IMPACTS OF CENTRALISED AIR-SOURCE HEAT PUMP LOCATION AND DESIGN IN URBAN HEAT NETWORKS

CONSIDERATIONS FROM CFD ANALYSIS AND DECARBONISATION CASE STUDY

All-Energy & Dcarbonise 2022

Heat Decarbonisation Floor Theatre

11/05/22

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HEAT NETWORK DECARBONISATION

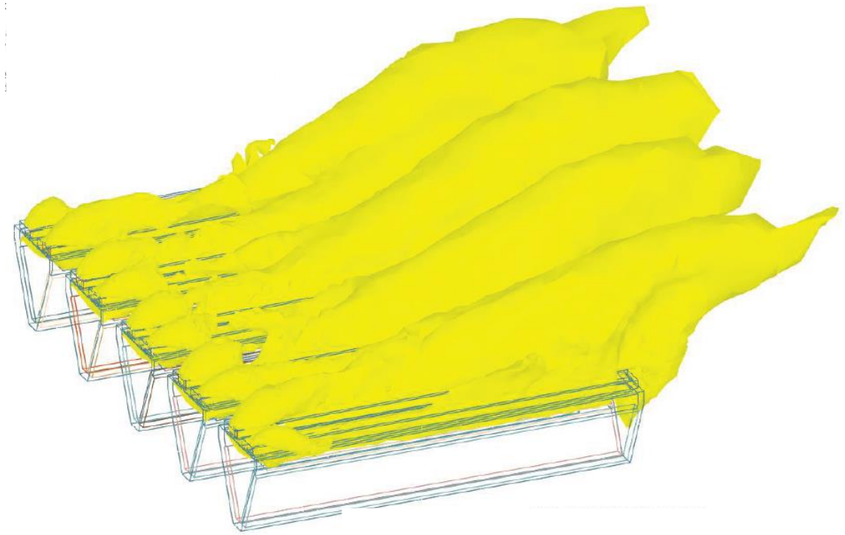
Benefits & Risks of Centralised Air Source Heat Pumps (ASHPs)

The Challenge:

- The majority of the UKs c.17,000 heat networks are in **urban environments**
- Government have advocated **air source heat pumps as a key enabler** for decarbonising heat supply

Benefits of Centralised ASHPs:

- ✓ **Highly versatile** – can theoretically be placed in any location, where space allows. Relatively low weight and footprint. Air is a ubiquitous and inexhaustible source of heat
- ✓ **Cost-effective** – CAPEX for interface with open water or large ground works elements is avoided (required for water and ground source options)



Risks for Centralised ASHPs:

- ➢ **Efficiency/COP** – given high electricity vs. gas costs, the **efficiency of electrified heat sources is critical to their economic viability**. ASHP COP is lower than Ground or Water
- ➢ **Air Chilling and Cold Nuisance** – removing heat from air in large quantities (on a localised scale) can cause a notable reduction of ambient temperature – leads to nuisance cold temperatures and the potential for visible cold plume formation
- ➢ **Air Recirculation** – if cold outlet air is recirculated to inlet, the above issue can be exacerbated. Lower inlet temperature will detrimentally effect the COP (hence higher OPEX & relative carbon emissions) and can even prevent the ASHP from operating

PROJECT CASE STUDY

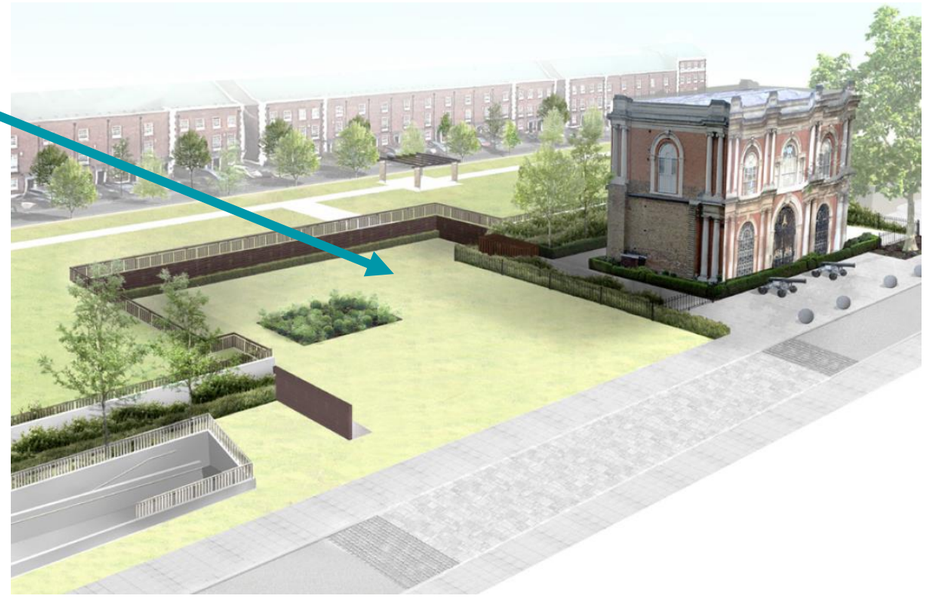
Decarbonisation of a Large Residential Heat Network in Central London

Overview:

- A large, domestic district heating network which serves >2000 residential units in London, fuelled predominantly by Gas CHP and boilers
- There are plans to expand the network to >5000 customers over the coming 10 years. New units must comply with **Part L of new building regulations**…..with stringent SAP factors

Site Specific Challenges:

- Limited potential for water source – **air source has been specified by client**
- Limited availability of ‘rooftop’ space to site air-cooled heat exchangers
- Location at **ground level** has been provided to site the heat pumps and HXs
- Built-up area, potential for **cold air recirculation** due to air (wind) flow characteristics
- Additional constraints due to nearby residents – **visual and acoustic impact**, comfort



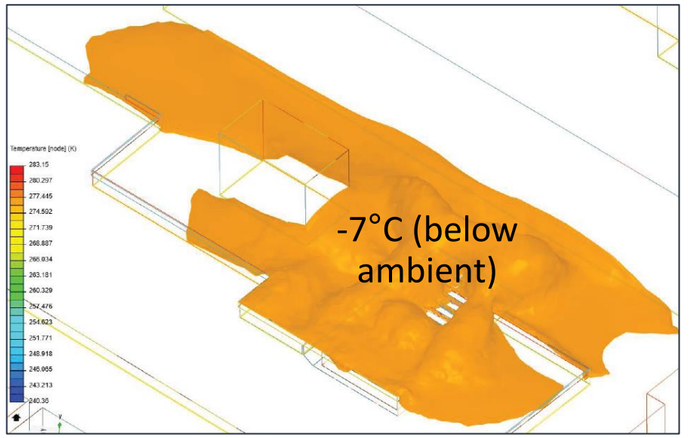
CFD Modelling Objectives

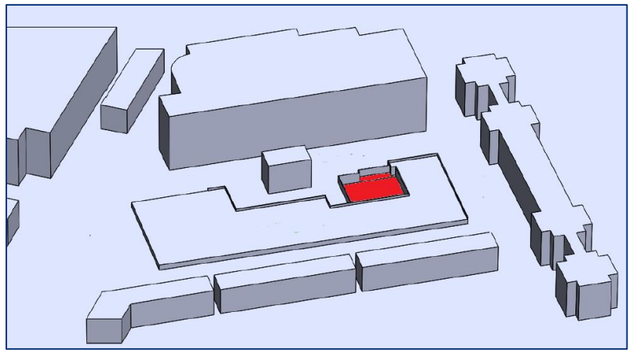
- To quantify ASHP **performance degradation due to air recirculation**
- Determine the likelihood and extent of **cold plume formation**
- To propose **mitigative design measures**, such that the risks can be reduced to a level as low as reasonably practicable

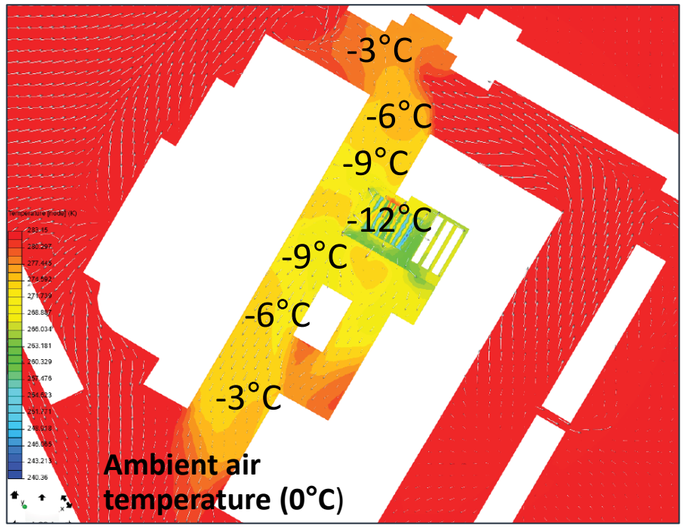
RECIRCULATION – THE PROBLEM

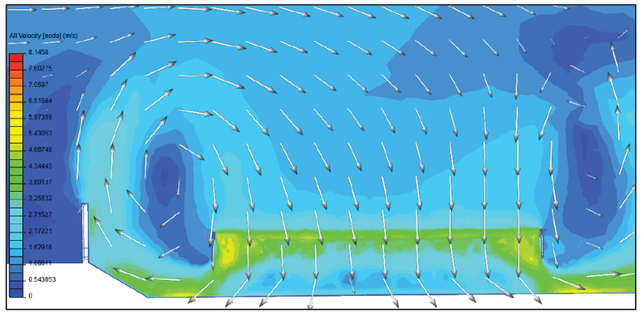
Modelling Results and Recommendations

- Site is surrounded by windbreaks
- Specific location is ‘sunken’
- Vertical discharge, site specific, only option here
- Orthodox approach:
  - Visible cold plumes would extend to adjacent buildings
  - Cold nuisance, year round
  - **Large COP reduction and plant shut down at low temps.**
- Rethink required









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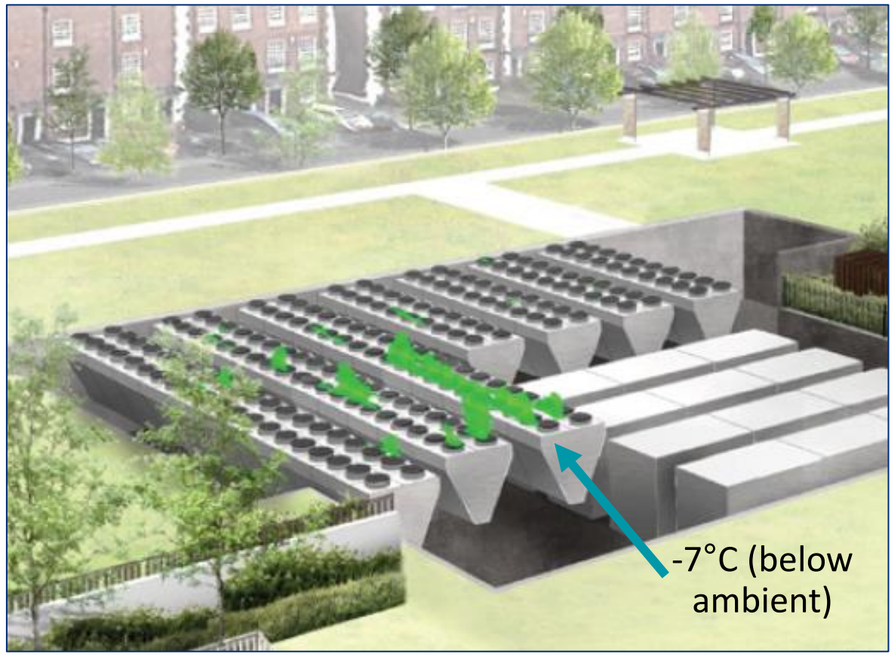
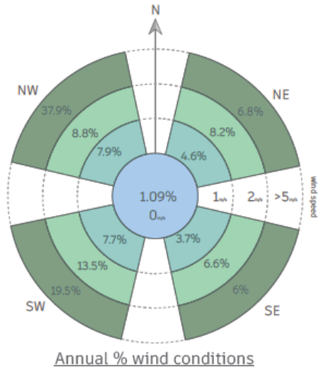
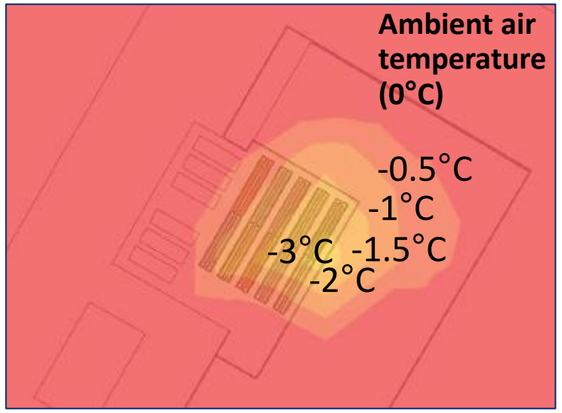
PROJECT CASE STUDY

Revised Design and Re-Modelling Results

- **Solution Headlines**
  - Vertical discharge: enable dispersion
  - Double air volume: warmer discharge air, less dense, less recirculation
  - Reconfigure plant area: lower pressure = less noise
- **Outcomes**
  - Air recirculation on a macro level was reduced to almost zero
  - Negligible impact on heat pump COP
  - Low (zero?) risk of visible cold plumes
  - Immediate surroundings more benign, maximum 3°C lower than ambient
  - ‘Stress test’ – wind conditions and wind speed.
- **Additional design considerations**
  - Urban context and architectural
  - Acoustic design, to mitigate impact to residents
  - Structural integrity, maintainability, access etc.
  - Safety considerations: Fire strategy, DSEAR, ATEX







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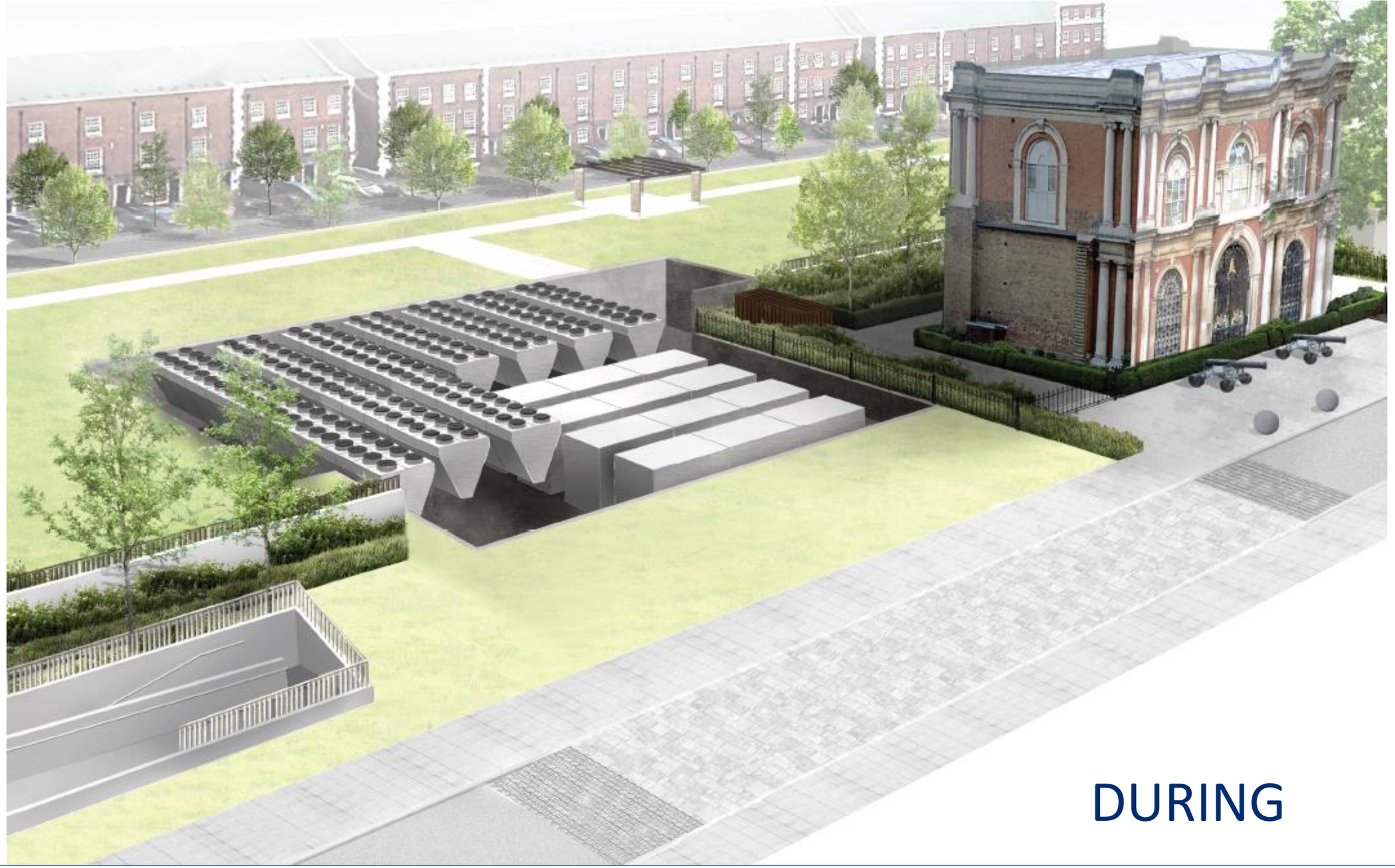
KEY POINTS

Guidance for Heat Pump System Design

- The impact of air cooling on urban environments can be problematic
- Where possible, consider more exposed and less sensitive locations
- Acoustics and air management conflict each other, fine balance
- CFD modelling is a valuable tool to inform a coordinated and holistic design

BEFORE



DURING

AFTER

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THANK **YOU**

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