Decarbonising heating and use of heat pumps - schools

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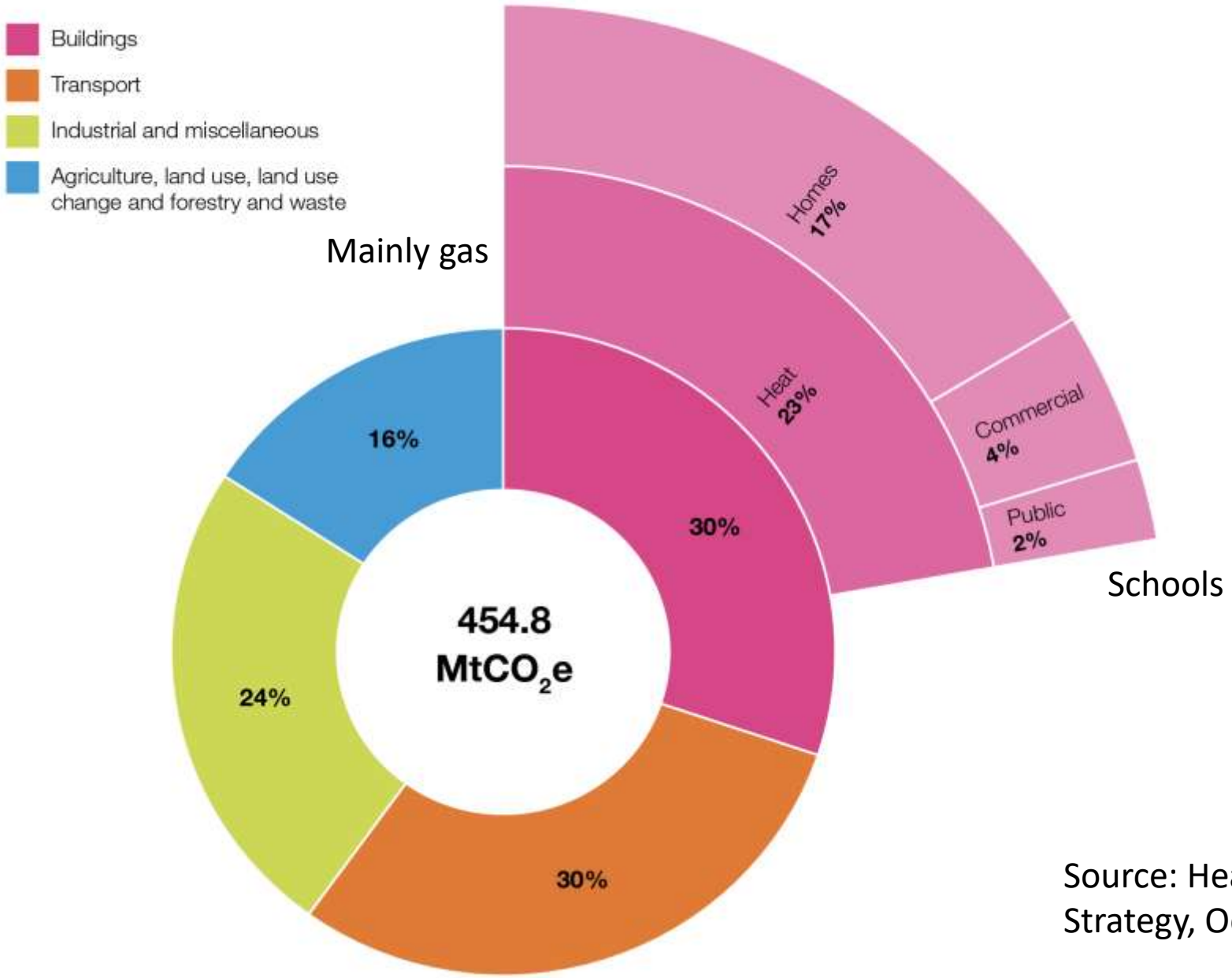
Drivers for school environments

- Providing comfortable, well-ventilated spaces
- Cost – fuels, capital
- Carbon reduction – net zero by 2050
- Future proofing – energy, climate change adaptation

Figure 2: UK emissions in 2019

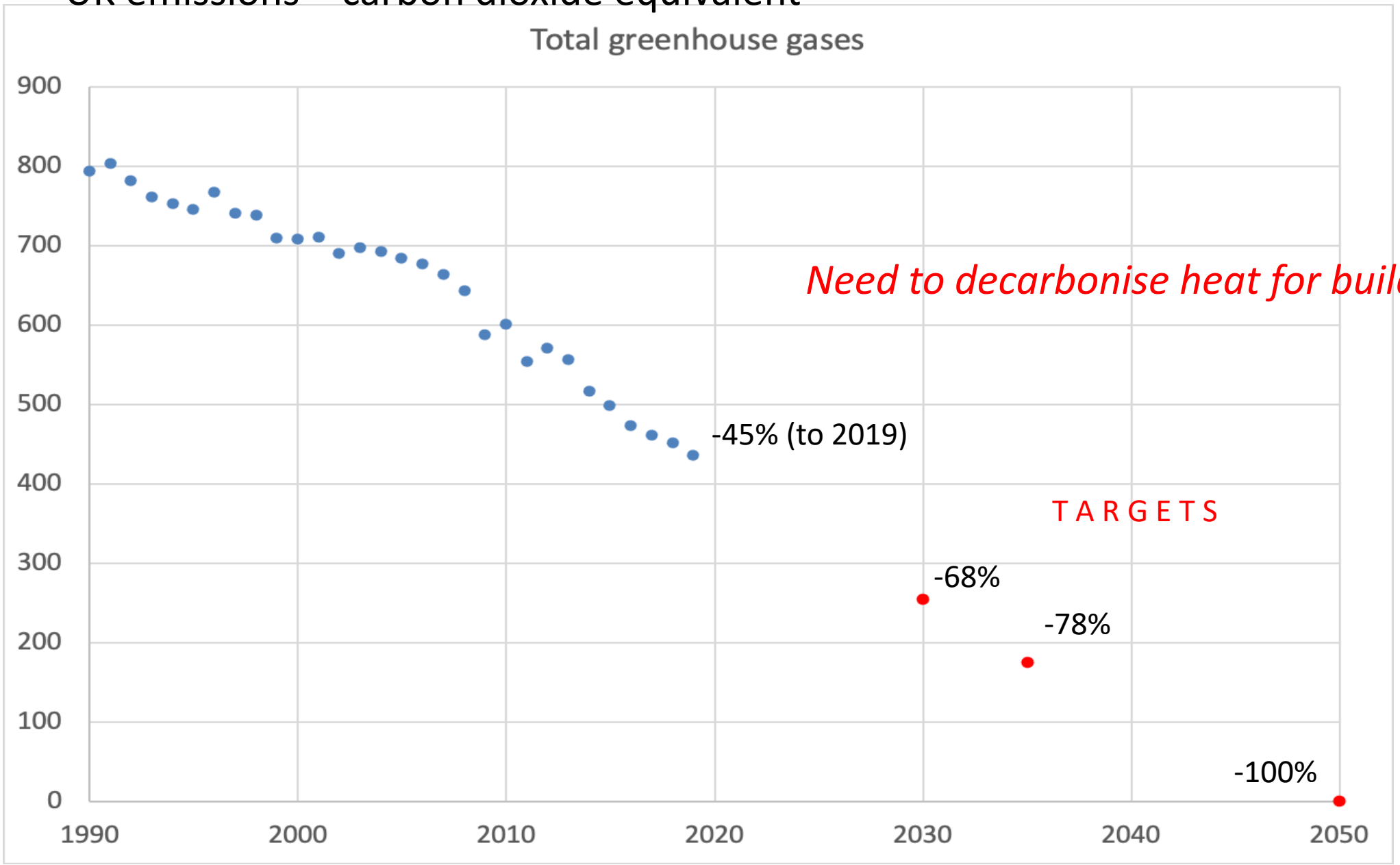


Mainly gas

Schools

Source: Heat and Buildings Strategy, October 2021

UK emissions – carbon dioxide equivalent



Need to decarbonise heat for buildings

Classrooms are unique spaces

- High density and metabolic heat gains when occupied
- High ventilation demand (CO_2 below 1000 ppm)
- Flexible use of space, many activities
- Daylit
- Natural ventilation usually favoured
- Often opened to external spaces
- External noise may be a problem
- Wall space used for displays etc.

CIBSE TM57 Integrated school design

Fabric first?

- New build
  - Much reduced heat loss and infiltration compared to old stock
  - Some Passivhaus schools
  - More likely to have mechanical ventilation
  - In theory low heat demand, but not always in practice
  - Commissioning, control complexity, Soft Landings
  - Overheating and ventilation sometimes a problem
- Older schools
  - High heat loss, heating dominated
  - ‘Deep’ refurbishment is very expensive
  - Careful lifetime analysis of capital and operational costs required, to balance retrofit against supply options

A few years ago

Gas

Low carbon fuel

Cheap

Simple to install and control

No local pollution

Obvious choice on gas grid

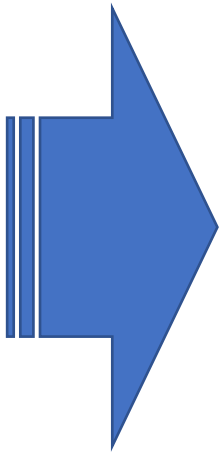
Electricity

High carbon

Expensive

No local pollution

Not suitable for heating



Now

Gas

~~Low~~ ~~carbon~~ fossil fuel

~~Cheap~~ expensive

Simple to install and control

No local pollution

~~Obvious choice on gas grid~~

Electricity

~~High~~ low, reducing carbon

Expensive

No local pollution

~~Not suitable for heating~~

Use in heat pump for heating

Can generate some on site

What is a heat pump?

- Moves heat from cooler to warmer
  - Opposite to the natural flow from warm to cool
- This requires energy input – usually into a compressor (a heat engine uses a heat flow to produce power – e.g. petrol engine, turbine)
- Extract heat from a space to outside
  - cooling: ‘air conditioning’, refrigeration
- Extract heat from outside to a space, or domestic hot water
  - heating (usually referred to as heat pump)
- Thermodynamic limits to efficiency: typically
  - Heat transferred ~ 2 – 4 times energy input (electric, usually)
  - This ratio is called the Coefficient of Performance or COP

Why heat pumps for heating?

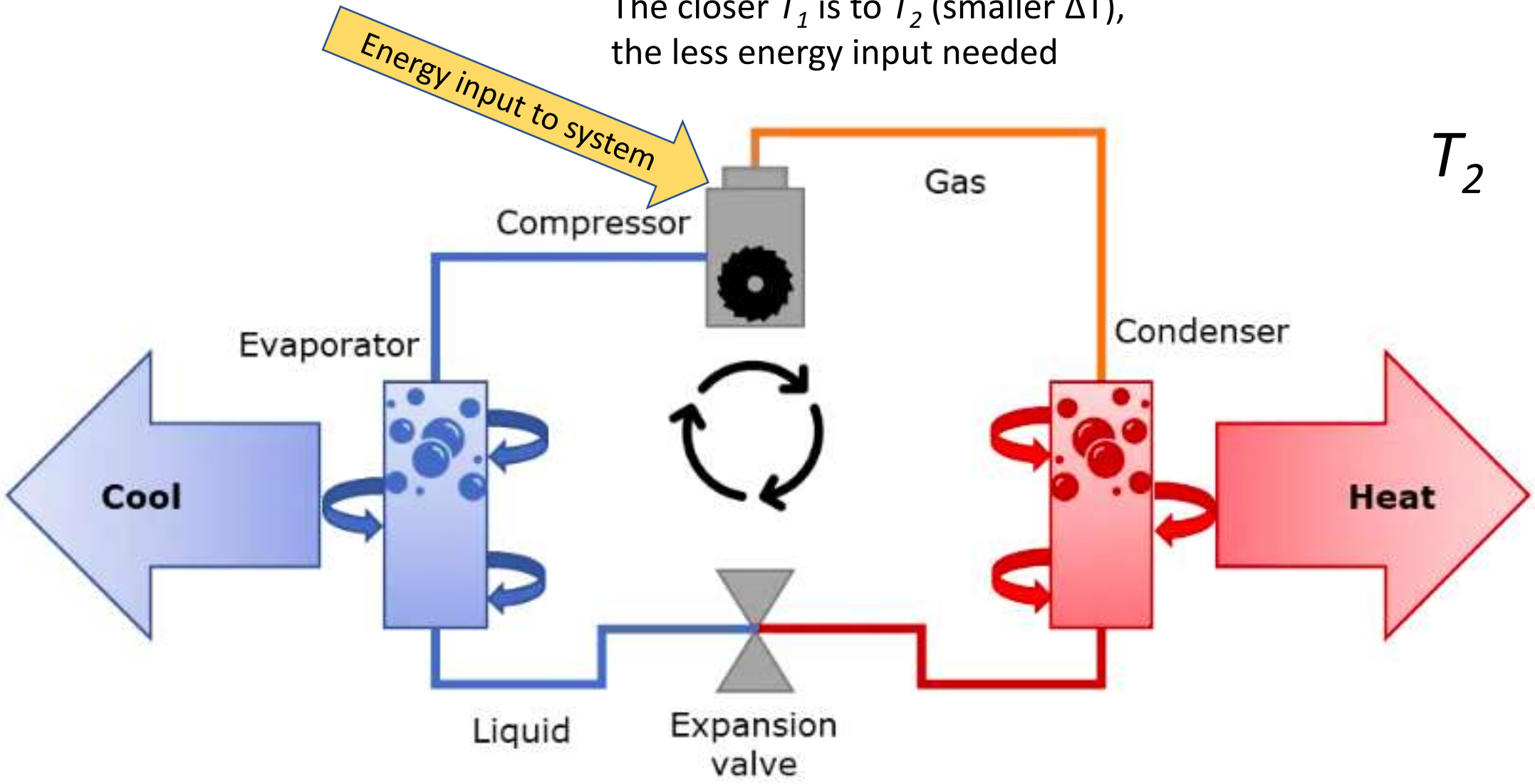
- Decarbonised electricity makes heat pumps low carbon
- Currently grid electricity produces ~ 0.2 kg. CO_2 per kWh
- A heat pump with COP of 3 gives 0.2/3 ~ 0.07 kg.CO_2 per kWh heat
  - Compare to gas boiler of about 0.22 kg.CO_2 per kWh heat
- Electricity should decarbonise further with more renewables, nuclear, less gas

Heat pumps

The closer T_1 is to T_2 (smaller ΔT), the less energy input needed

T_1

T_2



Air source heat pumps

- Cheapest, simplest solution
- Not efficient in cold weather due to low air temperatures and icing
- Generate some noise
- Could be used reversibly for cooling, with air delivery inside building

Ground Heat Exchangers

- Ground Source Heat Pump (GSHP) [system]
- More efficient than air as ground has more stable temperatures
- Typical borehole depth 100m
- Drilling is expensive! Major part of GSHP system cost

Drilling at DMU for Hugh Aston Building (this building)

Solar assisted ground heat storage

Rooftop with PV-thermal (PVT) panels collecting heat and generating electricity

Drilling shallow 1.75m boreholes

Dropping pipe network into holes to store solar heat

https://www.zerocarbonhub.org/solar-house

Video: https://www.dmu.ac.uk/about-dmu/news/2015/july/sky-tv-puts-dmus-solar-house-research-in-spotlight-video.aspx

Water source heat pumps

- Very location dependent
- Excellent heat transfer from water
- Stable temperatures
- DMU is looking at feasibility of using River Soar water for heating and cooling its buildings

Internal heat emitters

- Lower temperatures for high efficiency
- So larger surface areas
- May not be able to retrofit to existing radiators
- Underfloor heating (but better not carpeted)
- Air systems (can be used for cooling)

Figure 44 Thermal image of underfloor heating system

From CIBSE TM57

Other options

- ~~Combined heat and power~~
- Biomass boilers
- Hydrogen
- Direct electric

Questions and discussion