Opportunities & Challenges to recovering heat from Data Centres

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Opportunities

- 4% UK electric energy for Data Centres
- All of this energy is transformed into heat
- Most of this energy can be recovered for heating, hot water
  - Inside the Data Centre
  - External to the Data Centre
- Feasible if Data Centre is close to where heat is required

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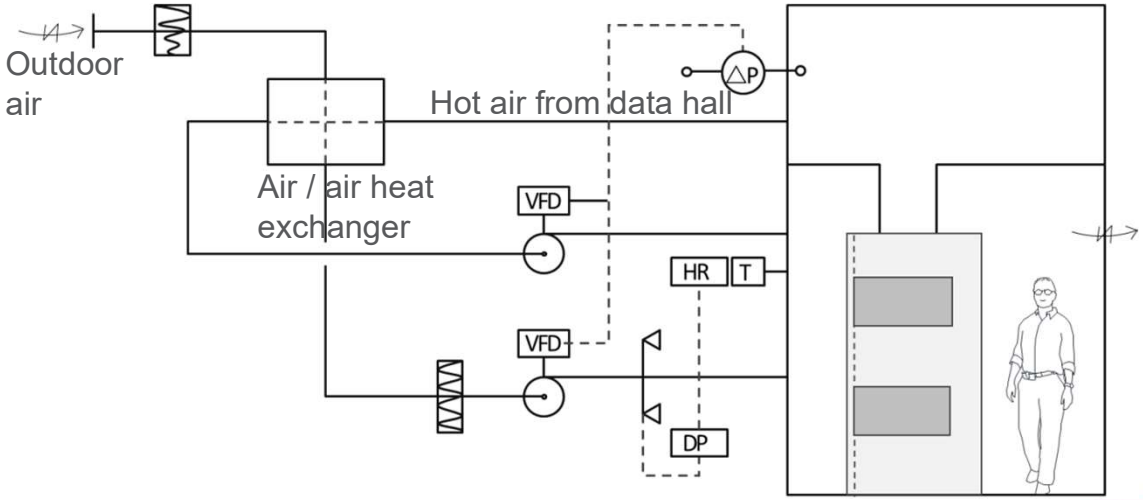
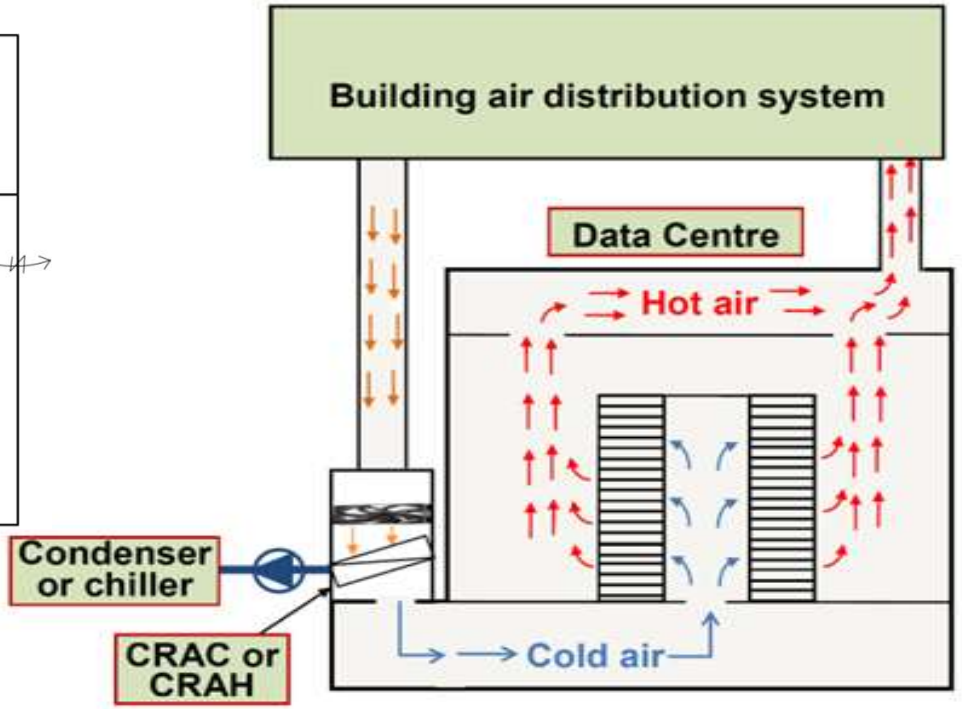
Heat recovery opportunities within the Data Centre

Heat recovery of outdoor air to pressurise the data hall (to minimize infiltrations)



Heat recovery to warm circulation corridors in data centre (fire zones and proximity for air circulation)



Reference: i-Stute Project (LSBU Dr Gareth Davies, Prof Graeme Maidment)

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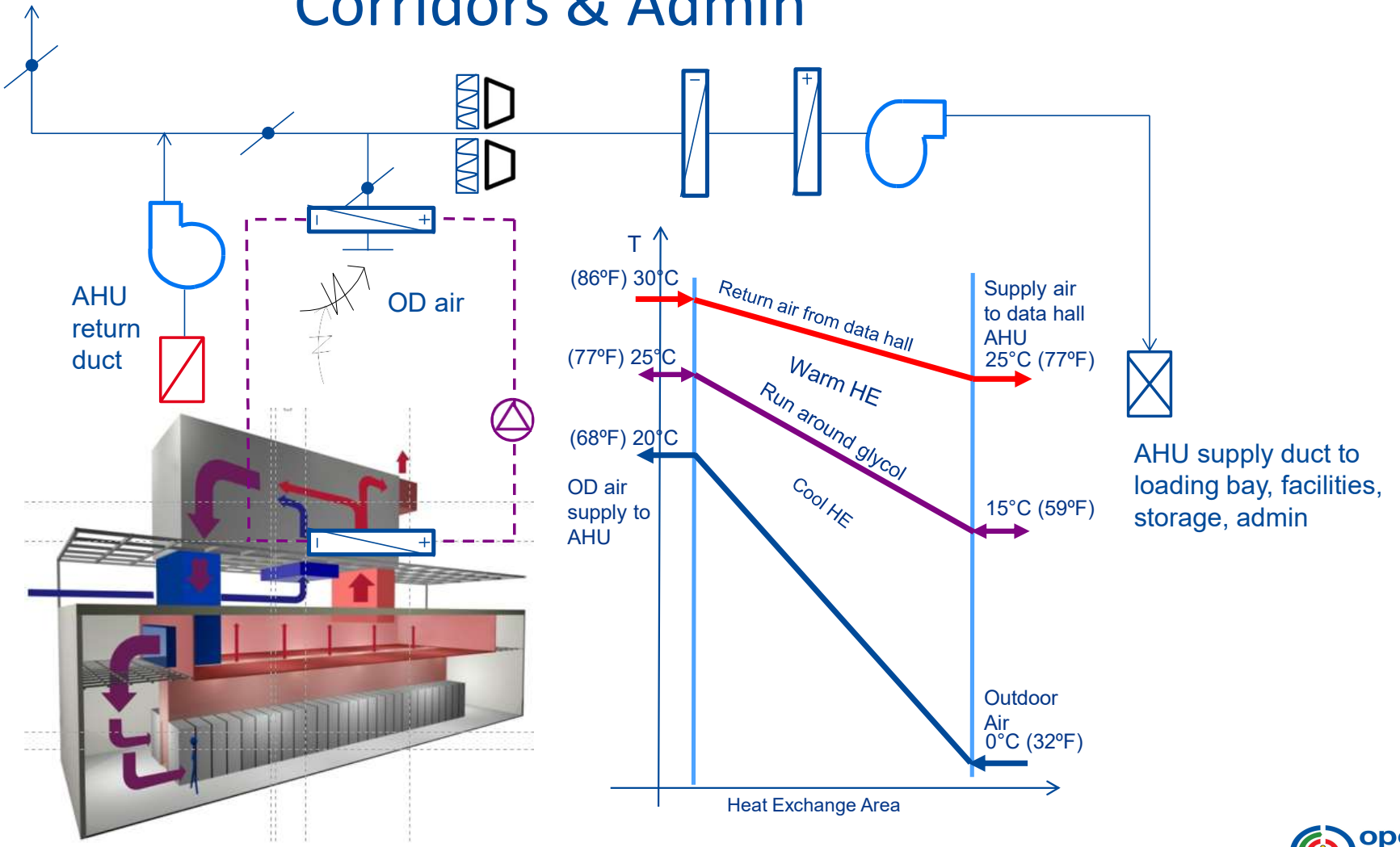
Heat recovery to Loading bay, Facilities, Storage, Corridors & Admin



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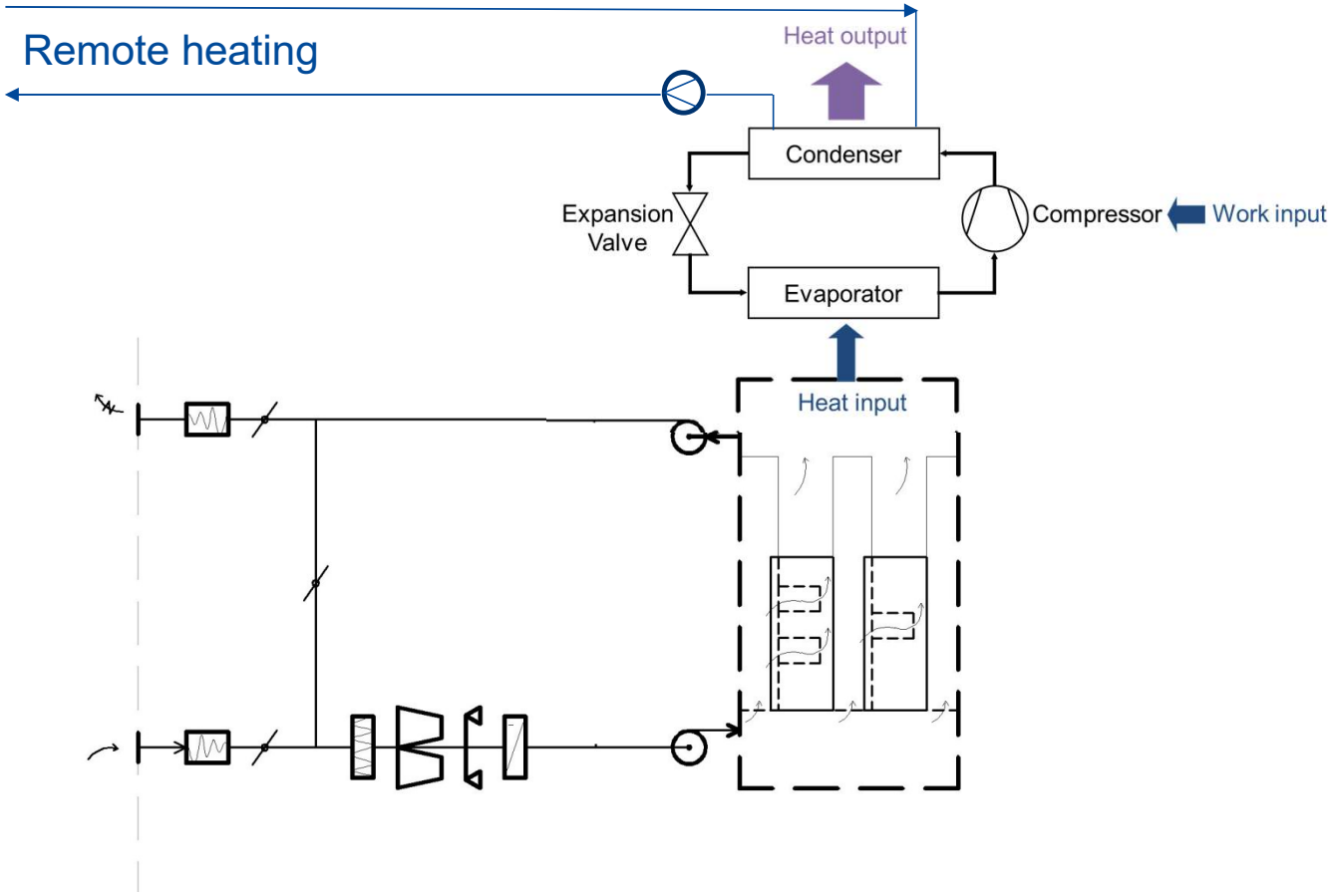
Heat pump heat recovery campus admin office



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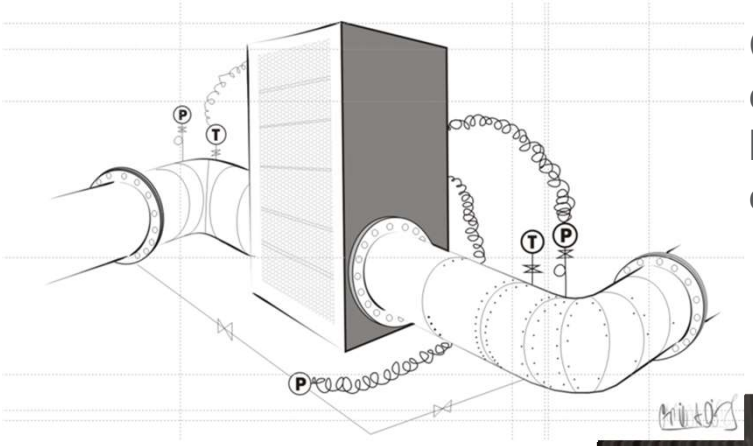
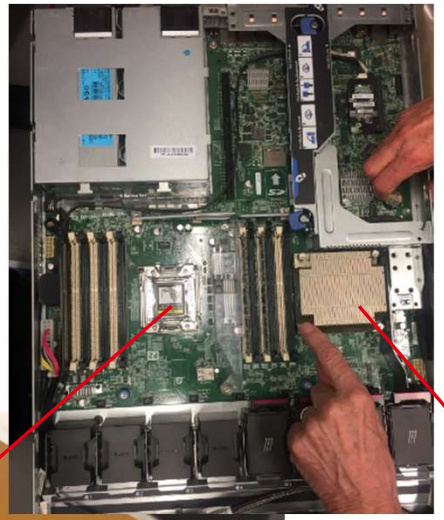
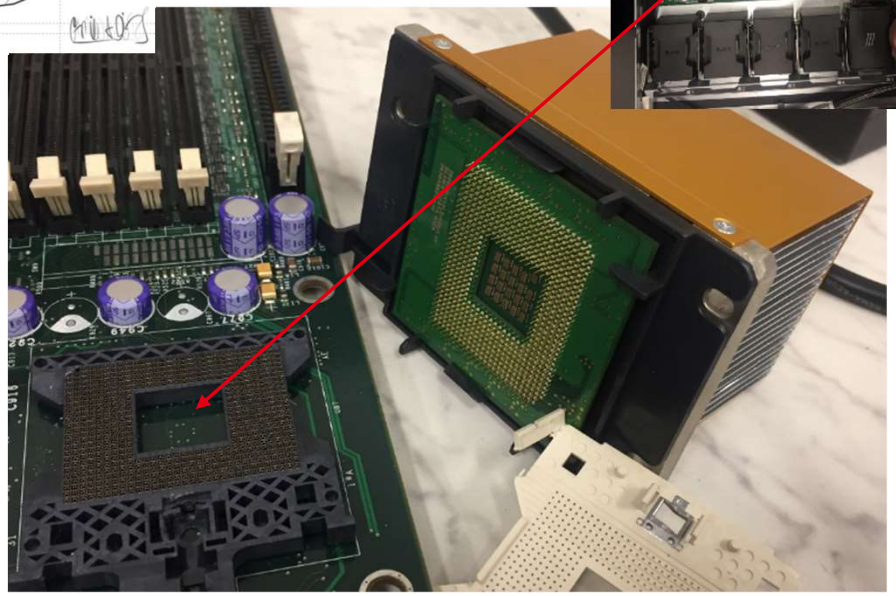
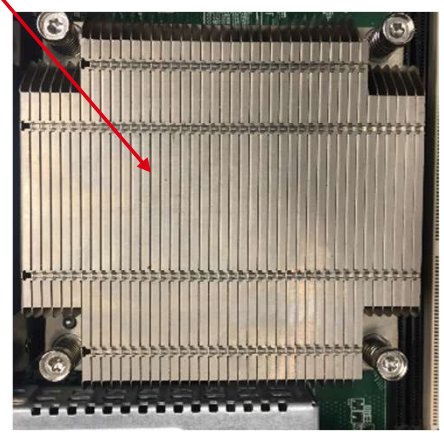
High chip density makes IT liquid cooling unavoidable



Critical density of chip 250W, requires large area of heat exchanger







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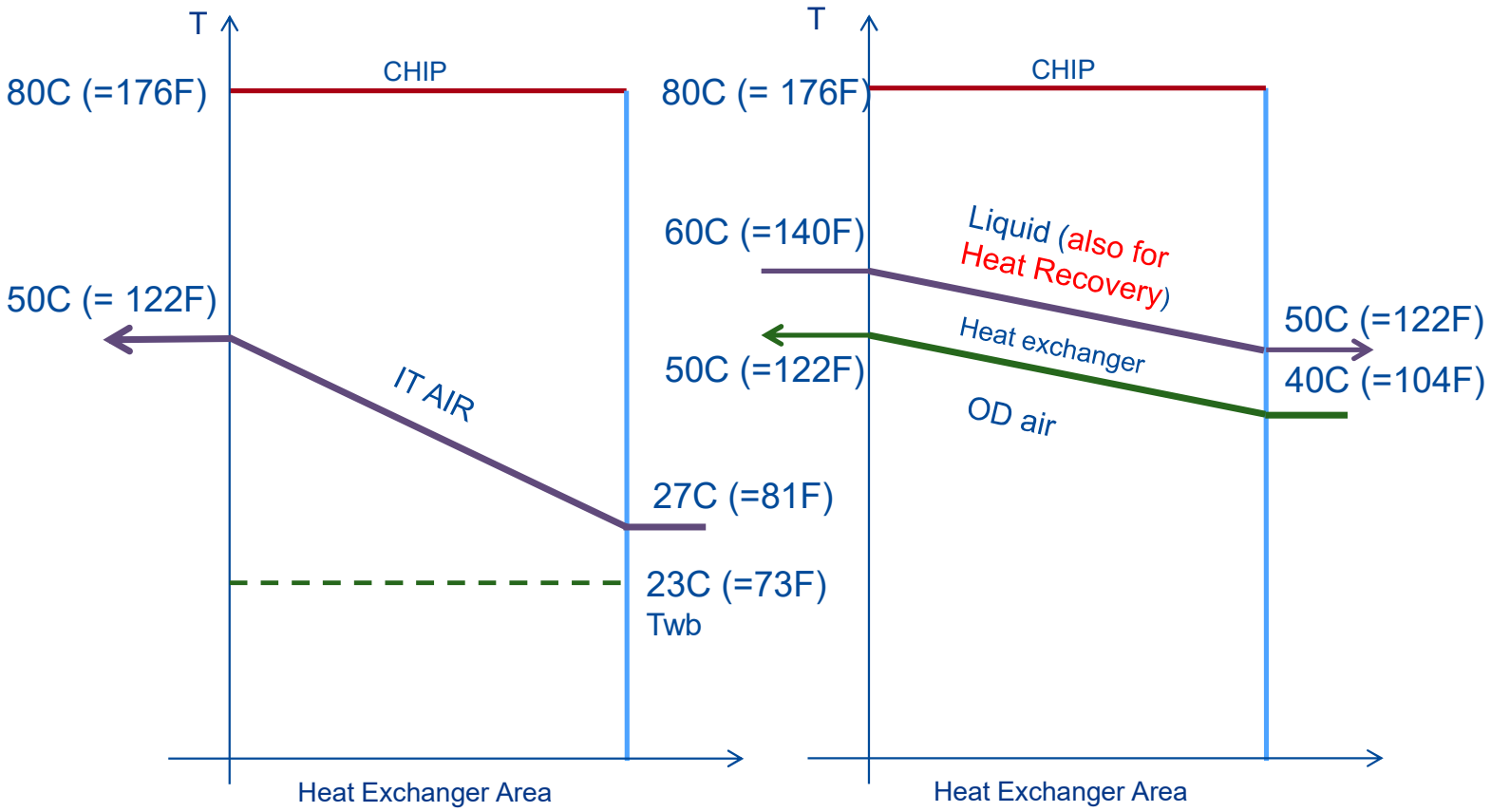
Liquid cooling efficiency



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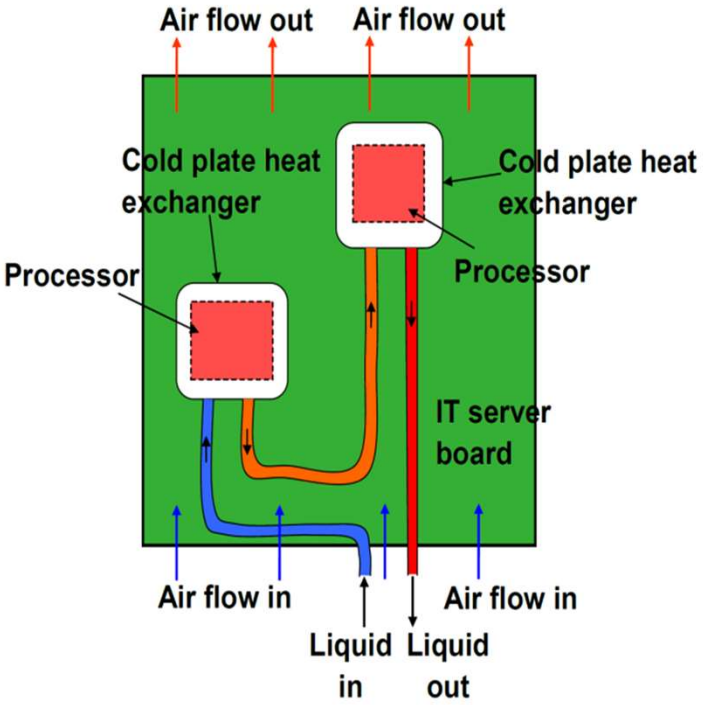
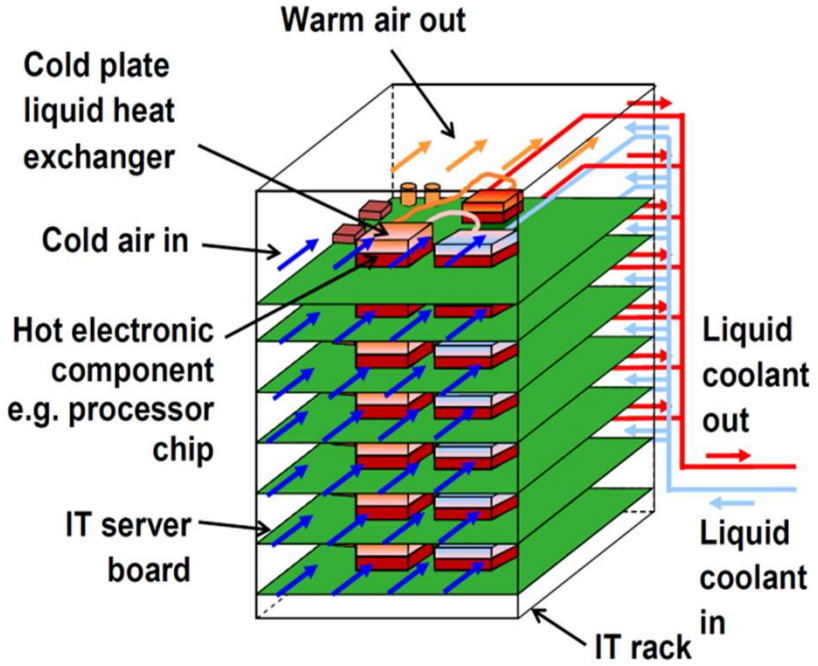
Direct liquid on-chip + air cooling of IT equipment





Heat at high temperatures from specific components

Images: DCPro

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Heat recovery options

DC cooling	IT cooling	Source for HR	Heat recovery (M&E)	Heat sink	Comments
Legacy & air free cooling (economiser)	Remote air	Air 22 - 35C	Direct air & run around coils	Adjacent & remote spaces	Direct air very close Coils lose temperature
			Air to water heat pump (50/60C)	Remote spaces	Heat pump at source
Water free cooling (economiser)	Remote air & local cooling	Water 20 - 30C	Water to water heat pump (50/60C)	Remote spaces	Option of heat pump at source or sink
Liquid immersion	Liquid	Liquid 45 - 50C	Direct water	Remote spaces	Heat pump possible, further small lift, viable?
Liquid chip (plus air)	Liquid & air	Liquid 45 - 50C	Direct water	Remote spaces	Heat pump possible, further small lift, viable?

For air or water with the same delta T and velocities the ratio of transversal area to transfer heat has a ratio of 3500
Aa/Aw = 3500, calculated from 4.2kJ/lK * 1000l/m3 / 1.2 kJ/m3K,
Pipe diameter 150mm with water is equivalent to an air duct of 8m x 8m

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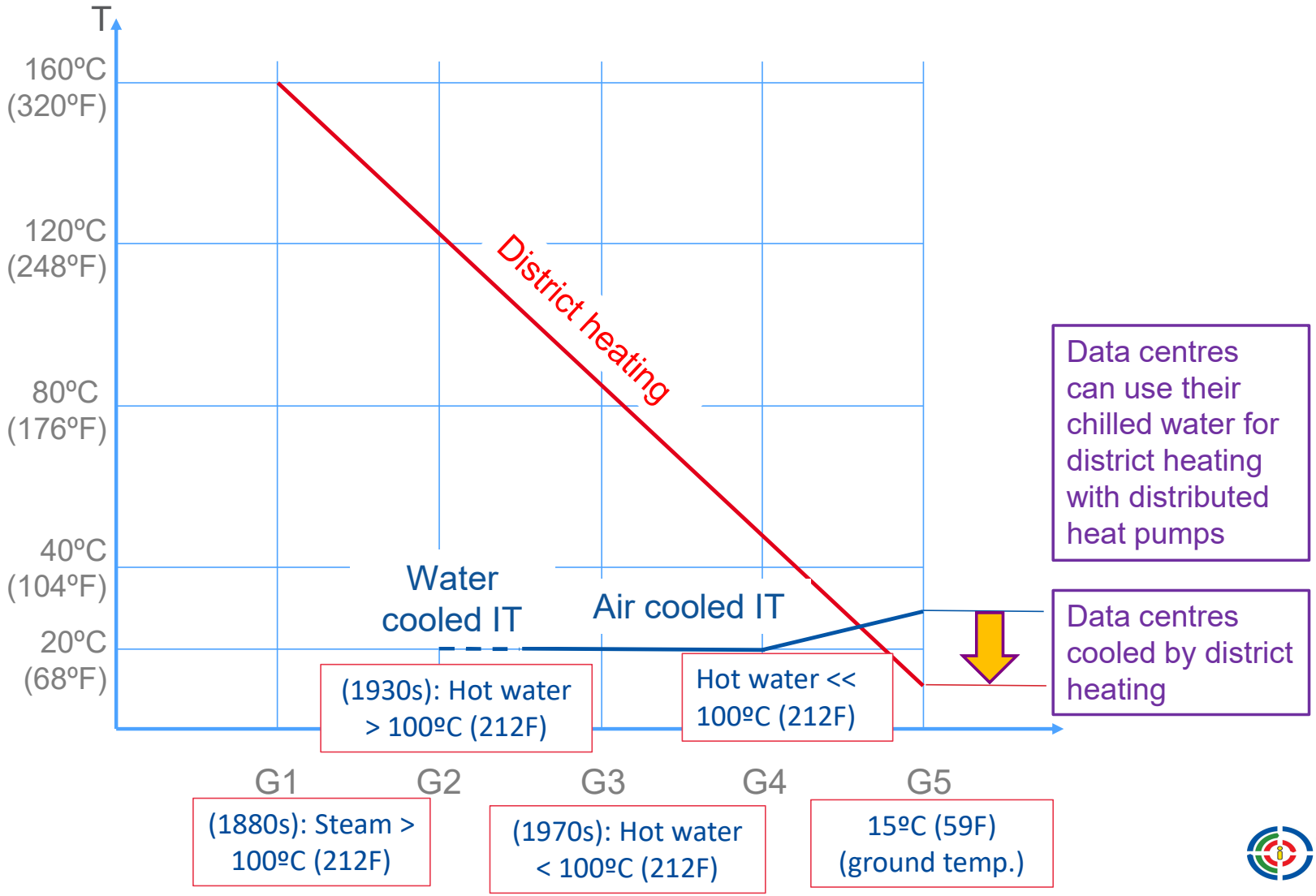
Heat recovery external to Data Centres



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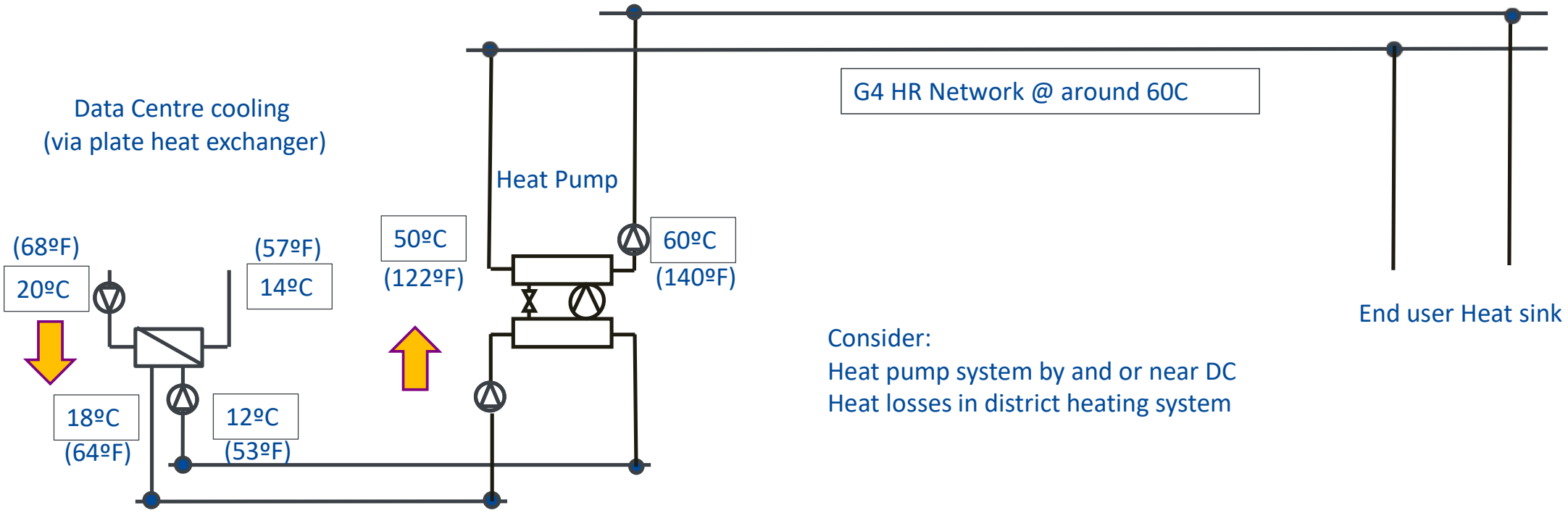
Heat pump heat recovery – G4 district heating



Consider:
Heat pump system by and or near DC
Heat losses in district heating system

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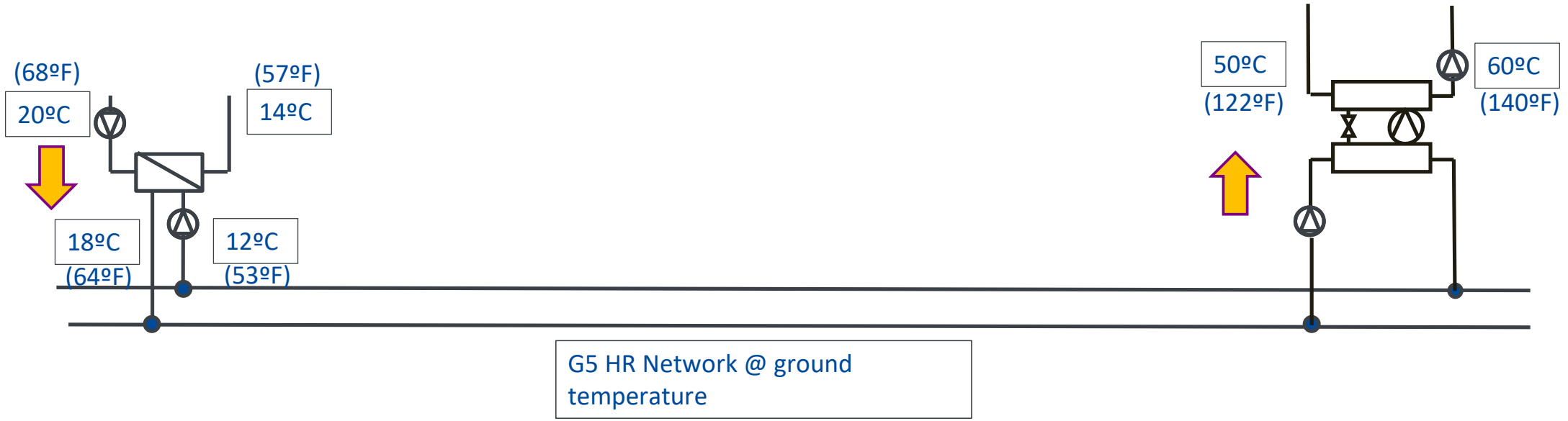
Heat pump heat recovery – G5 district heating

Consider:
Heat pump system at each end user
Value of heat at ground temperature

Data Centre cooling
(via plate heat exchanger)

End user Heat sink
(via heat pump)



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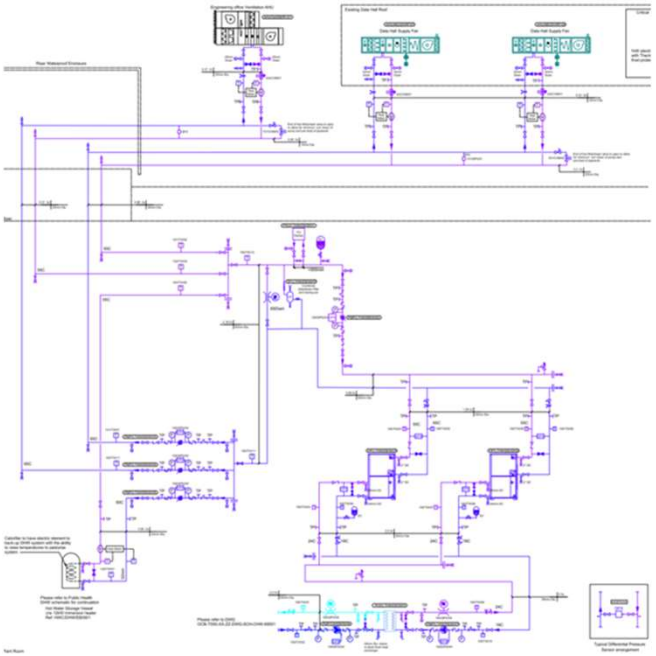
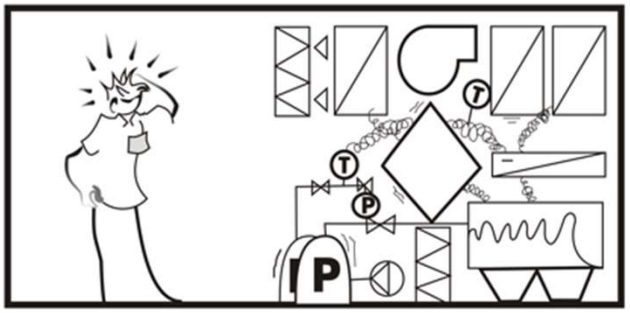
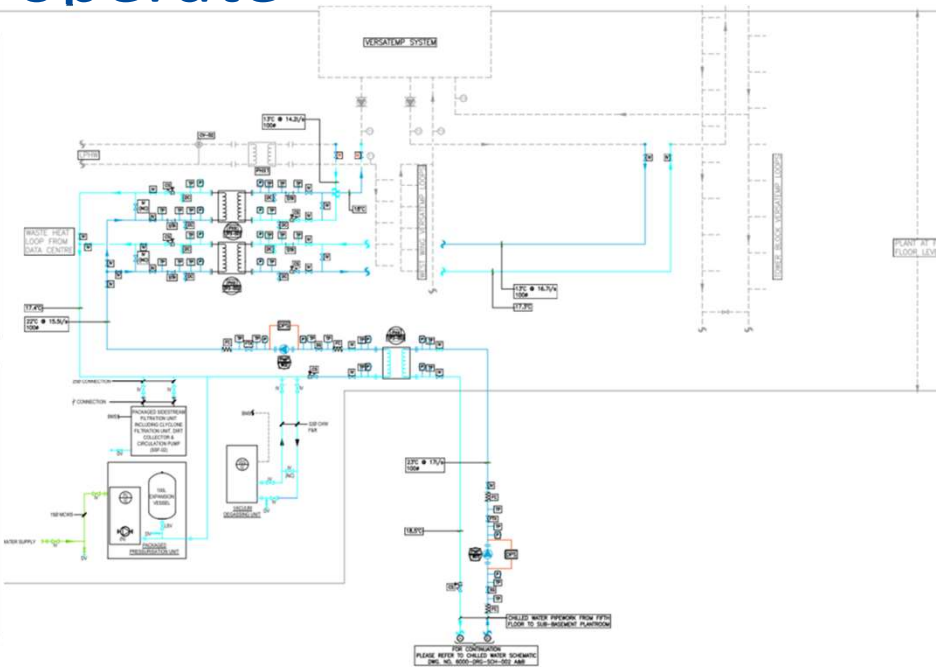
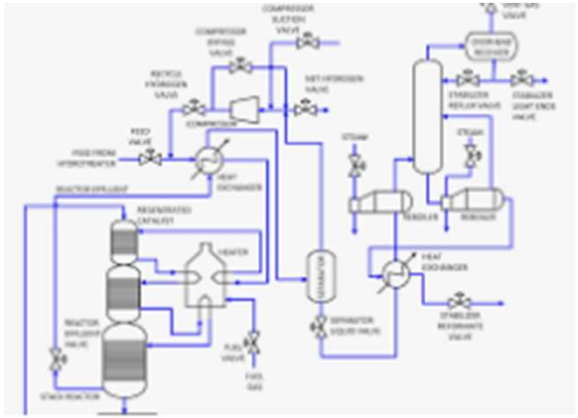
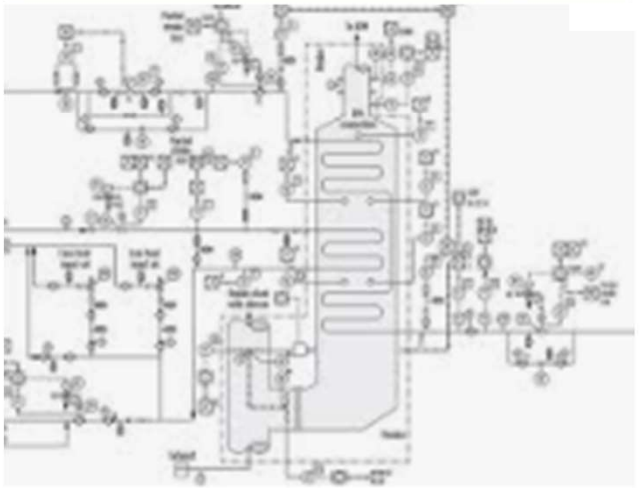
Heat recovery systems: design and operate

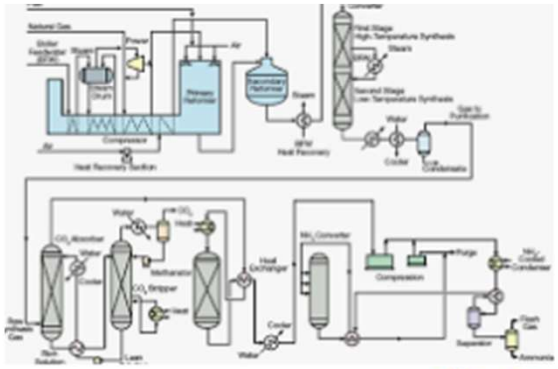












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Poll 1

How easy do you think it would be to operate / understand the data centre heat recovery systems?

- Very easy
- Easy
- Slightly challenging
- Difficult
- Very difficult

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Challenges

- Stakeholders: Many interested parties, requires management. End users (multiple) and Data centre clients (hosted in DC), business owners, consultants, contractors, project teams.
- Understand Liabilities: DC installation and operational survey required prior to feasibility study. Incidents will greatly impact district heating. With heat recovery, remaining chillers operate continuously at very low loads. Risk of hot piping in existing data centre applications. Risk analysis workshops (design, commissioning and operation phases)
- DC Energy optimisation: Data centre must be energy optimised (air man, VFD, high temps). Higher chw temperatures enable more HR. Ideally chillers with no free cooling, no glycol.
- Operations: Data centre operations teams comfortable with chw and HR systems. Most disasters are due to the human element, mostly management (80% Duffey and Saull). Simple solutions minimise risk.
- Proximity: Most DC are remote >90%, those that are close, are not close enough. Legislate Integrated Data Centres with Housing (Government action on planning)
- Data centre business requires continuity, supplying heat is a by-product. Few data centres, many heat users. Data centre culture is risk adverse, they would not rely on cooling solely from District heating. Understand DC future and district heating dependence on a few data centres which might / could move in future years.
- HR design in Data Centre: G4 or G5 district heating scheme. Heat recovery from air or water systems, primary or secondary chw systems. Care with pumps in parallel with different pump curves. Annual heat balance of district heating and data centre cooling. Also metrics: PUE: Power Utilisation Effectiveness, CUE: Carbon Utilisation Effectiveness, ERF: Energy Recovery Factor
- DC infrastructure risks: Understanding of DC redundancy / weaknesses, Single Points of Failure (SPOFs).

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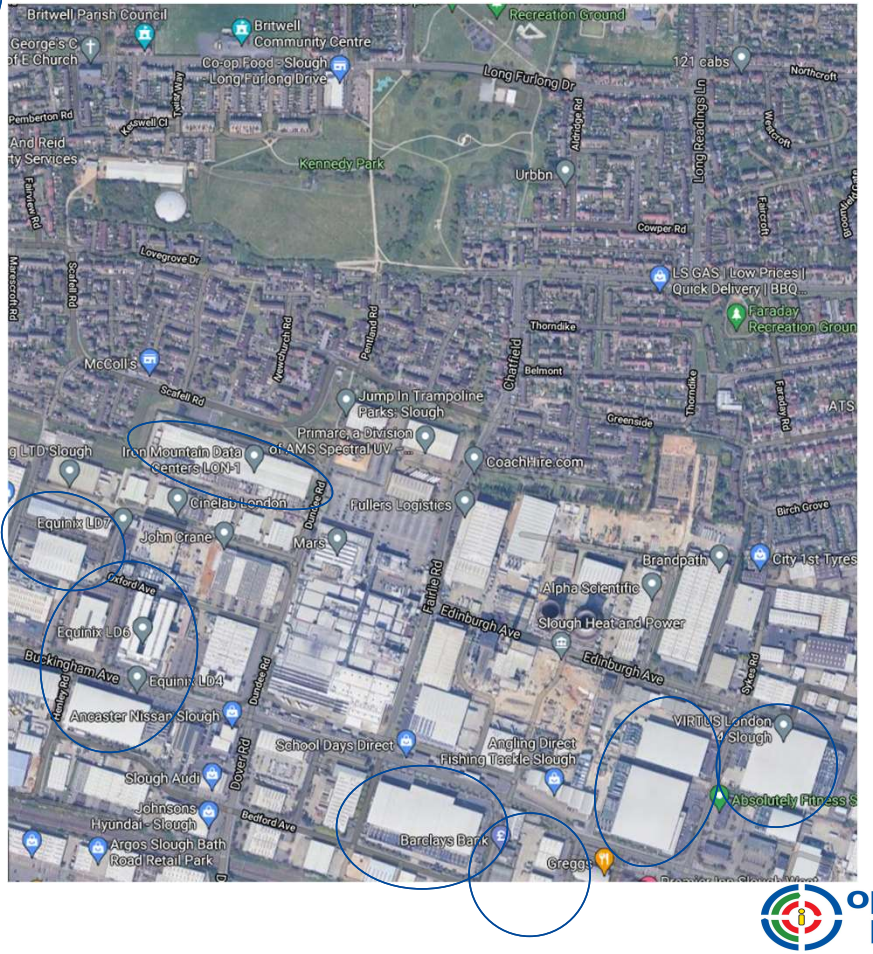
Heat from Data Centres - Proximity

Not close enough



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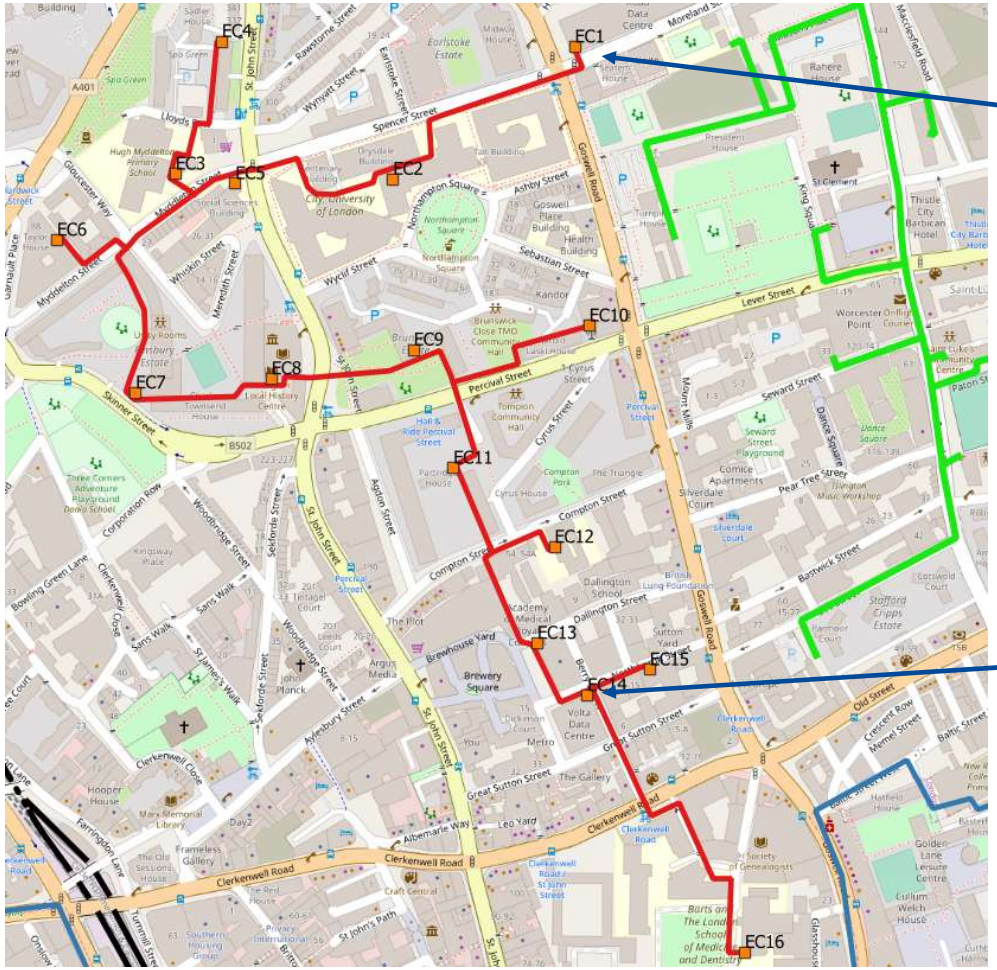
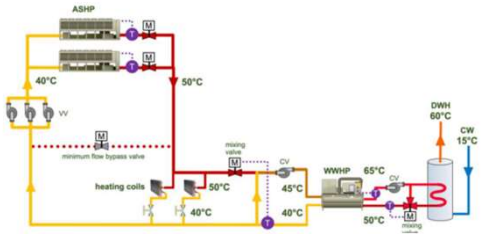
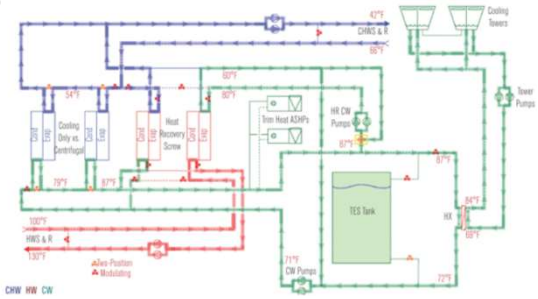
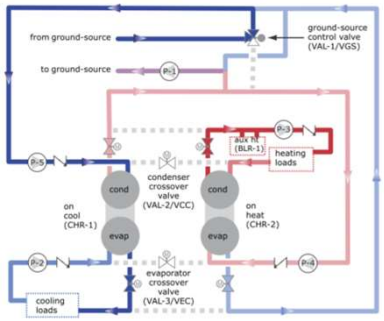
Many stakeholders: Few data centres, many heat users

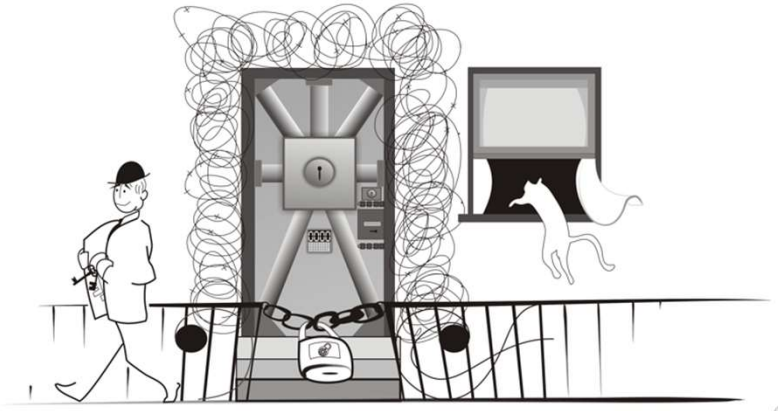


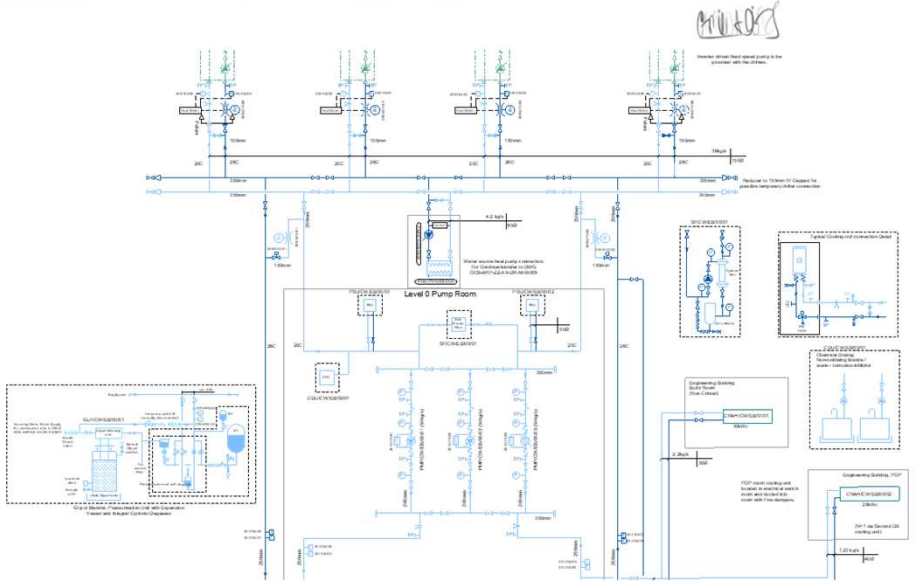
Chw & Heat recovery systems – understand weaknesses











Also:

Loss of district heating flow

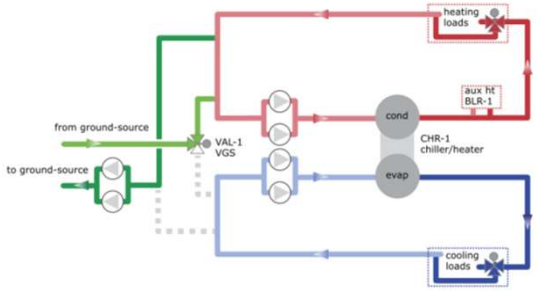
District heating temperature too high for DC

Control interfaces between DC & HR

Commissioning in a live data centre (risk)

Operational human errors HR system

Unknown unknowns / knowns



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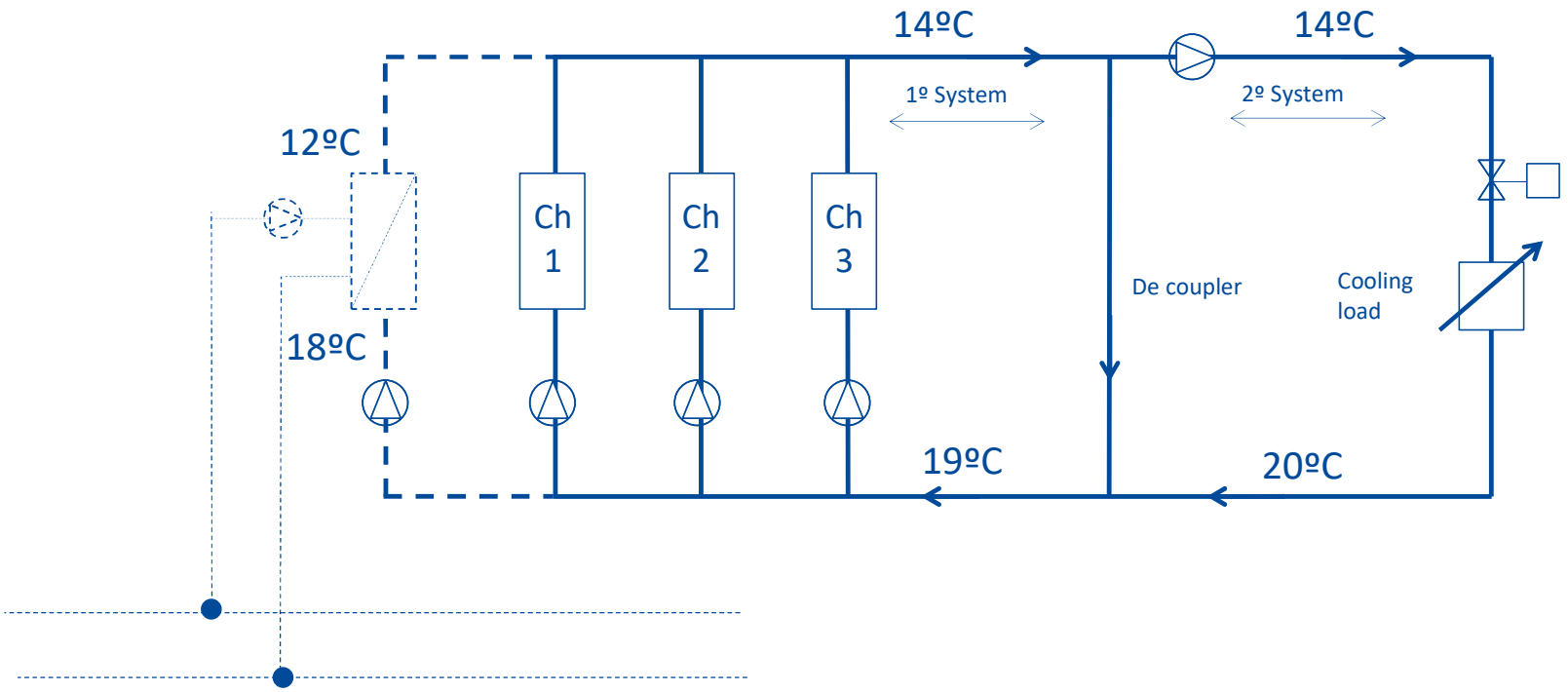
Primary ChW system HR



G5 HR Network: approx. 15ºC (ground temperature)

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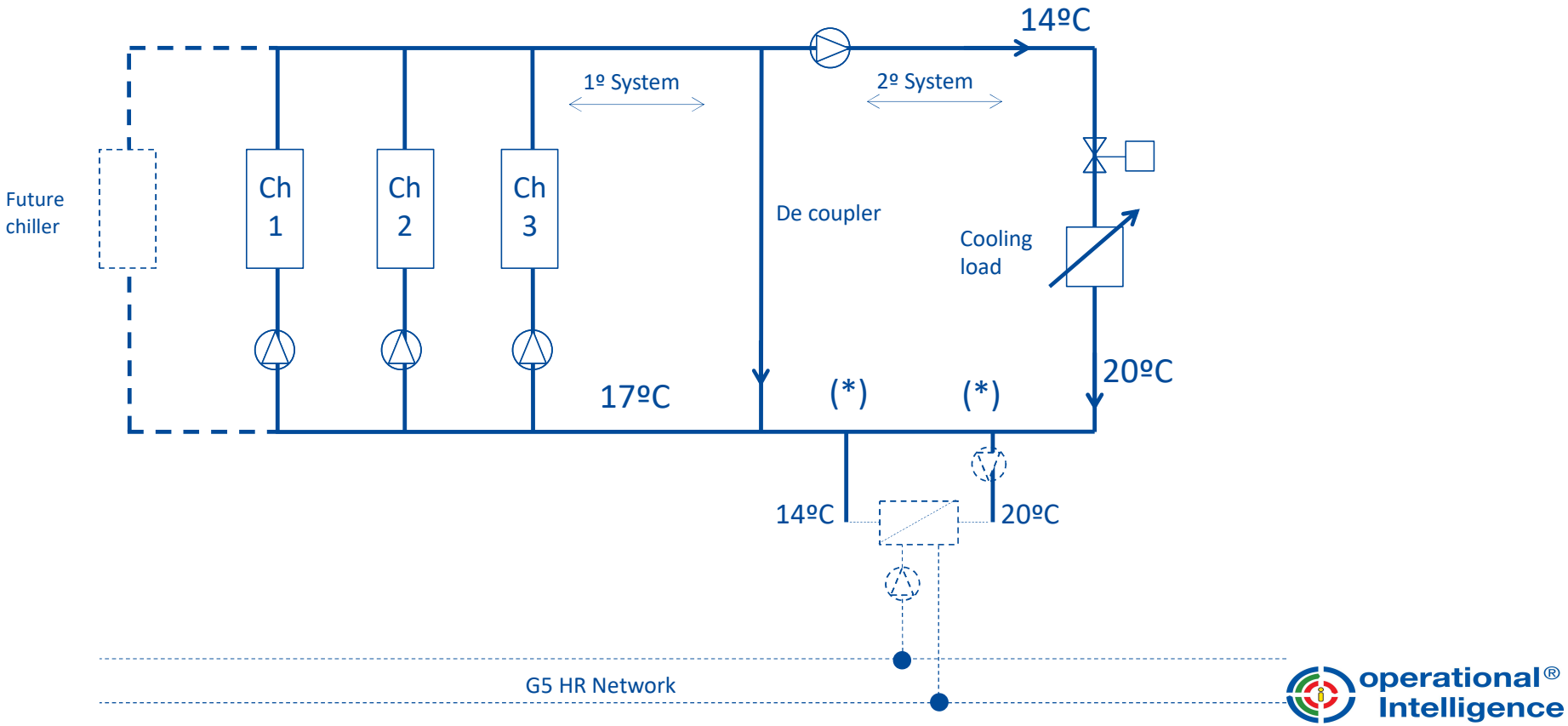
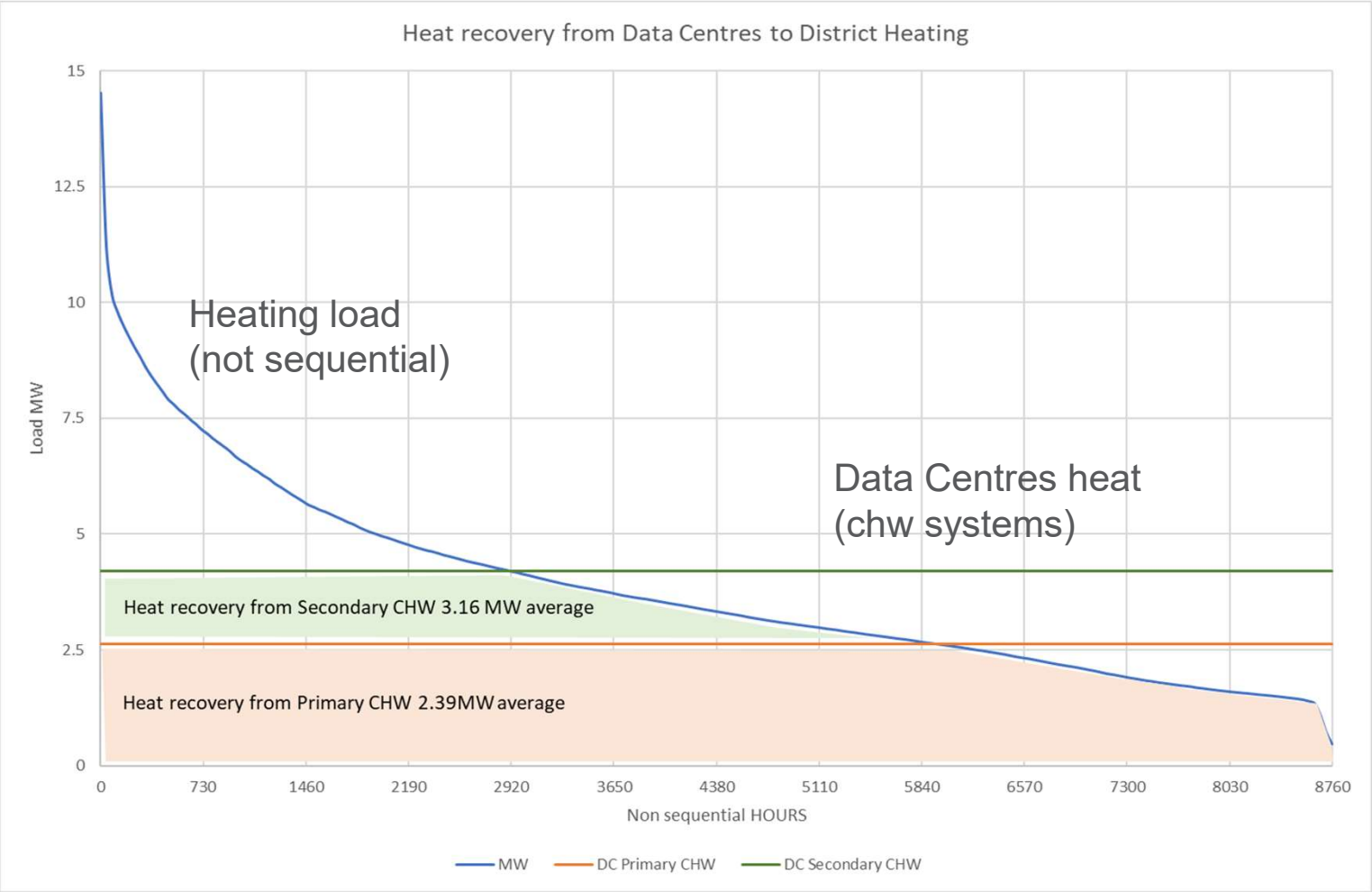
Secondary System HR



Data Centres District heating – heat balance



Ref: Green SCIES, London

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Poll 2

Which do you think are the 2 (two) most important challenges ahead for a wider implementation of heat recovery from data centres? Please select 2 options.

- Stakeholders: Many interested parties, requires management.
- Understand Liabilities: DC installation and operational survey required prior to feasibility study. Risk analysis workshops (all phases)
- DC Energy optimisation: Higher chw temperatures enable more HR.
- Proximity: Most DC are remote >90%, those that are close, are not close enough. Legislate.
- Data centre business requires continuity, supplying heat is a by-product. Few data centres, many heat users. Risk adverse culture.
- DC risks: Understanding of DC redundancy / weaknesses, Single Points of Failure (SPOFs). Most disasters are due to the human element, mostly management. Simple solutions minimise risk.

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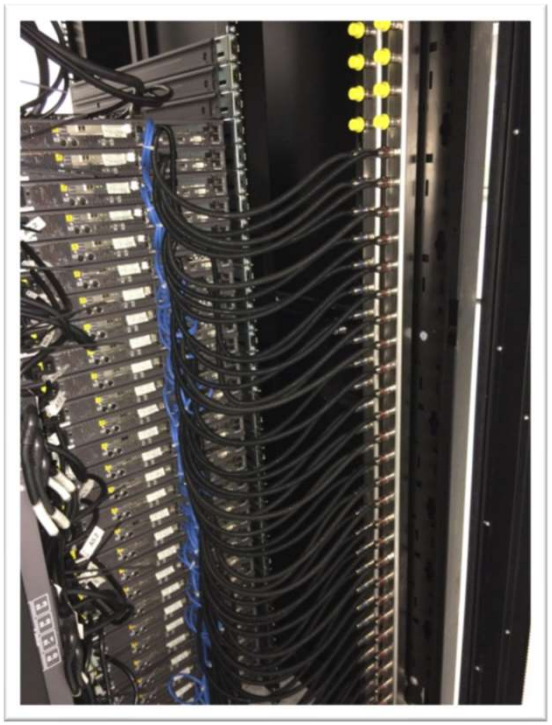
Direct liquid on-chip + air cooling of IT equipment



Cool IT SYSTEMS

Images: Jon Summers, University of Leeds, Cool IT systems

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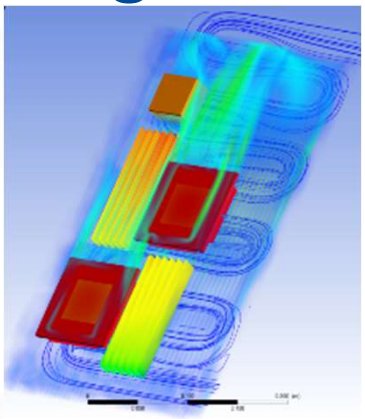
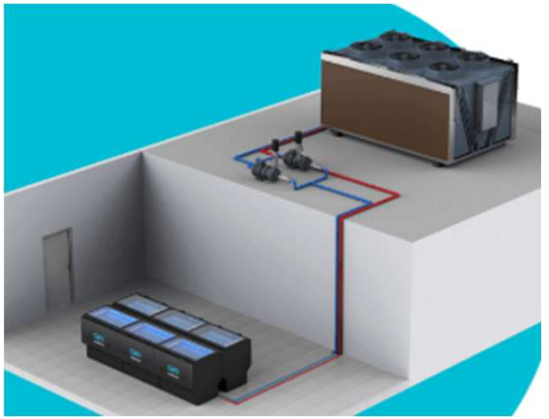
Liquid immersion cooling



Heat recovery



Reference: Dr Jon Summers, Leeds University, UK, and Submer

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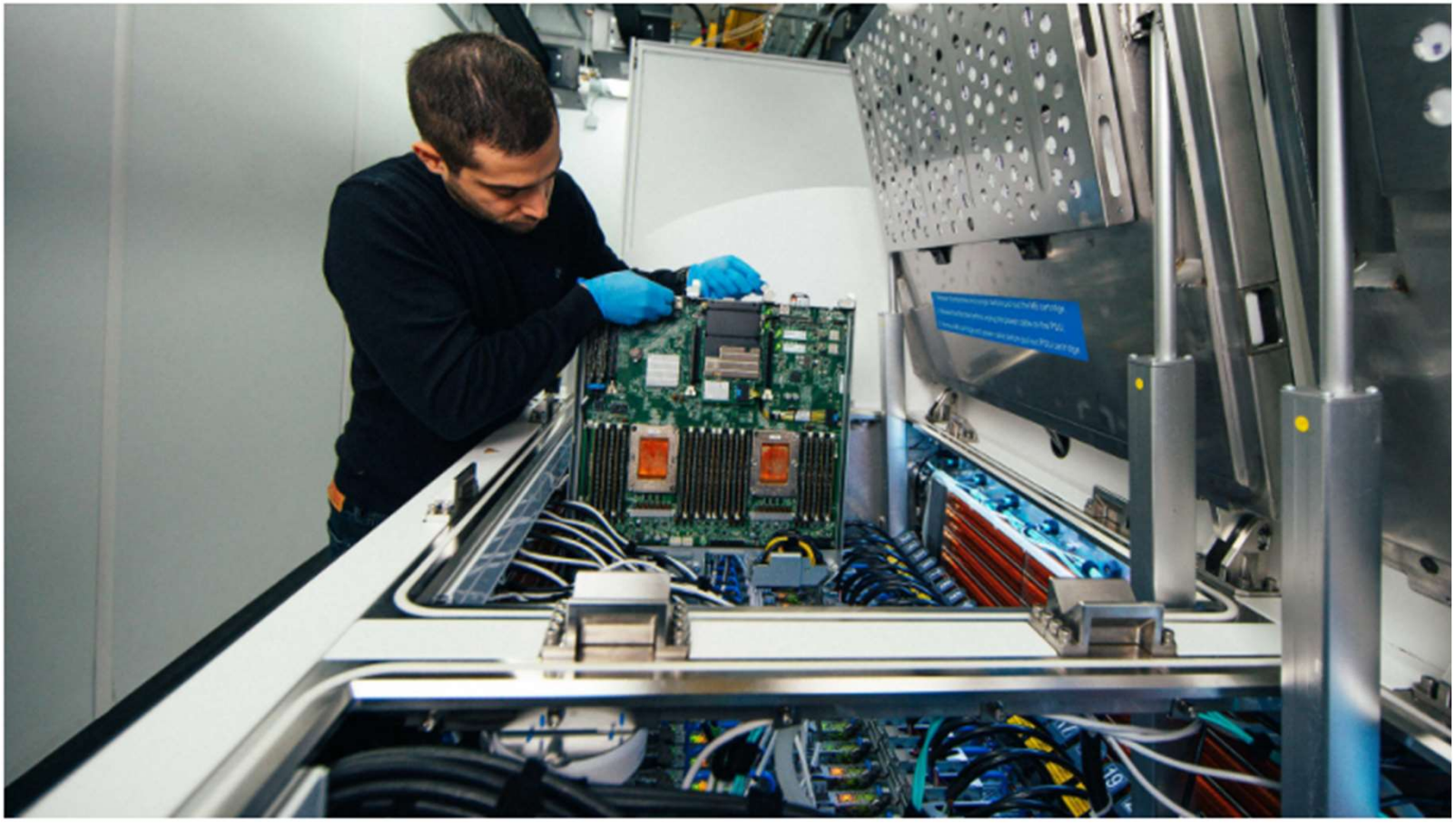
Microsoft 2 phases immersion cooling (50ºC)



Ioannis Manousakis, a principal software engineer with Azure, removes a server blade from a two-phase immersion cooling tank at a Microsoft datacenter. Photo by Gene Twedt for Microsoft.

https://news.microsoft.com/innovation-stories/datacenter-liquid-cooling/

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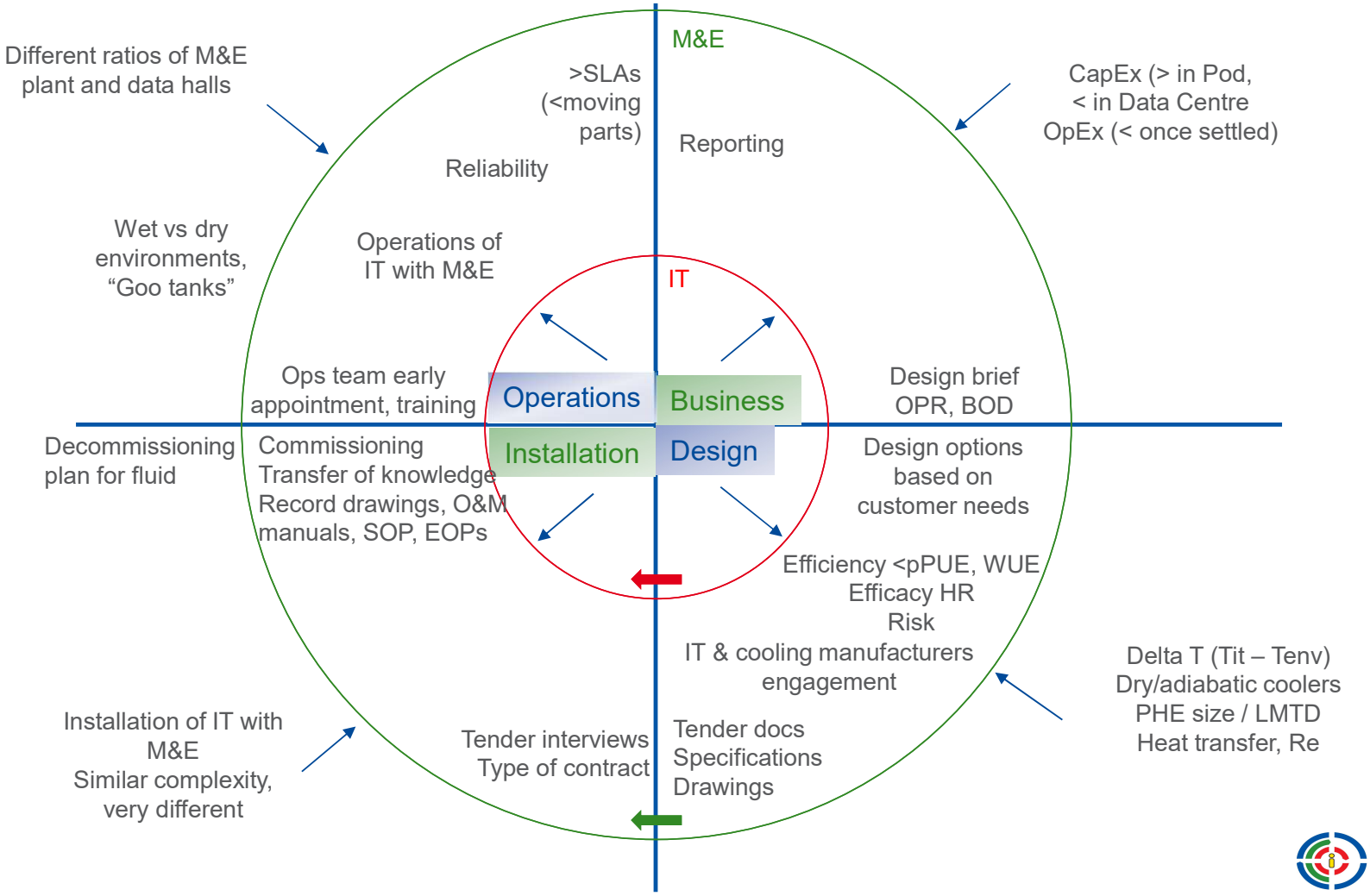
IT Liquid Cooling Challenges: training & connecting 2 different worlds (IT with M&E) – Add HR to this!



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Audience Questions

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