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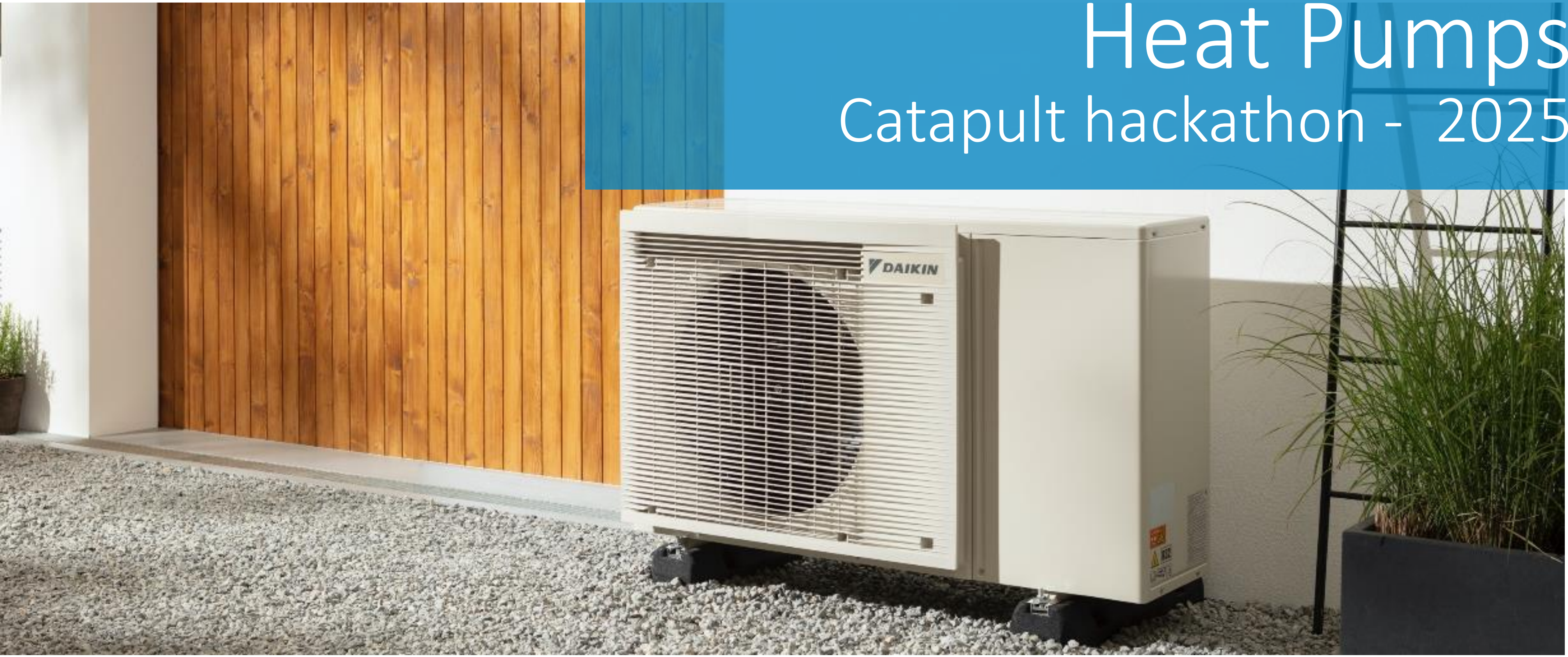
CATAPULT Energy Systems

Robert Heath a member of DAIKIN group

Heat Pumps

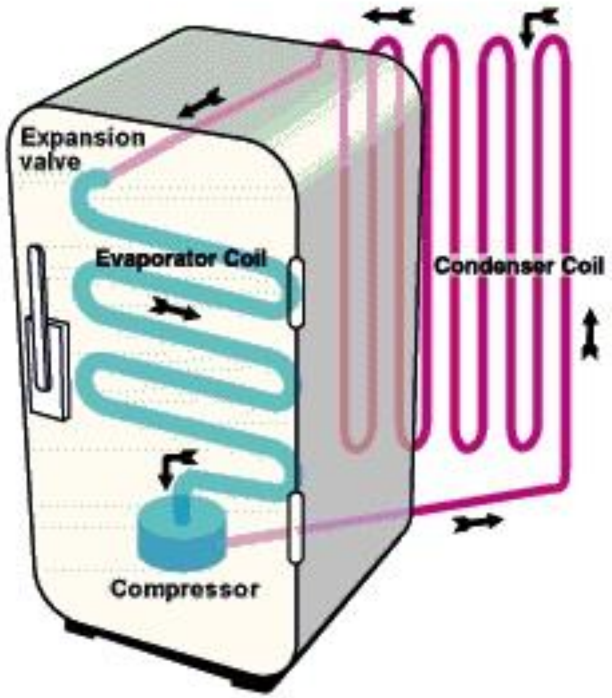
Catapult hackathon - 2025



Everyone is already comfortable with heat pumps (for cooling):

What is a heat pump?

- Your fridge at home is cold inside and hot at the back. The fridge absorbs heat from the inside and rejects it out the back.
- If you cut a large hole in the kitchen wall and install the fridge half inside and half outside with door open:
  - It will remove heat from the kitchen and pump it outdoors
  - In a crude way this would cool the kitchen...
- If you turned it around, the cold end (evaporator) would be outside and the hot end (condenser) would be inside
  - This fridge will now absorb heat from outside and transport it into your kitchen
  - It will therefore heat the room
- Essentially this is what a heat pump system does



Cycling and design temperature

Cycling:

- Cycling is when a compressor turns on and off known as a cycle, third party thermostats with TPI (time proportional & integral) control will cycle when close to set point, this should be avoided at all costs
- A compressors life is affected by cycling along with running hours, like a car engine
- Starting a compressor takes more energy than maintaining it at low modulation thus costing more to run
- Modern compressors are designed to modulate not cycle typically 30%-100% range

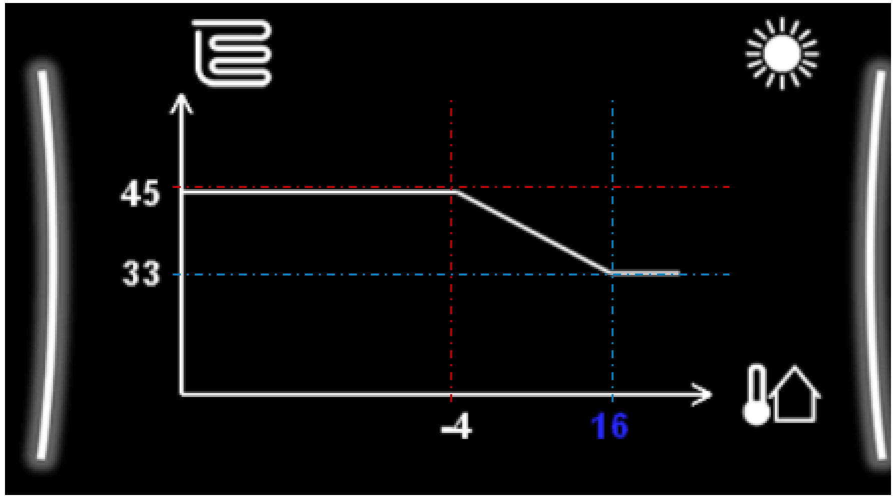
Design flow temperature:

- Lower flow temp = higher COP
- Not all emitters are equal: Underfloor 35c Radiators 45c [generally]
- To lower flow temperature you need to increase emitter surface area
- More energy is required to achieve higher temperatures as it requires more compressor/fan (electrical) input

Weather compensation [dependant]

Automated system flow temperature based on the outdoor temperature, This has two benefits, increased comfort by maintaining a more stable space temperature, as less likely to overshoot room set point. As we are lowing the designed flow temperature this will increase efficiency [SCOP].

- These are adjustable an engineer changing the main points of the WC, by the homeowner by using an offset +/-.
- These settings can have a negative impact on SCOP if the operator does not know what they are doing.
- Increases flow temperature during cold weather up to set limit on curve to meet heat demand
- Decreases flow temperature during warmer weather to increase efficiency



Example:

45^{o}C flow at -4 ^{o}C and below

33^{o}C flow at 16 ^{o}C and above

Considerations & differences

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Design – Not all surveys are equal

Fossil fuel boilers:

Extremely forgiving with simple commissioning.

Q: **Does the wider system impact heating performance?**

A: Yes for efficiency but this is not always automatically calculated and available to see, in some cases the home will still heat to target temperature

Q: Are room by room heat loss calculations carried out for gas boiler replacements

A: They should be but often are not carried out, sometimes even a full home heat loss is lacking

Q: Does the declared boiler efficiency consider system design

A: No a boiler is assessed as a product and its efficiency declared, yes for a heat pump (MCS cert)

Q: Does an EPC take into account the wider emitter and pipe sizing

A: No RDSAP is basic and declares the known boiler efficiency assuming SAP tables are not used, for a heat pump there is an option to select the system design temperature but this is not always used (this temp is on the MCS Cert)

Comparison – Gas boiler and Heat pump

- Rapid heat up for fast heat delivery
- Very forgiving on poor design, but efficiency is sacrificed (less obvious due to low gas cost)
- Understood and simple controls
- Instant hot water (combi) Faster heating stored
- Long established vast skilled workforce
- Stable efficiency throughout seasons
- Weather compensation is optional

- Designed to slowly (ish) achieve and maintain temperature
- Good system design essential to optimal efficiency
- Different control principles lesser known
- Stored priority hot water system
- Small but growing workforce skilled people in high demand
- Variable efficiency across seasons – seasonal average used
- Weather compensation is often a standard feature

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Surveyor knowledge and qualifications heat pumps vs gas boiler

Higher or Lower

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Design – The gas boiler surveyor

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Essential skills for an effective heat pump survey:

- Building fabric and ability to recognise it in real world
- Full heating system installations knowledge & understanding
- General building knowledge
- Asbestos recognition

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Essential qualifications:

- L3 Water bylaws
- L3 Part L energy efficiency
- L3 G3 unvented hot water
- NVQ L2/3 plumbing/heating or gas safe

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Note not all businesses use qualified surveyors

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Design – The heat pump surveyor

Essential skills for an effective heat pump survey:

- Building fabric and ability to recognise it in real world
- Full heating system installations knowledge & understanding
- General building knowledge
- Asbestos recognition
- **Understanding of priority hot water**
- **Retrofit and its sequencing**
- **Electrical loads and the load checking process**
- **MCS process**
- **MCS 023/PAS 2030 additional requirements to MCS 3005(usually funded and LAHA work only)**

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Essential qualifications:

- L3 Water bylaws
- L3 Part L energy efficiency
- L3 G3 unvented hot water
- NVQ L2/3 plumbing/heating or gas safe
- **L3 installation and maintenance of heat pumps**

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Note not all businesses use qualified surveyors

Design – Key considerations

Design & install – Key considerations

- Heat demand of home (at point of install)
- Heat demand for each room
- System design temperature
- Outside unit positioning
- Cylinder/inside unit positioning
- Minimum water volume
- Minimum external design temperature
- Hot water capacity
- Electrical load of home
- Other measures that may interact with the unit
- Planning permission/permitted development
- Sequencing if part of a wider retrofit
- Controls including location
- Future plans for the home
- Pipe and cable routes
- Disruption

Design & install– Key considerations	Potential issues
• Heat demand of home (at point of install)	Undersized or oversized unit
• Heat demand for each room	Comfort & performance
• System design temperature	Efficiency and pipe & emitter sizing
• Outside unit positioning	Air flow, noise, planning/PDR
• Cylinder/inside unit positioning	Maximum MI distance to external unit
• Minimum water volume	Anti-freeze cycle and compressor cycling
• Minimum external design temperature	Anti-freeze cycle and unit sizing
• Hot water capacity	Resident comfort
• Electrical load of home	Electrical damage to home or grid
• Other measures that may interact with the unit	Over/under sizing, efficiency, compatibility
• Planning permission/permitted development	Regulatory liability
• Sequencing if part of a wider retrofit	Over/under sizing risk
• Controls including location	Comfort and efficiency
• Future plans for the home	Over/under sizing or comfort
• Pipe and cable routes	Short cycling or poor comfort
• Disruption	Customer satisfaction

Basics of Heat Pumps

Design & install – Key considerations	Potential issues	Data insight
• Heat demand of home (at point of install)	Undersized or oversized unit	Low COP, iTemp, High energy use
• Heat demand for each room	Comfort & performance	Low itemp, High energy use, Low COP
• System design temperature	Efficiency, pipe & emitter sizing	Unusually high or low cop
• Outside unit positioning	Air flow, noise, planning/PDR	Low COP or low temp
• Cylinder/inside unit positioning	Maximum MI distance to external unit	Unlikely to identify
• Minimum water volume	Anti-freeze cycle and compressor cycling	High energy, no heat output, low COP
• Minimum external design temperature	Anti-freeze cycle and unit sizing	Failure in extreme temps
• Hot water capacity	Low COP, prolonged heat pump operation	COP, running time, drops in itemp
• Electrical load of home	Nuisance tripping, damage to home or grid	Drop-outs in data
• Other measures that may interact with the unit	Over sizing, efficiency, compatibility	Cycling reduced COP
• Other measures that may interact with the unit	Under sizing, efficiency, compatibility	Low int itemp, high energy use
• Planning permission/permitted development	Regulatory liability	Unlikely to identify
• Sequencing if part of a wider retrofit	Over sizing risk	Cycling reduced COP
• Sequencing if part of a wider retrofit	Under sizing risk	Low itemp, high energy use
• Controls including location	Comfort and efficiency	low COP, erratic itemp, high energy use
• Future plans for the home	Over/under sizing or comfort	See Sequencing response's
• Pipe and cable routes	Short cycling or poor comfort	Low temp, low COP
• Disruption	Customer satisfaction	Unlikely to identify

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Itemp = inside temperature

Potential issues – Post install

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Post install – Potential issues	Symptom	Fix
• Restricted air flow to external unit	Low COP, Low temp	Remove blockage
• User controls input	Erratic temp & low cop	Educate on controls & principles
• Debris in the system/quality of water	Failure & error code [7H]	Clear strainer and fix water quality
• Glycol mix	Low temp, COP or error code	Fix glycol level & ensure mixed
• Short cycling	Low cop, frequent power cycles	Check system design & control
• Home not achieving temp	Low temp, unit size	Check system design & control
• High running costs	High electric bills	Check system design, check other
• Poor COP	COP is just a snapshot	Check SCOP
• Poor SCOP	All of the above	SCOP VS running cost
• Pump noise	complaint of pump noise	sample speed can be adjusted

Please consider the reason could be setting related

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Thank you