Greening your home

SuperHome truths about energy efficiency

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Climate scientist at the University of Reading and the Met Office
Homeowner in Reading

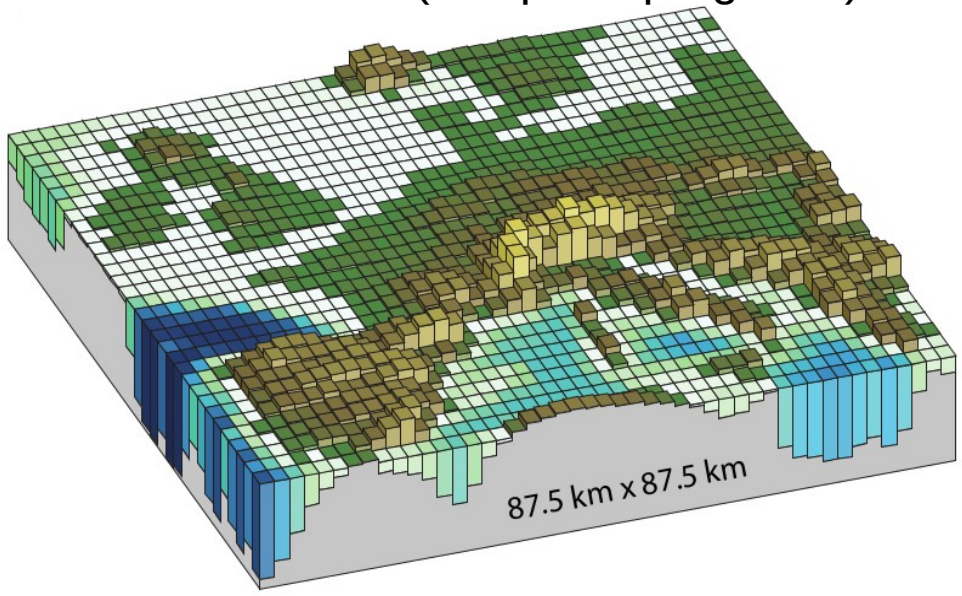
My house in Reading is Pioneer SuperHome 134 (of about 250)
superhomes.org.uk is a network for sharing best practice
in domestic energy reduction and home comfort

Climate science

Observations from space, in the atmosphere, at the surface, in the ocean

Partial knowledge of the real world

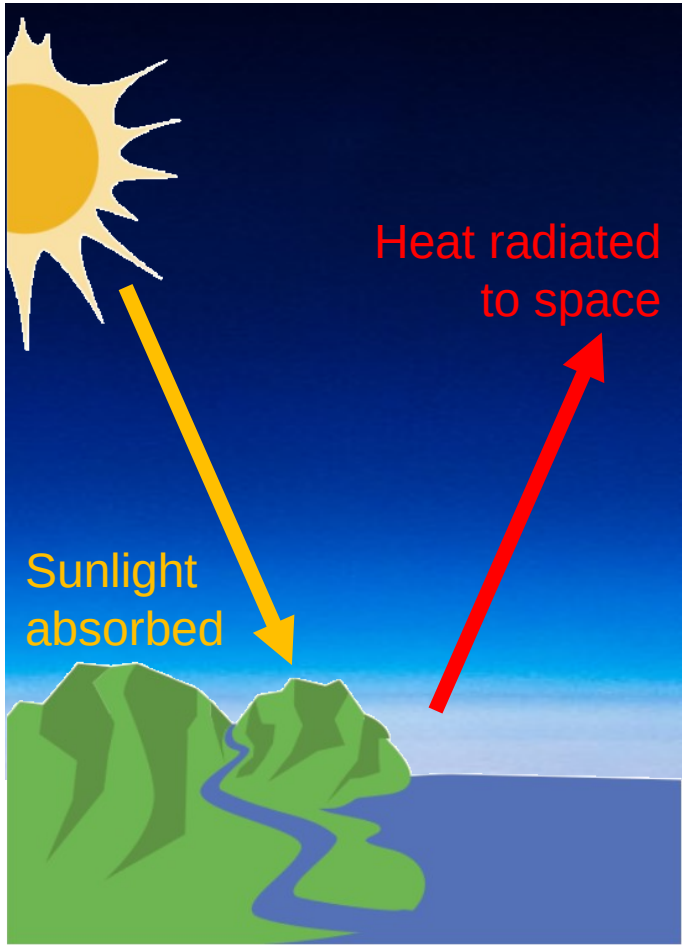
Simulations of past and future climate by climate models (computer programs)



Complete knowledge of an unreal world

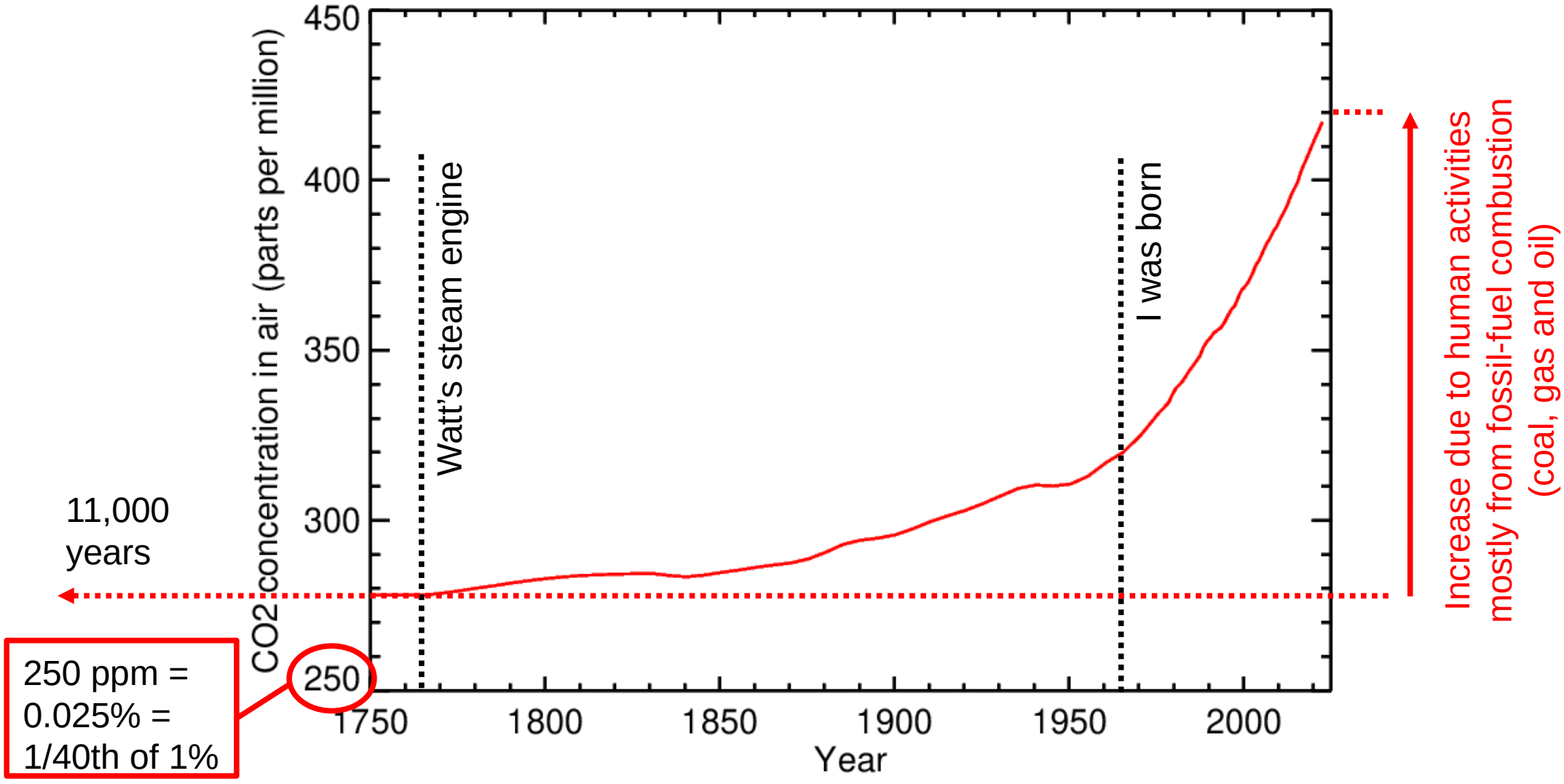
Through analysis and comparison of observations and simulations (“climate experiments”) and physical theory we seek to understand and predict the behaviour of the climate system

Carbon dioxide (CO_2) and other greenhouse gases warm up the climate by impeding heat loss



IPCC and Met Office

The amount of CO_2 in the atmosphere has risen by 50% because of us



It is unequivocal that human influence has warmed the climate

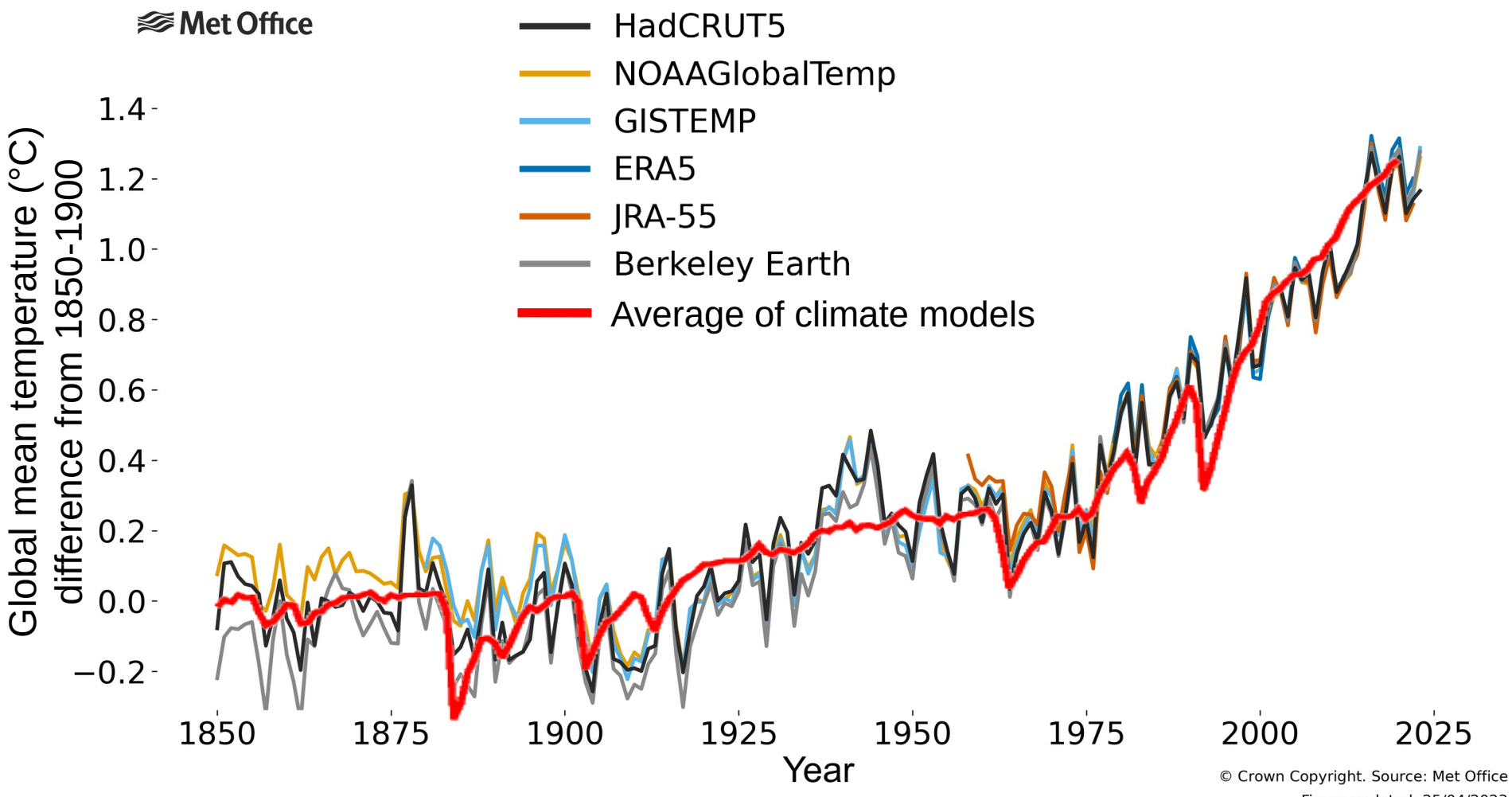
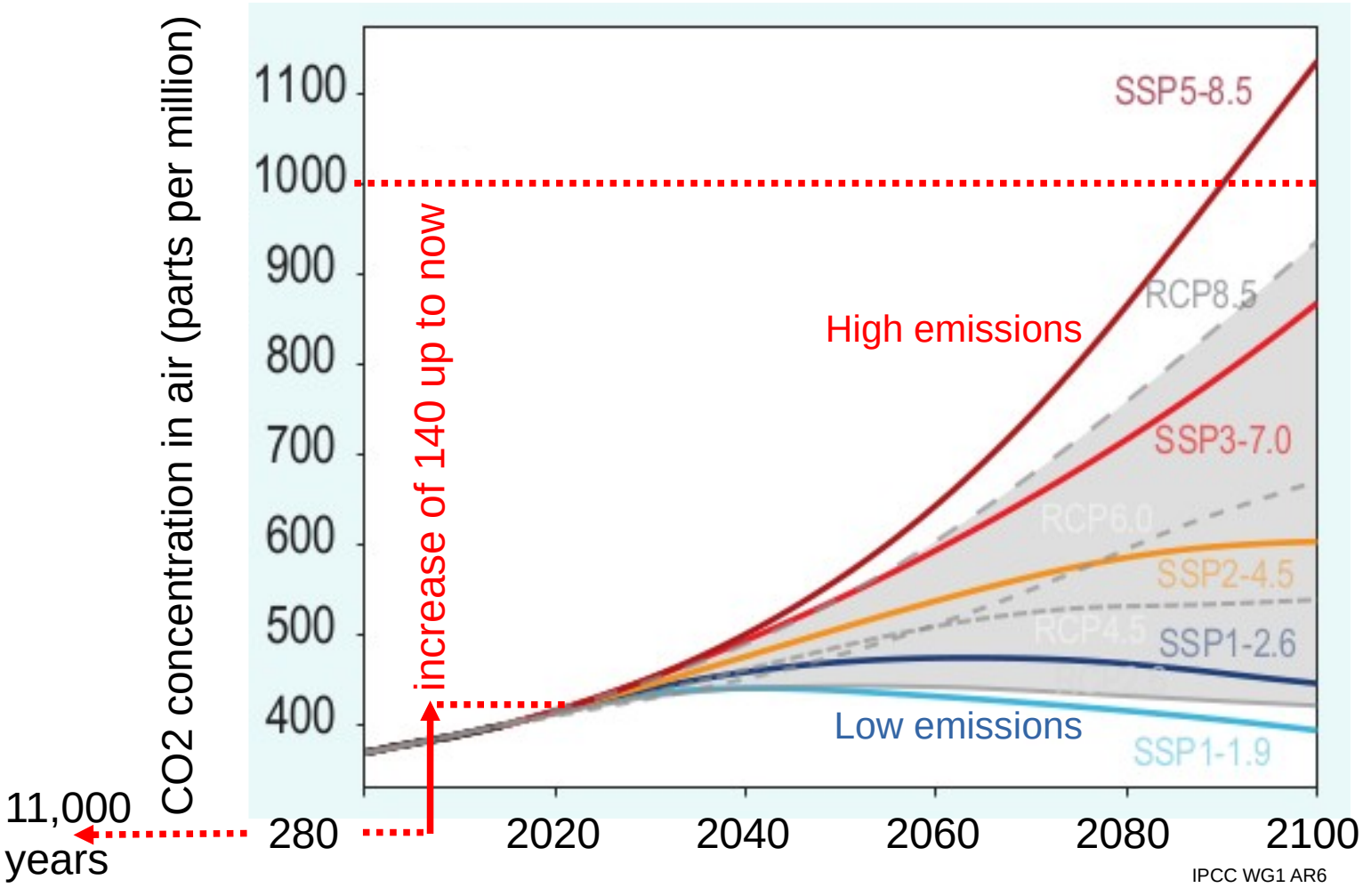


Figure updated: 25/04/2023

Climate model data from IPCC WG1 AR6 Fig 3.4b

Future CO_2 concentration depends on what we do—now and in the future

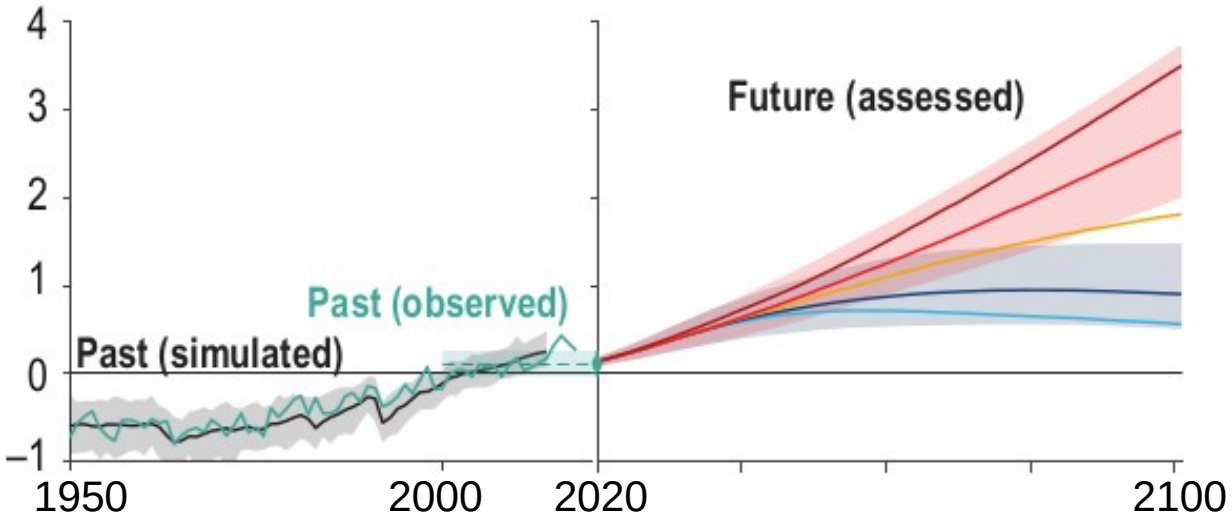


IPCC WG1 AR6

Humans suffer significant cognitive impairment at 1000 ppm CO_2

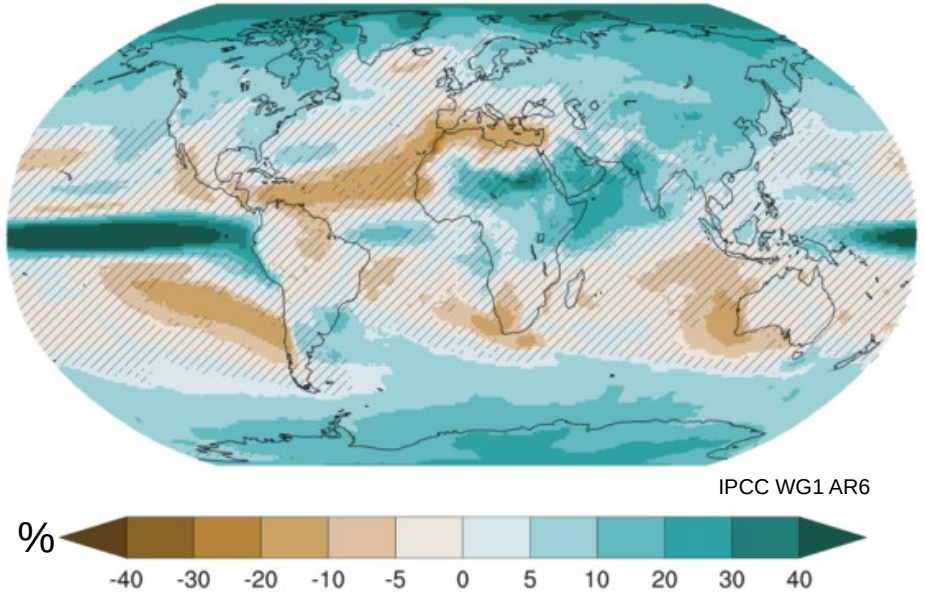
Future climate change depends on what we do—now and in the future

Global mean temperature (°C) difference from 1995-2014



IPCC WG1 AR6

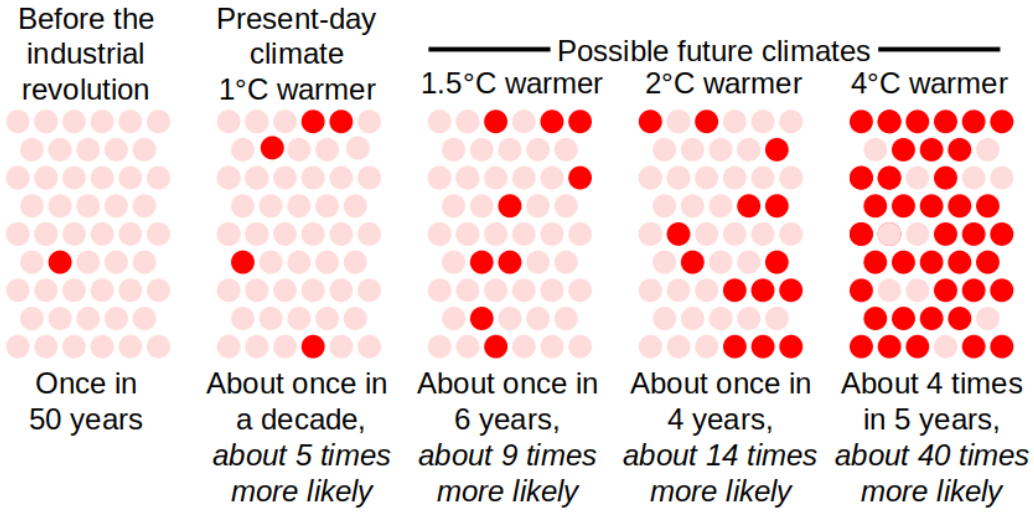
Change in precipitation
2080-2100 with medium emissions



IPCC WG1 AR6

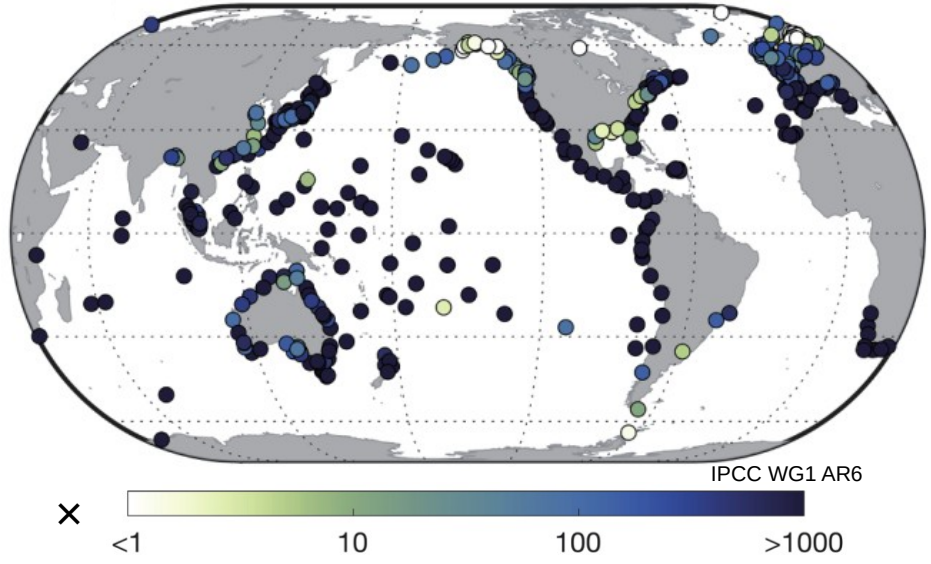
Future climate change depends on what we do—now and in the future

Extreme heat occurs more often in warmer climates



Increase in frequency of extreme sea level

2080-2100 with medium emissions



Intergovernmental Panel on Climate Change (IPCC)

The IPCC was established in 1988. It is an organisation of the UN, with 195 member-countries.

It makes policy-relevant (not policy-prescriptive) assessments of what we know about climate change.

The IPCC Sixth Assessment Report was published in four parts during 2021-2023.

UN Framework Convention on Climate Change (UNFCCC)

The UNFCCC was agreed at the Rio Earth summit in 1992 and signed by 154 countries.

The parties to the UNFCCC agree to stabilise greenhouse gas concentrations in the atmosphere at a level that prevents dangerous anthropogenic interference with the climate system.

The Conference of the Parties (COP) meets annually: Kyoto 1997, Paris 2015, Glasgow 2021.

It is unequivocal that human influence has warmed the climate; future climate change depends on what we do

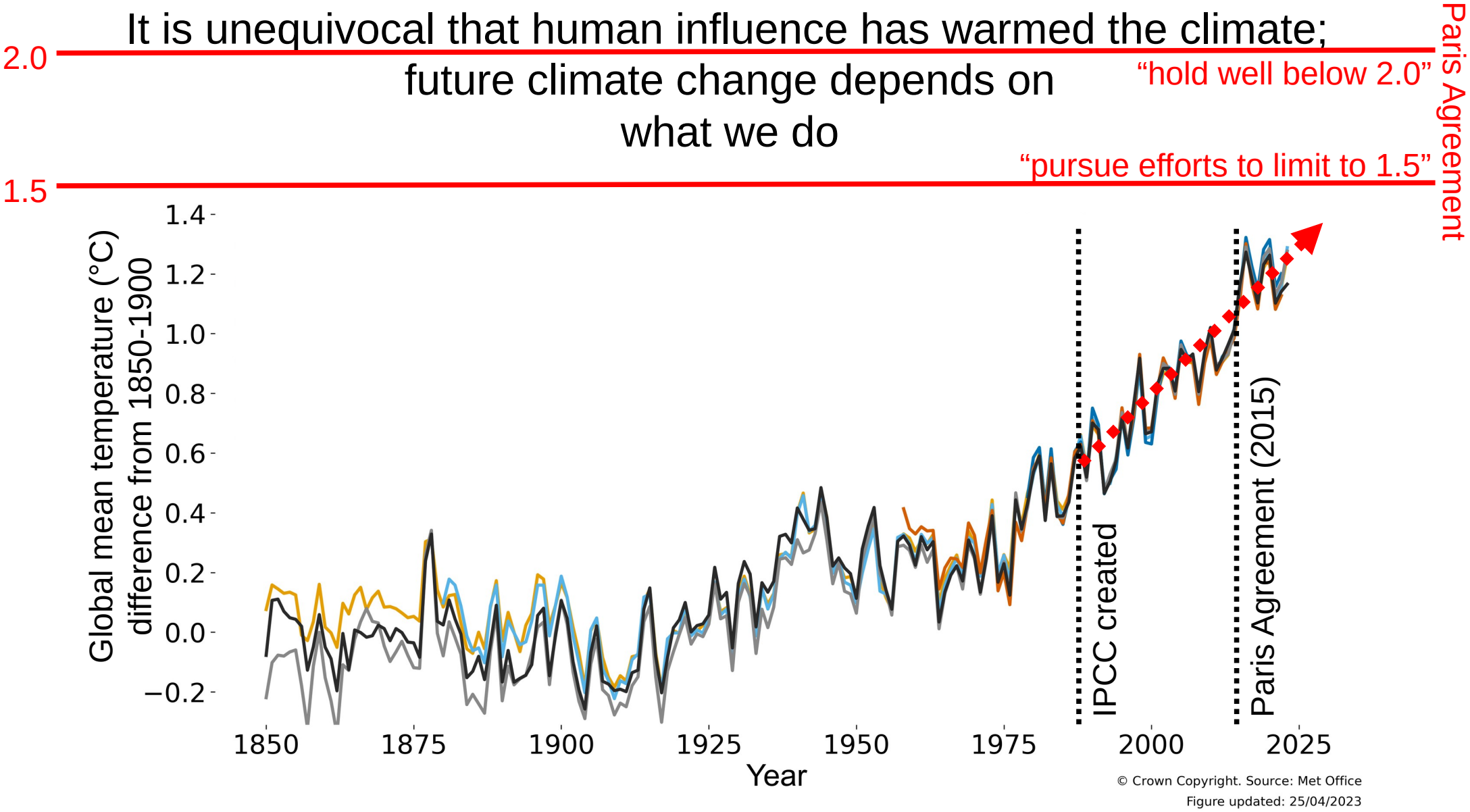
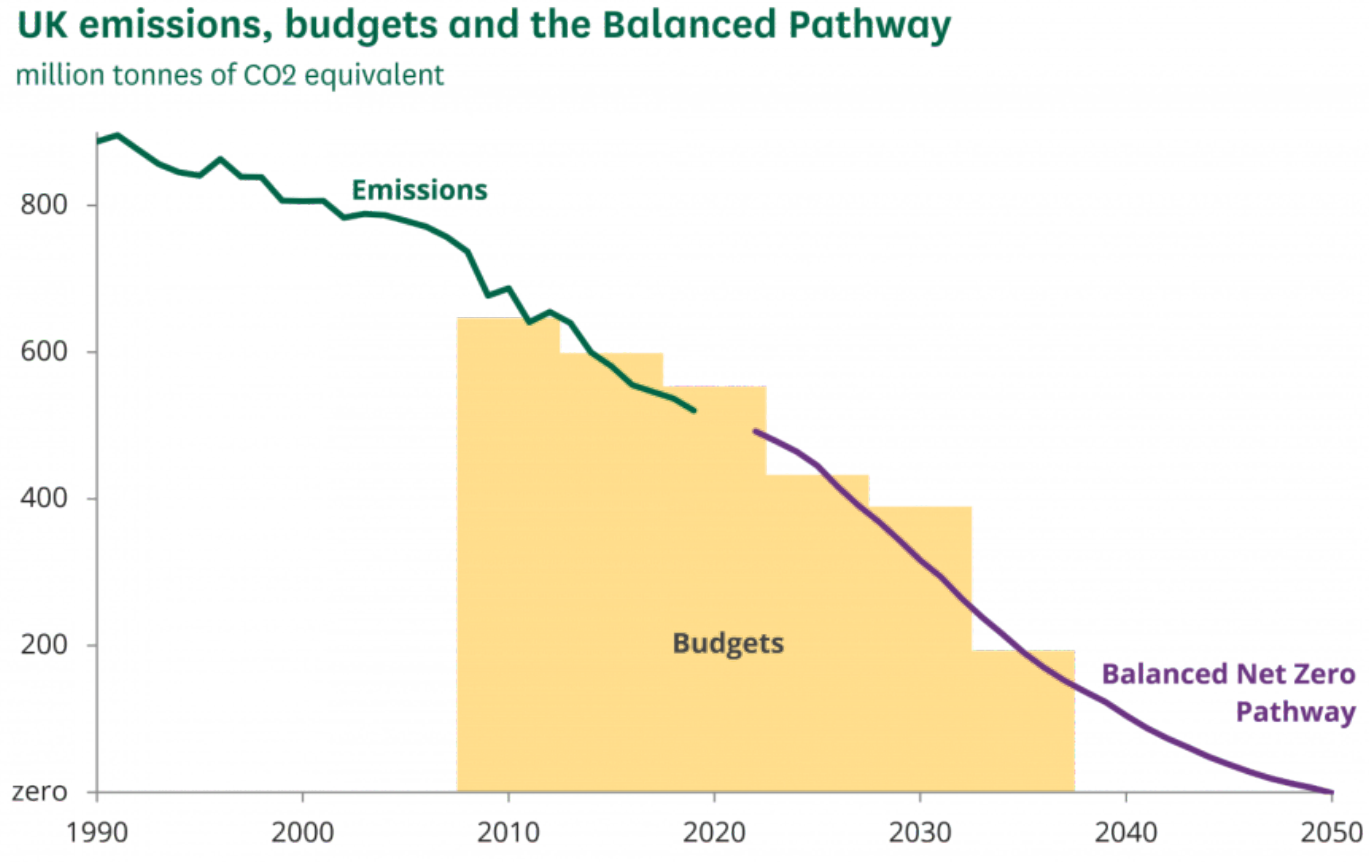


Figure updated: 25/04/2023

To stabilise the climate, we must stop putting CO2 into the atmosphere

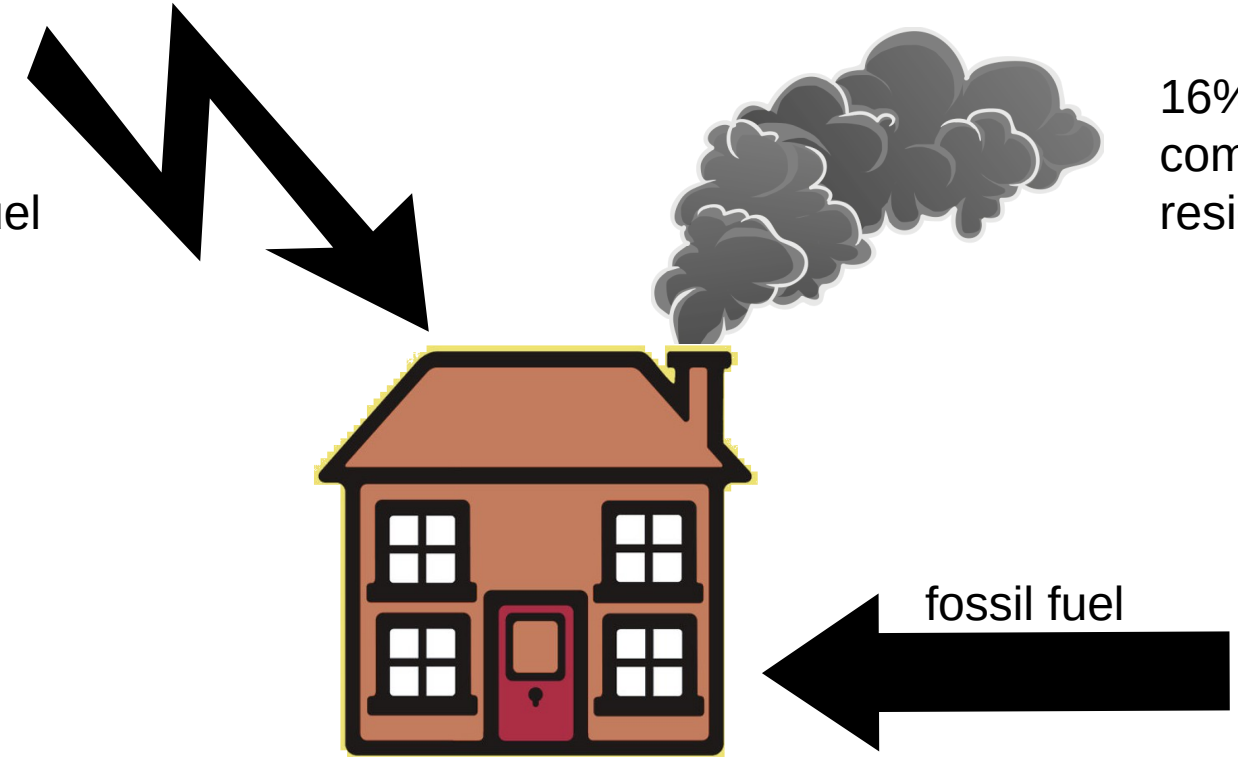
The UK target is to reduce greenhouse-gas emissions to net zero by 2050. We are about half-way there.



To stabilise the climate, we must stop putting CO2 into the atmosphere

The UK target is to reduce greenhouse-gas emissions to net zero by 2050. We are about half-way there. Residential emissions are about a quarter of the total.

8% of emissions come from generating electricity from fossil fuel for residential use



16% of emissions come from residential heating

To stabilise the climate, we must stop putting CO2 into the atmosphere

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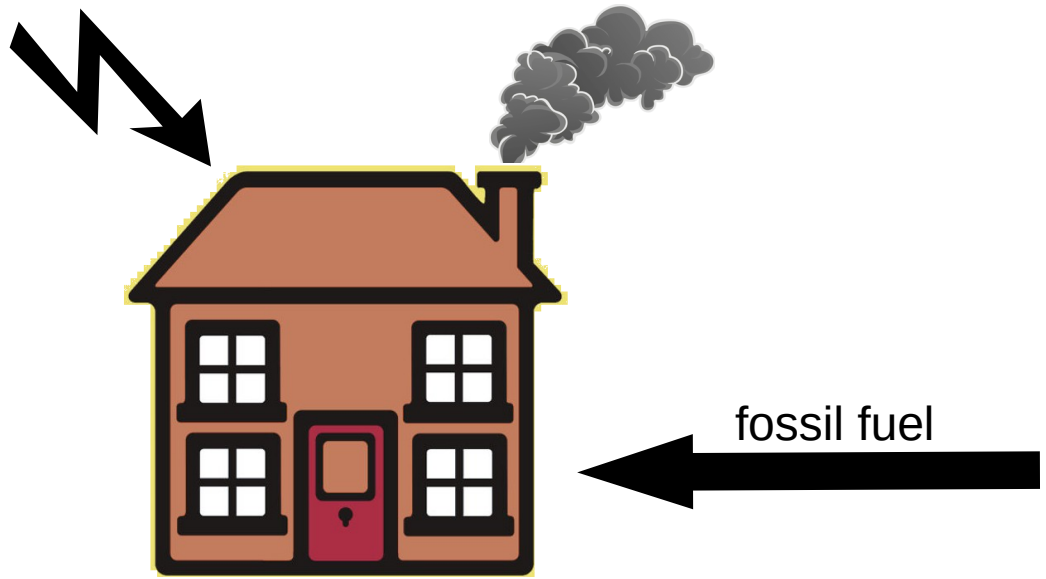
Residential emissions are about a quarter of the total.
To reduce residential emissions,
we must use less fossil-fuel energy

electricity from fossil fuel



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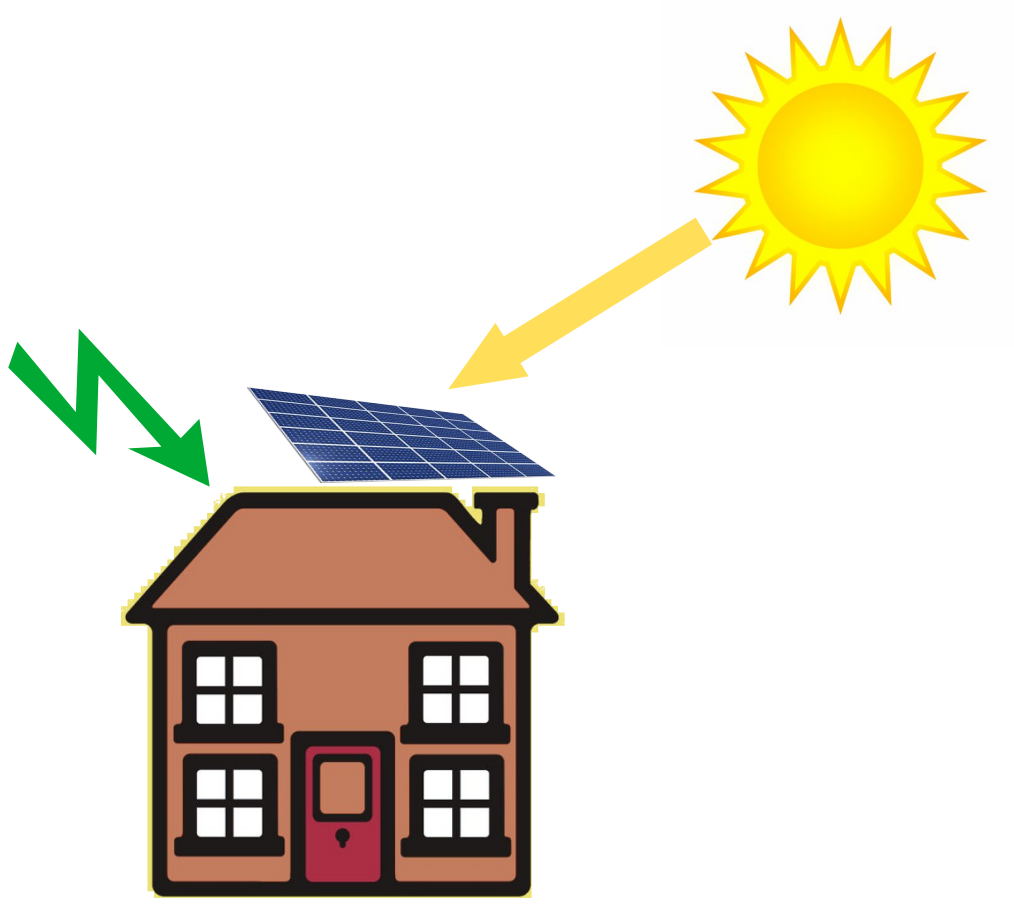
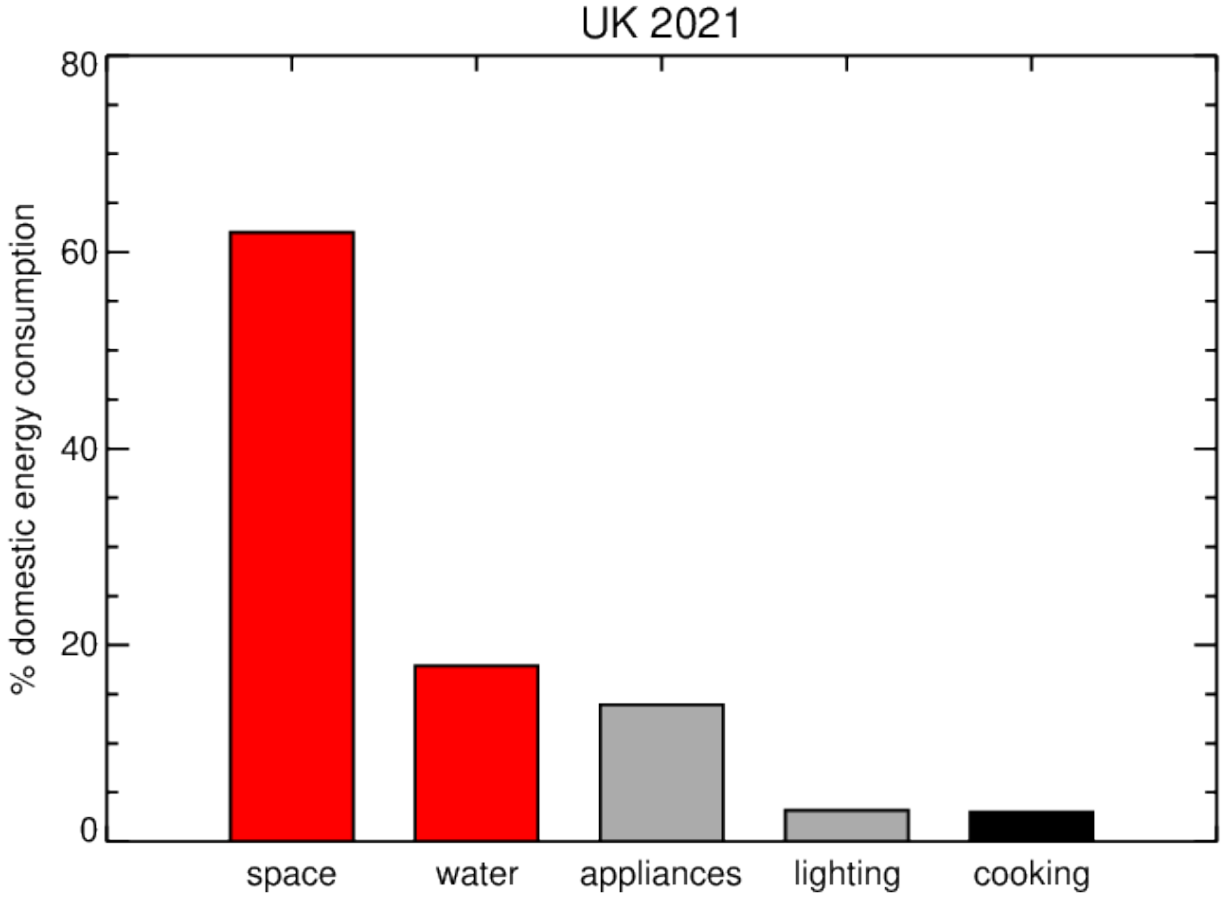
Residential emissions are about a quarter of the total.
To reduce residential emissions,
we must use less fossil-fuel energy
or use renewable energy instead

electricity from renewables



Effective ways to reduce residential CO2 emissions



Reduce space and water heating

Use a heat pump instead of a boiler

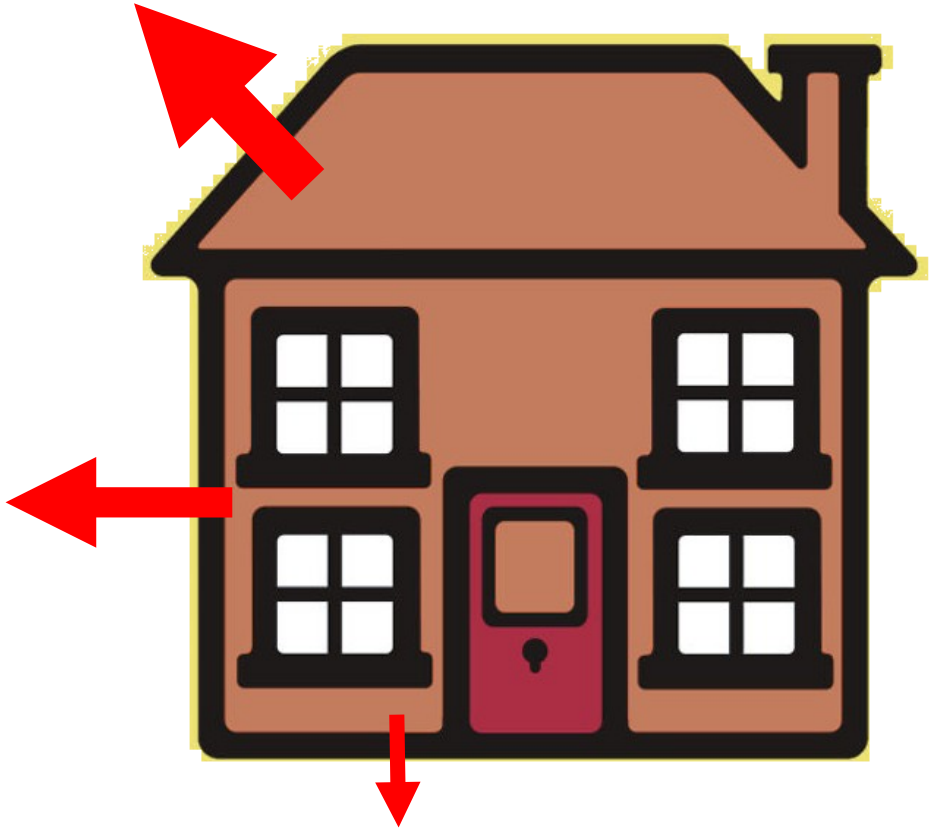
Use efficient electrical appliances (especially wet and cold appliances)

Buy renewable electricity or make your own

Don't be distracted by the myth that "Every little helps." If everyone does a little, we'll achieve only a little. We must do a lot. What's required are big changes in demand and in supply. (David Mackay)

Insulate Britain to reduce space heating

Heat leaks out of the house by conduction through the roof, walls, windows, doors and ground floor.
Reducing the “leakiness” means we need to supply less heat to keep the house “full of heat” (warm).



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Thermal insulation

To reduce the heat leak through a surface (roof, wall, door, floor) we add a layer of thermal insulation.

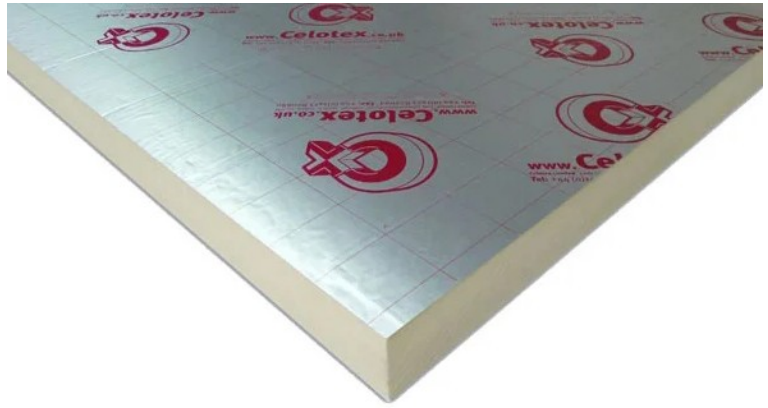
The ***U*-value** measures how effective the insulating layer is – the smaller the *U*-value, the better.
Building regulations specify maximum (worst) allowed *U*-values for new buildings and alterations.
A thicker layer gives more insulation and a lower *U*-value, which also depends on the material used.

For example, the roof of a new dwelling requires *U*=0.11, which can be achieved with loft insulation of

mineral wool layer
about 400 mm thick

or

PIR (polyisocyanurate) layer
about 200 mm thick



90% of the dwellings in Great Britain have lofts, of which 8.3M (30%) have **no loft insulation** (*U*≈2.5).

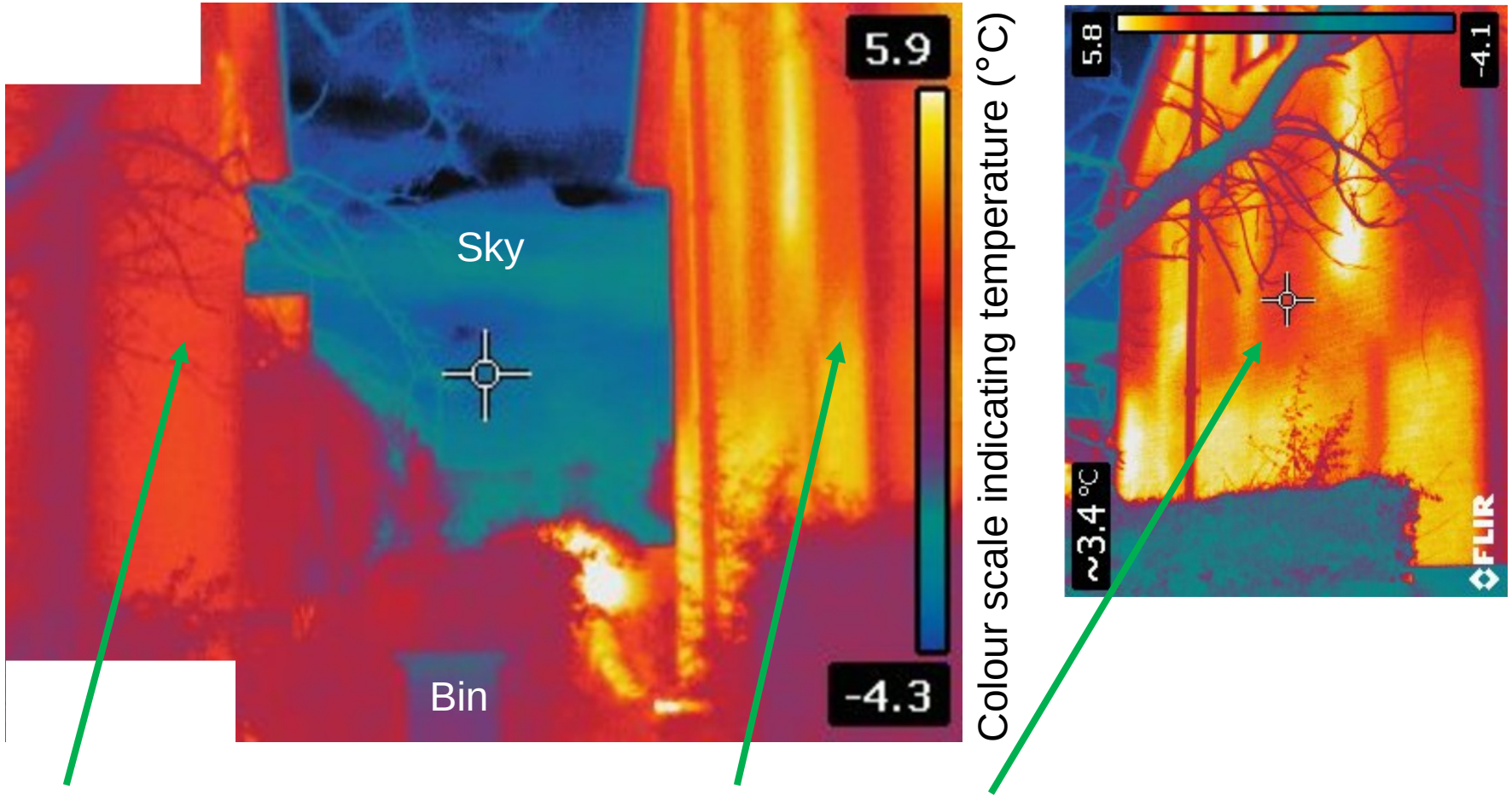
Exterior insulation of gable-end wall by creating a cavity

190 mm PIR

50% better than regulations for a new dwelling.

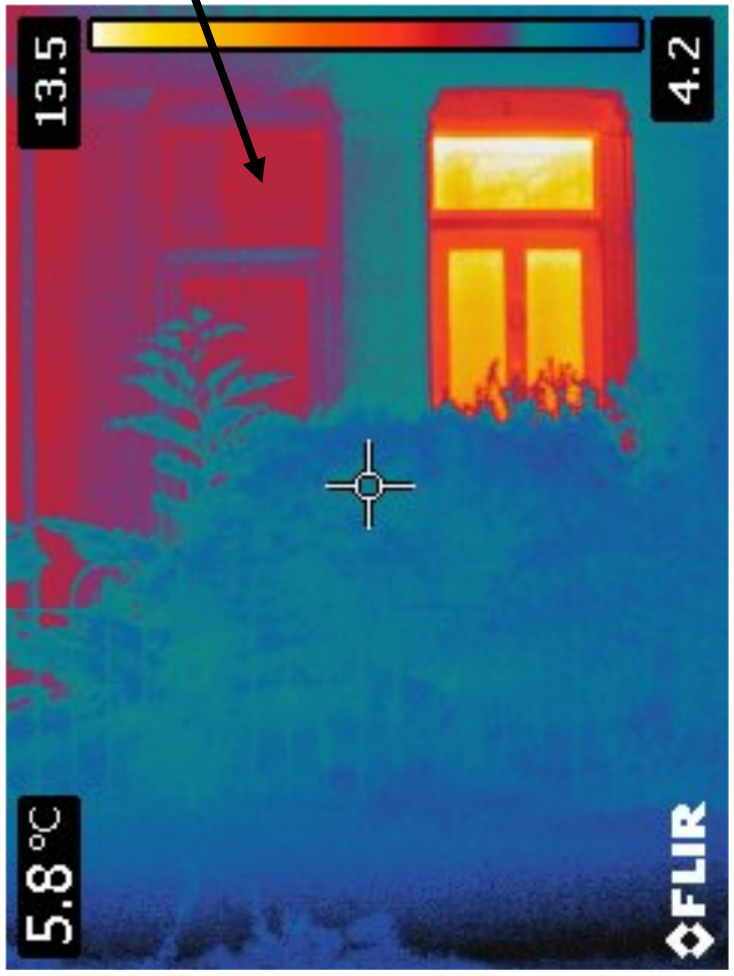
20 times better than two bricks.

Thermal view of the side of my house and detached neighbours’



Front door

Attached neighbours' front door



Our new front door

Compound door with insulating middle layer and triple glazing

meets the regulation for new dwellings

Interior insulation of other external walls and double glazing

New plasterboard wall
in front of insulation
100 mm PIR

New double-glazed
uPVC sash window
3 times better than
single glazing

Insulating under suspended ground floor

Ventilated space under floor

Floor joist

Old floorboard

New floorboard

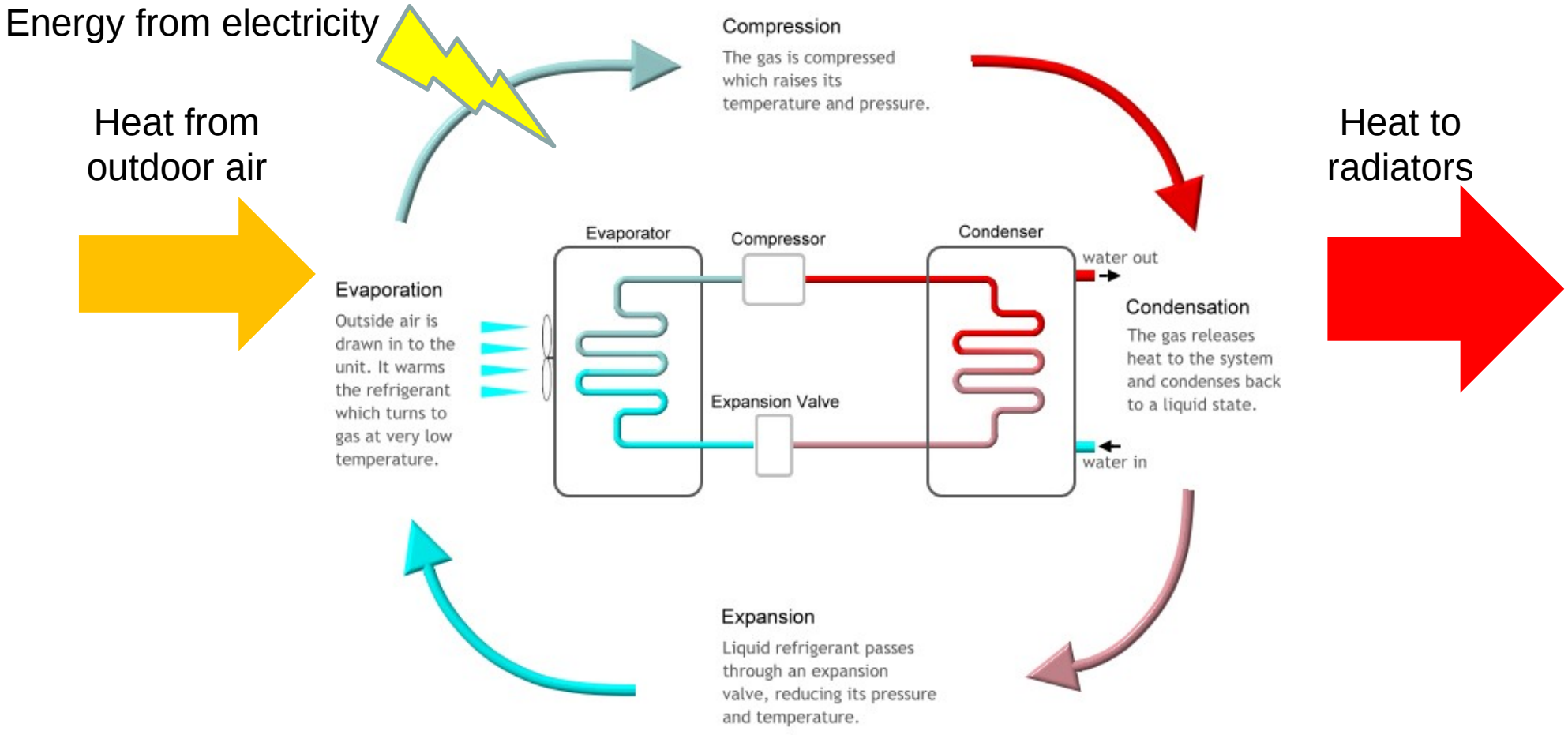
150 mm PIR between joists + 75 mm PIR under joists

7 times better than floorboards

Air source heat pump (ASHP) in my back garden

The heat pump replaced the boiler, with no other change to the central heating (radiators etc.)

A heat pump consumes less energy to produce a given amount of heat



Free **renewable energy** from the sun

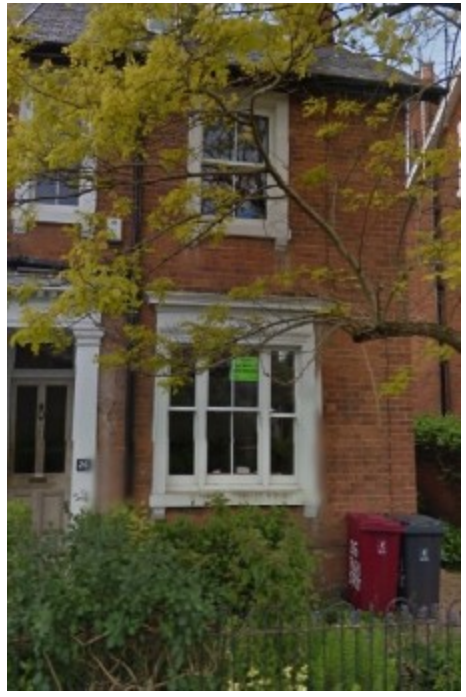
Solar photovoltaic panel (electricity)

Solar thermal panel (hot water)

Domestic electricity supply

Import from grid

Use



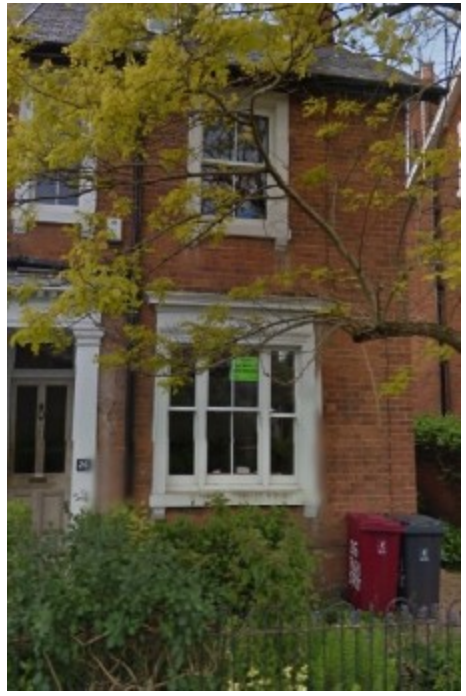
Domestic electricity supply

DC

AC

Import from grid

Use



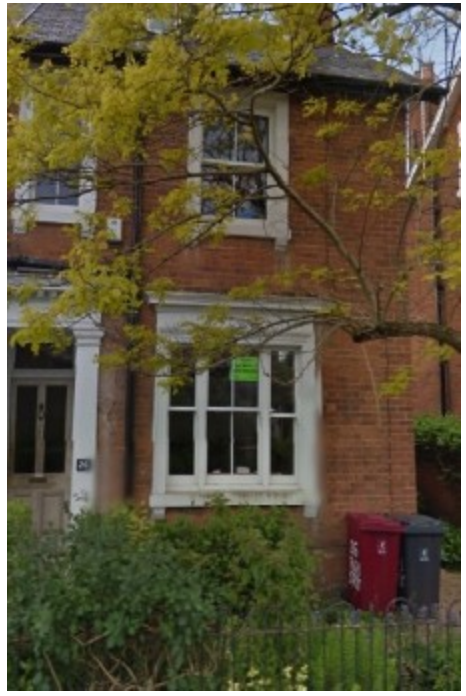
Domestic electricity supply

DC

AC

Export to grid

Use



Domestic electricity supply

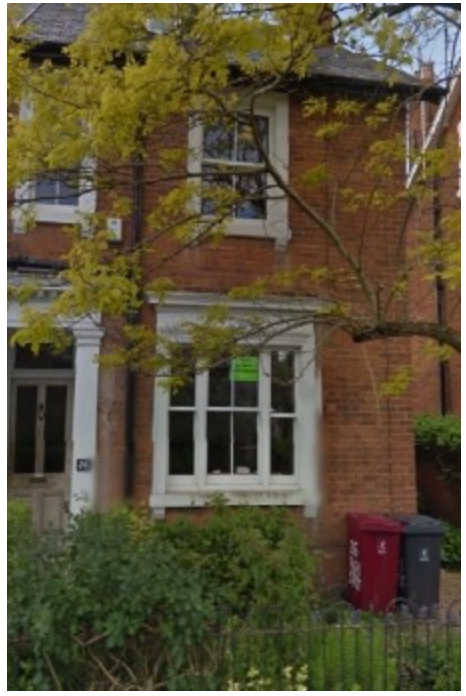
DC

AC

Inverter and battery
in the house

Charge battery

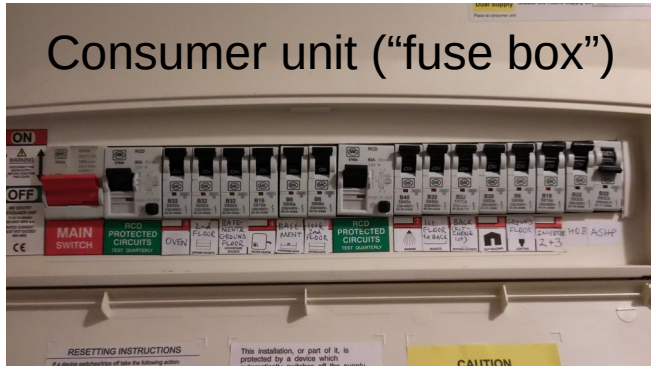
Use



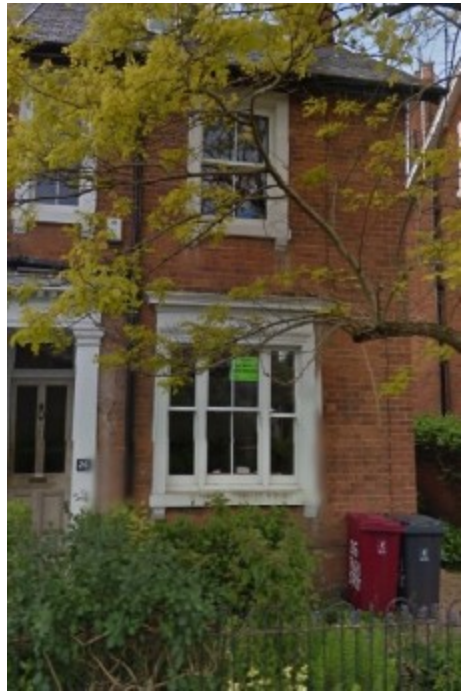
Domestic electricity supply

Inverter and battery in the house

Discharge battery



Use



CO_2 savings, costs and pay-back times

Loft insulation

1.1 tonne/year CO_2

£0.5k

1 year

Cavity wall insulation

0.8 tonne/year CO_2

£1k

3 years

Solar PV panels

0.8 tonne/year CO_2 ← CO_2 saved for house

£8k ← Cost for house

8 years if used ← Pay-back time

Typical house

CO_2 savings, costs and pay-back times

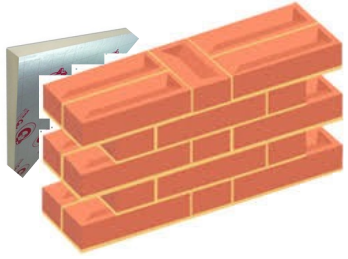
My house

Loft insulation
1.1 tonne/year CO_2
£0.5k
1 year

Cavity wall insulation
0.8 tonne/year CO_2
£1k
3 years

Solar PV panels
0.8 tonne/year CO_2
£8k
8 years if used

Double glazing
0.4 tonne/year CO_2
£14k
80 years



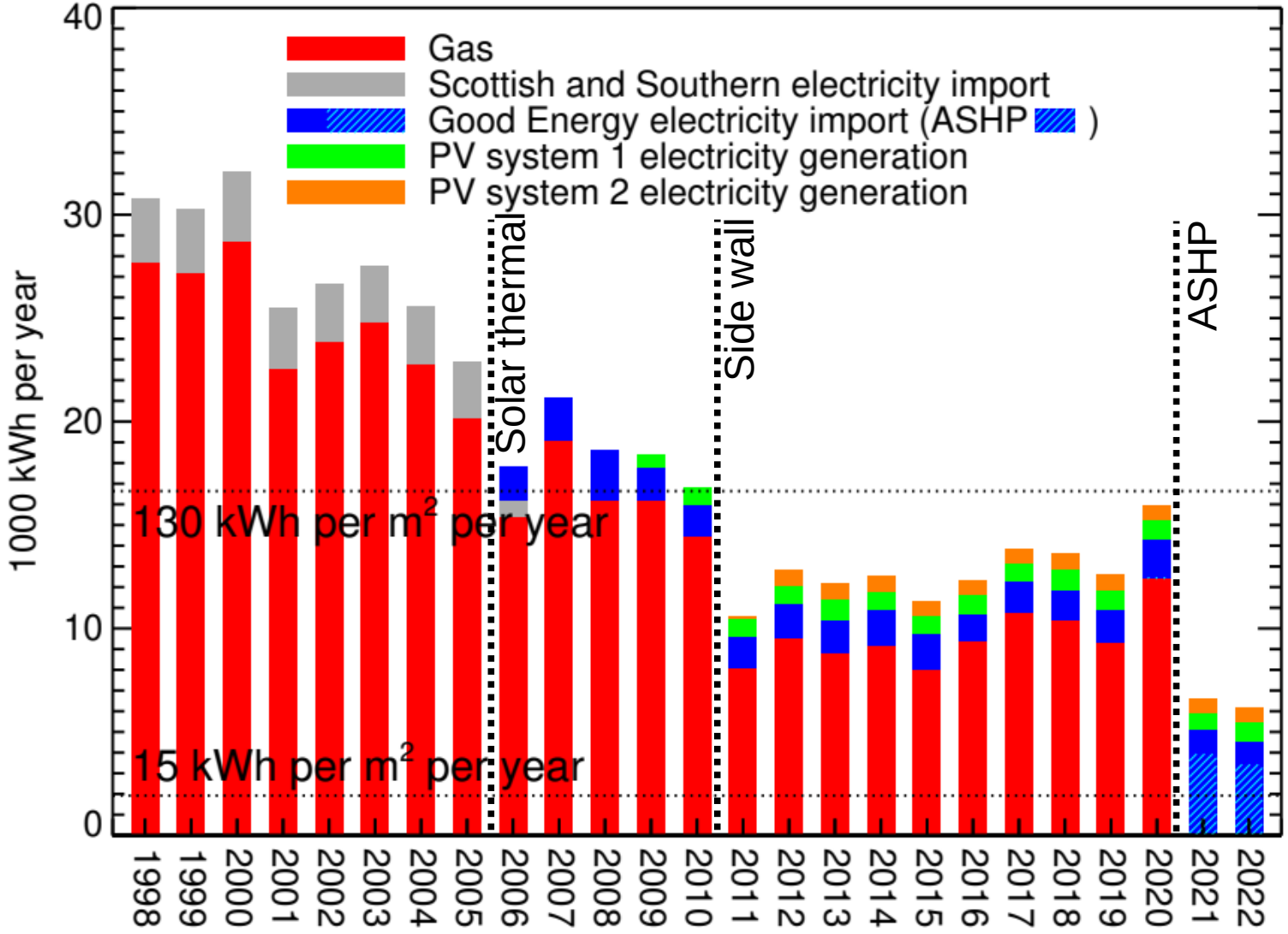
Exterior wall internal insulation
1.1 tonne/year CO_2
£12k
25 years

Exterior wall external insulation
1.3 tonne/year CO_2
£20k
33 years

Suspended floor insulation
0.3 tonne/year CO_2
£6k
55 years

Air source heat pump
1.0 tonne/year CO_2
£7k
never

Energy import, generation and use at my house, years beginning 1st Sep



Year from 1st Sep 2022

	kWh
Import	4544
Generation	1653
Export	1053
ASHP use	3433
Non-ASHP use	1711
Total use	5144

=16% of 1998-2000

CO2 emissions reduction >80%, arguably 100%

(was about 5 tonnes/year in 1998-2000)

Conclusions

About a quarter of UK CO2 emissions are due to residential energy consumption.

Many houses in the UK are old and were not built for energy-efficiency (unlike new ones).

It is possible to eliminate CO2 emissions due to an old house, by:

- Loft insulation
- Wall insulation (in the cavity if any, otherwise inside or outside)
- Solar electricity generation and solar water heating
- Double or triple glazing
- Air source, ground source or water source heat pump (which consume 2–3 times less energy)
- Importing the remaining energy requirement from suppliers of renewable electricity.

Final point

Average UK residential emissions are about 3 tonnes CO2 **per household per year**.

For comparison, flying from London to Sydney emits about 3 tonnes CO2 **per person per trip**.