



Advisory Board Meeting 5th October 2021

Heat Capture

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**Low Temperature Heat Recovery and Distribution
Network Technologies**

The big questions

- How big
- Where are they
- How to capture
- What's the benefit
- How do they compare

Waste heat source	Number of heat sources > 250kW	Waste heat recovery site/medium	Waste heat temperature(s) (°C)	Total thermal energy (heat) output (GWh.a ⁻¹)
Data centres	475	IT server exhaust air	30 to 40°C	9712
		Chilled water heat rejection	10 to 20°C	
Electrical substations	394	Transformer cooling system	40 to 70°C	2511
Wastewater	985	Final WWTP effluent	12 to 23°C Average 17.6°C	22515
Mine water	18584	Water	12 to 40°C	512807
Supermarkets	4853	Condenser heat rejection	21 to 27°C	6270
		Desuperheater	53°C	
Cold stores	306	Condenser heat rejection	15 to 30°C	4537
		Desuperheater	60 to 90°C	
Underground railway tunnels	65	Ventilation shaft air	11.5°C to 28°C	290
Cremations	161	Combustion exhaust gases	800 to 1000°C	146

Example : Food cold stores

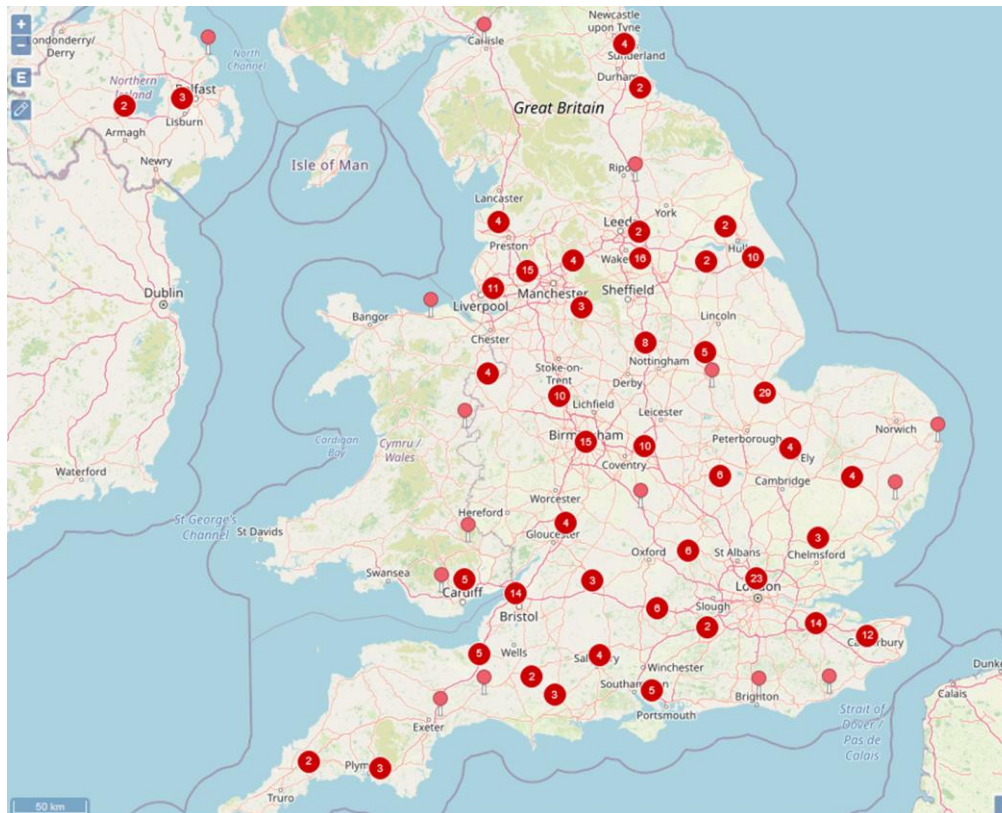
Headline numbers:

306 'large' stores in England, Wales, N Ireland (stores in Scotland removed)

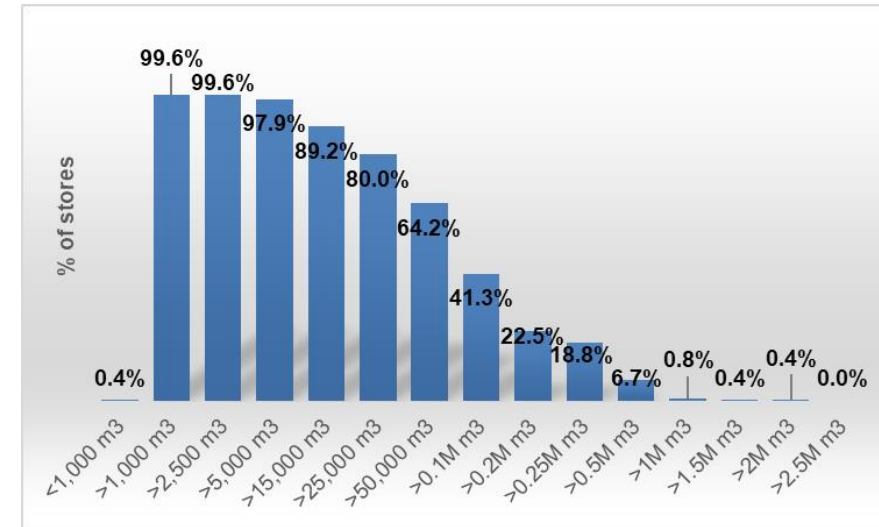
Volume: 46,842,880 m³ for all 306 stores

Energy: 2.7 TWh/yr for all 306 stores

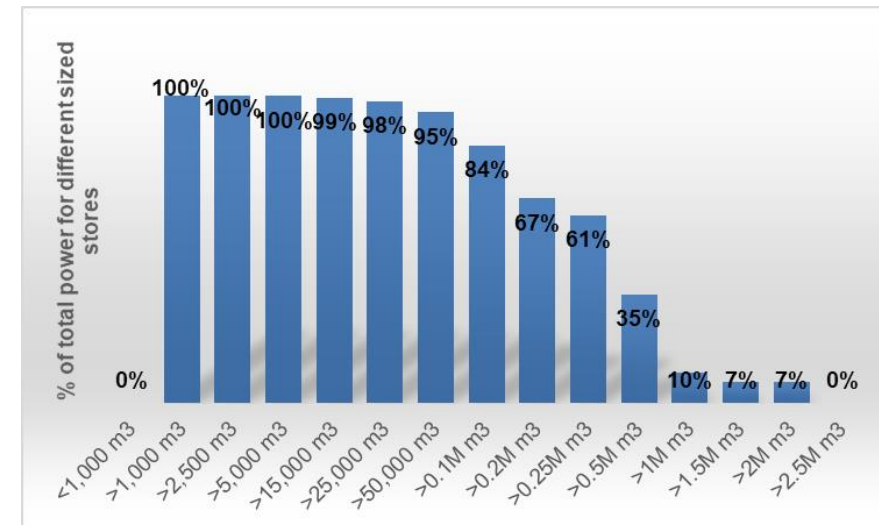
Average power: 1,017 kW/store



Map showing all cold store locations (numbers indicate multiple stores at location)



Volume of cold stores (all stores)



% of total power used by different store sizes (all stores)

Food cold stores: evidence and methodology

Energy benchmark(s) used

58.2 kWh/m³/y. Mean SEC for chilled and frozen stores (Evans et al, 2014)

Assumptions:
All stores had average SEC

Reference:
Evans et al. Specific energy consumption values for various refrigerated food cold stores. Energy and Buildings (2014). Volume 74, May 2014, Pages 141–151

UK numbers/volume (excl Scotland)

306 'large' stores identified in Fikiin et al (2017)
241 had data on volume
Volume for stores with missing volume was pro-rated based on type of store (chilled/frozen/mixed)
Energy use was based on SEC (see left)
Total energy used/year (all stores) = 2.7 TWh/year

Assumptions:
Pro-rating the stores is valid

References:
Fikiin et al. D2.1. Report on refrigerated food facility mapping. 2017.

Potential waste heat output

Calculated using:

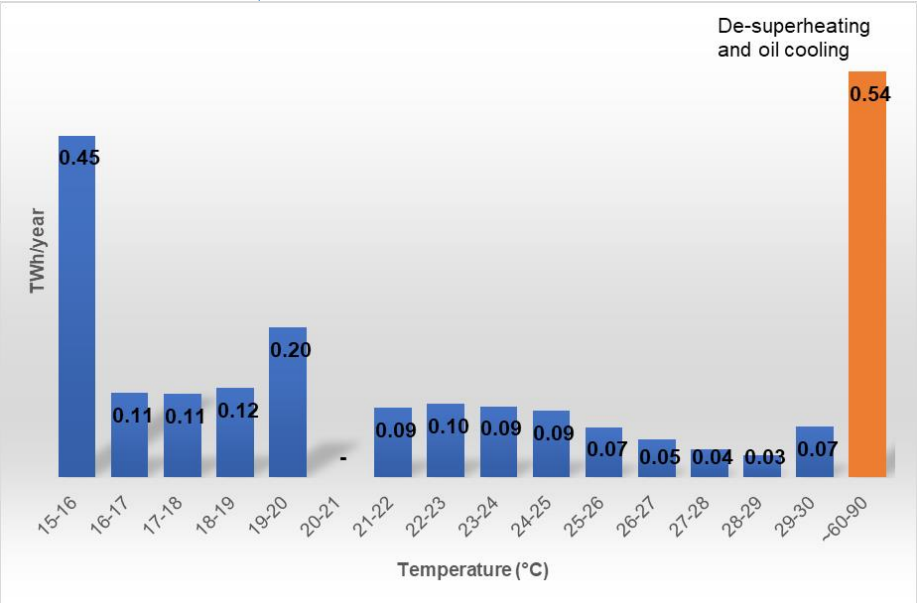
- COSP of 1.5
- 60% of energy in stores used for refrigeration (excludes offices, fans, pumps etc)

Stores with >250 kW heat output extracted

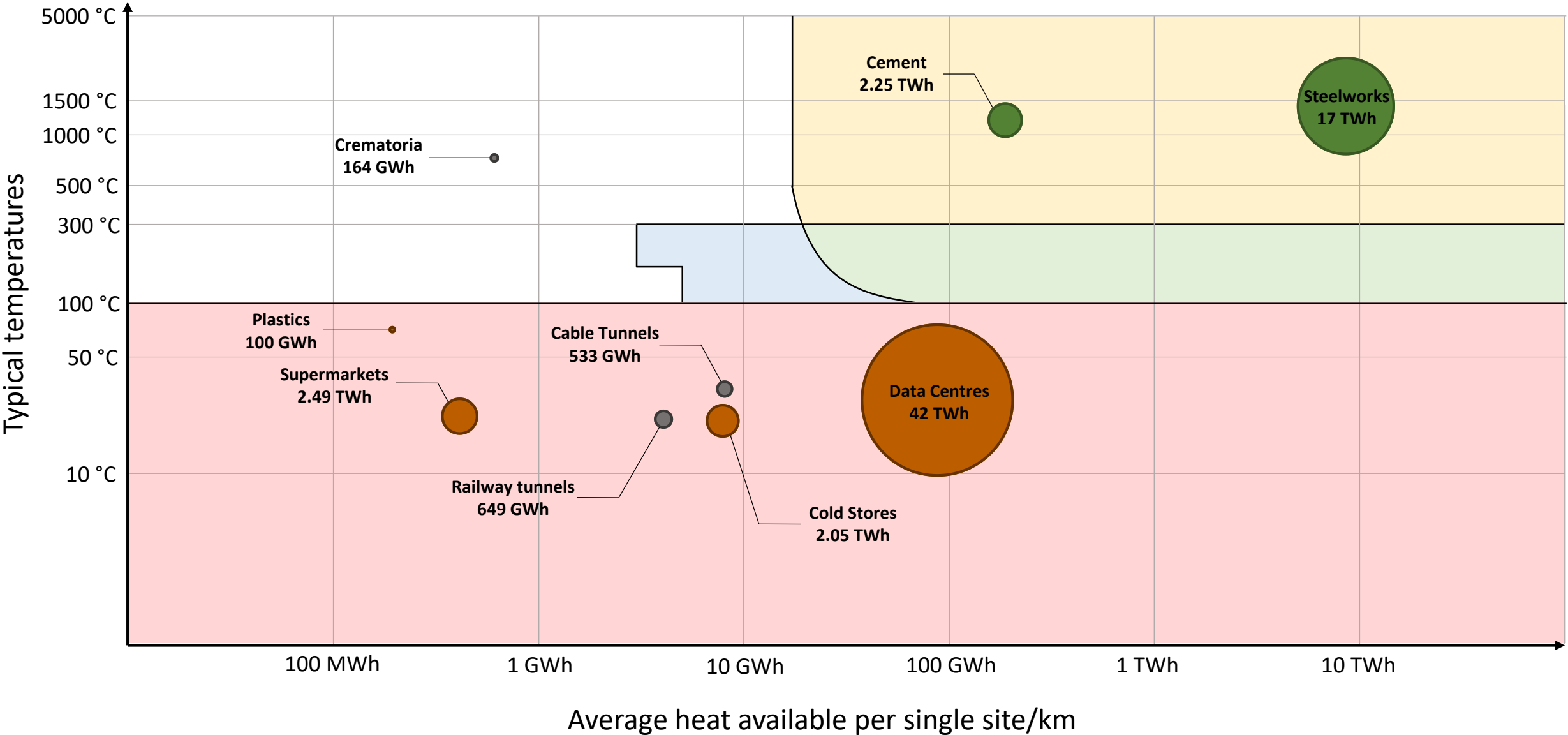
- 84% (by number) of stores >250 kW heat output
- Volume for stores with heat output >250 kW = 36,932,612 m³
- Total energy used/year (>250 kW stores) = 2.1 TWh/year
- 2.1 TWh of heat/year
- 25% at 60-90°C (desuperheating and oil cooling)
- 75% at 15-30°C (condenser)

Assumptions:
COSP of 1.5 is valid (based on survey and audit data from Evans et al, 2014 and confidential data from cold store surveys)
60% of store energy is used for refrigeration (based on survey and audit data from Evans et al, 2014 and confidential data from cold store surveys)
Minimum saturated condensing temperature of 15°C is required for hot gas defrosting (Clark and Gillies; Stoeker)
Detailed heat levels available (see left) based on detailed ambient data for Filton, Bristol. 8°C td for evaporative condenser based on confidential data from cold store surveys
That all desuperheating is available, it may already be used for underfloor heating or water heating in some stores
25% of heat from desuperheating based on confidential data from cold store surveys based on several ammonia plants

Reference:
Clark and Gillies, Comparison of evaporative and air cooled condensers in industrial applications, Proc. Inst. R. 2014-15. 3-1
Evans et al. Assessment of methods to reduce the energy consumption of food cold stores. Applied Thermal Engineering 62 (2014) 697-705
Stoeker. Ind Refrig Handbook, McGraw Hill. 1998



- Direct heat recovery
- Direct heat recovery or absorption cooling
- Direct heat recovery or Heat pumps
- Direct heat recovery or heat to electricity
- Direct heat recovery, absorption cooling or heat to electricity
- Urban
- Rural
- Mixed/Sub-urban



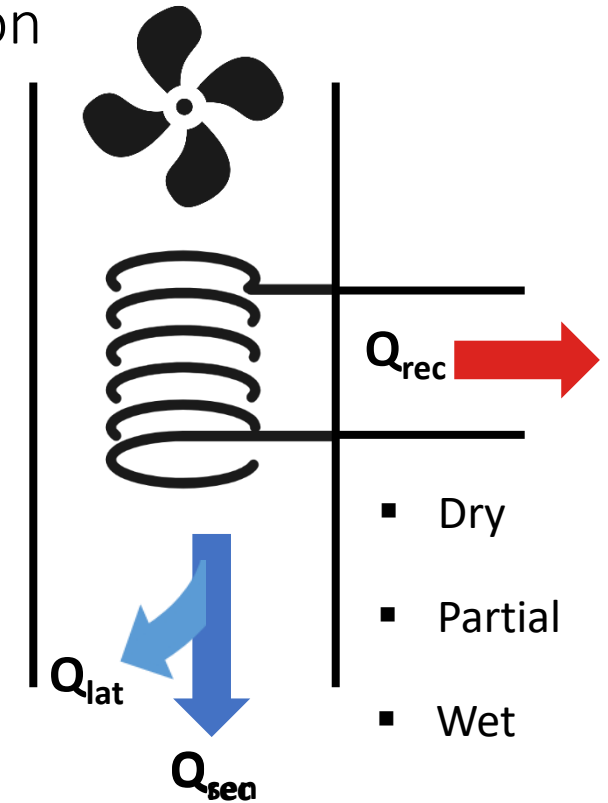
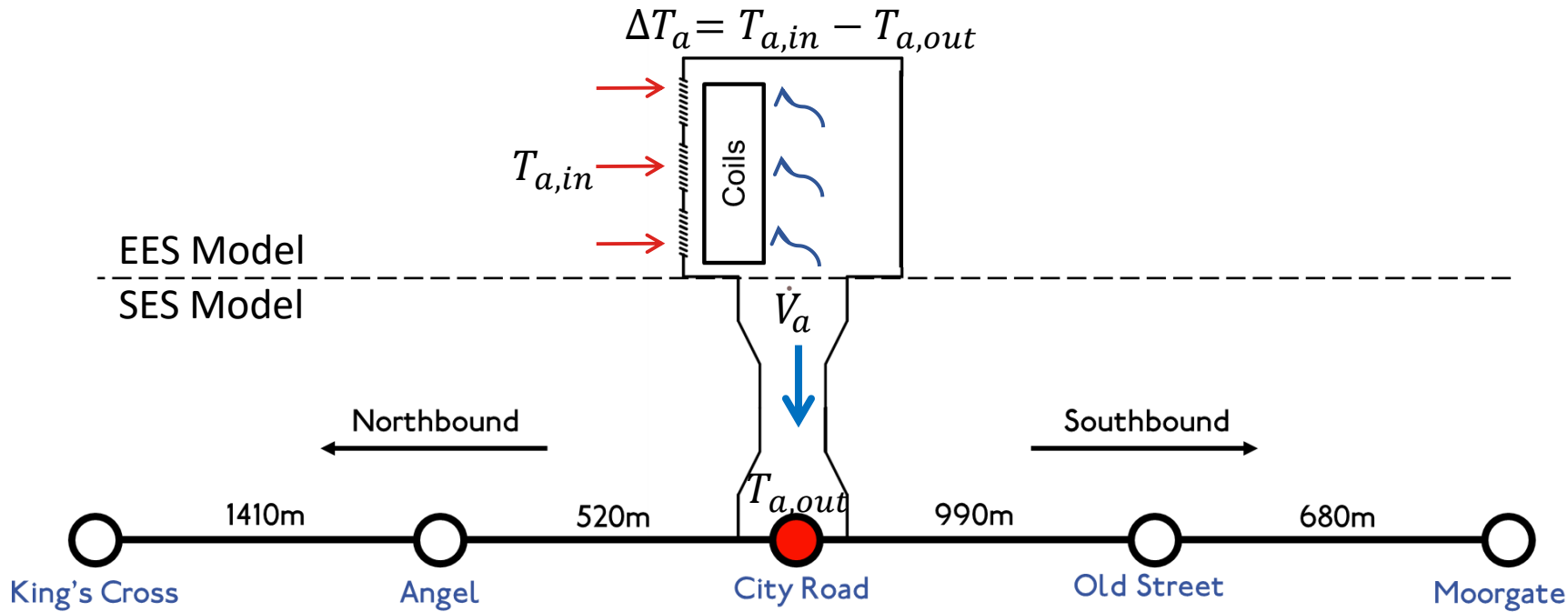
HEAT FUEL PROJECT

- Average of **770 kW** of heat recovered from the London Underground
- Upgraded by a **1 MW** heat pump
- Can also provide cooling when operating in Supply Mode
- Heat FUEL investigates both the heating and cooling benefits
- EES model has been developed to calculate system efficiency and outputs



COOLING THE UNDERGROUND

The EES model outputs are used as inputs to the SES investigation



$$Q_{rec} = Q_{lat} + Q_{sen}$$

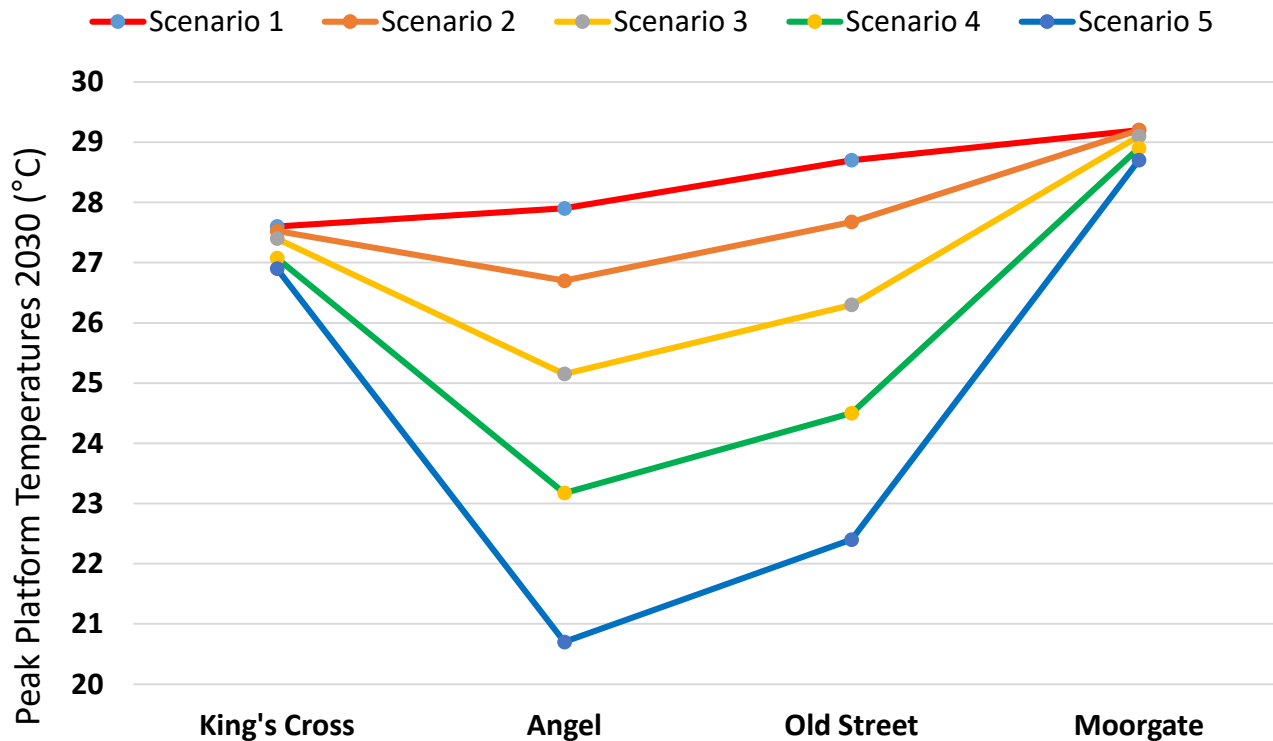
Outlet temperature and RH are supplied by EES model

EES model is able to account for condensation

Latent and sensible shares are used as inputs to SES

COOLING THE UNDERGROUND

Significant temperature reductions could be achieved at adjacent stations



	Peak platform temperatures (°C)				Cooling delivered (MWh/yr)
	King's Cross	Angel	Old Street	Moorgate	
Scenario 1 (12E/0S)	27.6	27.9	28.7	29.2	-
Scenario 2 (9E/3S)	27.5	26.7	27.7	29.2	1,618
Scenario 3 (6E/6S)	27.4	25.2	26.3	29.1	3,170
Scenario 4 (3E/9S)	27.1	23.2	24.5	28.9	4,530
Scenario 5 (0E/12S)	26.9	20.7	22.4	28.7	5,875

Average ΔT s of 1.1, 2.6 and 4.5°C for scenarios 2, 3 and 4 at adjacent stations

~5.9 GWh of cooling/year would lead to an average ΔT of 6.8°C at adjacent stations and +23% energy consumption

DATA CENTRES

- **Known number of data centres in UK as of 2018:**

- 25 Managed Service;
- 450 Colocation;
- 11500 Enterprise.

- **Decision to focus on Managed Service and Colocation DCs based on:**

- Availability of data, as specifications of Enterprise DCs are rarely disclosed to the public;
- Colocations and Managed Services would typically yield a larger heat output, considering the larger average white space area per site (Figure 1).

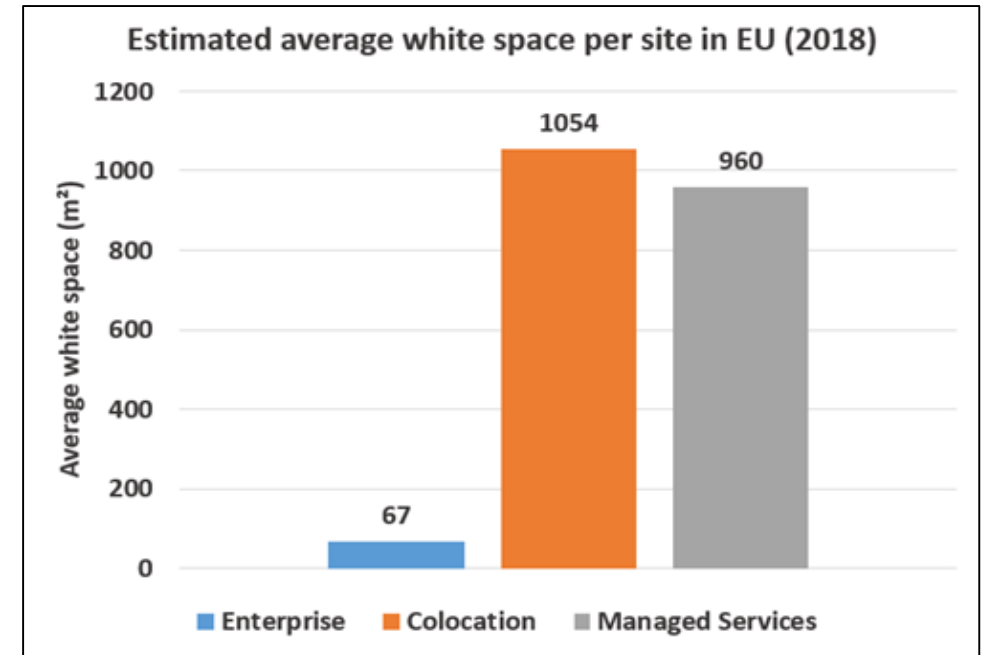


Figure 1

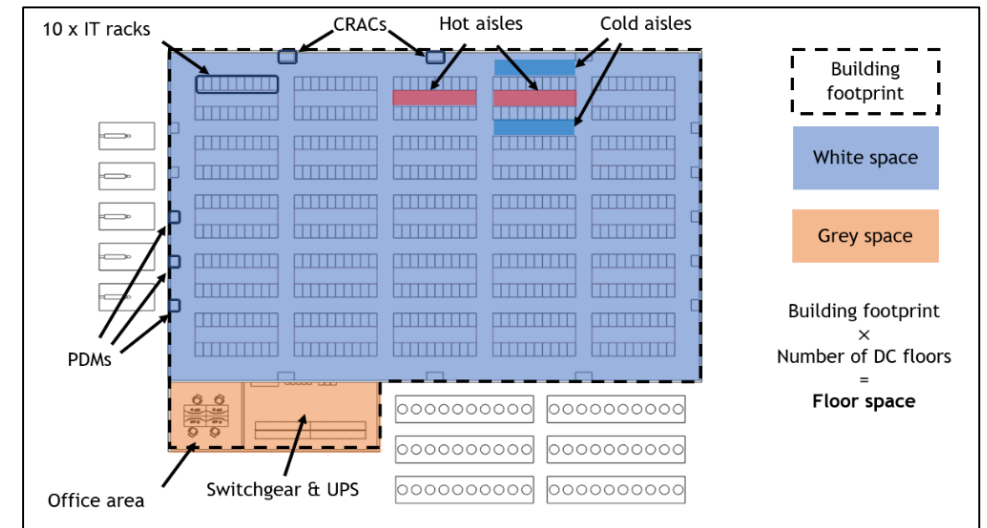


Figure 2 showing the components of a typical data centre

DATA CENTRES

- **Estimated heat output from 265 sites is 1939.7 MW**
- This represents 44.2% of the Managed Services and Colocation sector in 2018 (475 / estimated 4387.4 MW)

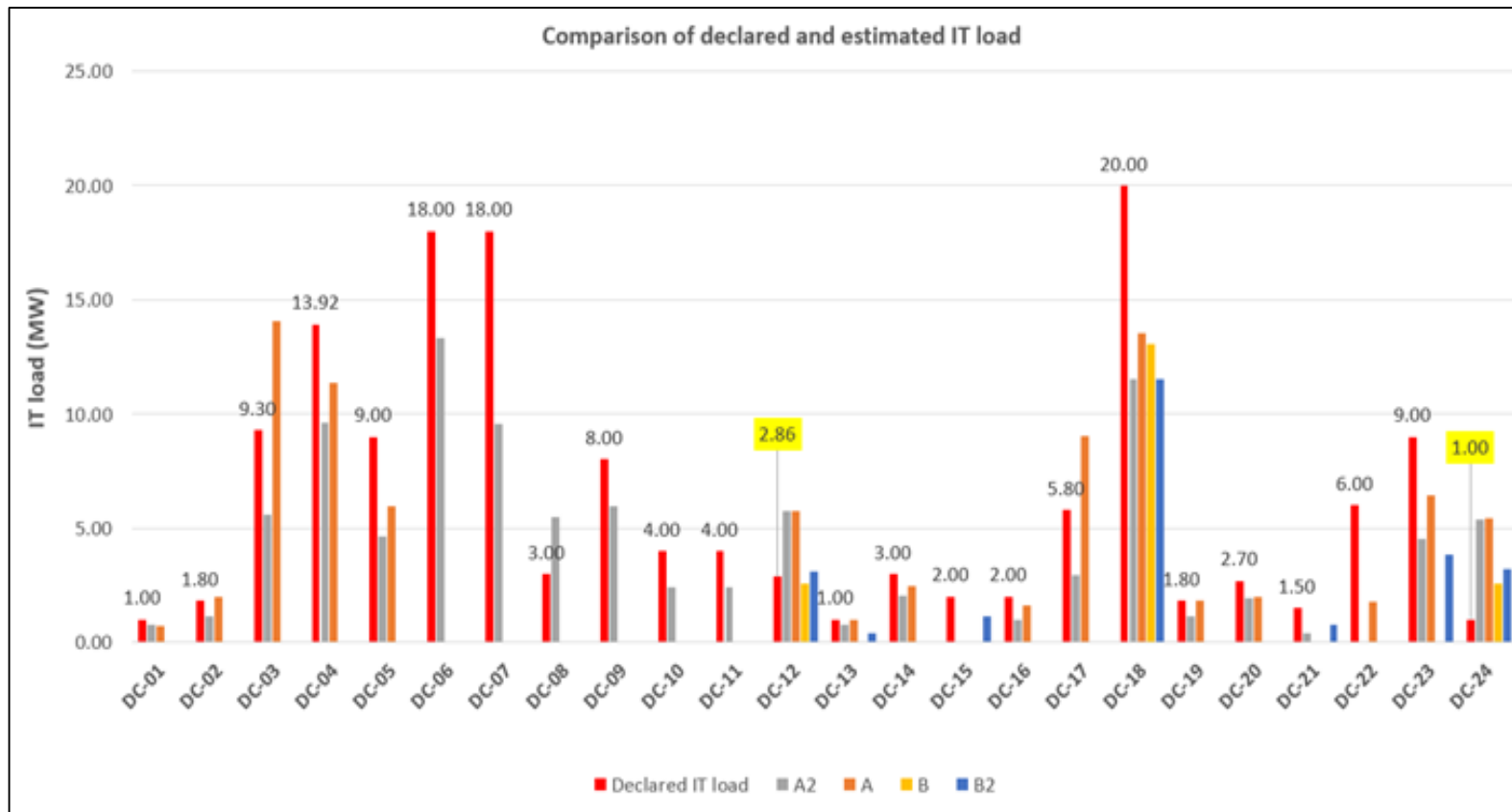


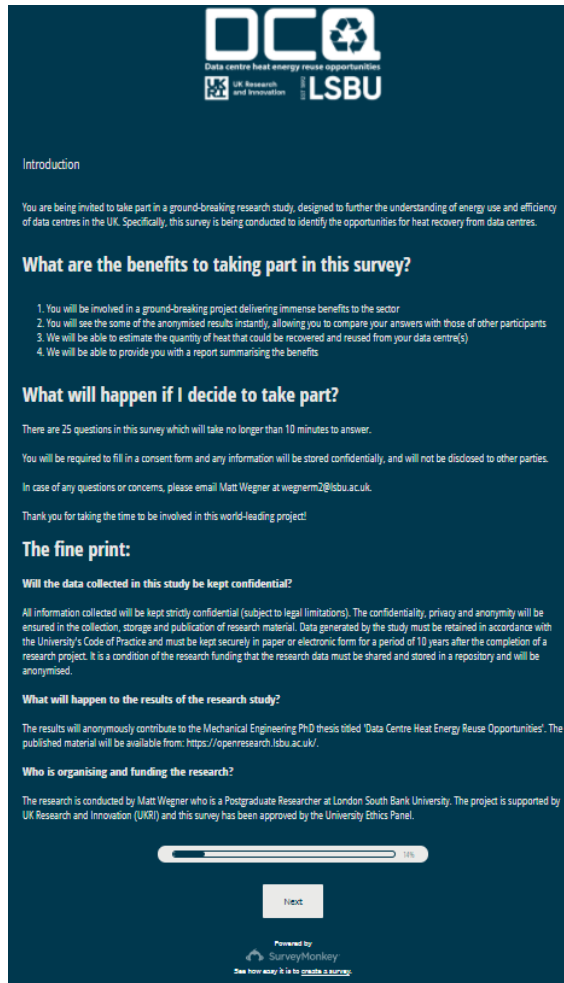
Figure 3 showing the comparison of IT load estimated for 24 data centres against the declared IT load

SIRACH - Data Centre Waste Heat Recovery

Tuesday 16th November 2021 10:00 to 12:30

Online survey aiming to:

- Overcome the lack of transparency within the sector
- Help establish generic factors between facilities
- Invite data centre owners and operators to participate in the project (case study data)
- Investigate the industry's attitude towards waste heat recovery



DCO
Data centre heat energy reuse opportunities
UK Research and Innovation | **LSBU**

Introduction

You are being invited to take part in a ground-breaking research study, designed to further the understanding of energy use and efficiency of data centres in the UK. Specifically, this survey is being conducted to identify the opportunities for heat recovery from data centres.

What are the benefits to taking part in this survey?

1. You will be involved in a ground-breaking project delivering immense benefits to the sector
2. You will see some of the anonymized results instantly, allowing you to compare your answers with those of other participants
3. We will be able to estimate the quantity of heat that could be recovered and reused from your data centre(s)
4. We will be able to provide you with a report summarising the benefits

What will happen if I decide to take part?

There are 25 questions in this survey which will take no longer than 10 minutes to answer.

You will be required to fill in a consent form and any information will be stored confidentially, and will not be disclosed to other parties.

In case of any questions or concerns, please email Matt Wegner at wegnerm2@lsbu.ac.uk.

Thank you for taking the time to be involved in this world-leading project.

The fine print:

Will the data collected in this study be kept confidential?

All information collected will be kept strictly confidential (subject to legal limitations). The confidentiality, privacy and anonymity will be ensured in the collection, storage and publication of research material. Data generated by the study must be retained in accordance with the University's Code of Practice and must be kept securely in paper or electronic form for a period of 10 years after the completion of a research project. It is a condition of the research funding that the research data must be shared and stored in a repository and will be anonymised.

What will happen to the results of the research study?

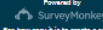
The results will anonymously contribute to the Mechanical Engineering PhD thesis titled 'Data Centre Heat Energy Reuse Opportunities'. The published material will be available from: <https://openresearch.lsbu.ac.uk/>.

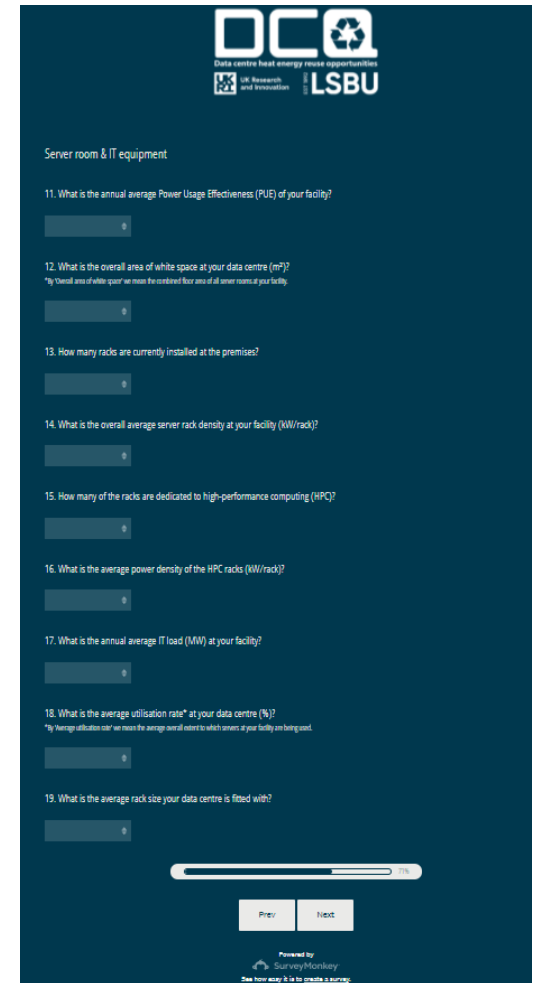
Who is organising and funding the research?

The research is conducted by Matt Wegner who is a Postgraduate Researcher at London South Bank University. The project is supported by UK Research and Innovation (UKRI) and this survey has been approved by the University Ethics Panel.

Progress: 0%

[Next](#)

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See how easy it is to create a survey



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Server room & IT equipment

11. What is the annual average Power Usage Effectiveness (PUE) of your facility?

12. What is the overall area of white space at your data centre (m²)?
*The 'overall area of white space' we mean the combined floor area of all server rooms at your facility.

13. How many racks are currently installed at the premises?

14. What is the overall average server rack density at your facility (kW/rack)?

15. How many of the racks are dedicated to high-performance computing (HPC)?

16. What is the average power density of the HPC racks (kW/rack)?

17. What is the annual average IT load (MW) at your facility?

18. What is the average utilisation rate* at your data centre (%)?
*The 'average utilisation rate' we mean the average overall extent to which servers at your facility are being used.

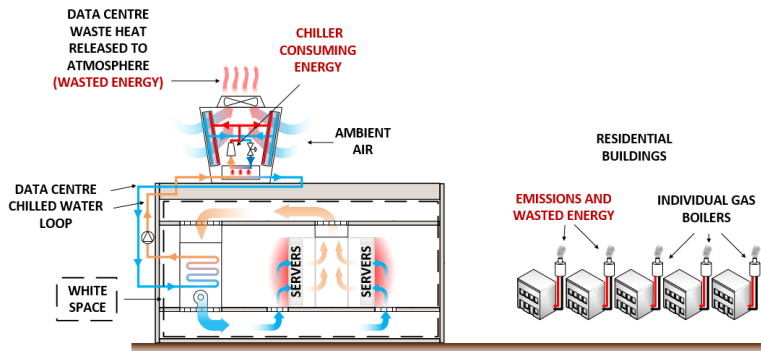
19. What is the average rack size your data centre is fitted with?

Progress: 0%

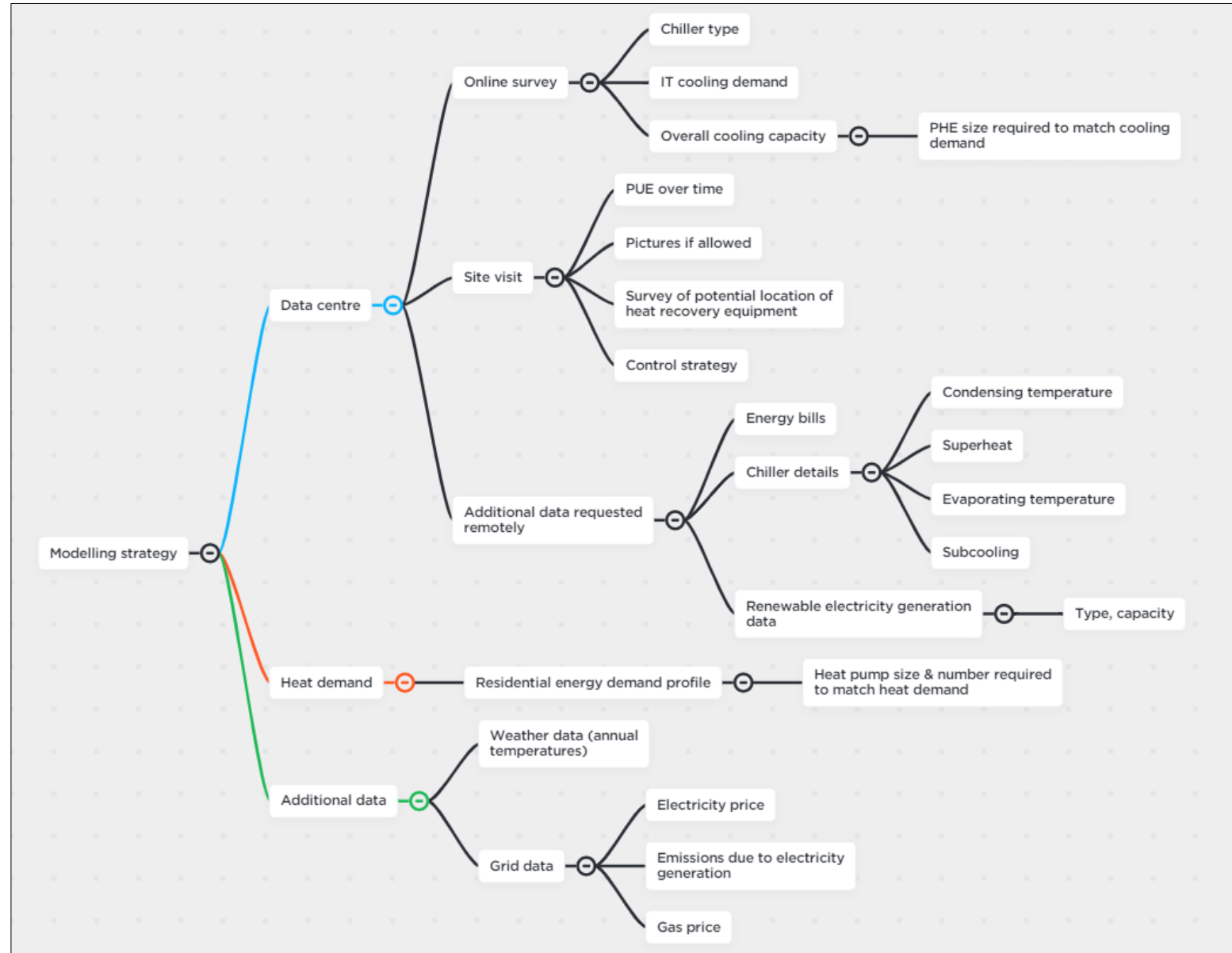
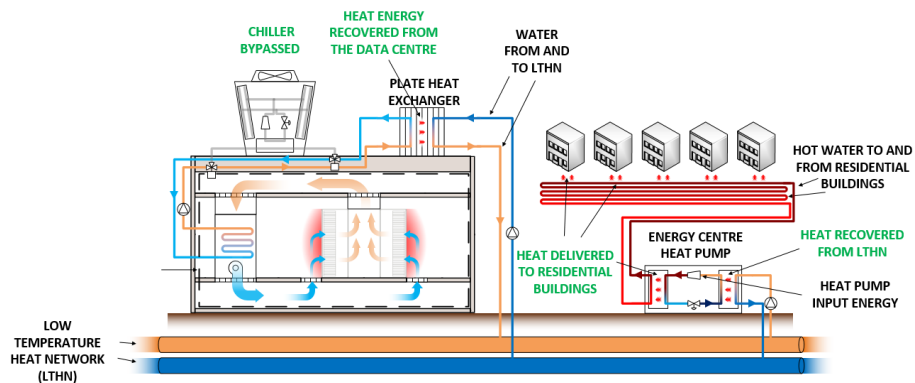
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Business as usual:



Heat recovery:



Publications

- Lagoeiro, H., Revesz, A., Davies, G., Maidment, G., Curry, D., Faulks, G. & Murawa, M. 2020. Assessing the Performance of District Heating Networks Utilising Waste Heat: A Review. Proceedings of the ASHRAE Winter Conference, Orlando, USA, 1–5 February.
- Lagoeiro, H., Revesz, A., Davies, G., Gysin, K., Curry, D., Faulks, G., Murphy, D., Vivian, J. & Maidment, G. 2021. Waste Heat Recovery from Underground Railways – Evaluating the Cooling Potential. Proceedings of the CIBSE Technical Symposium, UK, 13 – 14 July.
- Lagoeiro, H., Revesz, A., Davies, G., Curry, D., Faulks, G., Murphy, D., Vivian, J. & Maidment, G. 2022. Integrating Waste Heat Recovery from Railway Tunnels into Flexible Heat Networks. Proceedings of the ASHRAE Winter Conference, Las Vegas, USA, 31 Jan – 2 Feb.
- Wegner, M., Turnell, H., Davies, G., Revesz, A. and Maidment, G. (2021) *Combined benefits of cooling with heat recovery for electrical cable tunnels in cities*, Sustainable Cities and Society, 73 , pp. 103100. DOI: 10.1016/j.scs.2021.103100.
- Research group paper (Energies): *The opportunity for meeting net zero heating using low grade waste heat sources*. – contribution on data centres (work ongoing)
- Wegner, M., Turnell, H., Davies, G., Revesz, A. and Maidment, G. (2021). *Investigation of opportunities for utilising waste heat for district heating networks in cities*. CIBSE Technical Symposium 2021. Virtual online conference 13 - 14 Jul 2021
- Marques, C., Tozer, R., Revesz, A., Dunham, C., Jones, P., Matabuena, R., Bond, C., Roscoe Papini Lagoeiro, H., Wegner, M., Davies, G. and Maidment, G. (2020). *GreenSCIES – Green Smart Community Integrated Energy Systems – Integration with Data Centres*. Institute of Refrigeration TechTalk Webinar. London
- Revesz, A., Williams, H., Findlay, J., Dunham, C., Jones, P., Moggeridge, M., Riddle, A. and Maidment, G. (2022) Optimisation of Smart Local Energy Systems with Aquifer Thermal Energy Storage in Cities, 2022 ASHRAE Winter Conference, Las Vegas, US
- Revesz, A., Chadha, S., Roszynski, K., Fell, A., Jones, P., Hampton, C., Fenner, R. and Maidment, G. (2021) Engineering Value and Innovative Design Options for Smart Local Energy System, 2021 CIBSE Technical Symposium, UK
- Revesz, A., Jones, P., Dunham, C., Riddle, A., Gatensby, N. and Maidment, G. (2021) Decentralised heat pumps and thermal stores for 5th generation district heating and cooling networks, 2021 CIBSE Technical Symposium, UK
- Revesz, A., Jones, P., Dunham, C., Davies, G., Marques, C., Matabuena, R., Scott, J. and Maidment, G. (2020) Developing novel 5th generation district energy networks, Energy, 201, pp. 117389. DOI:10.1016/j.energy.2020.117389.
- Bowman, A., Revesz, A., Davies, G. and Maidment, G. (2020) Project SHOES: Secondary Heat Opportunities from Electrical Substations, 2020 ASHRAE Winter Conference, Orlando, USA, Vol. 126, pp. 29–38.