OUR CENTRALISED
HEAT PUMP EXPERIENCE

SSE Heat Networks
Low carbon in practise

sse Energy Solutions | For a better world of energy

HEAT PUMP **TECHNOLOGY**

Heat pump technology can provide a resilient and efficient heat network system designed around developers needs' that makes a major contribution to carbon reduction goals.

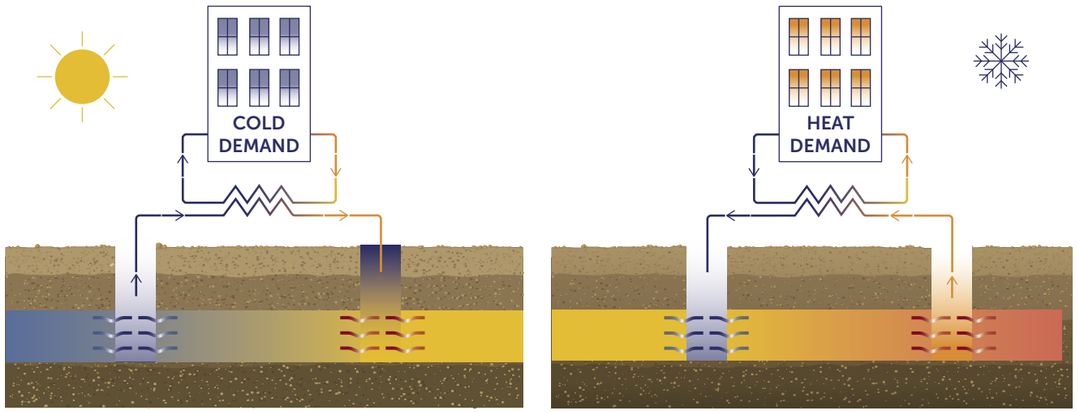
SSE has two innovative district heating schemes that utilise open loop ground source heat pumps, both approximately 1.7 MWth heating capacity which are "Riverlight" in Battersea and Wandsworth Riverside Quarter.

The schemes have both been used as key case studies in the Greater London Authority's heat pump review. Both schemes use the same ground water chalk aquifer but have been designed using different network distribution philosophies which reflects on the operational performance of each network.

The two schemes extract heat from an aquifer on the south bank of the Thames. The aquifer in both cases has relatively low ground water flow, so offers good seasonal storage opportunities enabling us to draw heat from the aquifer in the winter and return heat back into the aquifer during the summer under cooling loads.

Both schemes utilise approximately 100m (deep) wells drilled into the aquifer. These are open loop systems which carry with them particular maintenance requirements. For each scheme, there are four 'cold' wells and four 'warm' wells.

With multiple years experience, our Heat and Cooling team have been delivering multiple networks across the UK, helping to meet the significant challenge of decarbonising the heat sector. Our work with the respective developers on these sites included being involved in the design or construction process early on which ensured that commissioning of new phases could occur whilst the performance and integrity of the live network was protected.



Geothermal/heat extraction

WANDSWORTH
RIVERSIDE QUARTER

Wandsworth Riverside Quarter comprises 550 residential units together which consists of six blocks and a further 2,973 m^2 of commercial space.

Project details

SSE worked with IFTech, a geothermal/heat extraction expert, to design an Aquifer Thermal Energy System (ATES). This is a highly innovative, integrated energy system which combines open loop ground source heat pumps in combination with gas CHP to provide low carbon heat, hot water, cooling and electricity all under the control of SSE's ESCo team.

Under a JDA with Frasers, SSE worked throughout the construction process, bringing our many years' experience, to ensure that commissioning of new phases can occur whilst the performance and integrity of the live network is protected. This is a complex exercise and a common challenge for multi phase developments.

How it works

The design in this case was for the heat pumps to provide heat for space heating only. The system has three circuits; one for space heating, one for hot water and one for cooling. The heat pumps provide a 45°C flow that directly feeds underfloor heating (UFH) in each property. Efficiency gains are made as little or no cold water is required to blend into the UFH system to cool the flow down.

A 25,000-litre thermal store is fed by a CHP engine and gas boilers which provide hot water via the dedicated hot water circuit whilst also providing supplementary heat to the heat pumps if necessary.

Low carbon CHP electricity supplies the energy centre and heat pumps. Excess electricity is supplied via private wire to the landlord's common areas reducing costs to the landlord.

The system is eligible for RHI payments and SSE manages the ongoing relationship with the Environment Agency, who regulate abstraction and re-injection of water into the aquifer.

The three-circuit approach which enables the heat pumps to work at maximum efficiency levels providing space heating and 1.4MW of cooling capacity (whilst hot water is provided by CHP and gas boilers) coupled with low return temperatures and optimum use of CHP electrical and heat output mean that this is a great example of an integrated energy project.

In the so-called shoulder months between summer and winter, some customers have a heat demand and others cooling. Because the heat pump hydraulics are "reversible", they have the ability to provide both. Hence at certain points in the year instead of extracting heat or coolth from the aquifer, we can capture the heat rejected from the properties that are in cooling mode and send it back to the heat pumps to bring it back to operating temperature and recirculate in the heating circuit. Similarly, we take the cooler return flows from customers with a heating demand and send these to a heat pump to further reduce the temperature and recirculate in the cooling loop.

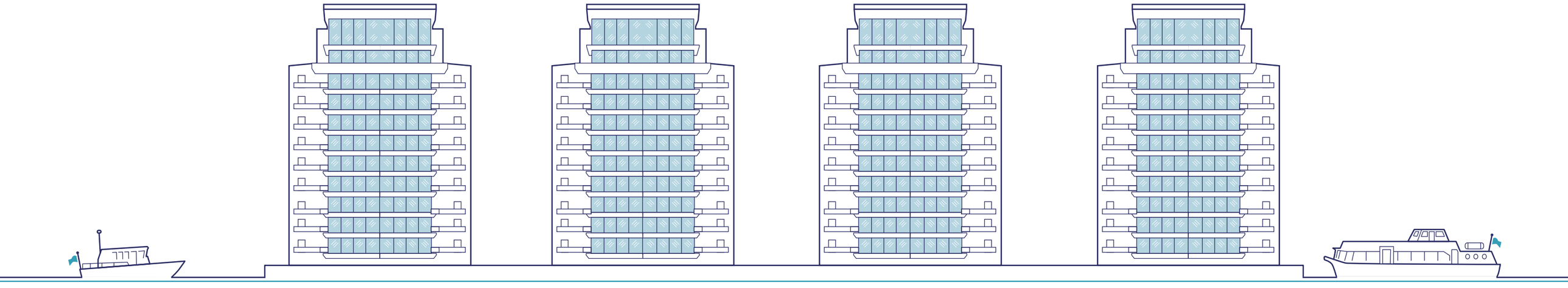
Lower carbon

These innovative technologies, when combined in an integrated energy solution, mean lower cost of operation, lower carbon and lower tariffs for residents.

The system has carbon savings at its heart. SSE's role has been to ensure that the design, commissioning and operation are optimized to maximize that carbon saving potential.

In 2019 we estimate that use of the heat pumps to provide heat and cooling rather than traditional gas boilers and electric chillers, saved 132 tonnes of CO^2.

One of the key benefits of this heat pumps led project is that as the electricity grid decarbonises so the heat and cooling we provide becomes ever more low carbon and the savings versus the gas boiler counterfactual continue to grow.



RIVERLIGHT
BATTERSEA

The Riverlight development is located on London's Southbank, adjacent to the famous Battersea Power Station. SSE Energy Solutions has delivered a multi-utility solution to the development consisting of 811 residential properties and 4,005 m^2 of commercial space.

Project details

It is a complex project with construction costs in excess of £200 million, developed by St James (Berkeley Group). SSE developed, own and will operate the multi-utility solution for the next 25 years. The solution consists of a heating & cooling network, electricity network, gas connections and water*.

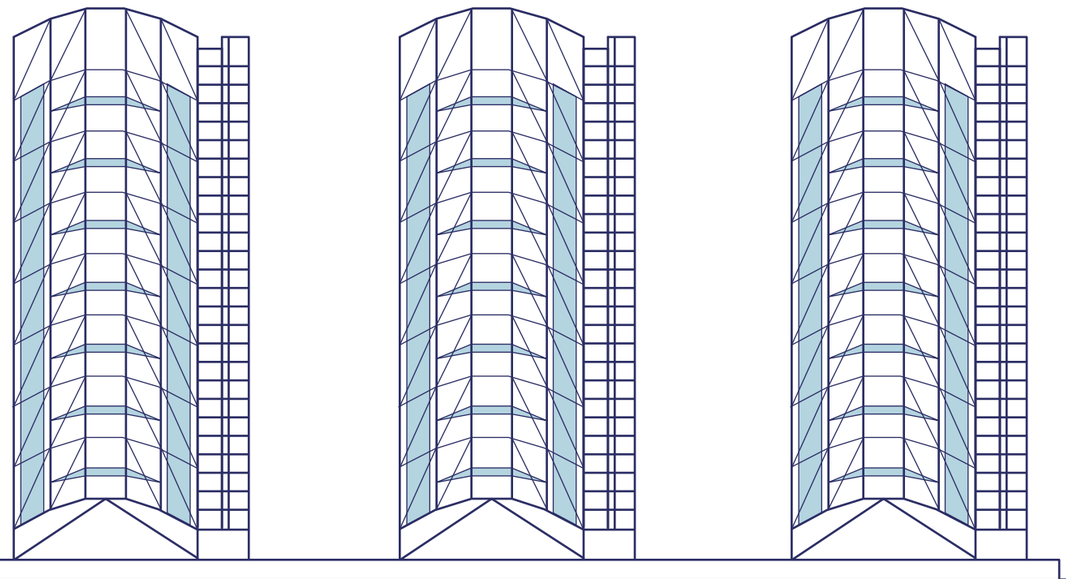
The heat pump concept design solution was designed by the client's consultant. SSE, under a Joint Development Agreement (JDA) with St James, provided input to the design focussing on desired efficiency outcomes which would improve performance, reduce operating costs and, in turn, reduce end user tariffs.

The design includes 8 boreholes, up to 4 of which are extracting heat at any time from an aquifer and pre-heating a common LTHW (space heating and hot water) circuit up to 45°C. In the summer, heat is then injected back into the boreholes under cooling loads. We are averaging 16°C source temperature from the warm wells.

The improved SSE design parameters and borehole temperatures mean SSE is currently operating the heat pump system at a COP of 5.0 (cooling) under full load, resulting in great value to consumers on the network.

*SSE sold its water business, including its "Inset Appointments" to LEEP Utilities in 2019

The boilers then boost the pre-heated LTHW up to 70^0C to feed the network and our customers. Low cost, low carbon electricity from the CHP is fed straight back into the energy centre supply further improving the value of heat we are supplying. The network is designed for a return temperature of up to 40^0C, which also contributes to the high COP of the heat pumps. We are achieving good run hours for both the heat pumps and CHP engine via a 60,000-litre common thermal store.



Project delivery

Under the terms of the JDA for heat networks, SSE provided St James with design input, specification, and on-site technical, project and commissioning expertise to assist St James' project team to deliver the network.

An extensive commissioning plan was drawn up by specialist contractors (controls, M&E, manufacturers) alongside our SSE commissioning manager. All parties were on site to follow the commissioning programme, which was completed in a week.

Lessons learned

Whilst SSE was able to make some changes to the design and commissioning philosophy before construction began, there remained a number of aspects which required attention post installation. Working closely with St James and the client team, we have focussed on system improvements (identified by SSE at the outset). These include focussing on modifications needed to ensure lower return temperatures from the above ground network.

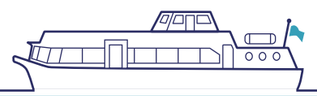
This then ensures the proper energy balance and thermal energy in the boreholes (sufficient cooling extracted in summer and returned in winter) to enable "free cooling" and optimum borehole operation to be maintained. Installation of dry air coolers like those found at Wandsworth Riverside Quarter would also provide more resilience to the cooling provision.

St James and SSE have positively worked together to protect residents and rectify ongoing issues. We have learnt a lot from this project and seek to bring this knowledge into new opportunities going forward.

"SSE is one of the few companies which has a lot of experience when it comes to energy centres. Working with SSE has been great as they have been very competent, they have the right experience, it's been a very simple process for us, and we have achieved all of our technical requirements.

"Our residents also have long term certainty and we are confident that the installation, which is very complicated, is going to be maintained and looked after for our residents over the next 25 years. The model we have developed with SSE provides them with a sense of security going forward."

Eddie Pinchin || Commercial Director for St James



COMMUNAL HEAT PUMPS **LEARNING POINTS**

Having delivered multiple sites that utilise heat pump technology we are well positioned to provide insight into how to approach such a solution.

Work with natural temperatures: Cooling
Ground loops provide free (passive) cooling (passive meaning electrical input is only required for pumping – there are no compressor electrical costs – great for reducing carbon further) if your chilled water system is designed for a flow temperature at or above ground water temperature.

Work with natural temperatures: Heating
Heat pumps are most efficient (low carbon) when operated at or below 45^{0}C for the flow temperature off the hot side. Install the two heating circuits needed for district heating, low grade and high grade. Summer overheating inside the building will be reduced when compared with high grade only

Identify single points of failure
Build in resilience - If the ground loop is all one system, even with multiple/repeated plant details, make sure you have an alternative/back up, especially if cooling as well as heating is being provided..

Heating & cooling to work in tandem
If the heat pumps work just in cooling mode and the aquifers never have a chance to 'unload' the heat – aquifer temperatures rise – and the free cooling element (see above) is lost and heat pump performance (CoP) drops due to increased pumping. The Environment Agency will likely stipulate maximum return temperatures to the aquifer.

Holistic design
Make sure the heat pump designs are integrated into the complete design of the network, so they all work together.

Control system
Install an open protocol control system to enable a range of operators and reduce costs.

Our high-level recommendations

As part of a Joint Development Agreement and Non-Disclosure Agreement, we would be happy to host technical visits to our sites and give detailed insight into the systems.

Our proposal is for SSE to be involved at the earliest possible stage to support the development of the design in order to minimise any risks to operation and performance. We can share our extensive lessons learned from operating large-scale heat pumps and district heating systems in general.

We are also willing to take on certain design risks to ensure the system is able to achieve the project objectives.

RECOMMENDATION 1

We understand that not every client wishes to pass risk and control of system operation and maintenance to an ESCo organisation. However, we believe the benefits of this approach for reliability, low carbon and low tariffs are demonstrable and, for larger projects we are happy to work in partnership with clients to deliver and operate these low carbon systems. We provide guaranteed standards and service levels in line with or exceeding Heat Trust requirements so customers can be sure they are protected or reimbursed if the heat goes down.

RECOMMENDATION 2

We strongly recommend that clients don't build the network and then bring it to market later under the guise of it being "de-risked". Our experience is the opposite – issues are harder to resolve, requiring replacement and recommissioning of components, resulting in a more expensive and onerous process. Implementing this opportunity successfully and ensuring correct installation and commissioning of the entire network will require all of our expertise, resources and experience from day one. We guarantee our "operator perspective" will find CAPEX, OPEX and REPEX savings in comparison to a typical consultant/contractor led installation.

RECOMMENDATION 3

Principally, inaccurate load diversity and consumer utilisation calculations at early design stages have had a major impact on system costs and performance. Commercial performance of heat pump led schemes are extremely sensitive to operational performance of the system incorporating the heat pumps. It is absolutely vital the intended long-term operator of the scheme is involved at concept design to ensure the scheme is designed for optimal operation.

RECOMMENDATION 4

We see the theoretical benefit of a low temperature primary loop boosted at use (or block), however unfortunately it is not clear this outweighs the additional operational and capital costs associated with this system; Including annual maintenance requirements (accessing every connecting property) to meet f-gas regulations for the DHW booster system and the cost of additional pipe diameters required to provide enough capacity at low temperature on such a small delta T. In addition, without significant DHW storage or oversized boosters, there will always be a volume capacity constraint on DHW for the users.

RECOMMENDATION 5

Ultimately (depending on scheme specifics) our current view would be to avoid DHW booster systems and instead utilise high efficiency heat pumps (dual stage compressor) which provide a system flow temperature of 60°C (required for DHW) at very high COP's. We believe this makes the overall system much cheaper in terms of both capex and opex. It should also be cheaper for the customer since they aren't having to pay for the electricity to run the booster.

RECOMMENDATION 6

SSE can help define a robust and automated metering strategy for the site. If enough data (metering) points are included in strategic locations, we can provide several innovative billing and charging arrangements based on different use cases, peak consumption, consumer types.

SMART DISTRIBUTED ENERGY **INFRASTRUCTURE SOLUTIONS**

Designed to meet local energy needs and drive Net Zero.

SSE Energy Solutions is part of SSE plc, a UK based FTSE 100 company with 75 years' experience operating in the fast-changing energy industry.

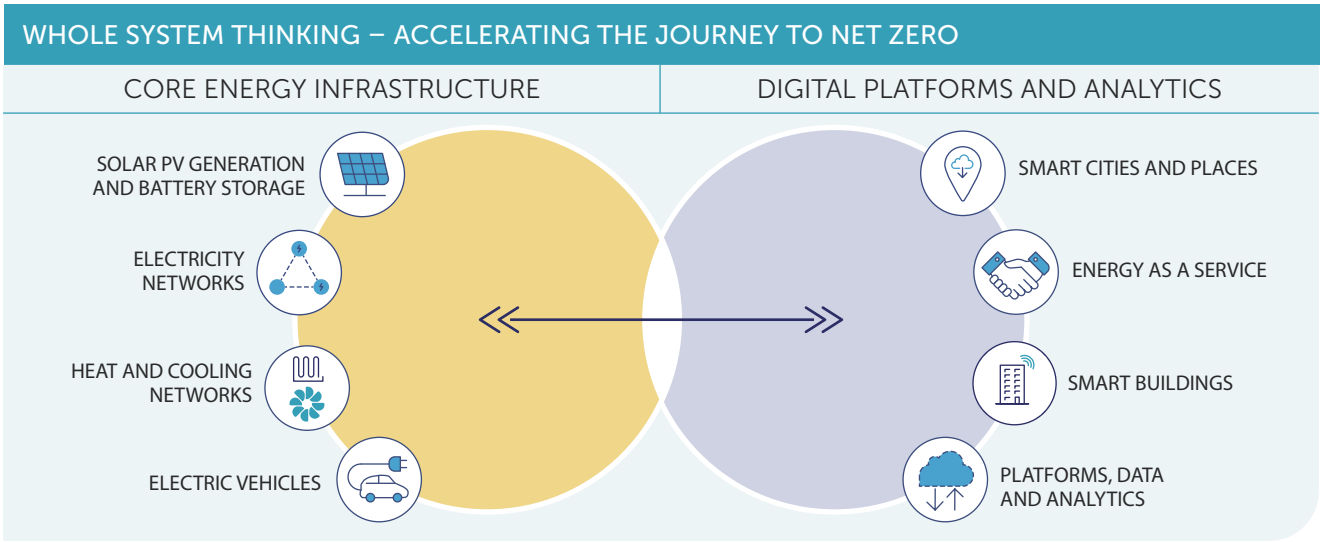
SSE Energy Solutions plays a major part in the emerging consumer-led energy system, and provides key services to enable users to benefit from new ways to optimise and manage their low carbon energy use.

Our Distributed Energy business teams adopt a whole system approach by investing in, building and connecting your localised, flexible energy assets to accelerate your path to net zero and create a more resilient energy system for the long-term.

Right now, your decision to pick SSE Energy Solutions, part of an established renewable energy company investing in all our futures, will be the right choice for you and for our environment.

Our energy solutions include:

- Electric vehicle infrastructure for public transportation and vehicle fleets
- Local electricity infrastructure including building, owning and adopting private HV networks
- Heating and cooling networks for residential, commercial and industrial consumers
- Local energy generation, including funded offsite/ onsite solar PV
- Energy storage solutions, including battery storage
- Optimising building energy consumption and use
- In-house digital twin engineering team for modelling optimised energy flows
- Data platform services to support smart buildings, places and cities
- SSE Enhance, our aggregation and trading platform for small energy assets
- A growing suite of green energy supply solutions, including corporate power purchase agreements.



Get in touch with our team to find out how we can help you

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