Air Source Heat Pump Review

Andy Nevill
Chartered Engineer

Sharing Learning and Good Practice

February 2025


STIEBEL ELTRON
Comfort through Technology

Certificate of Completion

Andy Nevill

has sucessfully completed the online course

Heat Pump Pass - an introduction to the basic concepts of heating and cooling with heat pumps.

Learning objectives:

» The basic physics of how heat pumps work and how performance is measured
» Different types of heat pumps and operating modes
» Requirements and best practice for device installation
» System design and considerations for special types of installations
» Tips for installation
» Troubleshooting

The STIEBEL ELTRON team wishes you all the success for the future.

STIEBEL ELTRON UK 04/24/2024

John Felgate

STIEBEL ELTRON Training Academy

Stiebel Eltron UK Ltd I Unit 12 Stadium Court I Stadium Road I Wirral International Business Park I CH62 3RP I
Email: sales@stiebel-eltron.co.uk I Telephone: 0151 346 2300

WHY – are we doing this?

WHAT – have we decided to do?

HOW – have we actually done this?

HOW HAS IT GONE?

HOW HAS IT GONE?

Efficient?	Effective?	Effective?	Cost Effective?
90% reduction in energy consumption	**YES**  	**96%**(i) **/ 97%**(ii) reduction in emissions	**64%**(i) **/ 80%**(ii) reduction in energy costs

(i): Octopus standard electricity tariff

(ii): with solar PV, battery and Octopus Cosy time-of-use tariff

N=1

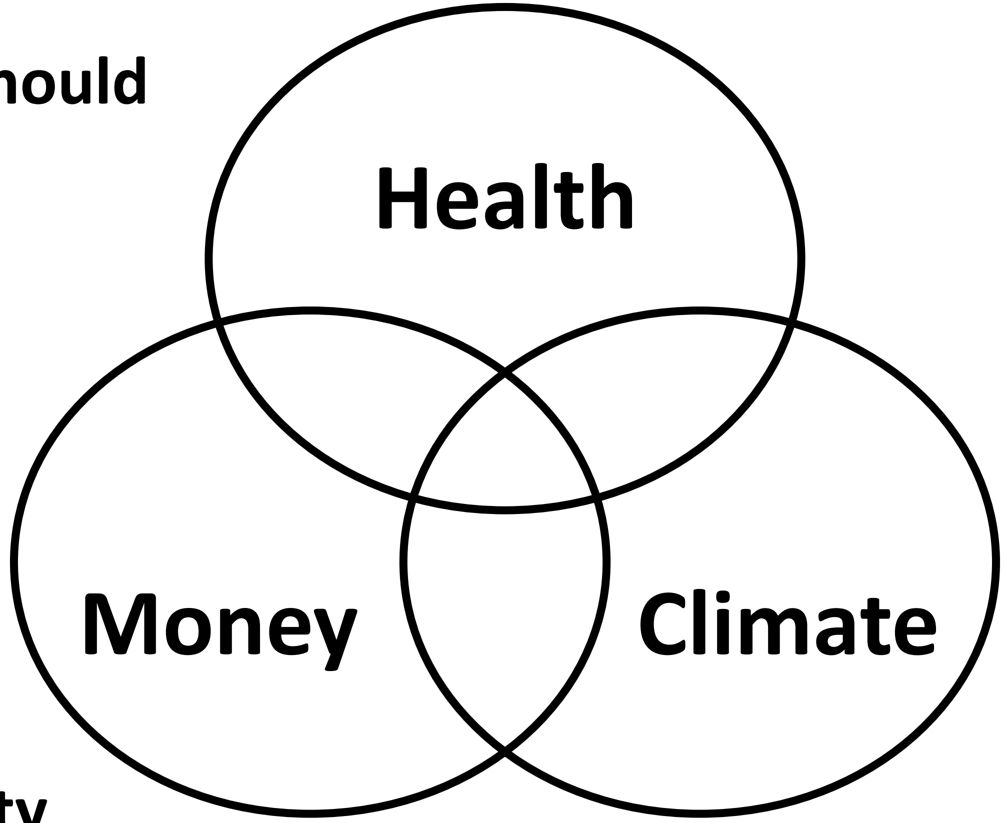
This review is just ONE example for ONE property.

The data presented here is actual measured data for the property and from published sources of information.

WHY? - Motivations

Warm enough

Deal with damp and mould and air quality



Reduce household emissions

Minimise energy costs

Add value to the property

WHAT? - Major Property Renovation Project

c.1600 traditional Cornish cottage

Solid stone walls

194m^2 with extensions

EPC rating: F

Replace old oil-fired system and stop burning coal

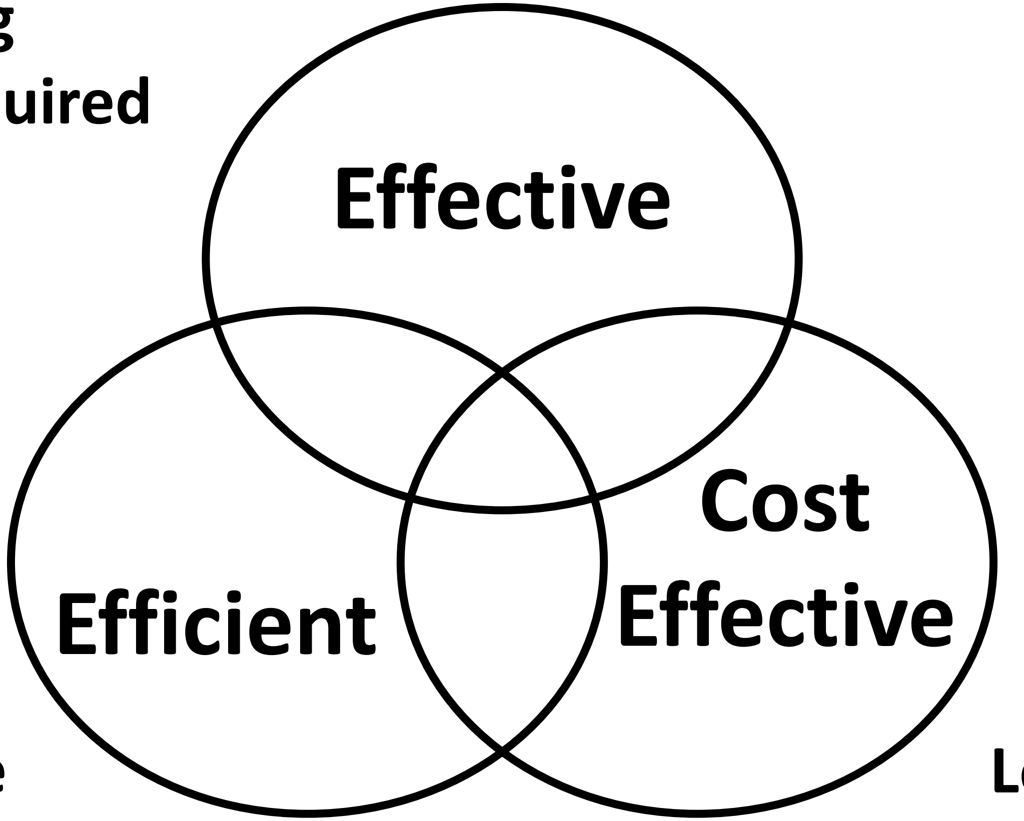
Decided to prepare for an ASHP back in 2014

Most disruptive decision – UFH downstairs throughout – no regrets!

Heating System Objectives

Comfortable Heating
Hot Water when required

Reduce emissions



Low Energy Use

Low Running Costs

Fabric Improvements

Essential

Easier improvements

- Air tightness: fix uncontrolled ventilation
- Positive Input Ventilation (PIV) system
- Extractor fans in wet rooms
- Double glazing throughout
- External doors
- 300mm loft insulation

More difficult improvements

- Kitchen and porch extensions
- Downstairs floor insulation – UFH throughout downstairs

What we chose not to do

- No solid wall insulation
- No cavity wall insulation – exposed location

Fabric Improvements – Ventilation – The Lungs of your Home

We put quite a lot of effort into moving from uncontrolled ventilation to controlled ventilation

Still more work to do – cross ventilation in the loft cavity needs to be improved

VENTILATION – INSULATION - VENTILATION

You should review ventilation **BEFORE** insulation

You should then review ventilation again, **AFTER** insulation

Air Source Heat Pump and Heating System

Installed August 2023

ASHP: Stiebel Eltron WPL25AS (A2/W35: 8.32kW, A-7/W35: 13.05kW) – positioned 13m from the house

Hot Water: Vaillant Unistor 273 litre unvented cylinder; pumped secondary return

Heating System: Panasonic 100 litre buffer tank; downstairs underfloor heating (UFH), 3 zones; upstairs radiators with thermostatic radiator valves (TRVs)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Heat Pumps - Examples

Refrigerator

Tumble Dryer

Dehumidifier

Air Source Heat Pump

Ice Machine

Air Conditioning

Freezer

Reference: *"A fridge but in reverse? The fascinating science of heat pumps – visualised"*, The Guardian, 23 Dec 2023, https://loom.ly/W54mzEo

Underground Primary Pipes

13m pipe run – 2 x 32mm Multi-layer Composite Pipes (MLCP)

- Pulled through 110mm flexible ducts
- Insulated: Armacell pipe insulation plus a well insulated trench

- Heat loss is approximately 10W per meter (Flow 40°C / Return 35°C)
- Approximately 800kWh for a full year
- Similar to heating a small room

Controls – Space Heating

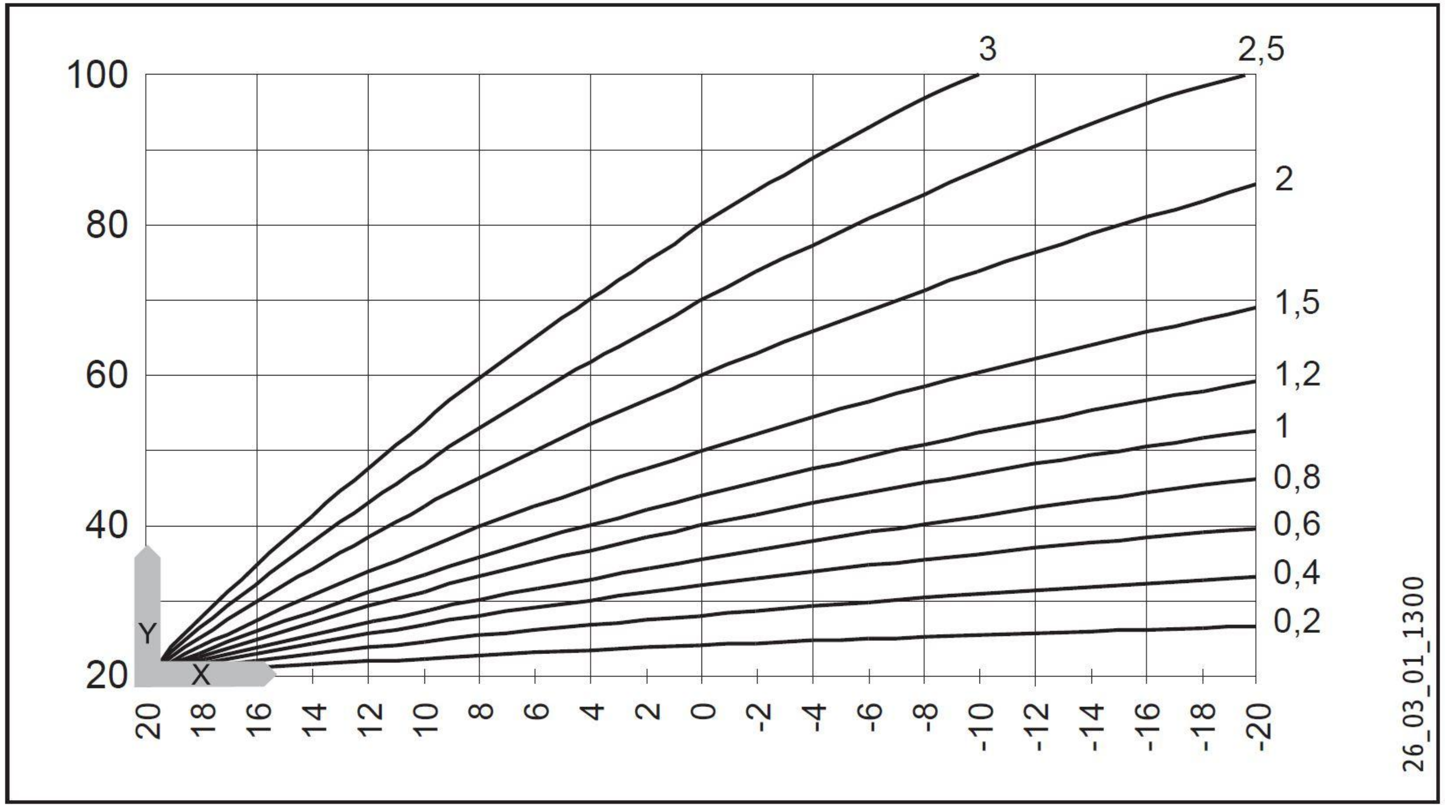
Weather compensation plus simple set point control

Only 3 Settings

- Heating curve rise: 0.5 (weather compensation setting)
- Heat pump set point temperature: 21°C
- Heat pump setback: 14°C timed 16:00 to 19:00 (Octopus peak rate period)
- All heating zone thermostats fully open (always on)
- All thermostatic radiator valves (TRVs) fully open (always on)

Controls – LESS IS MORE

Controls – Heating Curve Rise



X Outside temperature [°C]

Y Heating circuit 1, heat pump return temperature [°C]
Heating circuit 2, heat pump flow temperature [°C]

Reference: Stiebel Eltron WPM Commissioning Manual

Controls – Hot Water

Simple timed set point control

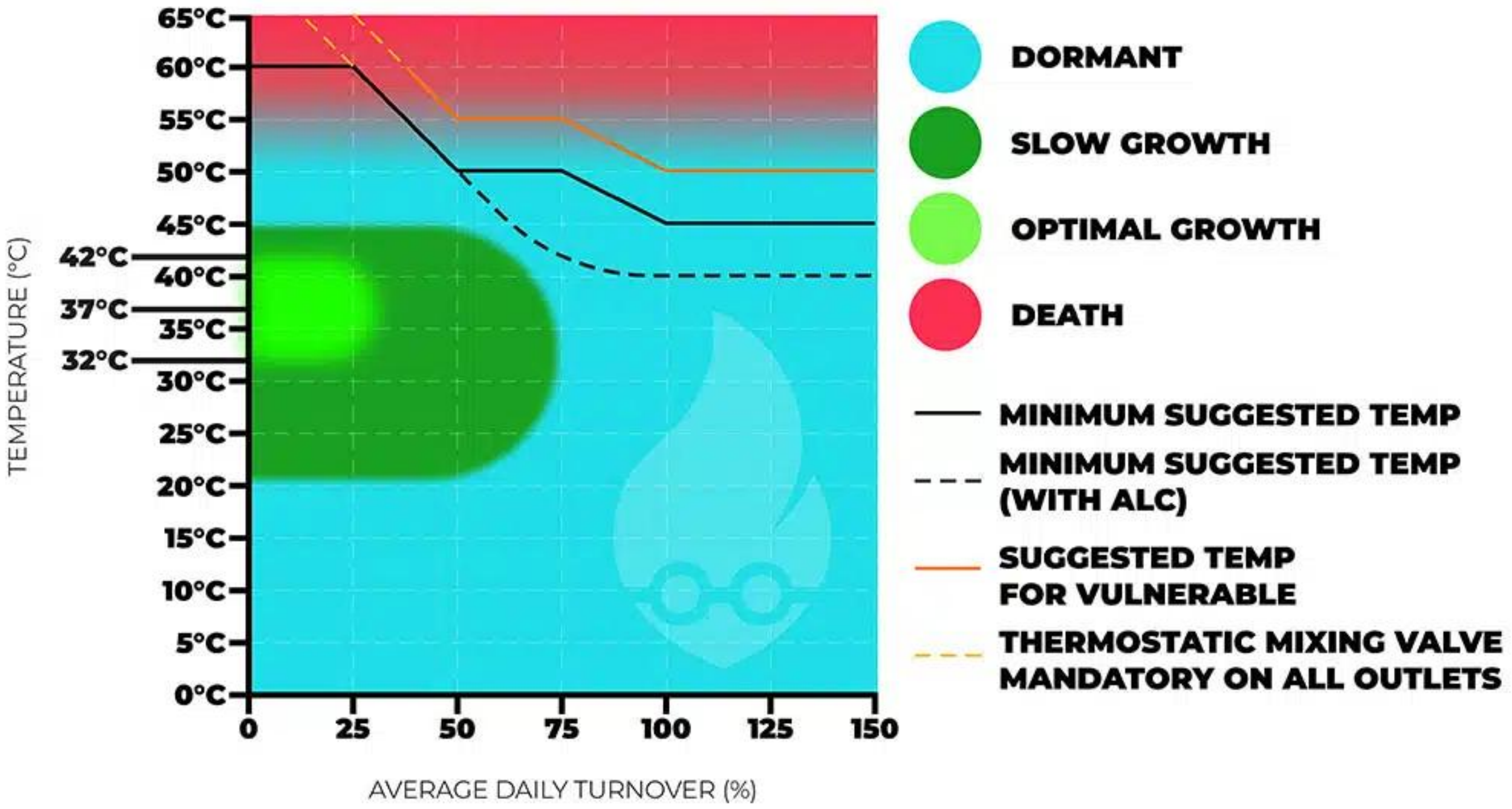
- Main setpoint: 47°C
- Timed setpoint: 53°C (daily: 14:00 to 16:00)

Only 2 Settings

This generally forces the heat pump to heat the water once a day in the middle of the day when the air temperature is highest (Octopus cheap rate period: 1300 to 1600)

Timed immersion heater for legionella control

Hot Water – Legionella



Reference: Hot Water Temperature - Scalding and Legionella - HeatGeek

HOW HAS IT GONE? - Review Period

A full year of performance data …

Review period: 29Aug23 to 28Aug24

"Heating On" period: 01Nov23 to 28Apr24 (6 months)

Efficient

Effective

Cost Effective

Heat Energy from the Air

High 17.5 °C
Ave 8.6 °C
Low - 3.8 °C

Air Temperature Range during Heating Period

100 °C — 373 Kelvin

0 °C — 273 Kelvin

- 273 °C — 0 Kelvin – Absolute Zero

Efficiency

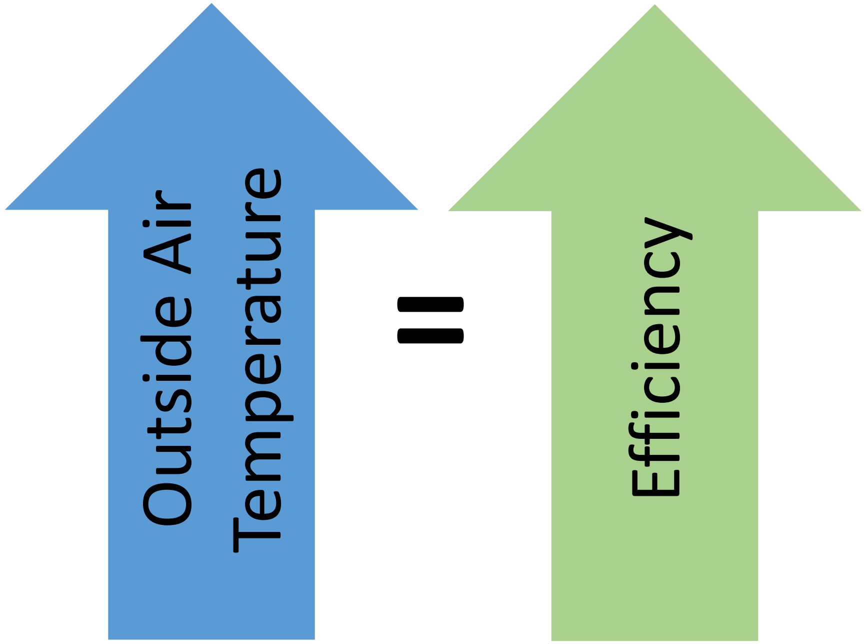
	Heat Provided	*Power Used*	*sCOP*
Heating	**10,800kWh**	**2,839kWh**	**381%**
Hot Water	**2,320kWh**	**827kWh**	**281%**
Combined	**13,120kWh**	**3,667kWh**	**358%**

Average Flow Temperature (combined): **33.4°C**

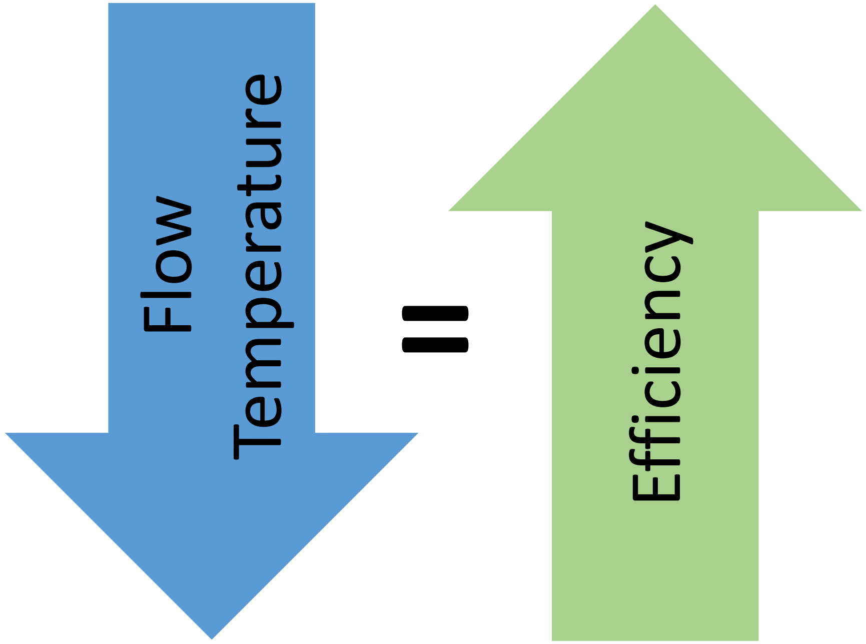
sCOP = Seasonal Coefficient of Performance

Efficiency

High air temperature = high efficiency



Low flow temperature = high efficiency



Efficiency relates to the **difference in temperature (delta T)** between the Heat Source and the Heat Sink

Efficiency – on the Warmest and Coldest days

	Air	delta T	Flow	Efficiency
12Apr24	17.5°C	**13.3°C**	30.8°C	**394%**
				358%
19Jan24	-3.8°C	**42.0°C**	38.2°C	**294%**

delta T

Actual measurements for air and flow temperatures and efficiency; sCOP = 358%

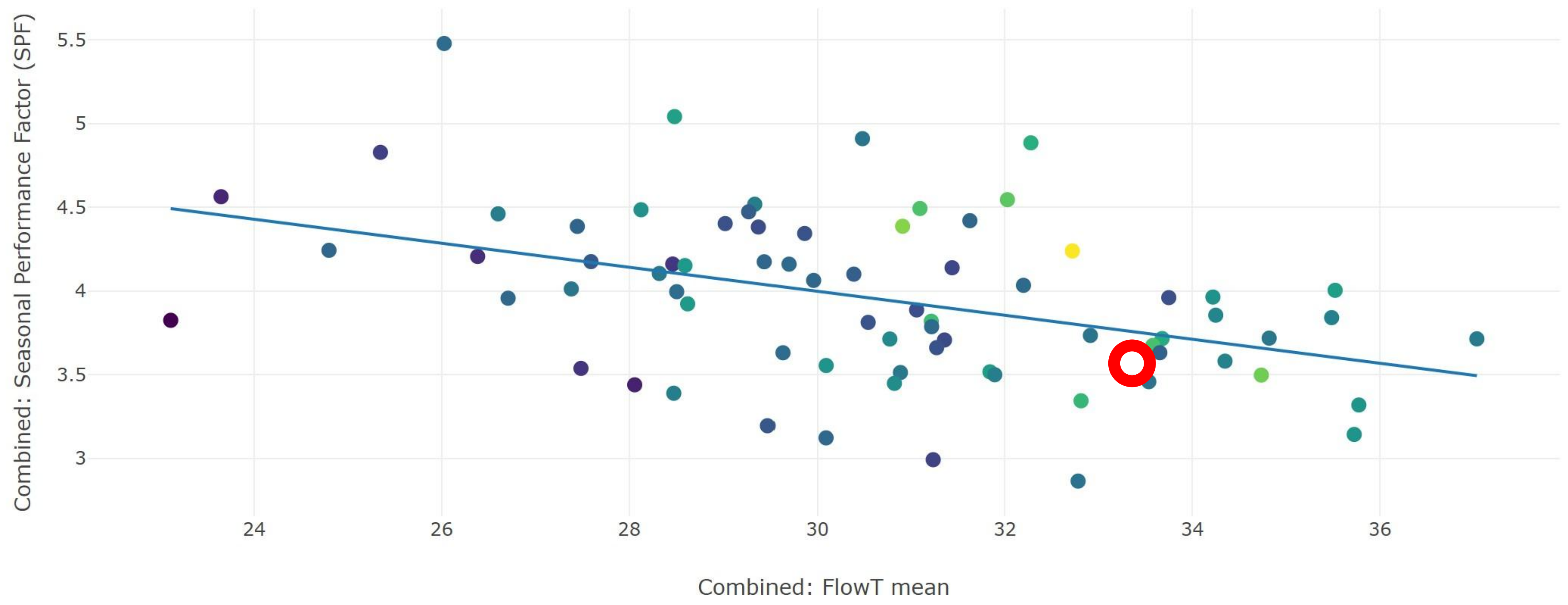
Efficiency Compared – HeatpumpMonitor.org (data extracted 19Jan25)

Last 365 days | 90 days | 30 days | 7 days | All

Data explorer

X-axis: FlowT mean | Y-axis: COP | Colour map: Heat output

R: -0.43, R^2: 0.18, n=73, (y=-0.07x + 6.15) ☑



Performance: Compressor Starts

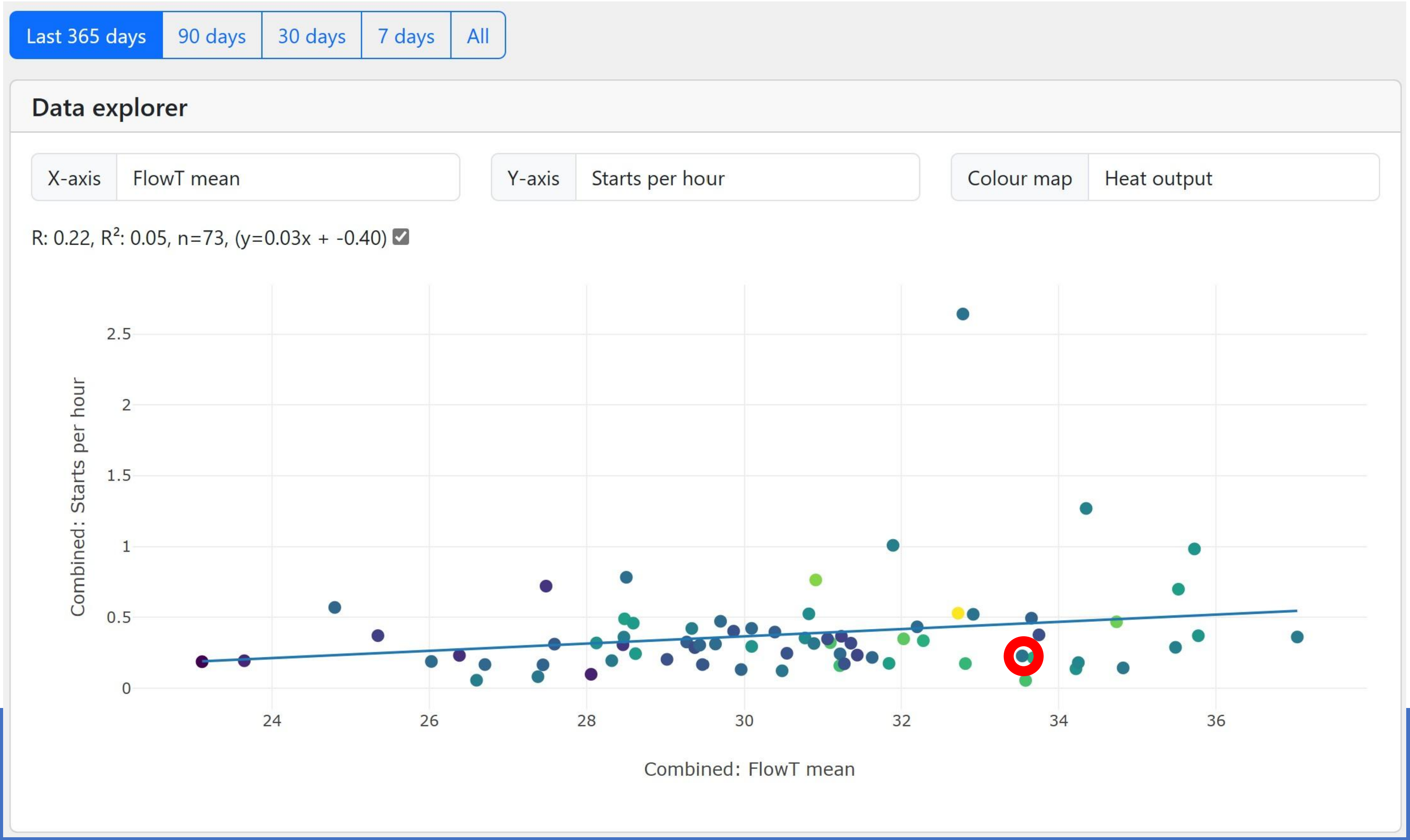
Ideally heat pumps should run with a low number of compressor starts. This improves efficiency and lifespan.

Full Year, Combined: 1,817 starts/year

DWH: 960 starts/year (53%)
Heating: 857 starts/year (47%)

Average: **0.21 starts/hour**

Compressor Starts per Hour – HeatpumpMonitor.org (data extracted 19Jan25)



HOW HAS IT GONE – Efficiency?

Efficient?

90% reduction in energy consumption

BEFORE: 38,135 kWh/year

Oil	**Coal**	**Electricity**
1,597 litres	2.52 tonnes	
16,437 kWh	21,098 kWh	600 kWh

ASHP: 3,664 kWh/year

Electricity
3,664 kWh

Reference: Greenhouse gas reporting: conversion factors 2024 - GOV.UK

HOW HAS IT GONE – Effective?

Effective?

YES

Comfort temperatures

- Downstairs (UFH): **20°C** (typical range: 19 – 21°C)
- Upstairs (radiators): **18°C** (typical range: 17 – 19°C)
- Setback period (16:00-19:00): no detectable change in temperature

Hot Water

- Average temperature: **50.5°C**

Lüften

Simple daily manual ventilation – known as Lüften in Germany

- Open doors and windows for 10-15 minutes every day

- Inside air temperatures recover within the hour
- No detectable change in the heating circuit water temperature
- Most of the stored heat energy is within the fabric of the property

Outside air at **5°C, 95% RH** (relative humidity) contains **32% LESS moisture** than **20°C, 50% RH** (6.5g/m3 water compared to 8.6g/m3)

Reference: www.calculator.net/dew-point-calculator.html

HOW HAS IT GONE – Effective? - Emissions

Effective?

96% / 97%
reduction
in emissions

BEFORE: 12,702 kgCO2e/year

Oil	**Coal**	**Electricity**
4,898 kgCO2e	7,722 kgCO2e	82 kgCO2e

ASHP: 498 kgCO2e

ASHP: With solar PV and battery 359 kgCO2e

Reference: https://bregroup.com/documents/d/bre-group/s10tp-15_-_co2_and_primary_energy_factors_for_sap_v1_1_10_1-pdf

HOW HAS IT GONE – Cost Effective?

Cost Effective?

64% / 80% reduction in energy costs

BEFORE: £2,941

Oil	**Coal**	**Electricity**
£1,198	£1,573	£170

ASHP: £1,053
Standard tariff

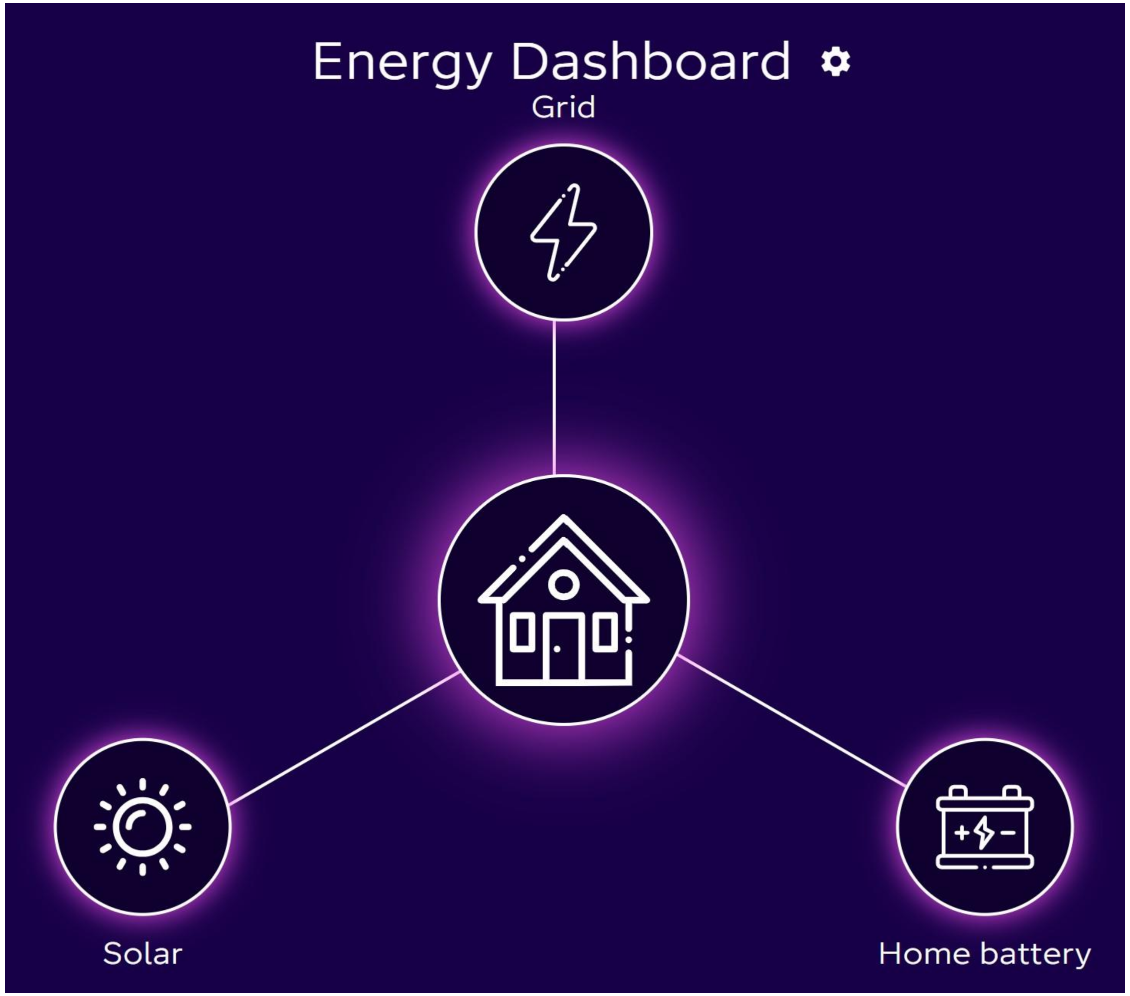
ASHP: £585
With solar PV, battery and time-of-use tariff

Cost Effectiveness – Annual Costs

	Tariff	Renewables	kWh	p/kWh	£££	£££ Savings
Historical			38,135	7.71	£2,941	
ASHP	Octopus Standard Rate		3,663	28.74	£1,053	£1,888
ASHP	Octopus Standard Rate	Solar PV	3,112	28.74	£894	£158
ASHP	Octopus Standard Rate	Solar PV + Battery	2,640	28.74	£759	£136
ASHP	Octopus Cosy Tariff	Solar PV + Battery	2,640	22.17	£585	£173

Calculated using Octopus rates for review period, including standing charge and VAT
Solar PV: 15% reduction in total annual imported electricity; 28% with the battery

Optimising the Battery with Solar PV: Octopus R&D Labs / My Energy Optimiser



Reference:

Octopus Labs

My Energy Optimiser – Scheduling for Home Energy Storage

Actual Heat Loss

Actual heat loss is BETTER / LESS than estimated

Likely reasons …

- Solid stone walls performing better than calculated (high thermal mass)
- Overstated ventilation rates (room air-changes)
- Solar heat gain and heat gains from body heat and domestic equipment
- Degree day assumptions

Reference: www.degreedays.net

Actual Heat Loss – Heat Loss Calculations Revisited

Heat loss calculation re-engineered …

- Solid stone walls: reduce U-Values by 25%
- Ventilation rates: reduce room air changes by 25%
- Solar/equipment/body heat gain: 10%
- Degree days base temperature: reduce by 1°C, from 15.5°C to 14.5°C

This produces a better match for the actual performance of the property

Reference: www.degreedays.net

ASHP vs Gas Boiler (using standard Energy Price Cap figures for comparison)

	Heat Provided	Efficiency	Energy Consumed	Cost/kWh	Cost	Emissions
Gas Boiler	13,120 kWh	83%	15,903 kWh	7.06p	£1,123	3,340 kgCO2e
ASHP	13,120 kWh	358%	3,663 kWh	28.33p	£1,038	498 kgCO2e
Comparison		4.3x	-77%	4.0x	-8%	-85%

ASHP is 4.3 times more efficient
ASHP consumes 77% less energy to provide the same amount of heat
Electricity is currently 4 times more expensive than gas
ASHP is 8% cheaper to run
ASHP would reduce emissions by 85%

Reference: In-situ monitoring of efficiencies of condensing boilers and use of secondary heating trial: final report (2009) - GOV.UK
Energy Price Cap figures, August 2023 – July2024, including VAT, excluding standing charge

HOW HAS IT GONE?

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And finally …

Make a **PLAN** for when your boiler needs to be replaced - avoid an unplanned emergency boiler replacement – do what you can when you can.

Investigate becoming **HEAT PUMP READY** – whether you think you will actually have a heat pump or not – because this is about best practice **efficient heating systems** (low flow temperature).