should be calculated and publicly disclosed on an annual basis.
- ***Increase renewable energy supply*** through first prioritising the use of on-site renewable generation and/or additionally through the use of off-site renewable generation
- ***Offset any remaining carbon*** using a recognised carbon offsetting framework and publicly disclose the level of offsetting used on an annual basis.

[1] UK Green Building Council; Net Zero Carbon Buildings: A Framework Definition, Scope 1.2. April 2019

2.5 Figure 2—1 illustrates how renewable energy supply and carbon offsetting measures are used to achieve a net zero carbon balance against direct emissions on-site (such as through the use of natural gas combustion) and indirect emissions (such as the carbon impact of using grid imported electricity.

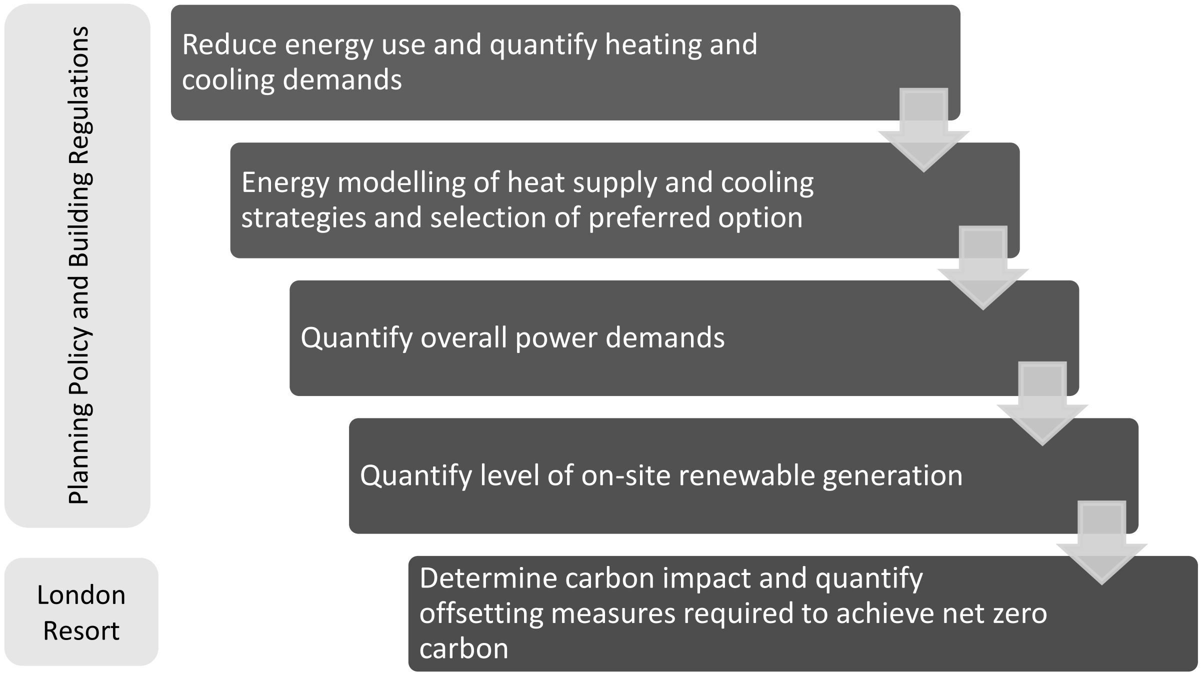
**Figure 2—1 UKGBC illustration on achieving net zero carbon in operation**



2.6 The approach taken in the development of the London Resort Energy Strategy has followed the UKGBC process through first estimating site-wide heating, cooling and power demands associated with an energy efficient scheme with measures implemented to reduce primary energy use. Energy modelling of a range of technologies and on-site renewables has been undertaken to quantify both direct and indirect carbon emissions, and as such the level of required offsetting measures to achieve net zero carbon.

2.7 Figure 2—2 summarises the steps taken in developing the London Resort Energy Strategy, illustrating how the outputs from individual assessments are used to arrive at key decisions relating to the use and scale of energy technologies used.

**Figure 2—2 Overview of approach to developing the London Resort Energy Strategy**




2.8 The UKGBC definition of net zero carbon has provided a framework against which the London Resort's carbon ambitions can be quantified and has allowed the development of an energy strategy that is compliant with national, regional and local planning policy and building regulations.

2.9 Section 3 provides an overview of key policy and regulatory requirements relating to the Proposed Development's energy use. Reference is made throughout this report to how these requirements have influenced decisions taken and a summary of compliance with planning and regulatory carbon performance is presented in the Carbon Offsetting section.

# Chapter Three ◆ Policy review

## National Policy

3.1 The following section outlines the key policy frameworks relating to energy and carbon that are applicable to the London Resort.

3.2 Policies applicable to the London Resort energy strategy have been considered to support the development of a compliant energy strategy. These policies, in combination with the London Resort's own carbon ambitions have informed the type and scale of energy generation equipment, as well as large-scale infrastructure installations, that will be necessary for the Resort to comply with the energy and carbon requirements.

3.3 There are no National Policy Statements (NPS) for business and commercial Nationally Significant Infrastructure Projects. However, Section 105 of the Planning Act 2008 sets out what the Secretary of State must have regard to in making his or her decision where a relevant NPS is not designated. This includes any matter that 'the Secretary of State thinks is important and relevant to the Secretary of State's decision.' In order to produce an appropriate energy strategy for the Proposed Development the relevant planning policies that may be a material consideration to the Secretary of State's decision have been reviewed and considered.

3.4 Policies relating to energy have been reviewed at the following scales:

- National-scale policy,
- Regional-scale policy, i.e. Kent County Council (KCC),
- Local-scale policy, i.e. Dartford Borough Council (DBC), Gravesham Borough Council (GBC), Ebbsfleet Development Corporation (EDC) and Thurrock Council (TC).

**Climate Change Act 2008**

3.5 The Climate Change Act 2008 (the 2008 Act) remains the most recent policy regarding climate change and its mitigation. This was updated in 2019 through the Climate Change Act 2008 (2050 Target Amendment) Order 2019 with a commitment to become net zero by 2050.

3.6 The 2008 Act established a legally binding target to reduce the UK's greenhouse gas emissions by at least 80% below base year levels by 2050. To drive progress and set the UK on a pathway towards this target, the 2008 Act introduced a system of carbon budgets which provide legally binding limits on the amount of emissions that may be produced in successive five-year periods, beginning in 2008. The first three carbon budgets took effect in May 2009 and require emissions to be reduced by at least 34% below base year levels in 2020. The fourth carbon budget, covering the period 2023–27, took effect in June 2011 and requires emissions to be reduced by 50% below 1990 levels. In July 2016 the Government agreed to set the fifth carbon budget, which has been recommended as a 57% reduction in emissions from 2028-2032 on 1990 levels.

3.7 The regional and local policies detailed in the Regional Policy and Local Policy section below are based on the 2008 Act, with the five year carbon budgets migrated into local planning policy and building regulations.

**National Planning Policy Framework (February 2019)**

3.8 In the absence of an up to date National Policy Statement on Energy (last update July 2011), The National Planning Policy Framework (NPPF) remains the most up-to-date document for guidance relating to planning policy and energy on a national level.

3.9 Within the NPPF matters relating to energy are set out in section 14 – "meeting the challenge of climate change, flooding and coastal change". Specific energy related statements are:

- To support the move to a low carbon future, local planning authorities should:
  - Shape places in ways that contribute to radical reductions in greenhouse gas emissions
  - Support renewable and low carbon energy and associated infrastructure
- In determining planning applications, local planning authorities should expect any new development to:
  - Comply with adopted Local Plan policies on local requirements for decentralised energy supply unless it can be demonstrated by the applicant, having regard to the type of development involved and its design, that this is not feasible or viable,
  - Take account of landform, layout, building orientation, massing and landscaping to minimise energy consumption.

- To help increase the use and supply of renewable and low carbon energy, local planning authorities should recognise the responsibility on all communities to contribute to energy generation from renewable or low carbon sources. They should:
    - Have a positive strategy to promote energy from renewable and low carbon sources,
    - Design their policies to maximise renewable and low carbon energy development while ensuring that adverse impacts are addressed satisfactorily, including cumulative landscape and visual impacts,
    - Consider identifying suitable areas for renewable and low carbon energy sources, and supporting infrastructure, where this would help secure the development of such sources,
    - Support community-led initiatives for renewable and low carbon energy, including developments outside such areas being taken forward through neighbourhood planning,
    - Identify opportunities where development can draw its energy supply from decentralised, renewable or low carbon energy supply systems and for co-locating potential heat customers and suppliers.

- When determining planning applications, local planning authorities should:
    - Require applicants to demonstrate the overall need for renewable or low carbon energy and also recognise that even small-scale projects provide a valuable contribution to cutting greenhouse gas emissions,
    - 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 also 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 UK Building Regulations Part L**

3.10 The Building Regulations Part L (2013) governs the conservation of fuel and power in both new construction and refurbishment of the UK building stock. Compliance with building regulations is a regulatory requirement for all new developments, and carbon emissions of a development comparative to compliance with Part L is the key performance indicator for many carbon targets. Amendments were made to the regulations in April 2016, with a further update to the regulations anticipated in late 2020.

3.11 It should be noted that the method for demonstrating Part L compliance is currently under consultation. The SAP is the methodology used to assess the energy performance of buildings and will be revised with the new Part L (2020) Building Regulations. This revision will see more stringent energy conservation requirements for new buildings and adoption of updated carbon factors that will have a significant impact on technologies such as gas CHP.

## Regional Policy

### Climate Local Kent

3.12 Climate Local Kent consists of a Climate Local Commitment, which local authorities can sign up to either individually or collectively, to demonstrate their commitment to addressing climate change. By signing the commitment local authorities are asked to:

- Set out what actions they intend to undertake locally to reduce carbon emissions and respond to changes in the climate both within their own operations and services and within the local community;
- Set out their level of ambition and how they are going to monitor and demonstrate achievements; and
- Share with other councils and national partners the actions being undertaken as well as ambitions, progress, experience learning and achievements.

3.13 Climate Local Kent targets a 34% reduction in carbon dioxide ($CO_2$) emissions by 2020, which are based on the Kent Environment Strategy (2016), which is in turn based on the Government's Carbon Budget (from the 2008 Act, above).

3.14 Both DBC and GBC are committed to Climate Local Kent, having signed up in January 2013 and March 2013, respectively.

### Climate Local Thurrock

3.15 Climate Local Thurrock includes a local commitment to taking action on climate change in support of national carbon reduction targets. An overall 35% reduction in emissions from 1990 levels is targeted by working towards:

- Reducing emissions per job by 22% by 2022
- Reducing emissions per resident by 15% by 2022
- Reducing emissions per daily road movement by 15% by 2022

3.16 The commitment identifies areas where carbon reductions will be targeted, including:

- Local transport
- Industry and commercial buildings
- Renewable energy
- Land use

**Climate emergency**

3.17 All local authorities within which the Project Site falls have declared climate emergencies committing to varying timescales to achieve net zero. These include KCC, DBC, GBC and Thurrock Council. The commitments are for both Council owned estates and then borough-wide commitments.

3.18 KCC declared a Climate Emergency on 23 May2019, with a press release on the council's website stating:

*"KCC recognises the UK environment and climate emergency and will continue to commit resources and align its policies to address this. Through the framework of the Energy and Low Emissions Strategy, KCC will facilitate the setting and agreement of a target of net-zero emissions by 2050 for Kent and Medway.*

*In September 2020, we will set an accelerated target with associated action plan for its own estate and activities including those of its traded companies using appropriate methodologies. KCC will in addition deliver a Kent and Medway Climate Change Risk and Impact Report and develop and facilitate adoption of a subsequent Kent and Medway Climate Change Adaptation Implementation Plan by the end of March 2020."*

3.19 DBC declared a Climate Emergency on 7 October 2019, stating:

*"That this Council recognises the serious impact of climate change and accepts that rising global temperatures presents a clear and present threat to our world. We are facing a climate emergency. The Council further recognises that all governments (national, regional and local) have a duty to act but feels that progress in Dartford should not be constrained by the actions of the slowest. Our town and its people have a part to play in securing a sustainable future and this Council must not only be a force for change in itself, but must inspire and encourage change in others."*

3.20 GBC declared a Climate Emergency on June 25 2019, pledging to make GBC carbon neutral by 2030 and working with partners across the county and region to deliver this goal through relevant strategies.

3.21 Thurrock Council declared a Climate Emergency on 23 October 2019 targeting net zero carbon by 2050 for council activities.

**Renewable Energy for Kent (August 2013)**

3.22 Renewable Energy for Kent: An Action Plan for Delivering Opportunities 2013-2018 was developed in 2013 with many of the actions incorporated into the Kent Environment Strategy and was largely driven by a study exploring the renewable resources in the county. The Action Plan identified actions required to build up technical capability (skills and training) and opportunities to enable greater access and deployment to renewable energy technologies considered key to the region including community energy, wind and bioenergy.

3.23 The Action Plan was updated in 2017 through Renewable Energy for Kent: Baseline carbon emissions and projected domestic electricity and gas demands (2017). This document provided an update to baseline carbon emission estimates as well as a review of the level of installed renewables and combined heat and power capacity in Kent and Medway. The report included projections on future gas demands, electricity demands, and renewable energy deployment in the region.

**Kent Environment Strategy (March 2016)**

3.24 The aim of the Kent Environment Strategy (KES) is to continue to support economic growth whilst protecting and enhancing Kent's natural and historic environment, and creating and sustaining communities that are vibrant, healthy and resilient.

3.25 The KES Steering Group consists of representation from across a range of regional strategic and delivery groups and will deliver the KES, which will act as a framework to prioritise action by the key public agencies, business and commerce in Kent.

3.26 The KES is a three-year strategy organised into three themes and ten priorities representing the major challenges and opportunities for Kent over the next 10 to 20 years. Each theme has a 20-year vision, supported by high-level targets. The themes and related priorities that are relevant to the energy aspects of the London Resort include:

- **Theme 2:** Making best use of existing resources, avoiding or minimising negative impacts
    - **Priority 6:** Improve our resource efficiency such as energy, water and land
- **Theme 3:** Toward a sustainable future
    - **Priority 10:** Supporting growth in the economy with a focus on low carbon
    - **Priority 10.4:** Widely promote the county of Kent as the place for low carbon and environmental businesses

3.27 The carbon reduction target chosen for Kent is based on the UK target of progressively reducing greenhouse gas emissions by 34% (by 2020), 50% (by 2025), 60% (by 2030) and 80% (by 2050), as per the 2008 Act.

## Local Policy

### Dartford Core Strategy (September 2011)

3.28 The Dartford Core Strategy sets out the approach of partners and those involved in community planning and development control to consider the and deliver the future needs of housing, transport, leisure, growth and jobs.

***Policy CS 23: Minimising carbon emissions***

3.29 Policy CS23 sets out the Council's policy to minimise carbon emissions, aiming to reduce energy consumption, and in turn contribute towards reducing growth in $CO_2$ emissions and reducing per capita $CO_2$ emissions.

3.30 Key clauses include:

- Require all new development to:
    - Demonstrate that reductions in energy use through passive design and layout of development have been explored and applied, where practical,

- Require housing development of 100 units or more to:
    - Achieve at least Code Level 4[173] (or its equivalent) in the energy category in advance of mandatory requirements,
    - Design buildings in a way that enables the potential for zero carbon through the later retro-fitting of zero and low carbon technologies, for example through solar thermal, photovoltaic systems, ground source heat pumps and connection to a CHP plant, where development commences prior to introduction of Code Level 6 [174].

- Require new non-residential development over 1,000 square metres gross floorspace to meet BREEAM 'excellent' (or any future national equivalent).

- Subject to assessment, seek that development on the following sites provides low/zero carbon CHP either on or off-site to supply the development with heat and power:
    - Eastern Quarry (see also Policy CS 5)
    - Ebbsfleet (see also Policy CS 5)
    - Northern Gateway (see also Policy CS 3)
    - **Swanscombe Peninsula (see also Policy CS 6)**

- Where the supply is provided in the later phases of development, infrastructure to enable future connection should be provided in the early phases. On these sites, the potential to supply existing buildings or smaller development sites with heat or energy from the CHP plant should be explored. Implementation of further sites and networks for low/zero carbon decentralised energy, as identified through the Kent Thameside Eco –Assessment Study will also be encouraged.

3.31 Reference is made to Policy CS 6: Thames Waterfront within the policy, which refers to the Thames Waterfront area and provides no further details in terms of energy requirements.

3.32 The Council identifies the BREEAM Excellent standard for non-domestic buildings of 25% improvement in carbon emissions as a reasonable target. It also identifies a strong case for the use of CHP systems linked to regeneration schemes in the Dartford area.

***Sustainable Energy Background Paper (2011)***

3.33 The Sustainable Energy Background Paper was produced by DBC in 2011 as part of Dartford's local development framework to signpost and clarify the evidence and background to policy CS23 of the proposed Core Strategy. It supplements and clarifies, where needed, the existing evidence base.

3.34 This document makes specific reference to specific regeneration areas including the Swanscombe Peninsula: where it states that

*"KTRP (Kent Thameside Regeneration Partnerships) and the local planning authorities should work in partnership with the landowners and developers to develop and implement a comprehensive energy strategy for the Project Site, ideally in conjunction with the Ebbsfleet regeneration site to the south. The development has the potential to be an exemplar project in terms of its low-carbon energy characteristics'. Technology to be considered includes solar thermal, solar PV, ground source heat pumps, biomass, CHP, medium-scale wind."*

## Gravesham Local Plan Core Strategy

3.35 The Core Strategy sets out the Council's long-term spatial vision for the borough. The Core Strategy covers the period from 1 April 2011 to 31 March 2028.

### *Policy CS18: Climate Change*

3.36 Through Policy CS18, the Council follows national policy on transition to zero carbon development, Part L of the Building Regulations. New developments are therefore required to consider potential and include proposals for low carbon and renewable energy generation, including combined heat and power. If chosen not to do so, developers must submit evidence demonstrating why compliance is not technically or financially feasible.

3.37 The Council supports stand-alone decentralised, renewable or low carbon energy development where compatible with national policies for protecting the Green Belt.

3.38 It also supports other carbon footprint-reducing proposals, such as local initiatives based on carbon off-setting via allowable solutions.

## Thurrock Sustainability Appraisal Scoping Report (2016)

3.39 The New Local Plan for Thurrock includes the Sustainability Appraisal Scoping Report setting out key sustainability objectives, baseline performance information and relevant policy.

3.40 The current Sustainability Appraisal Scoping Report references the Thurrock Energy Study (2010) under produced in response to Core Strategic Policy CSTP-26 – renewable or Low Carbon Energy Generation. No further update to the 2010 energy study has been produced.

## Energy strategy policy requirements

3.41 The above policy review demonstrates the London Resort must comply as a minimum to meet Building Regulations Part L 2013 requirement on regulated energy consumption.

3.42 To demonstrate best practice, it is suggested that a 35% reduction in carbon beyond the Building Regulations Part L 2013 requirements is adopted (as per Greater London Authority practice).

3.43 The net zero commitments of the councils have been considered within the energy strategy development.

3.44 Changes to Part L Building Regulations should also be closely monitored and implications on the energy strategy reviewed as necessary as this may have a significant impact on the installed energy systems on the London Resort, and may preclude some strategies (e.g. CHP systems).

# Chapter Four ◆ Heating and cooling strategy

## Introduction

4.1 This section summarises the approach taken in calculating heating and cooling loads for the Project Site and considers both peak demands and total annual energy consumption for heat (space heating and domestic hot water) and comfort cooling. These have been developed using typical energy and peak demand benchmarks (expressed on a per area basis) and energy demand profiles for the rides, attractions and building typologies across the Proposed Development.

4.2 Energy load build-out is based on phasing and the building area schedule information provided by Apt based on the illustrative masterplan (drawing reference LR-PL-APT-ILP-2.21.0). Gate One, Related Housing and the Associated Development are assumed to come online in 2024, with Gate Two opening five years later in 2029.

4.3 Heating, cooling and power peak energy demand levels for the themed rides and their associated buildings within Gate One have been estimated based on a range of rides, attractions, retail and food and beverage units generated as part of a previous design iteration in 2017. These demands have been pro-rated based on area to generate energy demands for Gate Two. These estimates are representative of a potential theme park design for the site similar to that shown in the illustrative masterplan.

4.4 A range of on-site heating and cooling technologies have been considered within this study to meet the estimated demands. Calculated peak heating and cooling demands have been used to provide an indication of plant sizing and has therefore supported subsequent assessment of costs and footprint impact.

4.5 Annual heating and cooling demand estimates have been used as the basis for assessing the carbon performance and running costs of different technology options. Combining annual demand estimates with typical energy usage profiles for the various building typologies and region-specific weather data has allowed this assessment to be undertaken on an hourly basis. An overview of the energy modelling approach adopted is presented in Figure 4—1. The energy modelling software package EnergyPro has been used as part of this assessment.

**Figure 4—1 Overview of approach to energy modelling**

## Heat demands

4.6 The majority of heat demands across the Project Site will be demands related predominantly to the Associated Development and Related Housing within Gate One. Heat demand estimates for these buildings have been developed using gross internal area (GIA) information.

4.7 In estimating Project Site heat demands, a combination of published energy demand benchmarks from industry bodies (BSRIA Energy Benchmarks, CIBSE TM46 and CIBSE Guide F) as well as an in-house database of metered energy demands for similar building typologies. Where older publications and benchmarks have been used, adjustments have been made to take into account building fabric improvements required to comply with Building Regulations Part L 2013 and the 2016 amendment.

4.8 An in-house database of hourly energy demand patterns over a typical week for various building typologies were combined with annual heat demand estimates in EnergyPro, along with building specific estimates on how heat demands are split between space heating (SH) and domestic hot water (DHW). The energy modelling software package's ambient weather profiles for the region (CSFR2 weather data) were used to distribute the temperature dependent (space heating) element of heat demands across a typical year. Through this process, building level energy demand profiles for a typical year were generated at a one-hour resolution.

4.9 Where 2017 energy demand estimates for the themed rides have been used, an improvement factor of 20% has been applied to account for an improvement in building fabric (U-values) as required through building regulations (accounting for 10% of the improvement) and additional energy efficiency measures (accounting for an additional 10% improvement) taken to reduce operational energy demands beyond building regulations. These heat loads relate to the demands within the indoor attractions and event spaces within the Leisure Core. With regards to the pattern of heat demand usage, relevant operational data was not available, however a morning peak and a late afternoon peak were predicted in line with the opening hours of the Resort. This profile was used to generate an hourly heat demand profile for a typical year.

4.10 Gate Two themed rides and associated buildings heat demands have been pro-rated using the Gate One estimates described above. A similar approach was taken to estimating heat demand patterns. Hourly profiles for the Gate One and Gate Two Leisure Core areas were subsequently developed.

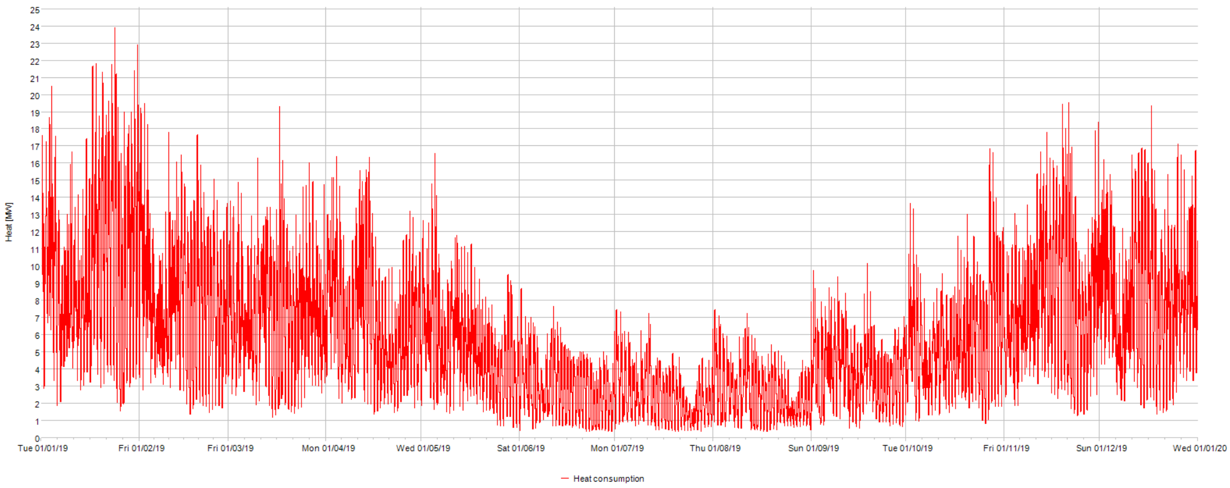
4.11 A summary of overall heat demands for the Resort is presented in Table 4—1 . Demands are dominated by the hotels (accounting for over 60% of the load), Related Housing, administrative offices, staff canteens and kitchens and resort retail buildings. More than 90% of the peak load comes online in the opening year, with Gate Two demands estimated to result in a 10% increase in peak heat demand.

**Table 4—1 London Entertainment Resort heat peak demands and annual consumptions**

| Heat Demand | Peak Heat Demand (MW) | Annual Heat Consumption (GWh/a) |
|---|---|---|
| Gate One | 26.6 | 41.4 |
| Gate Two | 2.8 | 5.5 |
| TOTAL | 29.4 | 46.9 |

4.12 Figure 4—2 below shows the combined heat demand profile for all buildings within the Gate One and Gate Two over a typical year and on an hourly basis. It is important to note that the calculated peak demand is not reflected in this graph, as the disaggregation is done exclusively using the annual consumption values.

**Figure 4—2 London Resort cumulative annual heat demand profile**



4.13 The above hourly heat demand profiles were used as the basis for the simulation of heat supply strategies described in the Energy Modelling section.

## Cooling demands

4.14 Cooling demand estimates for buildings across the Project Site have been developed using gross internal area (GIA) information and cooling demand benchmarks for similar typology buildings. Annual cooling demand benchmarks from CIBSE Guide F were used and adjusted to take into account improved building fabric of new builds. Similarly, the peak demands are estimated from BSRIA and CIBSE Guide A benchmarks and comparable buildings from past Buro Happold projects, including internal heat gains arising from occupancy trends.

4.15 The annual cooling consumption of the connections is disaggregated following the same methodology as the heating loads, using typical week hourly profiles sourced from previous project experience and relying on historical weather data to estimate the outside ambient temperature effect on the cooling loads strictly during the summer season. In a typical weather year, from September until May, a constant relatively low baseload is assumed to make up for internal heat gains due to occupancy. The annual hourly cooling loads of the Gates are estimated using an equivalent methodology to the heating loads, with a predicted peak load in the middle hours of the day. The weekly profiles are used as loading factors of the estimated cooling peak demand.

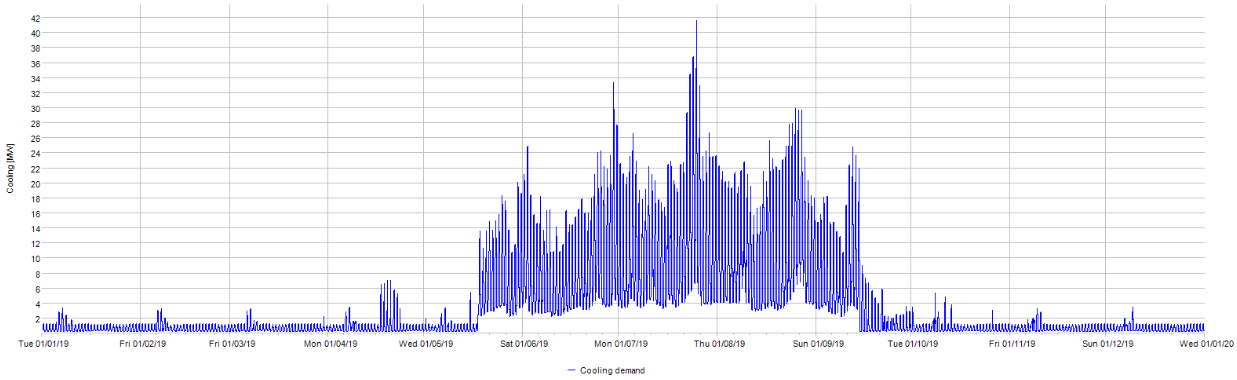
4.16 Table 4—2 provides the London Resort cooling peak demands and annual consumptions. Once again, these are mostly concentrated in the hotels, Related Housing, administrative offices, staff canteens and kitchens and resort retail buildings, accounting for three quarters of the overall site consumption. The hotels represent approximately 80% of these buildings loads. The respective contributions to the peak and consumption demands of the Gates are more reduced compared to the heating loads. In the opening year, around 90% of the peak cooling demand comes online.

**Table 4—2 London Entertainment Resort cooling peak demands and annual consumptions**

| Cooling Demand | Peak Cooling Demand (MW) | Annual Cooling Consumption (GWh/a) |
|---|---|---|
| Gate One | 31.8 | 30.4 |
| Gate Two | 3.1 | 1.4 |
| TOTAL | 35.0 | 31.8 |

4.17 Figure 4—3 below illustrates how the total cooling demand of the Project Site is distributed throughout the year, according to the methodology previously described. It is important to note that the calculated peak demand is not reflected in this graph, as the disaggregation is done exclusively using the annual consumption values.

**Figure 4—3 Cumulative annual cooling demand profile of the LRCH development**



## Technology review

### Technology screening

4.18 An initial high-level technology screening exercise was undertaken to identify heat generating technologies to take forward for further assessment and energy modelling. Table 4—3 provides an overview of technologies qualitatively reviewed against a set of five criterion. These criteria were chosen to provide a broad characterisation of technology options and their cost, carbon and environmental impacts. Consideration was given to the use of these technologies either as part of a centralised, district heating system or where possible as building level (decentralised) systems.

4.19 A similar exercise was not undertaken for chilled water generation due to the comparatively lower carbon impact of chilled water generation, wide scale adoption and high performance of vapour compression refrigeration (electrically driven) chillers. Instead variants of these systems have been chosen based on exploiting any shared benefits with the accompanying heating system. For example, river water cooled chillers were considered in combination with a WSHP configuration.

4.20 The Resort's carbon ambitions have been considered as part of this review as well as planning and regulatory requirements, which in some cases may rule out the sole use of fossil fuelled heat generation. Technology maturity and the maturity of fuel or supply chains required has also been taken into account, and systems which carry a high level of risk in these areas discounted given potential negative impacts on reliability and an increased uncertainty around achieving stipulated operation (and therefore carbon targets).

4.21 Given the sustainability ambitions of the London Resort, systems with low environmental impacts and discharges to air or water have been prioritised. Biomass fuelled systems have not been taken forward due to possible sustainability impacts at this scale relating to the large requirement for virgin wood fuel (as opposed to waste). Such systems will also result in an increased traffic requirement due to the need for regular fuel deliveries to site.

**Table 4—3 Summary of heat generation technology screening review**

| | Technology Maturity at Scale | Carbon Emissions | Cost | Fuel / Supply Chain Risk | Environmental Impact (noise, air quality, traffic) | Considered as part of energy strategy |
|---|---|---|---|---|---|---|
| Natural gas fired CHP | High | High | Low | Low | Med | Yes - but only in combination with low carbon heat |
| Natural gas fired boilers | High | High | Low | Low | Low | Yes - but only as back-up / top-up supply |
| Natural gas fuel cells | Low | High | High | Low | Low | No – high technical risk and carbon intensive |
| Closed loop ground-source heat pumps | Low | Low | High | Low | Med -subsurface and possible groundwater impacts | No – high cost at required scale |
| Open loop Ground-source heat pumps | Medium | Low | High | Low | Med – due to drilling | No – uncertain groundwater yields at required scale |
| Air-source heat pumps | Medium | Low | Med | Low | Low | Yes |
| Water-source heat pumps | Medium | Low | Med | Low | Med – impacts on river water if unmitigated | Yes |
| Ambient loop district heating | Med | Low | High | Low | Low | Yes |
| Solar thermal | Medium | Low | Med | Low | Low | Yes – this will be |

| | Technology Maturity at Scale | Carbon Emissions | Cost | Fuel / Supply Chain Risk | Environmental Impact (noise, air quality, traffic) | Considered as part of energy strategy |
|---|---|---|---|---|---|---|
| | | | | | | considered as part of a further assessment against solar PV |
| Biomass boilers | High | Low | Med | Medium | High – air quality, traffic, dust | No – potential sustainability impacts due to high requirement for virgin wood fuel |
| Biomass CHP | Low | Low | High | High – more specialist feedstock requirement | High – air quality, traffic, dust, discharge to water | No - potential sustainability impacts due to high requirement for virgin wood fuel |
| Biogas CHP | Medium | Low | Med | High | Med | No – fuel supply chain risk and emissions to air and water |
| Hydrogen boilers | Low | Dependent on fuel source | High | No current supply chain infrastructure | Med – air quality impacts | No – no fuel source and poor air quality performance |
| Hydrogen CHP | Low | Dependent on fuel source | High | No current supply chain infrastructure | Med – air quality impacts | No – no fuel source and poor air quality performance |

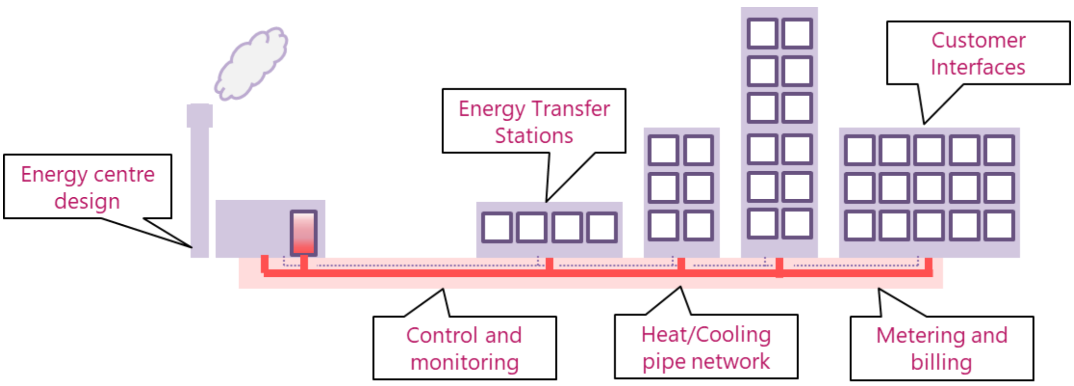
4.22 In summary, the initial technology screening identified a range of electrically driven heat pump configurations along with natural gas CHP and gas boilers to take forward for further assessment. In order to ensure regulatory compliance and target significant carbon reductions, gas CHP has been taken forward only if combined with a low carbon (or heat pump) system and gas boilers will only be used in combination with a heat pump led system to provide back-up and top-up heat (during winter periods).

**District energy**

4.23 Most of the heating and cooling technologies discussed in this Section can be applied on a wide range of scales, from individual dwelling level (such as gas boilers or air conditioning units in a home or office) to large scale city-wide energy systems where heating and/or cooling is generated in a central location and distributed as hot and/or chilled water to a variety of buildings.

4.24 District Energy systems most typically represent the latter of the above arrangements where heat and chilled water is generated in a single (or small number) of large energy centres. With district heating networks, hot water is generated within the energy centres and is pumped through a network of buried pipes to individual buildings as required. Heat is then transferred from the heat network to the building level (secondary) heating system and distributed to individual customers or commercial spaces via heat (or energy transfer) substations. The same concepts also apply for district cooling systems; however, it is chilled water that is generated centrally and piped through a separate district cooling pipe network. An example schematic is shown in Figure 4—4.

**Figure 4—4 Typical district energy arrangement**



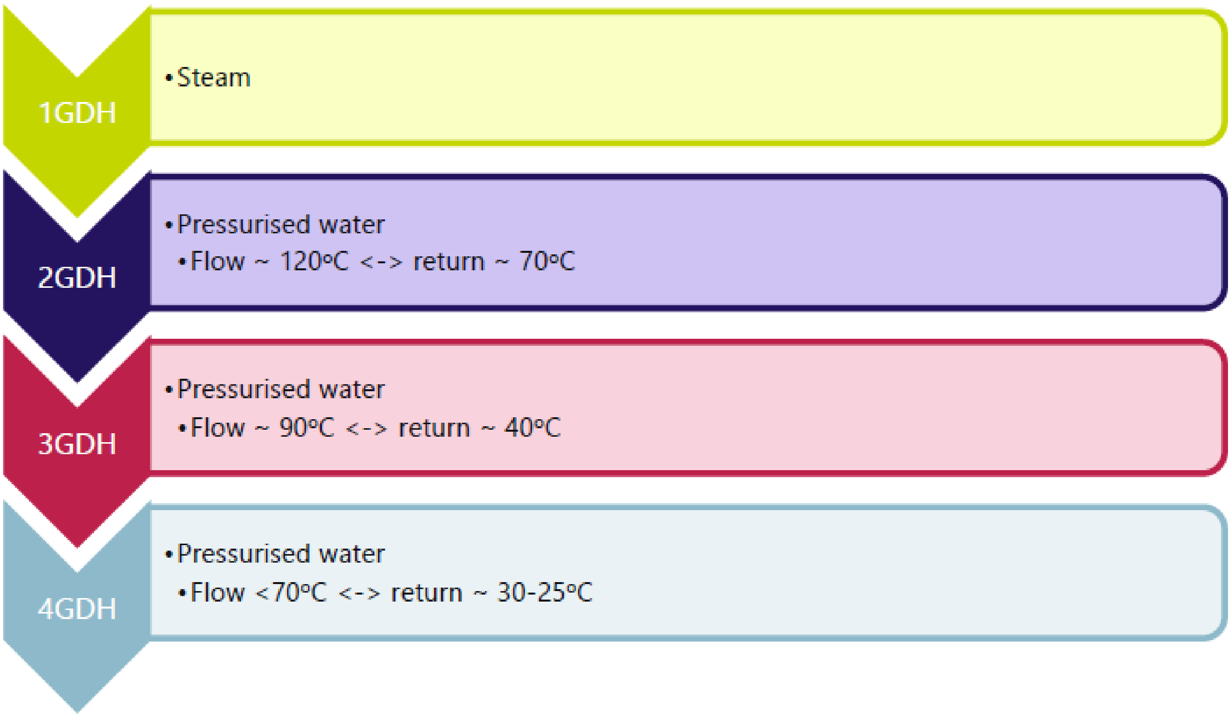
4.25 Compared to distributed (or decentralised) heating and cooling generation (at individual building level). District energy systems offer a key advantage in being able to locate all major energy generating equipment within a single central location, providing the following notable benefits:

- The use of fewer but larger plant items results in a cost benefit through economies of scale
- Enhanced resiliency in heat/cooling generation plant
- Energy efficiency advantages of using larger scale plant and higher quality heat sources
- Diversity in heat/cooling demands can reduce overall peak capacity of generating plant
- Provides an easier means of future proofing and technology flexibility where heat/cooling generating plant need only be swapped out in a single energy centre location (rather than at individual buildings)
- Power supplies and electrical infrastructure within individual buildings can be reduced
- Gas supplies and infrastructure to individual buildings can be reduced or eliminated
- Individual building rooftop plant requirement can be reduced significantly
- Visual impact of an energy generating plant can be confined to a single location and can be more easily managed or location moved to reduce impacts; and
- Environmental impacts on noise and air quality are confined to a single location and can be more cost effectively managed

4.26 A potential drawback of district energy systems over a decentralised approach would be the requirement for buried heating and cooling pipe networks and the associated capital cost associated with this. The cost benefits of a district energy network compared to a decentralised approach would need to outweigh the costs associated with the pipe networks, and as such tend to be preferred in scenarios where there is a high density of energy demand. As such district energy networks in the UK are most commonly seen in densely populated cities, apartment based residential developments, hospitals and university campuses.

4.27 For district heating systems, heat losses through the distribution networks are also a disadvantage when compared to decentralised systems; however, with appropriate design and reduction in operating temperatures, these losses can be reduced. Given the fully new build nature of the London Resort, low distribution temperatures would be targeted (4th generation district heating) to minimise heat losses and to offer an energy and carbon efficient alternative to a decentralised approach. This would represent the most advanced state of deploying low temperature district heating. Figure 4—5 provides an overview of how district heating temperatures have evolved and reduced over time.

**Figure 4—5 Evolution of district heating operating temperatures**



**Heat generating technologies**

4.28 This section provides an overview of the heat generating technologies taken forward for further assessment.

4.29 Electrically driven heat pumps feature in all heat strategies considered and as such will form the dominant low-carbon heat technology for the London Resort energy strategy. Heat pumps work by extracting heat from a source (such as the air, water or ground) and exchange heat with a refrigerant (either directly or via a transfer fluid), which is then compressed within the heat pump unit to 'upgrade' the heat to usable temperatures for a building heating system. This compression stage uses power, meaning that the carbon intensity of heat pump generated heat is dependent on the carbon intensity of the power source (normally the national grid). As the carbon intensity of the grid reduces in line with the expansion of utility scale renewable energy sources so does the carbon emissions arising from the heat, hence the current industry-wide shift away from gas fired heating sources towards heat-pumps.

4.30 The efficiency of a heat pump is defined by its coefficient of performance (COP) which is calculated by determining how many units of useful of heat are produce for each unit of electricity consumed. The higher the COP the more efficient the heat pump.

4.31 Air source heat pumps (ASHPs) work by extracting heat from the outside air via an external heat exchange unit. They are, however, typically less efficient (lower COPs) and are subject to efficiency fluctuations with the changing outside air temperature when compared to water source heat pumps (WSHPs). In winter, when heating requirements are highest, the cold outside air temperature means that ASHPs are at their lowest efficiencies.

4.32 WSHPs take advantage of the relatively consistent temperatures found in bodies of water, whether they be lakes, rivers, streams or aquifers, in order to achieve higher year-round efficiencies than ASHPs. The thermal capacity and thermal inertia of water enables it to retain some solar heat gained in the summer through to the winter. Bigger, centralised heat pump units also tend to achieve higher efficiencies than smaller, decentralised units. Similar efficiency penalties will occur over the winter periods as water temperatures drop but to a lesser extent in comparison to ASHPs. A key challenge with the use of WSHPs surrounds the infrastructure and regulatory requirements for river water abstraction and discharge, due to the large volumes of water required for the process. In addition, water quality is also a key factor, in particular silt levels within rivers which could result in considerable maintenance requirements.

4.33 CHP technology is now a well-established means of simultaneous, efficient heat and power production at the point of use from natural gas. The technology consists of a gas-fired internal combustion engine which generates power through a generator. Thermal energy is captured from the hot exhaust gases in the form of steam or hot water. This set-up can achieve combined (electricity and thermal) efficiencies up to 90%; however, it still relies on the combustion of fossil fuels and is therefore not future-proofed.

4.34 Gas fired boilers feature in all centralised heating strategies considered within this study and provide a reliable means of delivering low cost heat at scale. High efficiency condensing gas boilers are proposed. However, as a fossil-fired technology, the carbon impact of using gas boilers is large and the units are therefore included to provide back-up heat in the instance of primary low/zero carbon plant down time or top-up heat supply to meet short-term peaks or winter heat demands. As such the contribution of gas boilers to meeting heat demands has been limited to less than 10% in all centralised heat pump-based scenarios.

4.35 The 5th generation or ambient district energy loop approach employs heat pumps and chillers within each building to provide heating and or cooling. These are able to extract or reject heat into a central ‘ambient’ water loop. The temperature within the loop is allowed to swing between minimum and maximum limits. If the temperature swings outside of its set limits, a controlled heat source or heat dump should be used to bring the temperature back in line. Within this study, centralised ASHPs and back-up gas boilers have been used as the controllable heat source and indirect cooling towers have been used as a centralised means of heat rejection.

4.36 Due to the lower temperatures in ‘ambient loop’ circuits, the buried pipework specification may also be relaxed, allowing the use of uninsulated plastic pipework rather than pre-insulated steel systems. This system is most effective when site heating and cooling loads are simultaneous and of similar magnitude. A key downside to these systems is the relatively high CAPEX requirement associated with the requirement for centralised heating/cooling plant, distribution networks (due to small temperature differentials) and building level heat pumps and chillers.

4.37 In summary the heat generating configurations taken forward for further assessment, in no order of preference, are:

- Decentralised (individual building) heating with ASHPs located on building roofs
- 5th generation ambient loop using ASHP with back-up/top-up gas boilers as the centralised heat top-up system
- Centralised WSHP with back-up/top-up gas boilers
- Centralised ASHP with back-up/top-up gas boilers
- Centralised ASHP and gas CHP with back-up/top-up gas boilers

4.38 Further detail on these configurations is presented below.

**Energy from the River Thames**

4.39 Noting a key opportunity to the Project Site is the proximity to the River Thames, the option of large scale WSHPs has been investigated in further detail for supplying heat to the Kent Project Site. Input from the team's marine specialists and a specialist district heating design and build contractor with WSHP experience in the UK were key to the review of the technology. As noted above, key risks associated with the technology relate to the river water abstraction and discharge systems along with water quality.

4.40 A review of tidal data, charts and river depth information was undertaken to establish requirements for a river water abstraction and discharge system. Both bank-side and submerged "in-river" intake systems were considered; a bank-side arrangement on the Kent Project Site would result in a less complex structure with smaller civils and footprint requirements; however, is very much dependent on good bank-side depth throughout the year. A submerged intake arrangement requires a larger "in-river" structure, allowing for water intakes to be located in deeper parts of a river to ensure required water depths are maintained throughout the year.

4.41 A review of minimum water levels and tidal range for three possible WSHP intake locations determined that a submerged "in-river" intake would be required to ensure minimum water coverage above an intake would be maintained throughout the year (and at lowest river water levels). A minimum depth of 2.8m has been estimated based on an intake strainer design analogous to that considered on the Queen's Quay WSHP project (4 MW heat pump installation on the River Clyde, Glasgow).

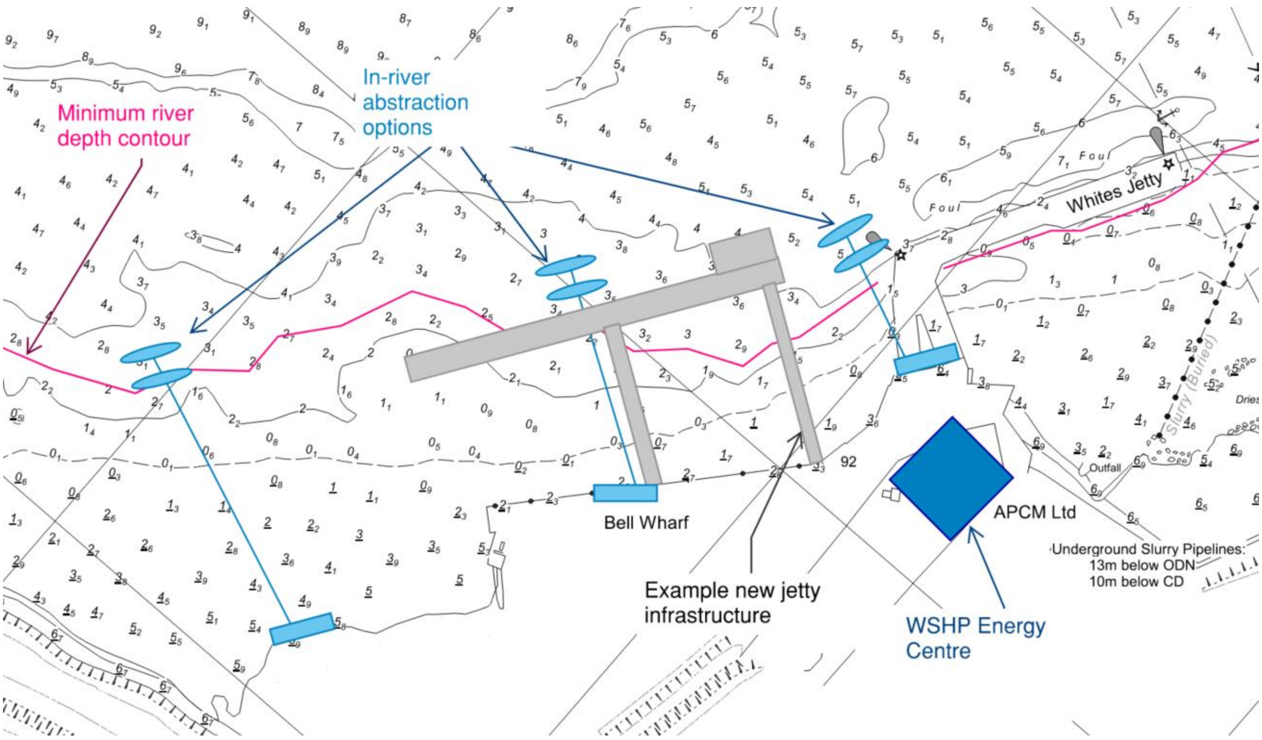
4.42 Under the water-source heating and cooling scenario considered in this study, intake and discharge pipes would be sized at DN600, which at low tides would be exposed and visible to passengers arriving by river to the Resort at the Kent Project Site. Intake filters would have to be sufficiently sized to ensure intake velocities are maintained below 15 cm/s (as measured 10cm in front of the screens), and maximum mesh size restrictions should be adhered to in order to comply with Environment Agency and Best Practice guidance for fish screening. As such these intake strainers would be a large specialist element of the design with specialist maintenance requirements.

4.43 Analysis undertaken by river water abstraction specialists on the Queen's Quay project was shared and highlighted the large impact of river water silt on maintenance requirements. For intakes located on the river-bed or within a dredged section of the river, the accumulation of silt throughout the year could result in a considerable maintenance burden. In particular for dredged intakes (as may be common for a bank-side intake), silt levels of 500 mg/L could result in up to 2.5m of silt accumulation per year. Within estuarine environments, silt levels could be as high as 1000 mg/L and as such would require, as a minimum, quarterly removal/clearance of silt build up within intake chambers.

4.44 An indication of the in-river infrastructure requirements needed to locate intake chambers at a minimum water depth is presented in Figure 4—6. Three locations were assessed at varying distances from the WSHP energy centre located in the Kent Project Site. The length of the river water abstraction pipework for these scenarios ranges from 80 to 150m in length. Intake locations further away from the energy centre would benefit from a reduced level of river transport traffic which could impact result in an increased disturbance of river bed silt; however, these arrangements would require the longest river water intake pipes.

4.45 The river water intake infrastructure requirements represent a notable infrastructure requirement with a large visual impact. Experience from the Queen's Quay project suggests that this also represents a key area of cost risk and has been considered as part of the technology review.

**Figure 4—6 Indication of required abstraction pipework infrastructure for a WSHP system**



## Chilled water generation

4.46 As noted in the Technology Screening section all scenarios involve the use of vapour compression refrigeration (electrically driven) chillers; however, consideration has been given to the heat rejection side of these systems. The thermodynamic principals of electric chillers are identical to those of heat pumps; however, with a reversal of heat flows to suit a requirement to provide cooling to system rather heat. As such, heat is transferred out a system (or cooling network), electrically compressed and rejected to a higher temperature heat dump (or condenser circuit) such as the air or river.

4.47 The main electric chiller system variants considered in this study relate to different means of dumping or rejecting heat and are summarised as follows and have been considered as part of either centralised (district cooling) or decentralised (individual building level) configurations.

**Table 4—4 Overview of electric chiller configurations**

| Electric Chiller Configuration | Heat Rejection | Comments |
|---|---|---|
| Air Cooled Chillers (ACCs) | Rejection to air via a single packaged chiller unit | Limited in scale < 2 MW per unit |
| Water cooled chillers (WCCs) | Rejection any water system | Relevant to ambient loop systems |
| Water cooled chillers (WCCs) + cooling towers (CTs) | Rejection to air via cooling towers and an intermediate condenser water circuit | High efficiency, high cooling tower maintenance and make-up water |
| River water (RW) cooled chillers | Direct rejection to river water | High efficiency, environmental restrictions on maximum water temperature rise of river |
| Indirect cooling towers / Free cooling | Process fluid is of high enough temperature to be able to reject to air via cooling towers and an intermediate water circuit | High efficiency, large CAPEX requirement due to multiple water circuits |

4.48 Given the electric chiller variants and heat rejection options shown on Table 4-4, configurations were matched with the selected heating technologies (summarised in Heat Generating Technologies section) based on shared system requirements and synergies. For the decentralised heating scenario with ASHPs being located on the building roofs for heat generation, air cooled chillers (ACCs) were proposed also at roof level to provide cooling. Where river water heat recovery was proposed for the centralised WSHP configuration, RW cooled chillers were proposed to share the common river water abstraction and discharge infrastructure and energy centre building. For centralised ASHP arrangements located further away from the river then WCC with cooling towers were chosen.

## Summary of heating and cooling configurations

4.49 A summary of all heating and cooling configurations taken forward for detailed energy modelling is summarised in Table 4—5.

**Table 4—5 Summary of modelled heating and cooling configurations**

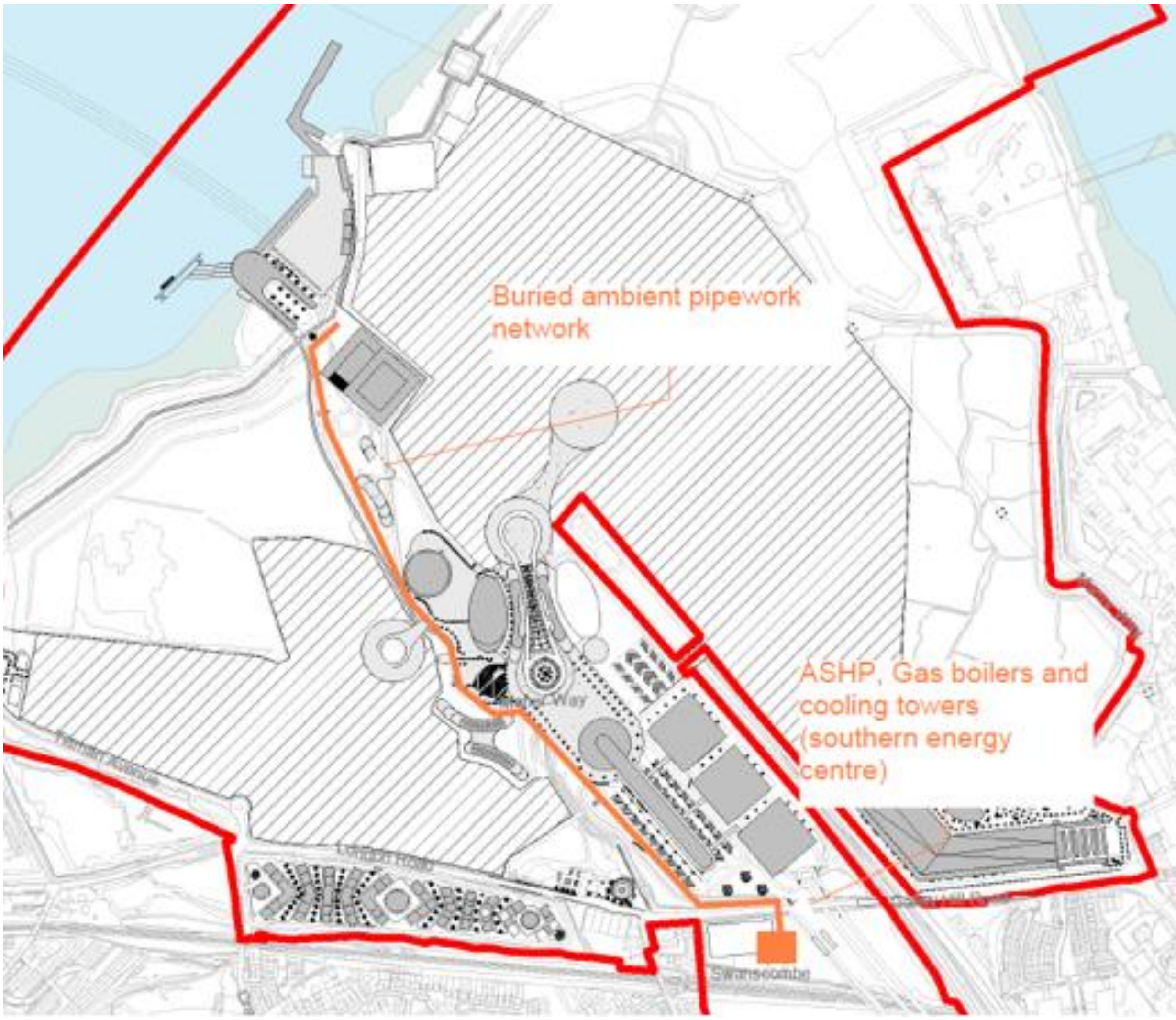
| No. | Scenario Description | Centralised Heating Plant | Building Level Heating Plant | Centralised Cooling Plant | Building Level Cooling Plant |
|---|---|---|---|---|---|
| 1 | Decentralised heating and cooling | None | ASHPs (roof mounted) | None | ACCs (roof mounted) |
| 2 | Ambient loop with centralised ASHP and CTs | ASHPs with back-up boilers (energy centre) - Figure 4—7 | WSHP (ground floor plantroom) | Indirect cooling towers -Figure 4—7 | WCCs (ground floor plantroom) |
| 3 | Centralised WSHP and RW cooling | WSHP (river-side energy centre)<br>Back-up boilers (secondary energy centre) - Figure 4—8 | Heat exchanger substation (ground floor plantroom) | River water source WCC (river-side energy centre) -Figure 4—11 | Heat exchanger substation (ground floor plantroom) |
| 4 | Centralised ASHP and WCCs | ASHPs with back-up boilers (energy centre) - Figure 4—9 | Heat exchanger substation (ground floor plantroom) | WCCs with cooling towers (energy centre) - Figure 4—12 | Heat exchanger substation (ground floor plantroom) |
| 5 | Gas CHP and ASHP with WCCs | ASHP and CHP with back-up boilers (energy centre) - Figure 4—10 | Heat exchanger substation (ground floor plantroom) | WCCs with cooling towers (energy centre)- Figure 4—12 | Heat exchanger substation (ground floor plantroom) |

**Location of centralised plant**

4.50 The locations for the centralised energy centres for the above scenarios have been determined based on access to utility/energy sources. A high-level overview of energy centre and affiliated buildings, along with the main district energy pipework infrastructure spine for each centralised scenario is presented below.

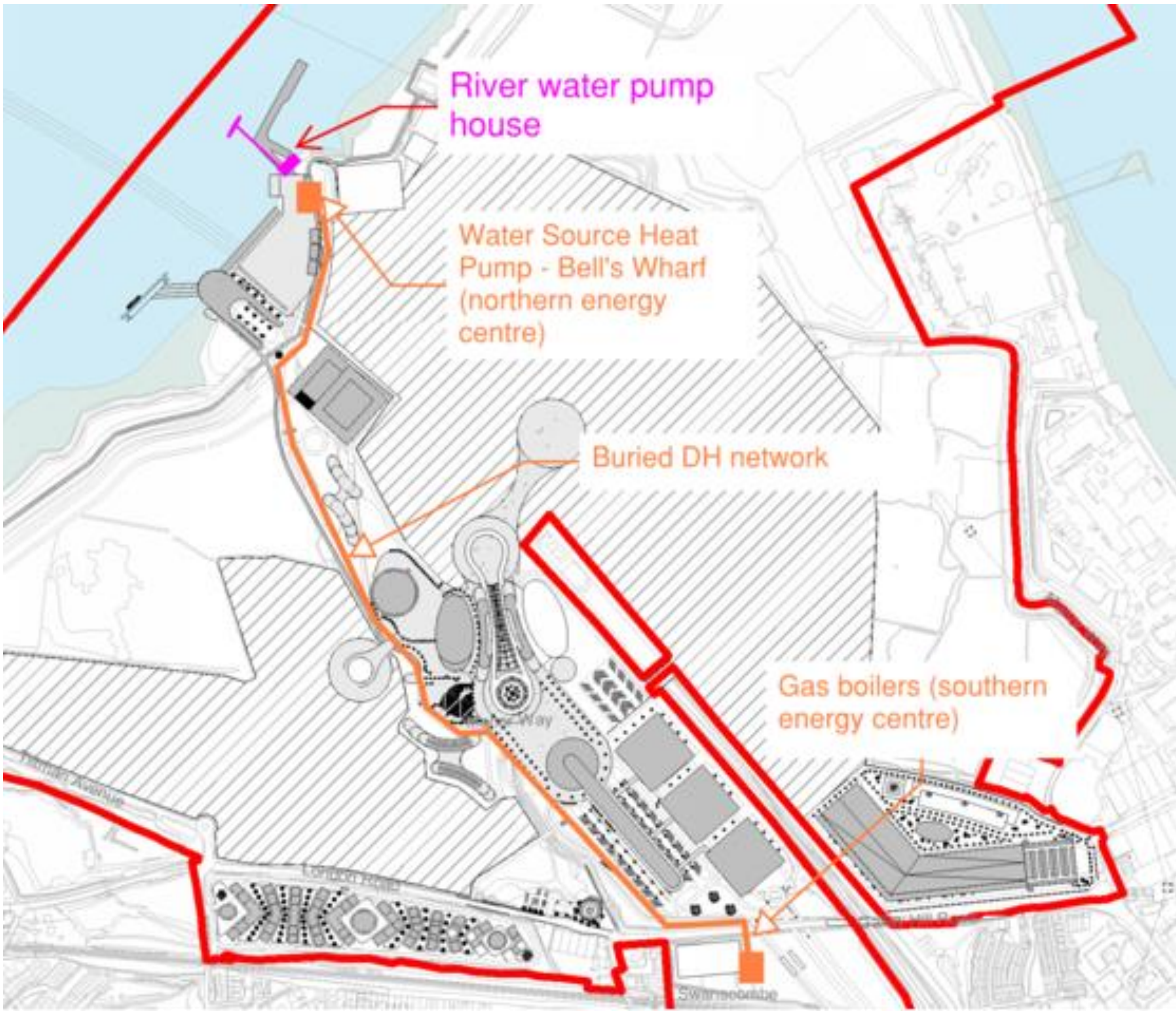
4.51 Figure 4—7 shows the requirement for a centralised energy centre containing ASHPs and back-up gas boilers to provide low grade top-up heat to the ambient loop network when network wide heating demands exceed cooling demands. The buried ambient network will be a low temperature (<20 °C) loop from which individual building level heat pumps and chillers will extract or reject heat into, respectively. The main energy centre building has been located to the south of the site to ensure proximity to existing natural gas infrastructure.

**Figure 4—7 Ambient loop energy centre and main pipework locations, Kent Project Site**



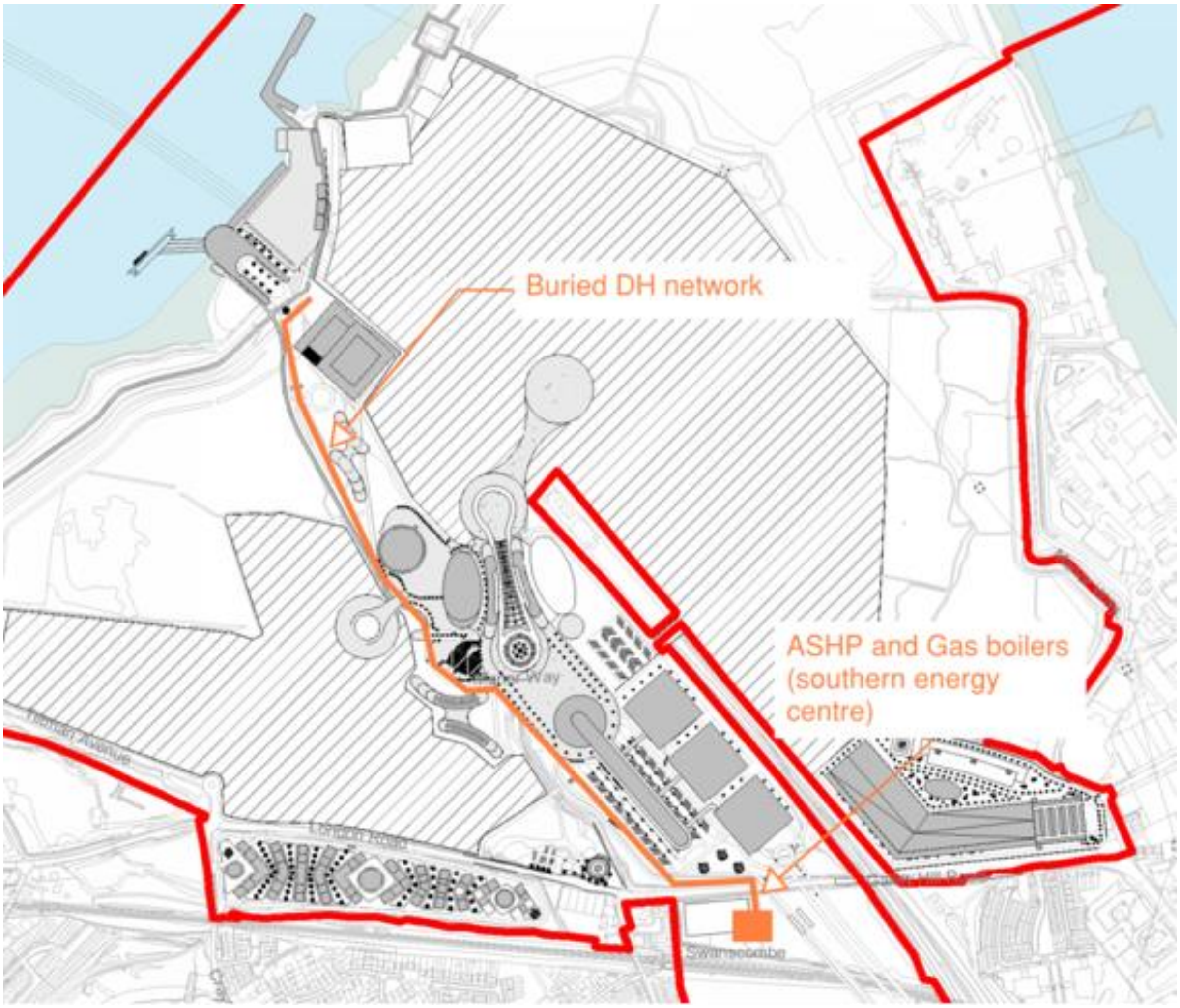
4.52 Figure 4—8 shows the building requirements for the WSHP based district heating configuration, which will require a river water pump house and abstraction and discharge pipework to transport river water to the WSHPs. A dedicated "riverside" energy centre building will be required to house the WSHPs and will include pumps in order to distribute hot water to the DH network. A secondary energy centre will be located to the south of Kent Project Site and will house gas boilers to provide top-up and back-up heat supply, along with DH distribution pumps and ancillaries. A buried pre-insulated steel pipework network will be required to distribute heat throughout the Kent Project Site.

**Figure 4—8 WSHP + gas boiler energy centre and DH network locations, Kent Project Site**



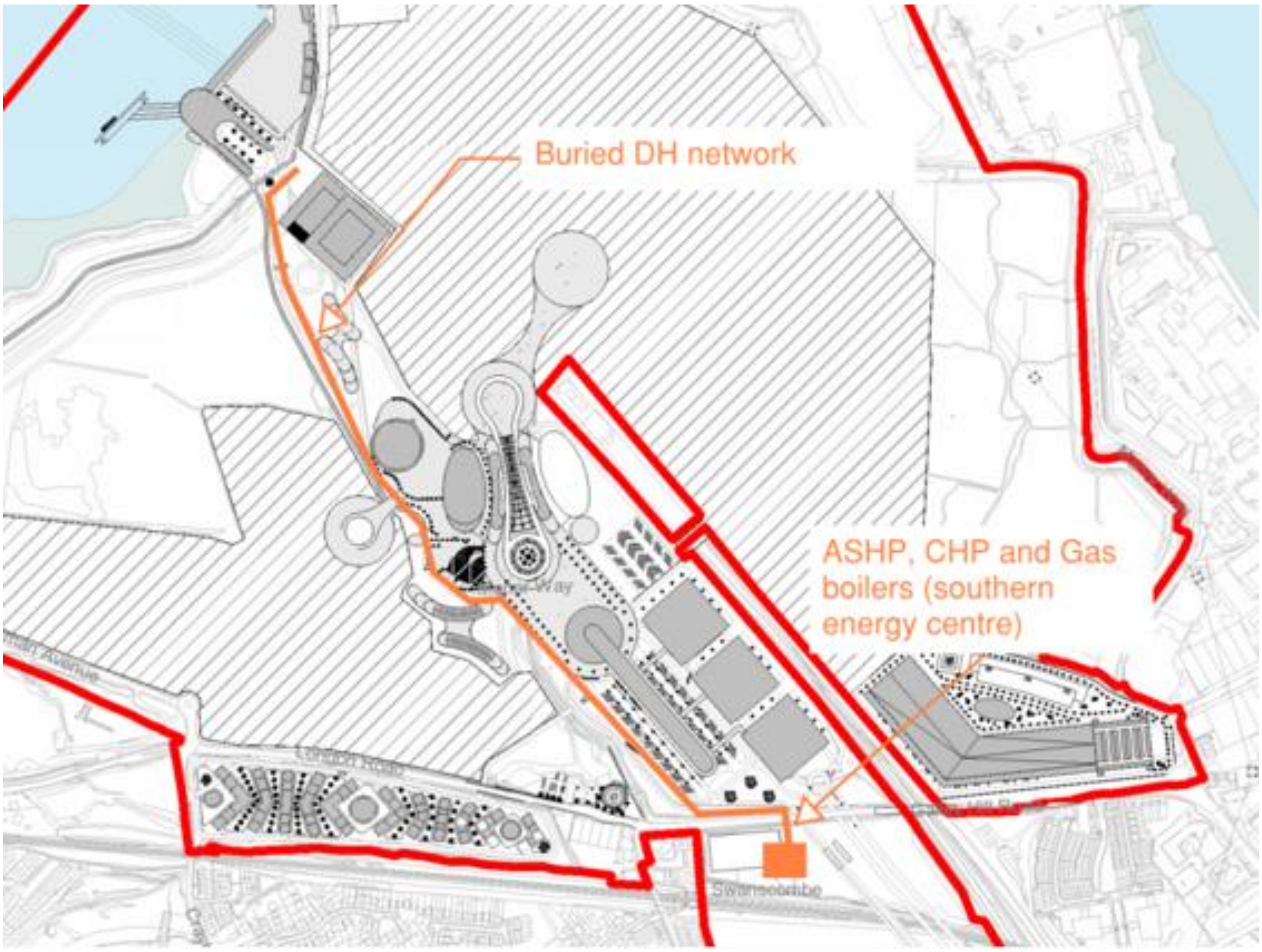
4.53 Figure 4—9 shows the requirement for a single energy centre building to house the ASHP plant and gas boilers, along with DH distribution pumps and ancillaries at the Kent Project Site. A buried pre-insulated steel pipework network will be required to distribute heat throughout the Resort (Kent Project Site). Space will also be required to accommodate the outdoor evaporator units associated with the ASHP system.

**Figure 4—9 ASHP + gas boiler energy centre and DH network locations, Kent Project Site**



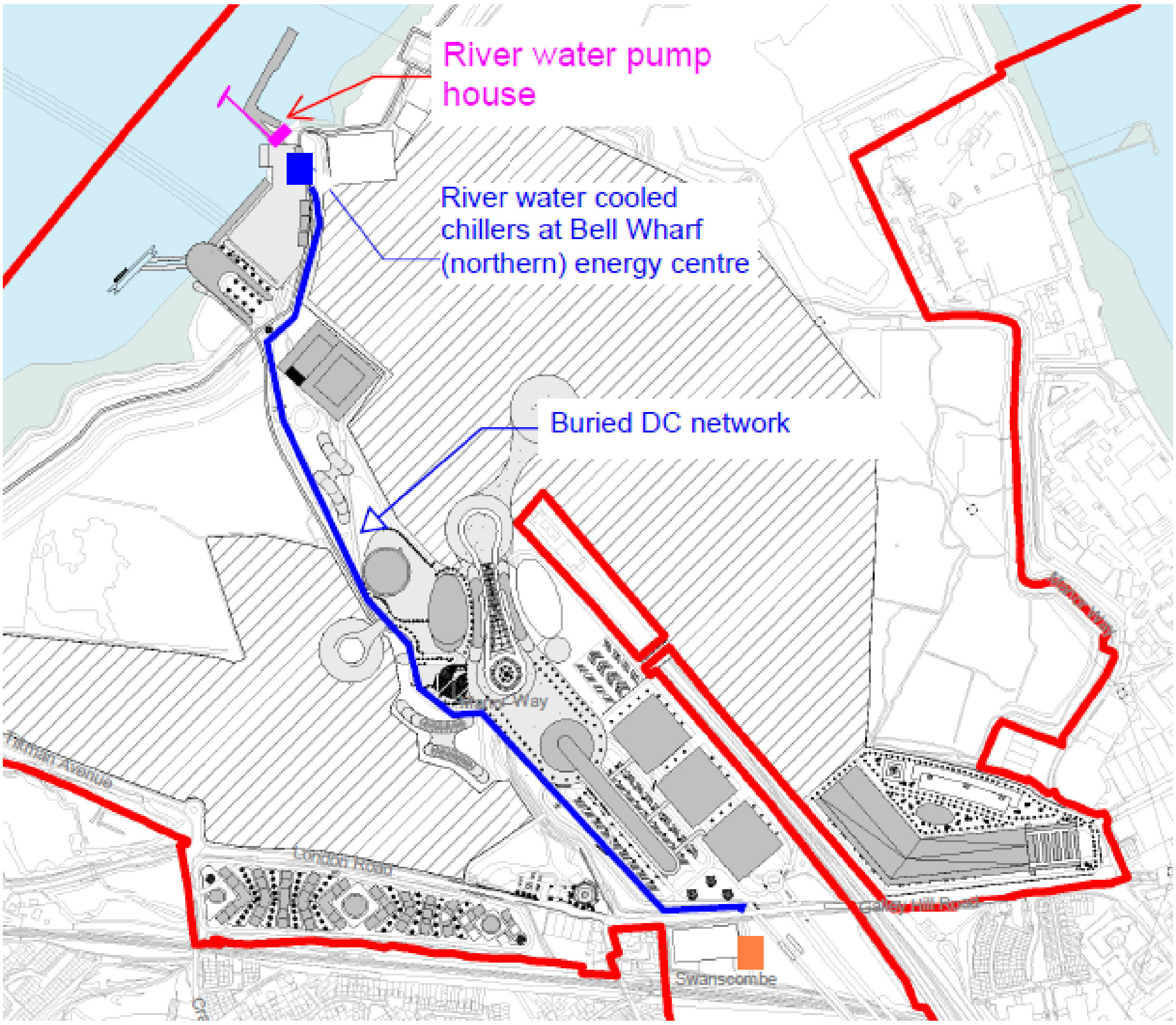
4.54 Figure 4—10 shows the requirement for a single energy centre building to house the ASHP plant, gas CHP and gas boilers, along with district heating distribution pumps and ancillaries at the Kent Project Site. A buried pre-insulated steel pipework network will be required to distribute heat throughout the Kent Project Site. Space will also be required to accommodate the outdoor evaporator units associated with the ASHP system.

**Figure 4—10 ASHP + CHP + Gas boiler energy centre location and DH network locations, Kent Project Site**



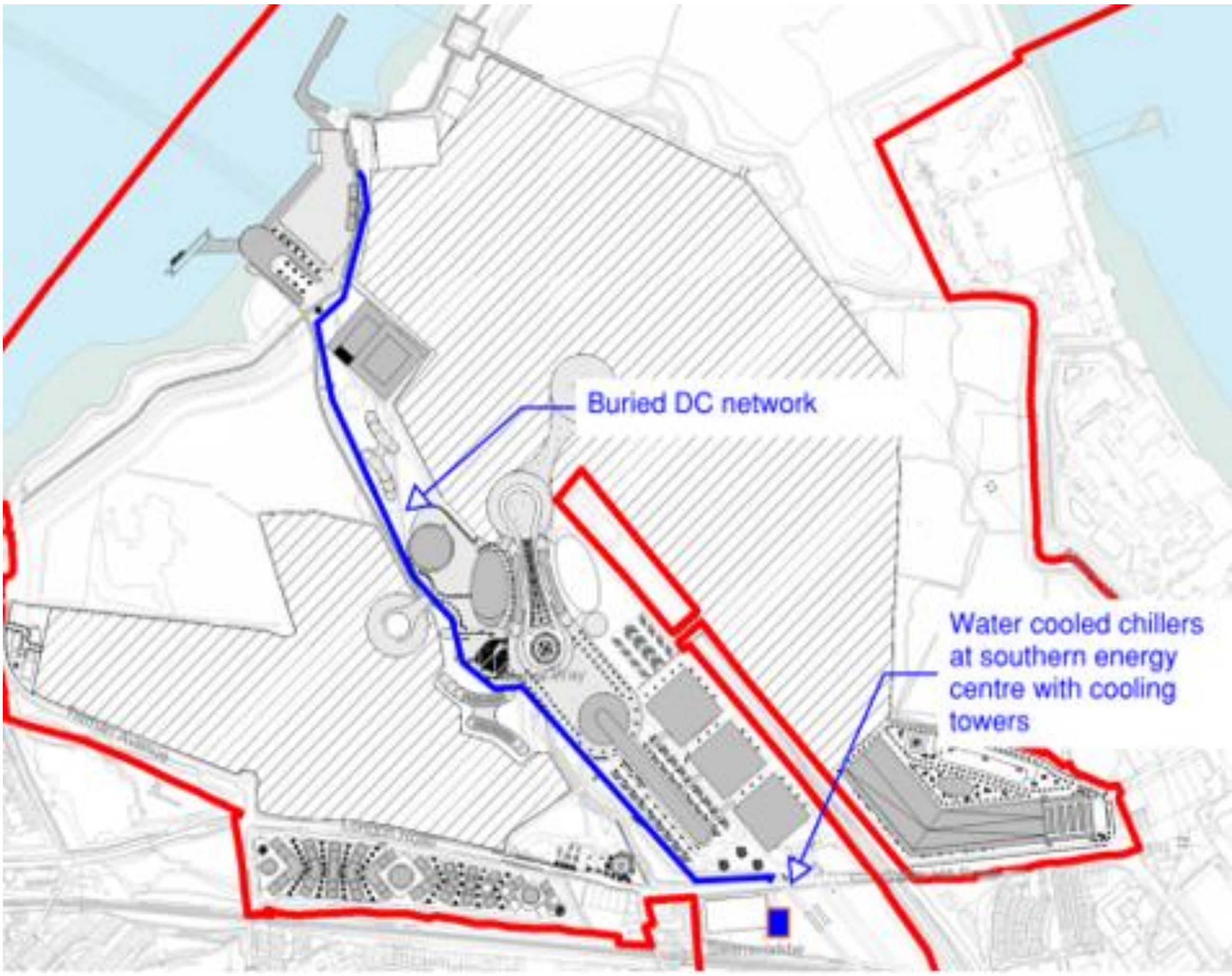
4.55 Figure 4—11 shows the building requirements for the river water based district cooling configuration which will be implemented only alongside a WSHP district heating arrangement in order to make use of the same river water pump house, abstraction and discharge pipework and “riverside” energy centre building. This will also contain district cooling (DC) network pumps and ancillaries to supply a buried pre-insulated steel DC network. This network will be in addition to the buried DH network.

**Figure 4—11 RW cooled energy centre and DC network locations (only in combination with WSHP heating), Kent Project Site**




4.56 Figure 4—12 shows the building requirements for the all other DC configurations where chillers and cooling towers can be located in the same energy centre as heating plant. An additional DC network is required in all cases apart from the Ambient Loop scenario where centralised heat rejection plant operates to regulate the temperature of the ambient temperature (< 20 °C) water network

**Figure 4—12 Non-RW cooled energy centre and DC network requirements, Kent Project Site**



## Energy modelling

### Approach

4.57 Sizing of the primary low carbon heating plant was undertaken through the energy modelling software EnergyPro utilising the aggregated annual heating and cooling profiles described in the Heat Demands and Cooling Demands sections and relying on industry standard and / or supplier plant efficiency parameters. The operation of different plant sizing strategies was simulated against the developed heat demand profiles on an hourly basis throughout a typical year. Sizing of the primary low carbon plant (heat pumps) was undertaken to provide a minimum of 90% of the annual heat demand for all heat-pump only configurations, with the residual demand provided by top-up gas boilers.

4.58 A similar approach was taken for simulation of the ambient loop scenario whereby the performance of different plant sizing strategies was simulated on an hourly basis against heating and cooling demands; however, a bespoke in-house Excel based tool was used for this exercise. For modelling the energy requirements of various cooling configurations, manufacturer data and seasonal COP (SCOP) information was used to estimate annual electricity requirements.

4.59 In addition to developing plant sizing, the energy modelling provided a detailed view of primary energy requirements such as grid imported gas and electricity, for the generation of heat and cooling. These estimates were used in quantifying the operational cost and carbon performance of each option.

4.60 A summary of all assumptions and parameters used in in the energy modelling is provided below.

**Table 4—6 Summary of energy modelling assumptions**

| Parameter | Value | Comments |
|---|---|---|
| District heating diversity factor | 85% | Typical diversity factor |
| District cooling diversity factor | 85% | Typical diversity factor |
| District heating annual heat losses | 10% of annual demand | CP1.2 Heat Networks Code of Practice |
| Centralised WSHP SCOP | 3.20 (kWth/kWe) | Based on River Thames temperatures |
| Centralised ASHP SCOP | 2.70 (kWth/kWe) | Based on ambient air temperatures |
| Decentralised ASHP SCOP | 2.50 (kWth/kWe) | Smaller units are less efficient |
| Decentralised WSHP SCOP | 3.20 (kWth/kWe) | Based on preliminary ambient loop modelling |

| Parameter | Value | Comments |
|---|---|---|
| Centralised ASHP ambient loop heat pump SCOP | 2.70 (kWth/kWe) | Based on ambient air temperatures |
| Heat pump minimum load | 50% | Manufacturer's specification |
| Gas CHP thermal efficiency | 42.7% | Manufacturer's specification |
| Gas CHP electrical efficiency | 44.1% | Manufacturer's specification |
| Gas CHP minimum load | 50% | Manufacturer's specification |
| Gas boiler thermal efficiency | 90% | Manufacturer's specification |
| Minimum thermal storage capacity | 50 m3 | Low load buffering only |
| Ambient loop chiller SCOP | 4.70 (kWth/kWe) | Manufacturer's specification |
| Water cooled chiller SCOP | 4.70 (kWth/kWe) | Manufacturer's specification |
| Air cooled chiller SCOP | 3.20 (kWth/kWe) | Based on ambient air temperatures |
| Centralised Heat pump resilience | N | Boilers to provide back-up |
| Centralised CHP resilience | N | Boilers to provide back-up |
| Centralised chiller resilience | N | No back-up chillers |
| Centralised gas boiler resilience | N+1 | Resilience on heat generation |
| Decentralised heat pump resilience | N+1 | Also applies for ambient loop scenario |
| Decentralised chiller resilience | N+1 | Also applies for ambient loop scenario |

**Results**

4.61 The results from the energy modelling activities and plant sizing is summarised below in Table 4—7.

**Table 4—7 London Resort heating and cooling options equipment sizing selection**

| Option | Low-carbon heat technology capacity | Peaking heat technology capacity | Cooling technology capacity | Hot thermal storage capacity (m3) |
|---|---|---|---|---|
| 1 | 31MW ASHP (cumulative building-level)<br>100% of annual heat load | Not required. | Cumulative 35.0 MW of building-level air-cooled chillers. | As required at the building level for DHW. |
| 2 | 31MW WSHP (cumulative building level)<br>6.5 MW ASHP (centralised 2 x 3.25 MW) 96% of annual heat load | 6 x 5 MWth gas boilers (N+1). | Cumulative 35.0 MW of building-level water-cooled chillers.<br>Centralised cooling towers | 50 |

| Option | Low-carbon heat technology capacity | Peaking heat technology capacity | Cooling technology capacity | Hot thermal storage capacity (m3) |
|---|---|---|---|---|
| 3 | 10 MW WSHP (centralised 4 x 2.5 MW) 93% of annual heat load | 6 x 5 MWth gas boilers (N+1). | 6 x 5 MWth river water-cooled chillers. | 50 |
| 4 | 12 MW WSHP (centralised 3 x 4 MW)<br>93% of annual heat load | 6 x 5 MWth gas boilers (N+1). | 6 x 5 MWth water-cooled (with cooling towers) chillers. | 50 |
| 5 | 6 MW ASHP (centralised 2 x 3 MW)<br>40% of annual heat load<br>4.2MWth gas CHP (centralised 1 x 4.2 MW)<br>40% of annual heat load | 6 x 5 MWth gas boilers (N+1). | 6 x 5 MWth water-cooled (with cooling towers) chillers. | 50 |

4.62 For Option 5 (gas CHP and ASHP) a lower overall heat fraction of 80% was targeted in order to assess a worst-case carbon performance.

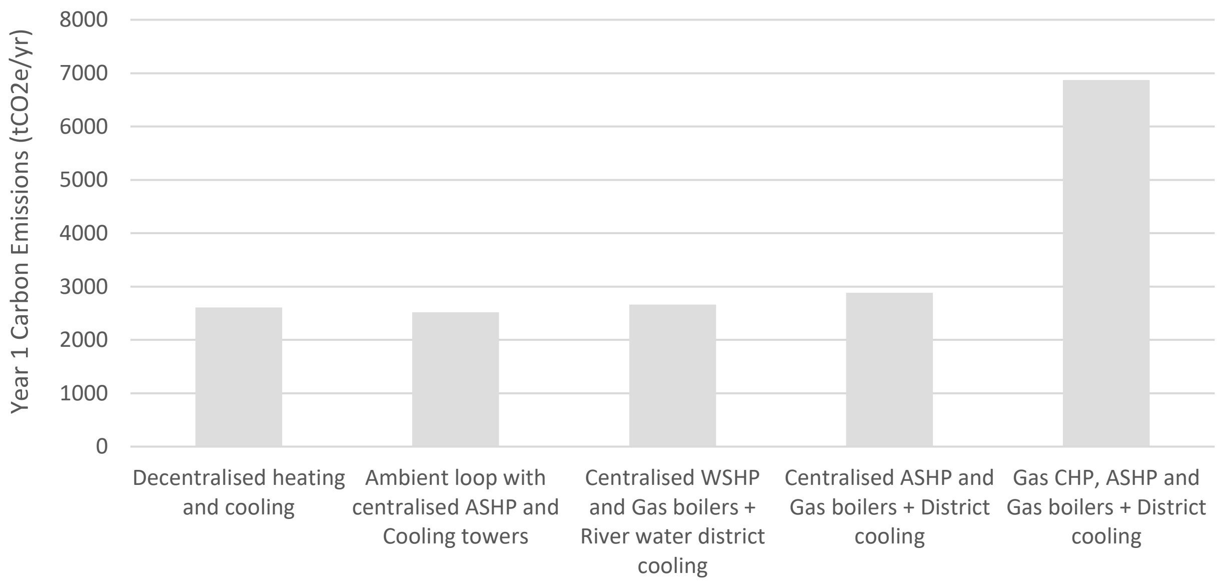
4.63 Plant and pipe schedules developed for each option were used as the basis for system CAPEX estimates. Costing benchmarks and an in-house database of historic manufacturer quotes were used to develop cost estimates for each option. In addition, annual electricity and gas consumption estimates for each configuration were used to determine annual running costs and carbon emissions.

4.64 Given the 100% reliance on electricity as a means of heating and cooling, the decentralised option results in the highest annual running costs. Ambient Loop and ASHP options show a similar performance largely due to the common use of ASHPs; a small running cost advantage is observed for Ambient Loop as a result of lower annual heat losses.

4.65 WSHP demonstrates the lowest running costs for a heat pump only configuration at due to the efficiency advantage of ASHPs and Gas CHP + ASHP results in the lowest running costs due to a greater reliance on natural gas and the use of CHP generated power (rather than grid imported power) to drive the ASHP.

4.66 An initial assessment of carbon performance was undertaken for the energy assessed configurations using government Green Book carbon factors (March 2019 factors) for the 2024 opening year. An overview of annual carbon emissions associated with meeting the Resort heating and cooling demands is presented in Figure 4—13.

**Figure 4—13 Overview of annual carbon emissions for heating and cooling in Year 1**

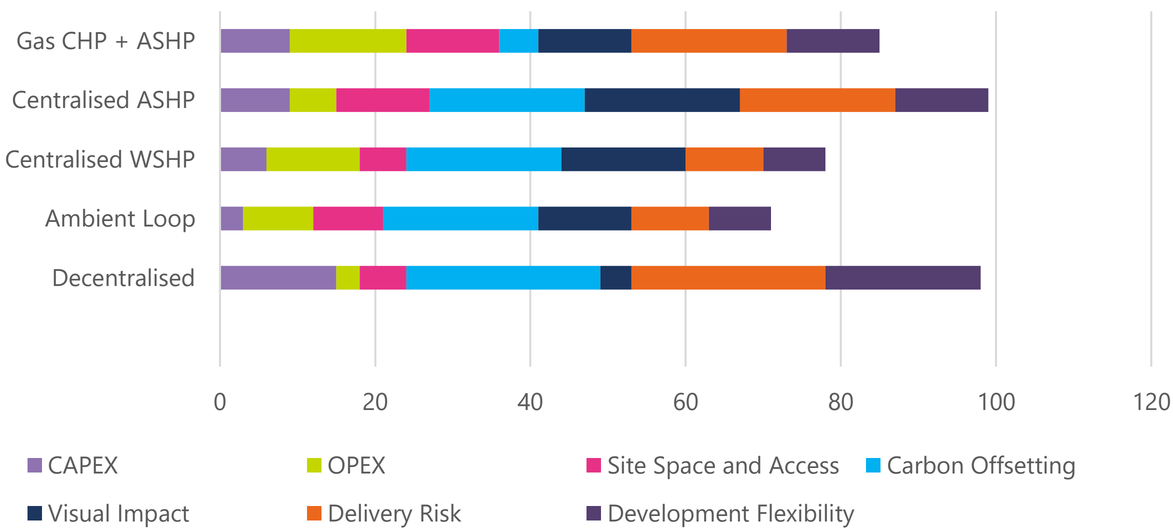


4.67 As expected, the gas CHP and ASHP scenario performs the worst in terms of carbon emissions and given the Resort's operational net zero carbon ambitions would result in the most costly strategy to offset. A more detailed analysis of carbon emissions, including the electricity demand of the Resort and the impact of on-site renewables is presented in Chapter Seven.

4.68 In addition to the cost analysis, a qualitative review of each option was undertaken with configurations scored against space requirement, visual impact, development flexibility and delivery risk. Higher scores were awarded for higher performance; for example, low CAPEX configurations would score a high score and high carbon emissions would result in a low score.

4.69 A comparison of total scores for each heating (and associated cooling) configuration is presented below, identifying centralised ASHPs (with centralised district cooling) and decentralised heating/cooling as the leading options overall.

**Figure 4—14 Technology scoring comparison**



4.70 A decentralised heating and cooling configuration will generate larger carbon savings and provides the lowest delivery risk as plant can be installed as buildings are developed. In comparison, a centralised district heating and cooling system will need to take into account future building energy demands during initial design, ensuring suitable space allowances and pipework sizing for future requirements. However, some of this delivery risk can be mitigated through appropriate phasing of centralised plant and distribution pipework installation.

4.71 A key advantage of centralised heating/cooling over a decentralised (building level) approach is the ability to contain all main energy plant within a central location which is remote to the main attraction space or public access. With a decentralised configuration individual building ASHPs and chiller plant will need to be located externally either adjacent to individual buildings at ground level or located on building rooftops. This will result in a notable visual impact and space requirement compared to a centralised district heating/cooling system which only requires indoor ground level or basement level plantroom space to accommodate a heating and cooling substation interface with the Project Site wide heat and cooling networks.

4.72 An example assessment of rooftop space impacts was carried out for a sample hotel comparing rooftop space requirements for centralised and decentralised heating and cooling arrangements. In both cases a base level of building services equipment will be required (air handling units, water storage, ventilation plant); however, this analysis demonstrated that an approximate 70% reduction in building rooftop plant footprint requirements can be achieved with a centralised district heating and district cooling arrangement compared to a decentralised approach.

4.73 Such savings in rooftop plant space present a whole host of opportunities to enhance the Kent Project Site's architectural impact and energy performance through measures such as rooftop solar PV or the use of green roofs. Given the relatively large contribution of the Kent Project Site's power demands on lifetime carbon emissions, freeing up rooftop space to accommodate solar PV may enable deeper on-site carbon reductions for a centralised heating/cooling configuration when compared to the decentralised option.

4.74 Given the individual merits of centralised and decentralised strategies, further analysis may indicate opportunities for a hybrid approach where only certain parts of the Resort are served by a centralised district energy arrangement whilst others are served by individual building-level heating and cooling systems.

4.75 However, at this stage, in order to ensure spatial plans accommodate the worst case scenario in terms of site footprint impact, the centralised ASHP with district cooling configuration has been selected as the preferred heating and cooling strategy.

4.76 Whereas similar scale ASHP systems are operational in Denmark and Sweden, it should be noted that at this scale, the centralised ASHP configuration would represent a “first of a kind” energy system for the UK. As such, this strategy provides the London Resort with a unique opportunity to demonstrate an innovative technology that is considered integral to the decarbonisation of heat.

# Chapter Five ◆ Power and gas supply

## Principal Development power demands

5.1 Electricity demands for the London Resort have been estimated in order to support the sizing of electrical infrastructure and to quantify the impacts on the Resort carbon performance. This section considers electrical demands relating to Gate One and Gate Two and Associated Development. Electricity demands relating to electric vehicle charging is covered in the EV Load Demands section.

5.2 Individual building peak power demands were primarily estimated using CIBSE Guide A benchmarks, coupled with an 80% diversity factor to estimate the overall Gate One Associated Development peak power demand. The annual electricity consumption figures were estimated from normalised typical weekday and weekend hourly profiles, which vary depending on the season (winter, spring, summer, high summer and autumn) and the user typology or representative profile class 1 through 8 as defined by the balancing operator Elexon.

5.3 Table 5—1 summarises the London Resort power peak demands and annual consumptions for Gate One and Gate Two at the Kent Project Site, as well as the Essex Project Site. Unlike for the heat and cooling loads, the power peak loads and annual consumption of the Project Site are dominated by the high electricity demand and utilisation of the attractions and rides of Gates One and Two.

**Table 5—1 London Resort power peak demands and annual consumptions (excluding heat, cooling and EV charging)**

| - | *MW* | *GWh/a* |
|---|---|---|
| Kent Project Site Gate One – Associated Development | 29.3 | 148 |
| Kent Project Site Gate Two | 11.4 | 58.7 |
| Essex Project Site | 0.3 | 1.3 |
| **TOTAL** | **41.0** | **208.0** |

## EV load demands

5.4 The UK Government intends to use planning regulations in the near future as part of its strategy to facilitate mass adoption of electric vehicles. It is currently reviewing the feedback on a public consultation to alter building regulations for new residential and non-residential developments to include electric vehicle infrastructure requirements. The Government is proposing every new non-residential development provides one EV Charge Point (CP) for each five parking spaces. Some local authorities already have their own requirements, for example the Greater London Authority (GLA) already requires 10% of active and 10% of passive (e.g. with the EV infrastructure in place but not necessarily provided with a charger) parking spaces in new non-residential developments.

5.5 To align with the requirements and to provide future-proofing, 20% of the total number of parking spaces available in the Project Site both for visitors and staff are assumed to be provided with an EV CP. Based on a total car park space provision of 15,000 (for visitors, hotel guests and staff), provision would have to be provided for 3,000 EV CPs.

5.6 A build-up of EV energy consumption up to the Proposed Development maturity in 2038 was estimated based on average EV take-up rates of visitors, increasing from 2.5% in 2024 up to a maximum of 20% of the total number of visitors and staff vehicles by 2038. The daily energy demand of an EV has been estimated as the equivalent amount of energy consumed during its trip to the London Resort. The average forecast number of visitors and staff in a day and their respective car share percentages were obtained from WSP's Technical Note 1: Trip Generation (appendix to the Transport Assessment). Technical Note 2: Trip Distribution (appendix to the Transport Assessment) provides the share of visitors' trip length on the day of travel, split into a 0 – 60 minutes trip, a 60 – 120 minutes trip and a 120+ minutes trip. This provided an indicative EV energy consumption figure per trip.

5.7 Table 5—2 summarises the annual EV energy demand building up to maturity in 2038. To account for the additional electricity peak demand as a result of this provision, two charging scenarios are considered during peak attendance days:

1. Scenario 1: slow CPs with a maximum charge speed of 3kW. This is the minimum charging rate allowable, suitable for home charging overnight (8-12 h)
2. Scenario 2: fast CPs with a maximum charge speed of 7kW. This is typically the minimum charging rate advised for non-domestic developments.

**Table 5—2 London Entertainment Resort EV energy peak demands and annual consumptions**

| Reference year | Average EV take up rate | EVs parked daily | Annual EV energy demand (MWh) | Maximum EV charging peak - 3kW chargers (MW) | Maximum EV charging peak - 7kW chargers (MW) |
|---|---|---|---|---|---|
| 2024 | 2.5% | 135 | 960 | 0.4 | 1 |
| 2029 | 15.0% | 980 | 8077 | 3.7 | 8.5 |
| 2038 | 20.0% | 1907 | 17428 | 6.6 | 15.4 |

5.8 An undiversified electrical peak of 15.4 MW for the worst case (7 kW charging) scenario is estimated; however, in practice considerably lower (diversified) electrical demands would be expected. As the number of charge points and charging rate increases, diversity in demands will also increase, with analysis undertaken by UK Power Networks[2] indicating diversity factors of around 20% for a large sample size of around 150 charge points. Without modelling EV charging profiles or taking into account the effects of the Resort opening hours, a conservative diversity factor estimate of 40% has been taken to arrive at diversified peak EV demand of 6.2 MW.

5.9 With the future increase of the average EV take up of visitors particularly as a result of the government's policy direction, the annual EV energy demand increases significantly. However, given the early development stage of the project and the lack of local planning guidance, these EV load figures are to be considered preliminary and will be subject to further refinement in future design studies.

[2] "Electric Vehicles Workshop" Steve Halsey, UKPN 2017. https://www.ukpowernetworks.co.uk/internet/en/have-your-say/documents/EV_WORKSHOP.pdf

## Summary of power demands

5.10 In estimating a total peak power demand for the London Resort, the peak demand estimates for the Principal Development and for EV charging have been added to the power requirement for heating, cooling and catering.

5.11 The combined electrical peak demand for the heating and cooling system will occur in summer and will be driven by peak cooling requirements. Based on a diversified thermal peak cooling demand of 30 MW, a peak electrical demand of 7.5 MW has been calculated based on a worst-case COP of 4. The coincident heating demand at this point in the year will be low but has been conservatively estimated at 4 MW. Assuming a heat pump COP of 3, an electrical demand of 1.3 MW has been estimated.

5.12 In addition to these electrical demands an estimate of electrical demands for catering and kitchen operations has also been calculated on the basis that all kitchen facilities will be fully electric. Previous analysis, based on a gas supplied arrangement, estimated a peak demand of 10 MWth. This estimate has been converted directly to an electrical requirement; this is a conservative approach given expected efficiency benefits of electric cooking appliances compared to gas. Annual power consumption for catering has been derived using CIBSE TM50 good practice benchmarks and estimates on annual hotel visitors (and duration of their stays) as summarised in the WSP Stakeholder Advisor Technical Document.

5.13 An overall diversity factor of 90% has been applied to arrive at a total diversified power demand of approximately 60 MW. A summary of electrical loads is provided in the below table.

**Table 5—3 Summary of Project Site power demands**

| | **Peak Power (summertime) Demand (MW)** | **Annual Power Consumption in 2038 (GWh/yr)** |
|---|---|---|
| Project Site | 41.5 | 208 |
| Diversified EV charging | 6.2 | 17.4 |
| Power for cooling | 7.5 (summer peak load) | 7.1 |
| Power for heating | 1.3 (corresponding summer load) | 17.8 |
| Power for development catering | 10 | 17.3 |
| **TOTAL undiversified** | **66.5** | 267.6 |
| **TOTAL diversified (90%)** | **59.9** | |

## Stand-by power generation

5.14 Provision has been made within the energy strategy for back-up electrical generation to be included on-site. In the instance of any disruption of power supply to the Resort from the national power grid, emergency power demands will be met by stand-by diesel generators.

5.15 Diesel fuelled generators have been selected given this technology represents the current standard and best practice for life safety systems and resilience. The electrical capacity of the back-up generation system has been sized to meet around 30% of peak electrical demands (around 18 MW). Which given the diversity of site electrical demands is deemed sufficient to bring rides/attractions into a safe state following loss of power.

5.16 Other measures relating to the use of uninterruptable power supply (UPS) units and electrical load shedding will also be used.

5.17 An allowance has been made to locate the stand-by diesel generators (5 x 1.5 MVA units) in a dedicated building located within the Bamber Pit area. The building will also house the required electrical equipment (transformer and switchboards) along with bulk fuel storage and fuel conditioning equipment.

## Summary of natural gas demands

5.18 Within the London Resort energy strategy natural gas will be used to provide back-up heat in the instance of any ASHP outages or downtime as well as top-up heat supply during periods of high heat demands. Although the natural gas capacity will be sized for peak heat demand, only 8% of annual heat demands will be met by natural gas.

5.19 The natural gas supply to the Kent Project site would be sized for a diversified peak heat demand of 25 MW. A worst case gas boiler efficiency of 83% (gross basis) has been assumed (although higher efficiency condensing boilers should be specified) to estimate the gas flow requirement as summarised in Table 5—4.

**Table 5—4 Summary of gas demands**

| | |
|---|---|
| **Peak Gas Demand (2038)** | 30 MW |
| **Annual Gas Demand from 2024** | 3466 MWth/yr |
| **Annual Gas Demand from 2029** | 4067 MWth/yr |
| **Gas volumetric flow requirement** | 3264 $Sm^3$ /h |

# Chapter Six ◆ On-site renewables

6.1 In line with the UK Green Building Council's (UKGBC) framework on targeting net zero carbon in operations, an assessment of renewable energy potential across the Kent Project Site has been undertaken. As renewable power or heat generation is increased then reliance on imported energy sources is reduced along with the overall carbon impact. As such, the level of off-site carbon offsetting measures required to achieve net zero carbon is also reduced.

6.2 Within this study, the deployment of onsite solar PV panels on available roof space has been assessed on the basis of using monocrystalline 360W / 400W panels. A review of available roof space was undertaken in collaboration with the architects, Apt, in order to quantify useable roof area across the Resort. Through this exercise it was identified that up to 84,000 $m^2$ of PV panels could be accommodated across the Resort.

6.3 In calculating the resulting electricity generation and carbon benefit of this scenario, the following assumptions were made:

- A total mean capacity factor of 12% has been used to estimate the annual electricity supply from installed solar PV capacity based on typical solar irradiance profiles for the region.
- A total 14% of system losses are taken into account.
- The mounting angle of the panels was chosen at 10° to offer a compromise between performance, ballast requirement, area required and installation costs.
- A ratio of module area to available roof area of approximately 70% was assumed to allow minimal energy losses from self-shading for south-facing modules.

6.4 Taking into account the above solar PV performance characteristics and area coverage, it was estimated that an annual electricity generation of 13,920 MWh could be achieved through an installed solar PV capacity of 13.3 MWp (summarised in Table 6—1). As such, this results in an equivalent reduction of grid imported power and therefore carbon benefit. The carbon benefit of including this level of solar PV is covered further in Chapter Seven.

**Table 6—1 London Resort solar PV deployment (Kent Project Site) modelling results**

| **Total available PV area ($m^2$)** | **84,000** |
|---|---|
| Installed PV capacity (MWp) | 13.3 |
| Annual PV electricity production (MWh/ yr) | 13,920 |

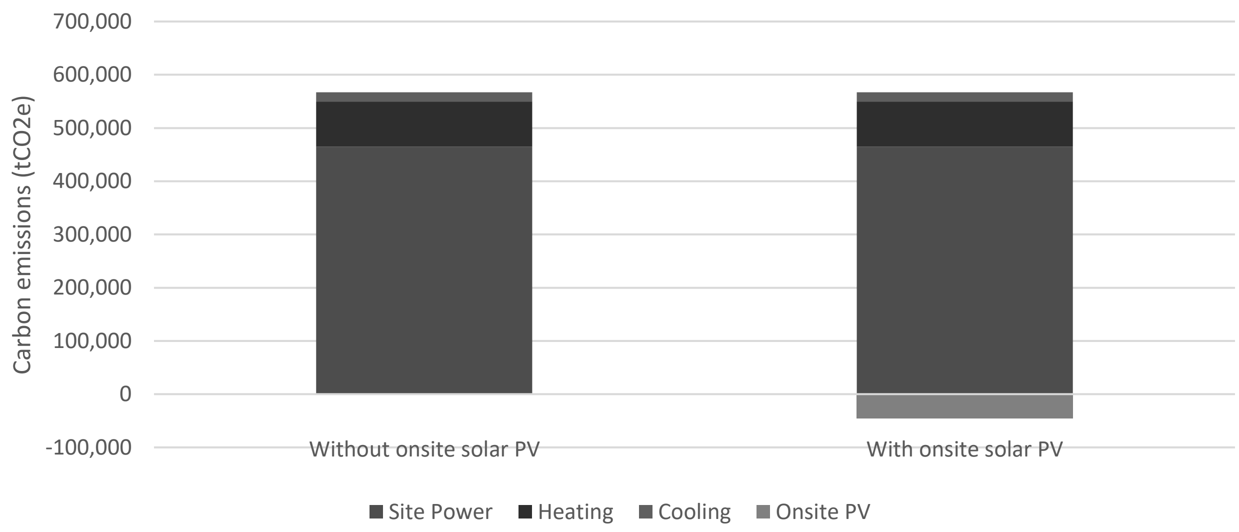
# Chapter Seven ◆ Carbon Assessment

## Carbon Offsetting

7.1 In reviewing the selected energy strategy against the London Resort's net zero carbon in operations targets, an assessment of carbon performance has been undertaken using the UK Government's "Green Book" carbon factors[3]. The carbon impact of the heating and cooling strategy as determined in Chapter Five has been combined with the estimated electricity demands of the Principal Development (set out in Chapter Six) and analysed on a year by year basis. Additionally, the cumulative carbon impact over 60 years has been assessed in line with EN 15978:2011 and recommendations set out by the Royal Institution of Chartered Surveyors (RICS) Whole Life Carbon Assessment for the Built Environment. Carbon emissions relating to EV charging have been excluded from this analysis in line with UKGBC definition of operational energy.

7.2 An overview of overall operational carbon emissions over a 60-year project life are presented in Figure 7—1. A breakdown of carbon emissions associated with heating, cooling, and Principal Development power demands is provided, along with the carbon benefit achieved through the use of on-site solar PV. The use of on-site solar results in a total reduction in lifetime carbon emissions of around 44,800 $tCO_2e$, resulting in an overall lifetime carbon impact of 522,270 $tCO_2e$.

**Figure 7—1 60-year lifetime carbon emissions of the London Resort (excluding EV charging**)

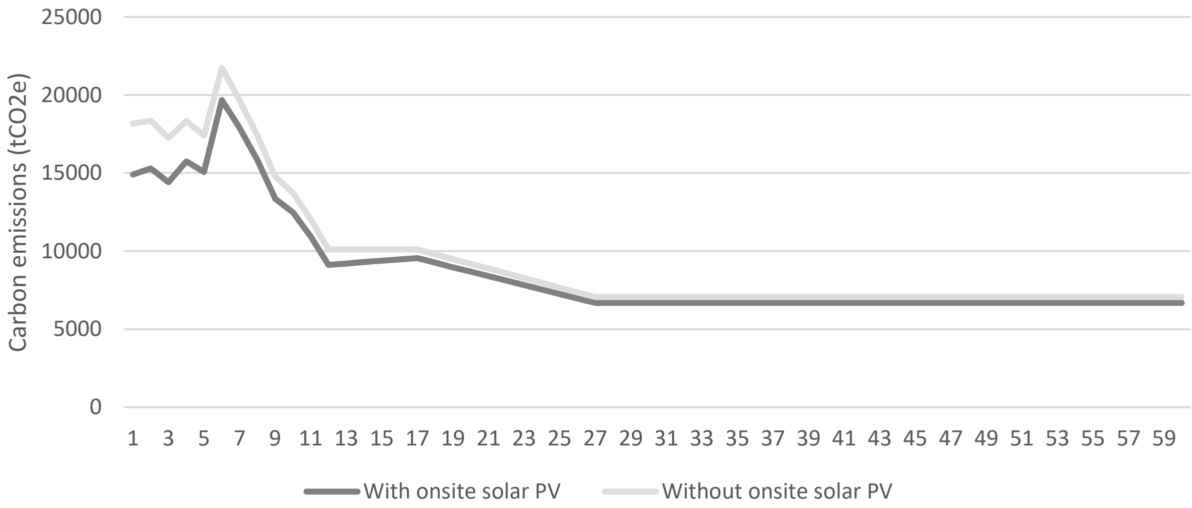



[3] "Valuation of Energy Use and Greenhouse Gas", Department for Business, Energy & Industrial Strategy, 2019. Supplementary guidance to the HM Treasury: Green Book

7.3 The above breakdown provides an indication of the relative carbon contributions associated with the Resort energy demands, noting that almost 90% of carbon emissions are associated with the Principal Development power demands.

7.4 In illustrating the impact of electricity grid decarbonisation on the carbon impact of the London Resort over time, Figure 7—2 shows the annual carbon emissions of the Resort over the 60 year life of the Resort. The impact of on-site solar PV is also shown, demonstrating a larger impact on reducing emissions during the earlier years of operation where the carbon intensity of the electricity grid is higher.

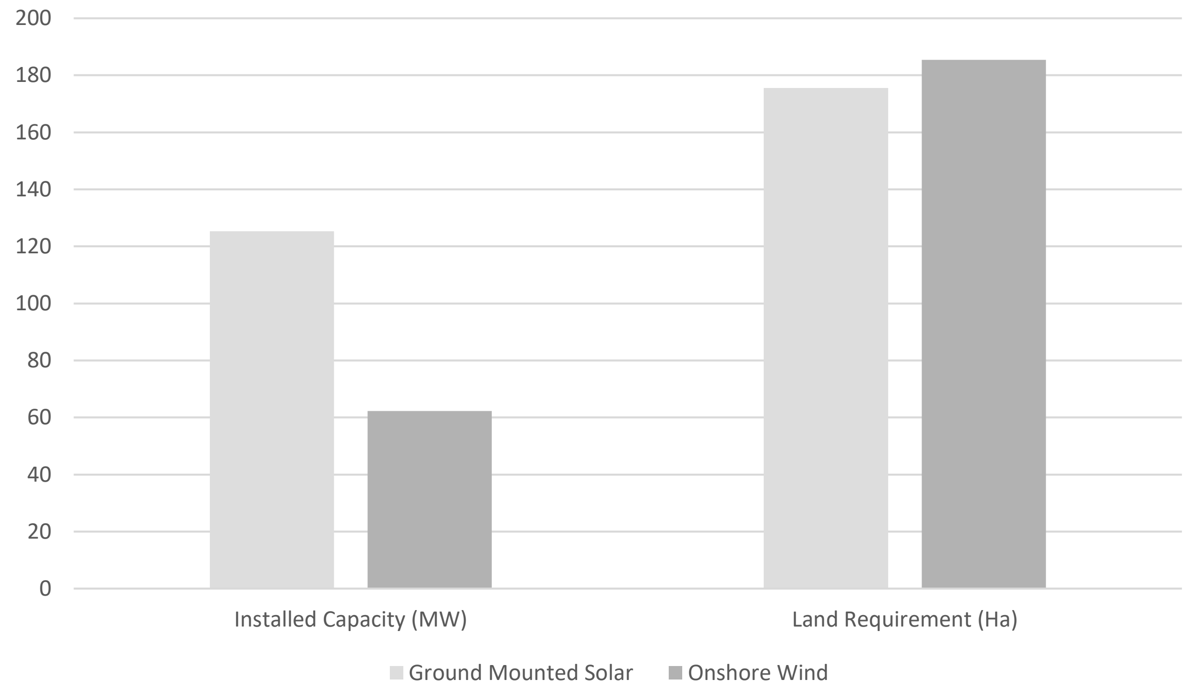
**Figure 7—2 Annual Resort carbon emissions with and without on-site solar PV**



7.5 These figures also indicate the extent to which off-site carbon offsetting measures must be implemented in order to achieve net zero carbon in operation. Such measures can include off-site renewable generation, either through land ownership or procurement models via recognised offsetting frameworks.

7.6 To help illustrate the scale of carbon offsetting, the equivalent ground-mounted solar PV and onshore wind farm capacity needed to offset lifetime carbon emissions has been calculated, should all offsetting measures be achieved by offsite renewable energy. The requirement is expressed in terms of both installed power capacity and area requirements.

**Figure 7—3 Solar PV or onshore wind requirement if offsetting residual carbon entirely by offsite renewables**



7.7 Capacity factors and power density benchmarks comparable to existing UK solar and wind farm installations are used in this exercise. This highlights how direct carbon offsetting through an onshore wind farm would require around half the installed capacity of a solar farm, but a slightly larger (approximately 6% more) site area.

7.8 This demonstrates the extensive land and installed renewable capacity required to achieve net zero carbon in operation if using only offsite renewables. The purchase of carbon offsetting certificates can either partially or fully mitigate direct investment in an offsite renewable scheme. Through the purchasing of these certificates the London Resort will be indirectly investing in renewable energy projects at a level required to offset residual carbon emissions and achieve net zero carbon in operations.

## Policy compliance

7.9 The development of an energy strategy driven by a net zero carbon in operations target has led to technology choices and a resulting carbon performance that is compliant with current building regulations (Part L 2013). The use of a heat pump-based system to meet more than 90% of the Resort's heating demands will lead to significant carbon reductions when compared to a scenario where only gas boilers for heating. Carbon reductions with this strategy for heating are estimated at a minimum of 75% when compared to a gas boiler scenario in 2024, with greater savings expected over time and with decarbonisation of the power grid. Actual carbon reductions compared to the Part L 2013 baseline are expected to be even higher once energy efficiency and improved building fabric measures are considered.

7.10 Based on this performance, the current strategy for heating allows comfortable compliance with the Part L 2013 regulations and a minimum carbon reduction target of 35% (compared with the Part L 2013 baseline scenario). However, with the imminent update of building regulations and the SAP carbon factors, the proposed energy strategy should be reviewed to determine performance against any future regulations as building designs come forward.

# Chapter Eight ◆ Conclusion

8.1 In developing an energy strategy driven by the London Resort's ambition to achieve net zero carbon in operations, energy demands for power, heating and cooling have been calculated for the Project Site and a range of energy system technologies assessed.

8.2 Central to the development of the energy strategy has been the reduction of base energy demands through energy efficiency measures and maximising the use of on-site renewables. A range of low carbon heating options for the Kent Project Site were assessed including decentralised/building level heat pumps and more centralised, large scale heat pumps as part of a site-wide district heating system. Both air and river water source heat pumps have been reviewed as part of a detailed options appraisal considering not only the carbon and cost impact of these systems but also visual impacts, environmental influences and delivery risks.

8.3 At this stage, in order to ensure spatial plans accommodate the worst case scenario in terms of site footprint impact, a district heating scheme based on centralised ASHPs with back-up gas boilers has been selected as the preferred heating strategy for the Kent Project Site.

8.4 The energy strategy has identified that there may be some benefit to a decentralised or building level ASHP approach. However, further analysis should be undertaken as designs develop to consider a hybrid approach where only certain parts of the Kent Project Site are served by a centralised district energy arrangement whilst others are served by individual building-level heating and cooling systems.

8.5 A range of site-wide cooling configurations for the Kent Project Site have also been defined and appraised as part of this study. As with the review of heating configurations, both decentralised strategies and centralised district cooling systems have been considered and, in all cases, using electric chillers. A preferred cooling strategy for the Kent Project Site of district cooling using water cooled chillers with cooling towers is proposed; however, as with the heating strategy, opportunities will be considered for a mix of centralised and decentralised cooling as designs are progressed. This will be considered as part of the Energy Strategy review.

8.6 In estimating the Resort power demands and for sizing of electrical infrastructure, an assessment of EV charging was undertaken. To align with anticipated requirements and to provide future-proofing, 20% of the total number of parking spaces available in the Project Site both for visitors and staff are assumed to be provided with an EV charge point. Based on a total car park space provision of 15,000 (for visitors, hotel guests and staff), provision would have to be provided for 3,000 EV CPs. A conservative diversity factor estimate of 40% has been taken to arrive at diversified peak EV demand of 6.2 MW.

8.7 With the future increase of the average EV take up of visitors particularly as a result of the government's policy direction, the annual EV energy demand increases significantly. However, given the early development stage of the project and the lack of local planning guidance, these EV load figures are to be considered preliminary and will be subject to further refinement in future design studies.

8.8 Taking into account the above solar PV performance characteristics and area coverage, it was estimated that an annual electricity generation of 13,920 MWh could be achieved through an installed solar PV capacity of 13.3 MWp (summarised in Table 6—1). As such, this results in an equivalent reduction of grid imported power and therefore carbon benefit.

8.9 The carbon impact of the Resort over a 60-year term was quantified, taking into account the carbon benefit achieved through the use of on-site solar PV. The use of on-site solar results in a total reduction in lifetime carbon emissions of around 44,800 $tCO_2e$, resulting in an overall lifetime carbon impact of 522,270 $tCO_2e$. This value indicates the extent to which off-site carbon offsetting measures must be implemented in order to achieve net zero carbon in operation. Such measures can include off-site renewable generation, either through land ownership or procurement models via recognised offsetting frameworks.

8.10 Based on this performance, the current strategy for heating allows comfortable compliance with the Part L 2013 regulations and a minimum carbon reduction target of 35% (compared with the Part L 2013 baseline scenario). However, with the imminent update of building regulations and the SAP carbon factors, the proposed energy strategy will be reviewed to determine performance against any future regulations as building designs come forward.