An affordable net zero house retrofit.

Phil Hemsley
CEng FIMechE
**CO$_2$ concentration is at unseen levels and rising**

Global warming exceeds 1.5 degrees

Temperature rises pass 1.5°C for full year
Average global air temperature compared with pre-industrial levels, running average of 365 days

Source: ERA5, C3S/ECMWF
Global temperature increase is higher on land

Land and Ocean Temperatures 1850-2022

Temperature anomalies relative to 1850-1900 average and 95% confidence intervals.
Land data from Berkeley Earth, ocean data adapted from HadSST after interpolation.
Temperature anomalies for sea ice regions are calculated separately and not shown.

HYPOTHETICAL PROJECTION FOR 2050, MADE IN 2020
UK lifestyle has been unsustainable since the industrial revolution.

Per capita CO₂ emissions
Carbon dioxide (CO₂) emissions from fossil fuels and industry¹. Land use change is not included.

Source: Our World in Data based on the Global Carbon Project (2022)  OurWorldInData.org/co2-and-greenhouse-gas-emissions • CC BY

1. Fossil emissions: Fossil emissions measure the quantity of carbon dioxide (CO₂) emitted from the burning of fossil fuels, and directly from industrial processes such as cement and steel production. Fossil CO₂ includes emissions from coal, oil, gas, flaring, cement, steel, and other industrial processes. Fossil emissions do not include land use change, deforestation, soils, or vegetation.
Annual CO₂ emissions from fossil fuels, by world region

Source: Global Carbon Project

Note: This measures CO₂ emissions from fossil fuels and cement production only – land use change is not included. 'Statistical differences' (included in the GCP dataset) are not included here.
How do we respond?

• Do we try to prevent the rest of the world sharing our standard of living?
• Are we willing change our behaviour and expectations?
• Do we abdicate responsibility to government?
• Do we give up in despair?
• Do we ‘do our bit’?
WHAT CAN WE DO TODAY?
A study led by the University of Nottingham found that the average cost of an extensive retrofit would be £69,000 per house.
Doing the sums

27 million homes in UK @ £70,000 each
= £2 trillion (£2,000,000 million)
~10 years funding for NHS
2/3 of UK GDP

Is there a better way?
My experience: 1930s ‘retrofit’ – cost ~£10k
Progress so far…

Net energy use per day

- total kWh
- year ave kWh/day

kWh per day


-20.00  |     0.00  |     40.00  |     60.00  |     80.00  |  100.00  |     40.00  |     20.00  |     0.00  |     0.00  |     0.00  |     0.00  |     0.00  |     0.00
Progress so far... better than “net zero”
LED lights

LEDs use

- half the energy of fluorescent lights
- 90% energy saving compared to incandescent lights
Solar energy

9 Solar panels

Conservatory
Biggest energy consumer: heating

- Heat in
- Heat out
- Draughts

Minimise Energy in
Maximise Sun
Minimise Heat out
Did you know there’s a new portable heater the size of a car battery that can warm up any room in under 5-minutes?

I Recently Discovered How To Heat Any Space In My House In Under 5-Minutes, WITHOUT Using My Home's Costly Heating System

Andrea Stewart | Smarter Choice | Oct 15, 2022

SAVE 30% ON YOUR ENERGY BILLS & HEAT YOUR ROOM FAST WITH THE MOST EFFICIENT HEATER ON THE MARKET

Rated 4.8/5 by 8K+ Customers

- Slash your electric bills as much as 30% with ultra-energy efficient technology
- Advanced safety features for worry-free, continuous heating – great for families
- Sleek, attractive design for your home
- No waiting – Heat any room to a cozy temp in less than 2 minutes
- Noise Free Operation – so quiet you won’t even notice it’s on

ORDER NOW & SAVE 50%!
‘Professional’ scams

The Model 3 Hydro-Zero is the UKs first self-generating hydrogen powered heat generation unit. It retains the same features as traditional combination boilers, without the need for any non-renewable carbon fuels or the need for an external flue. This Heat Generation Unit paves the way for zero-carbon and emission home heating products with high COP values and the added benefit of AAA+ ErP rating.

KEY FEATURES
- Zero carbon emissions
- High COP Values - Up to 3 COP
- Compatible with existing radiators and underfloor heating systems
- Fast installation time
- Extremely quiet - Less than 10dB
- No need to install on an external wall with no flue.

Designed to meet the zero-carbon targets of the future whilst delivering the heating and hot water demands of today.
Reduce the leakage

Heat generator

Energy in

Minimise

Heat in

Heat out

Minimise draughts
Reduce the leakage

When we moved in:

- Loft insulation
- Double glazing
Where does the heat leak out?

<table>
<thead>
<tr>
<th>Room Type</th>
<th>Heat Required per Day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hall and Landing</td>
<td></td>
</tr>
<tr>
<td>Bedroom 3</td>
<td></td>
</tr>
<tr>
<td>Bedroom 1</td>
<td></td>
</tr>
<tr>
<td>Bedroom 2</td>
<td></td>
</tr>
<tr>
<td>Bathroom</td>
<td></td>
</tr>
<tr>
<td>Dining Room</td>
<td></td>
</tr>
<tr>
<td>Living Room</td>
<td></td>
</tr>
<tr>
<td>Kitchen</td>
<td></td>
</tr>
</tbody>
</table>

![Floor Plan](image)
Where does the heat leak out?

Hall and Landing Heat Loss

<table>
<thead>
<tr>
<th>Component</th>
<th>Heat Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>Floor</td>
<td></td>
</tr>
<tr>
<td>Walls (exc. windows)</td>
<td>High</td>
</tr>
<tr>
<td>Windows</td>
<td>Low</td>
</tr>
<tr>
<td>External Ceiling</td>
<td>Low</td>
</tr>
<tr>
<td>External doors</td>
<td>Low</td>
</tr>
</tbody>
</table>
### How much does external wall insulation cost?

The cost of external wall insulation depends on a number of factors, including:

<table>
<thead>
<tr>
<th>Cost provided item</th>
<th>Cost+VAT (Lower range)</th>
<th>Cost+VAT (Higher range)</th>
<th>Average cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Detached</td>
<td>£15,000</td>
<td>£20,000</td>
<td>£17,500</td>
</tr>
<tr>
<td>Semi-detached</td>
<td>£8,000</td>
<td>£10,000</td>
<td>£9,000</td>
</tr>
<tr>
<td>Mid-terrace</td>
<td>£6,000</td>
<td>£8,000</td>
<td>£7,000</td>
</tr>
</tbody>
</table>

Our costs are ballpark averages – get a local tradesperson to quote now

Cavity walls are common in houses that were built post-1920. These are generally quick and easy to insulate, with the typical semi-detached house costing around £475 to insulate.
Reduce the leakage - the benefit of insulation
Simple internal wall insulation - 20mm tile backer board:

10 panels at ~£20 each, £400 for plasterer

Cost ~£600 installed
Saving ~0.5kW
Hall/landing, part of bathroom and small bedroom
Under floor insulation

Dining room: 12m²
Cost ~£200 for insulation (100mm)
No labour cost (DIY)
Saving ~0.5kW
Under floor insulation

Living room: 15m²
Cost ~£150 for insulation and membrane
No labour cost (DIY)
Saving ~0.6kW
Low cost secondary glazing

Window glass:
Wooden spacer and glass held in place with silicone sealant

Door ‘glass’:
Wooden spacer and perspex held in place with silicone sealant
Single brick bay window
Thick curtains inside double glazed windows:

- In room
- Behind curtains
- Outside
Minimise the energy in per unit of heat in?
Traditional UK solution – gas boiler and water filled radiators

เหมาะสม Condensing gas combi boiler + radiators

ิ่ง Non-renewable energy source

ิ่ง At best ~95% efficiency

ิ่ง Heat up radiators before heat up rooms – slow and inefficient

ิ่ง Heat lost to walls
Direct heating analogy (e.g. gas boiler)

- Boiler converts chemical energy to heat
- Inside temperature
- Outside temperature

1kW energy gives 0.9kW heat
Heat pump analogy

1kW energy pumps 4kW heat
Air to water heat pumps: Cost £12–18k

- Renewable energy source – electricity
- Heats domestic water
- Typically, 350% ‘efficiency’
- Fully replace existing system
- Disruptive installation
- Probably need to replace radiators and pipework
- Large installation space needed
- Expensive – even with government grant
- Slow heat up – must run continuously
- Integrated electrical resistance heater – risk of high running cost
- Radiated heat lost to walls
- High embodied carbon
Air to air heat pump: Cost £1.5k

- Renewable energy source - electricity
- Typically 420% ‘efficiency’
- Fast heat up
- Fast and easy installation
- Old system not removed
- No radiated heat lost to walls
- Lower embodied carbon
- Cooling in summer
Self-contained air conditioning units are available

AIRCO290

The new AIRCO290 is a packaged wall-mounted twin duct heat pump air-conditioning unit that is compatible and built and ready for the UK, European and American markets. It’s technically advanced to use R290 refrigerant gas, which has the lowest GWP (Global Warming Potential) of any gas in its class. The new AIRCO290 is an affordable and economical air conditioning for homes, offices, hotels and garden rooms with rapid installation and minimalistic design without needing any outdoor condenser unit.

MOUNTING
HIGH & LOW WALL

SUPPLY
ELECTRIC

INSTALLATION TIME
3/4 HOURS
Heat pump still work when it’s cold outside

1kW energy pumps 4kW heat

1kW energy pumps 3kW heat
How big to make the heat pump?

Heat requires increases as outdoor temperature reduces.
What to do if there is not enough heat in?

- Shut off rooms to reduce heat loss
- Accept lower temperature (put a woolly on!)
- Supplementary local heat:
  - Wood burning stove / electric fan heater
  - Heated cushions / blanket ....

Remember: **Gas boiler still in place as ‘back-up’**
Supplementary heating

Cost ~£1000 installed
Up to 4kW
Renewable energy
DEFRA approved
Proven energy savings from heat pump
How has our gas use changed?
How has our electricity use changed

[Graph showing electricity imported vs. import long term average kWh/day with data points from October 2017 to January 2024.]
Annual energy cost pre heat pump

Gas

- 26.3 kWh/day average @ 5.9p/kWh x 365 days
- £566 per year

Electricity

- 5.0 kWh/day average @ 23.77p/kWh x 365 days
- £434 per year

Total = £1000
Annual energy cost post heat pump

Gas
• 2.5 kWh/day average @ 5.9p/kWh x 365 days
• £54 per year

Electricity
• 10 kWh/day average @ 23.77p/kWh x 365 days
• £868 per year

Total = £922 (8% saving compared with £1000)
It is worth getting the most efficient unit

Annual heating cost benefit for best performance

Annual heating cost @27p/kWh

Rated COP
With renewable electricity supply we reach net zero
WHAT ELSE CAN WE DO TODAY?

LIFESTYLE CHOICES
How we travel:

How many kg of CO₂?

- 6000 passenger miles on Queen Mary II: 2600
- Driving 6000 miles a year: 1200
- Economy return flights to Spain (6000 miles): 1060
- 6000 miles by national train: 340
- 6000 miles by international train: 40

Note: typical 3 bed semi energy consumption might be around 3 tonnes per year
What we eat:

Foodprints by Diet Type: t CO₂e/person

Note: All estimates based on average food production emissions for the US. Footprints include emissions from supply chain losses, consumer waste and consumption. Each of the four example diets is based on 2,600 kcal of food consumed per day, which in the US equates to around 3,900 kcal of supplied food.

Sources: ERS/USDA, various LCA and EIO-LCA data

https://www.greeneatz.com/foods-carbon-footprint.html

Note: typical 3 bed semi energy consumption might be around 3 tonnes per year
How we deal with the impact of our lifestyle:

To donate:
Account Name: 1 JOHN 3 BEIRA
Sort Code: 08-92-99
Account Number: 67198719