DOMESTIC GROUND SOURCE HEAT PUMPS IN THE UK

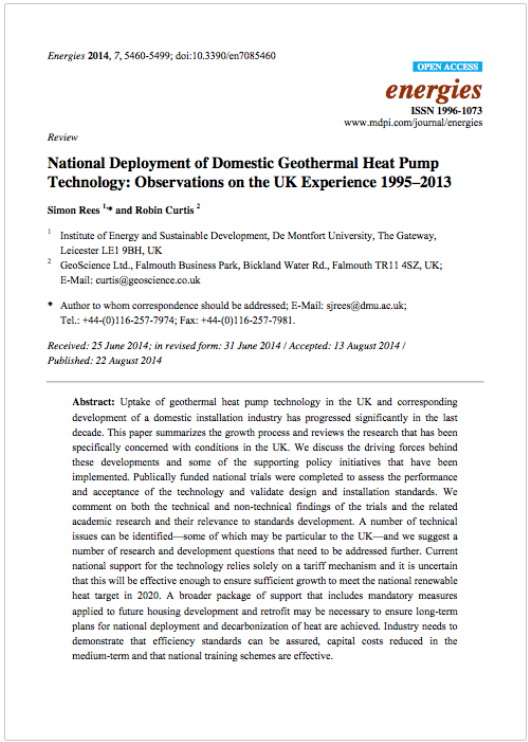
The Story so far…

Simon Rees

10th December 2014

OUTLINE

- Technology
- EU context
- Early developments in the UK
- National trials
- Support programmes
- RHPP preliminary findings
- The outlook



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Review

National Deployment of Domestic Geothermal Heat Pump Technology: Observations on the UK Experience 1995–2013

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Abstract: Uptake of geothermal heat pump technology in the UK and corresponding development of a domestic installation industry has progressed significantly in the last decade. This paper summarizes the growth process and reviews the research that has been specifically concerned with conditions in the UK. We discuss the driving forces behind these developments and some of the supporting policy initiatives that have been implemented. Publically funded national trials were completed to assess the performance and acceptance of the technology and validate design and installation standards. We comment on both the technical and non-technical findings of the trials and the related academic research and their relevance to standards development. A number of technical issues can be identified—some of which may be particular to the UK—and we suggest a number of research and development questions that need to be addressed further. Current national support for the technology relies solely on a tariff mechanism and it is uncertain that this will be effective enough to ensure sufficient growth to meet the national renewable heat target in 2020. A broader package of support that includes mandatory measures applied to future housing development and retrofit may be necessary to ensure long-term plans for national deployment and decarbonization of heat are achieved. Industry needs to demonstrate that efficiency standards can be assured, capital costs reduced in the medium-term and that national training schemes are effective.

Rees, S. and R. Curtis (2014) National Deployment of Domestic Geothermal Heat Pump Technology: Observations on the UK Experience 1995–2013. *Energies*. 7(8): 5460-5499

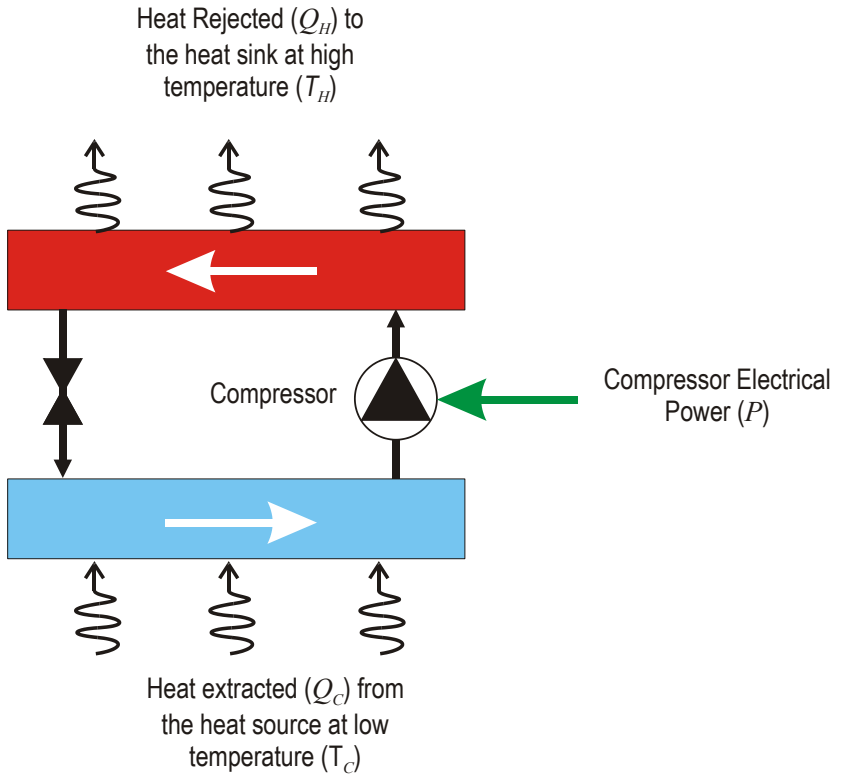
What is a Heat Pump?

- Based on a vapour-compression refrigeration cycle
- Heat is 'pumped' by a compressor: more heat out than electrical power in.
- Coefficient of Performance defines thermodynamic efficiency

$$COP = \frac{Q_C}{Q_H - Q_C} = \frac{Q_C}{P}$$

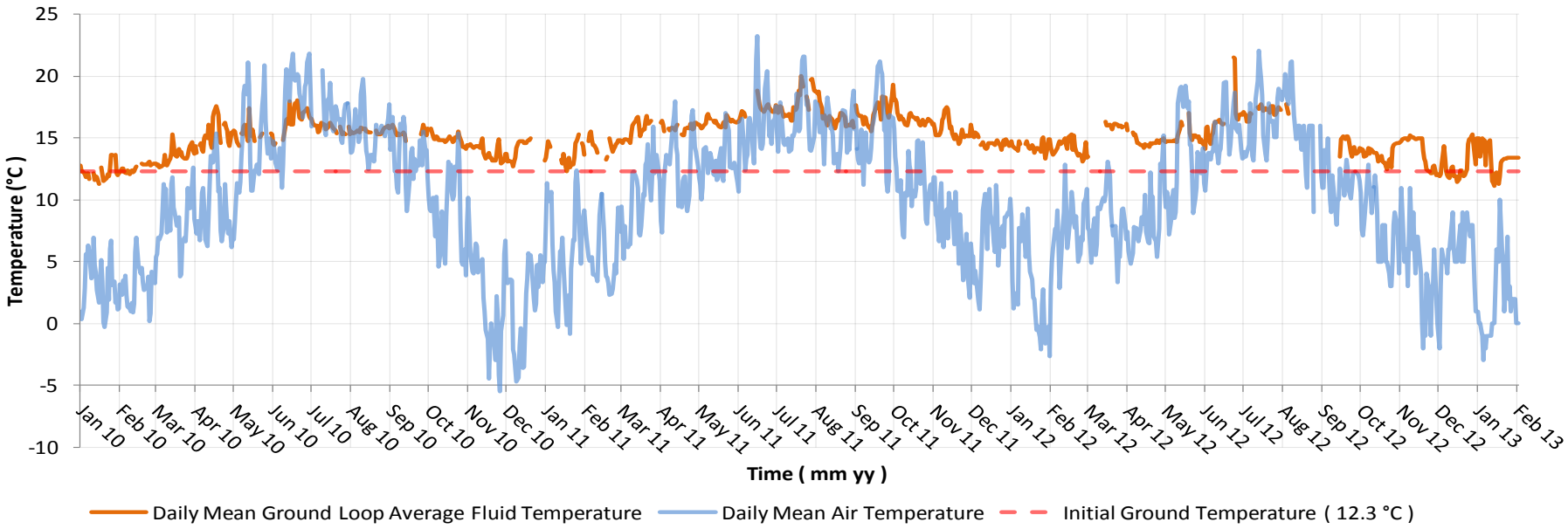
$$COP_{MAX} = \frac{T_H}{T_H - T_C}$$

- The smaller the temperature difference Inside – Outside the more efficient



HEAT SOURCES: AIR OR GROUND?

The grounds high thermal mass means it has a temperature that is more favourable than the air



HEAT EXCHANGER TECHNOLOGY

- Vertical Boreholes:
  Drill, Insert, Grout.

HEAT EXCHANGER TECHNOLOGY

- Slinky horizontal heat exchangers – coiled HDPE pipe
- Horizontal heat exchangers with straight pipe loops

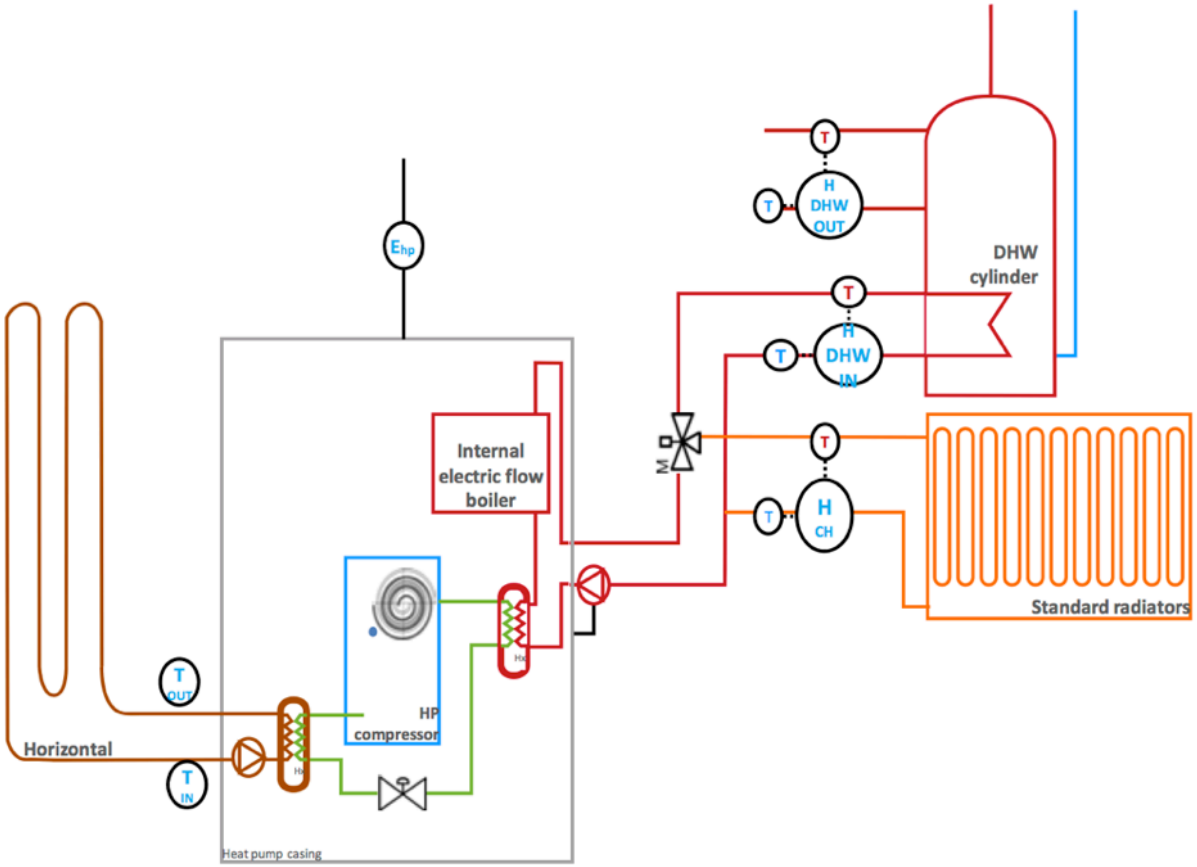
Source: GeoScience Ltd

Source: Carbon Trust

SEASONAL PERFORMANCE

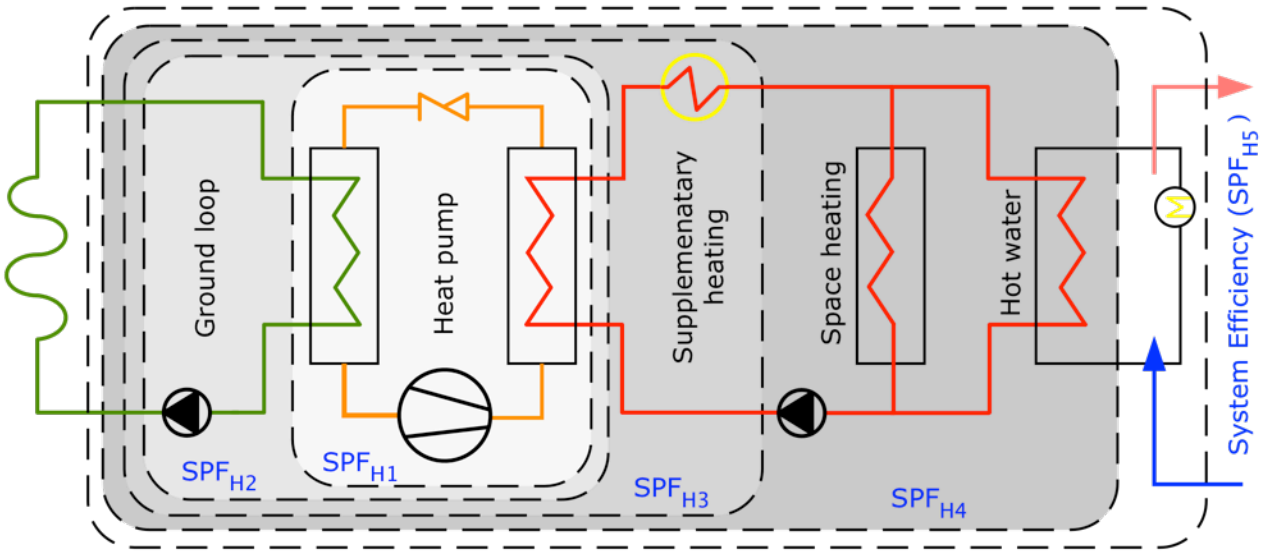
- COP is a steady-state parameter at particular operating conditions (catalogue values).
- Seasonal Performance Factor (SPF) is of more interest and is expected to be lower
- SPF is the ratio of Total useful heat output/power consumed.
- In reality systems are complex and SPF can be calculated different ways depending on what electrical demands are included

A 'TYPICAL' SYSTEM



SPF Defined

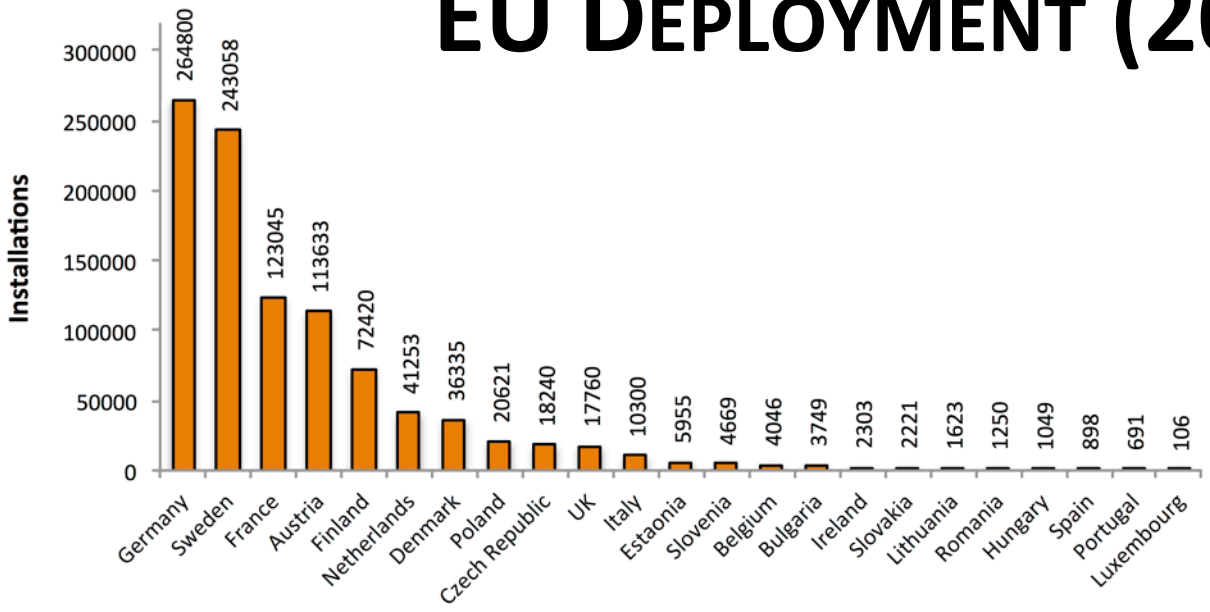
- SPF_1 is heat pump product alone
- SPF_2 includes the ground loop pump
- SPF_3 includes supplementary heater
- SPF_4 includes the heating circulating pump

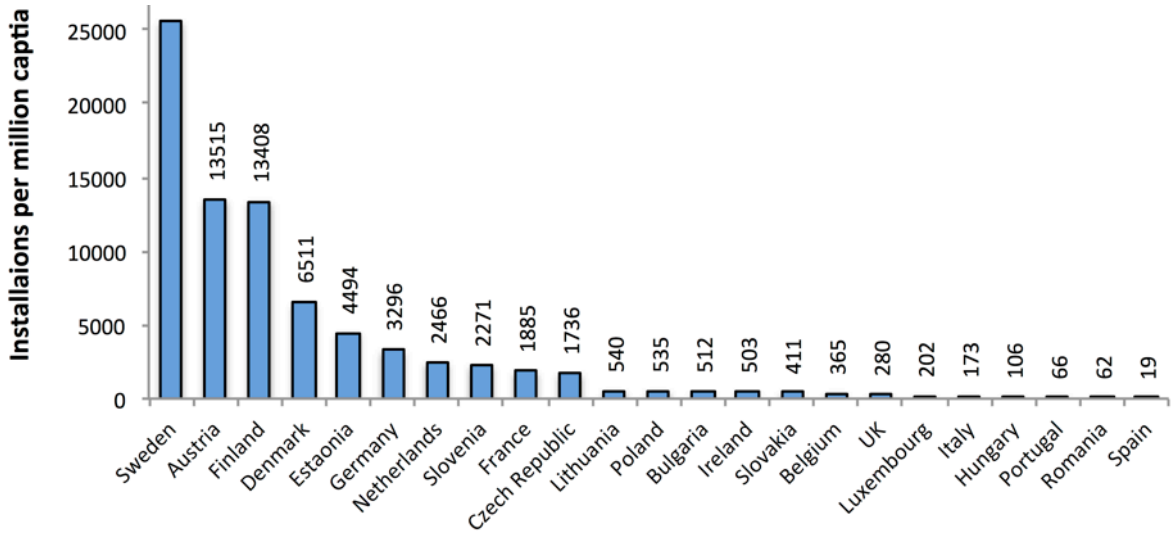


SPF Target Values

- Acceptable values vary depending on the comparison being made: site energy, primary energy, carbon saving, running cost, renewable contribution…
- A modern gas boiler system has SPF_4 about 0.85.
- For carbon benefits in the UK SPF_4 needs to be > 2.21
- For cost savings SPF_4 needs to be:
  - > 2.49 relative to gas
  - > 1.9 relative to LPG
  - > 1.65 relative to oil
- For the purposes of the RES Directive SPF_2 >= 2.5 to be classed as renewable (saving in primary energy).

EU Deployment (2013)





EARLY UK DEVELOPMENTS (LATER 1990S)

Initial installations – one-off 'low energy' houses and refurbs

Source: GeoScience Ltd

ALONG CAME ECC AND CLEAR SKIES …

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Hot earth to heat homes

A "heat exchanger" is sent 70 metres underground

Energy is being "pumped" from underground to heat elderley peoples' homes in Nottingham.

The scheme will install "ground source heat pumps" in retirement homes which will provide hot water and central heating.

The pumps extract the heat of the sun's rays stored in the earth under and around a building and are cheaper and greener than other heating systems.

The housing group which is putting in the pumps says it is a first for the UK.

Source: GeoScience Ltd

Successfully shaping our world

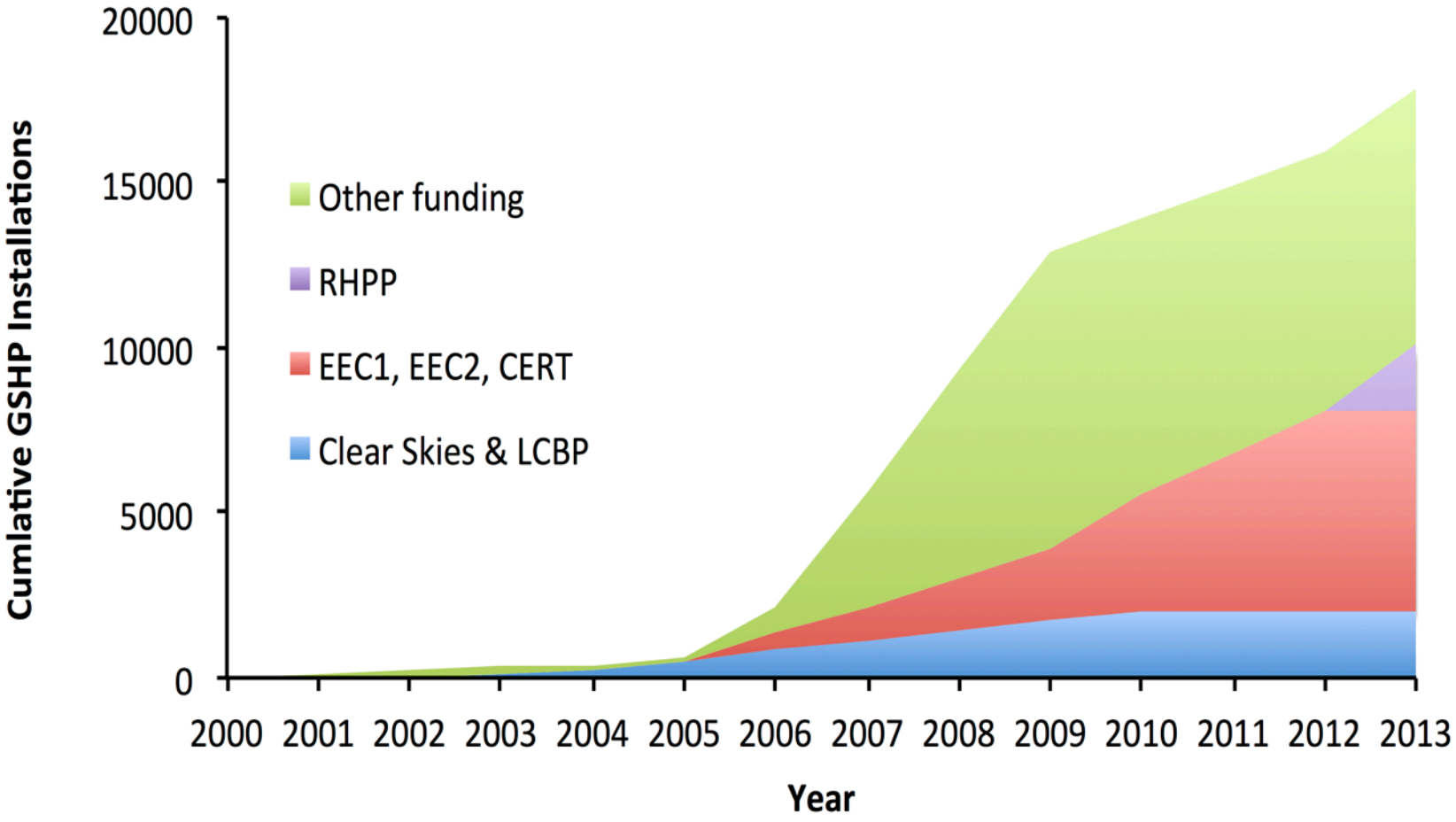
ALONG CAME ECC AND CLEAR SKIES …

Source: GeoScience Ltd

UK Support Programmes

- Grant programmes
  - Clear Skies (£10m, 8.2% for GSHP)
  - Low carbon building Programme (£139m)
  - RHPP
- Energy supplier obligation programmes
  - Energy Conservation Commitments (ECC1, ECC2) (£500m)
  - CERT (£1.2bn)
  - ECO (£1.3bn – now cut) – renewables not included
- Current programmes: RHI and the Green Deal
- Other supporting measures
  - Clear skies information and promotion
  - MCS standards/certification
  - GSHPA trade body
- Problems: policy gap following 2010 election, delay to RHI, economic downturn

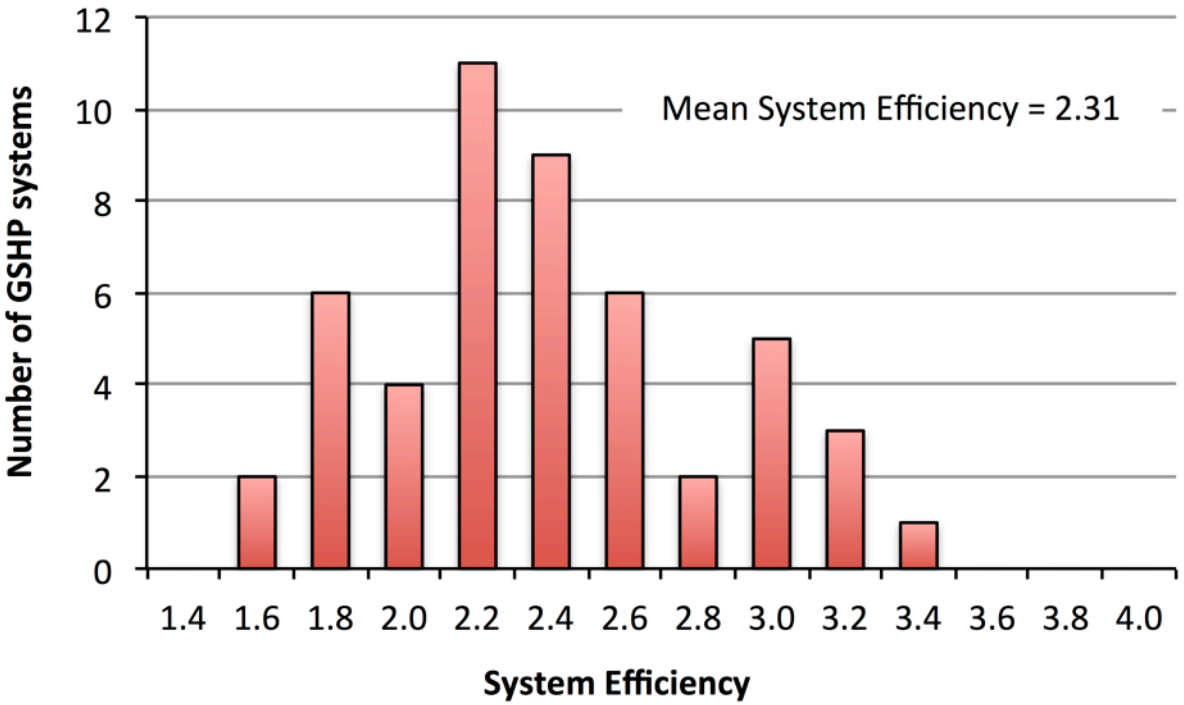
UK Support Programmes and Growth



National Trials and Monitoring

- EST National Field Trial – Phase 1 (54 GSHP sites)
  - Monitored 'system efficiency'
  - User research by OU
- DECC technical investigation
- EST National Field Trial – Phase 2. After a range of interventions
- RHPP – more detailed monitoring but without manufacturers. User data from online questionnaires. Initial results are out…

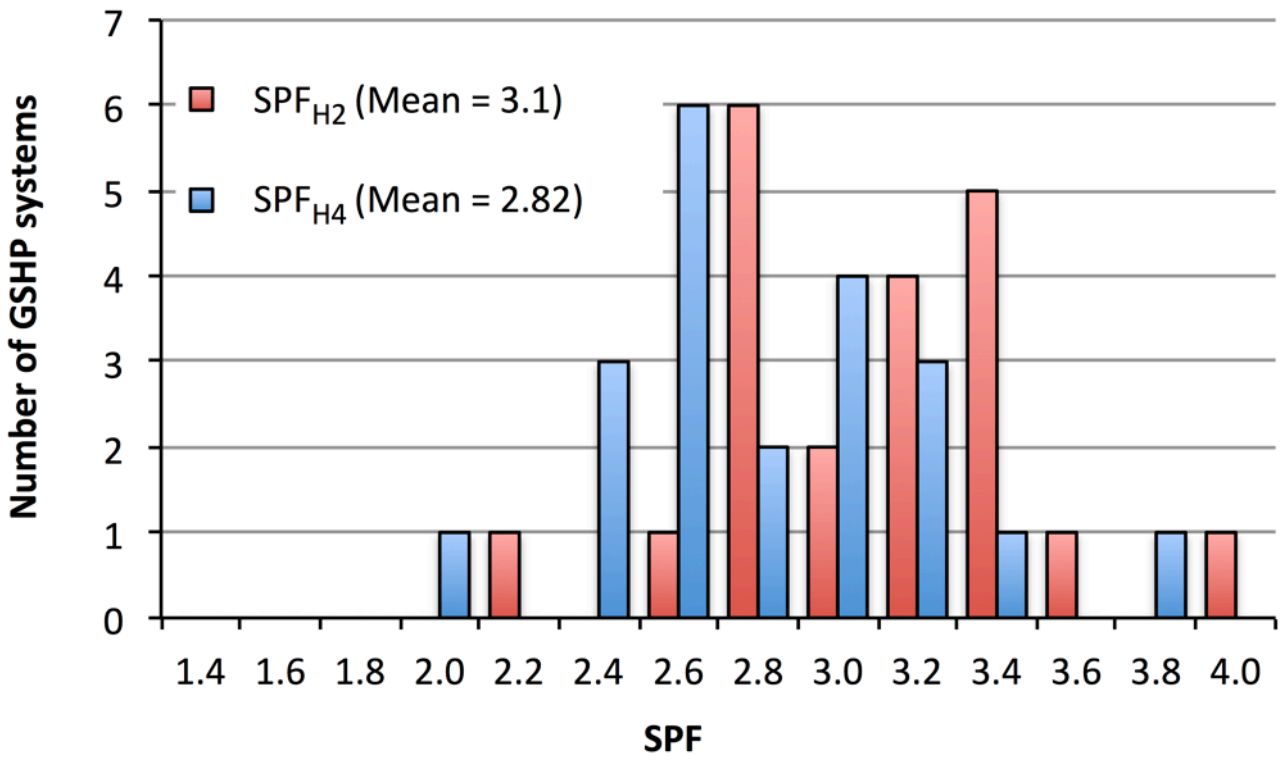
FIELD TRIAL RESULTS – PHASE 1



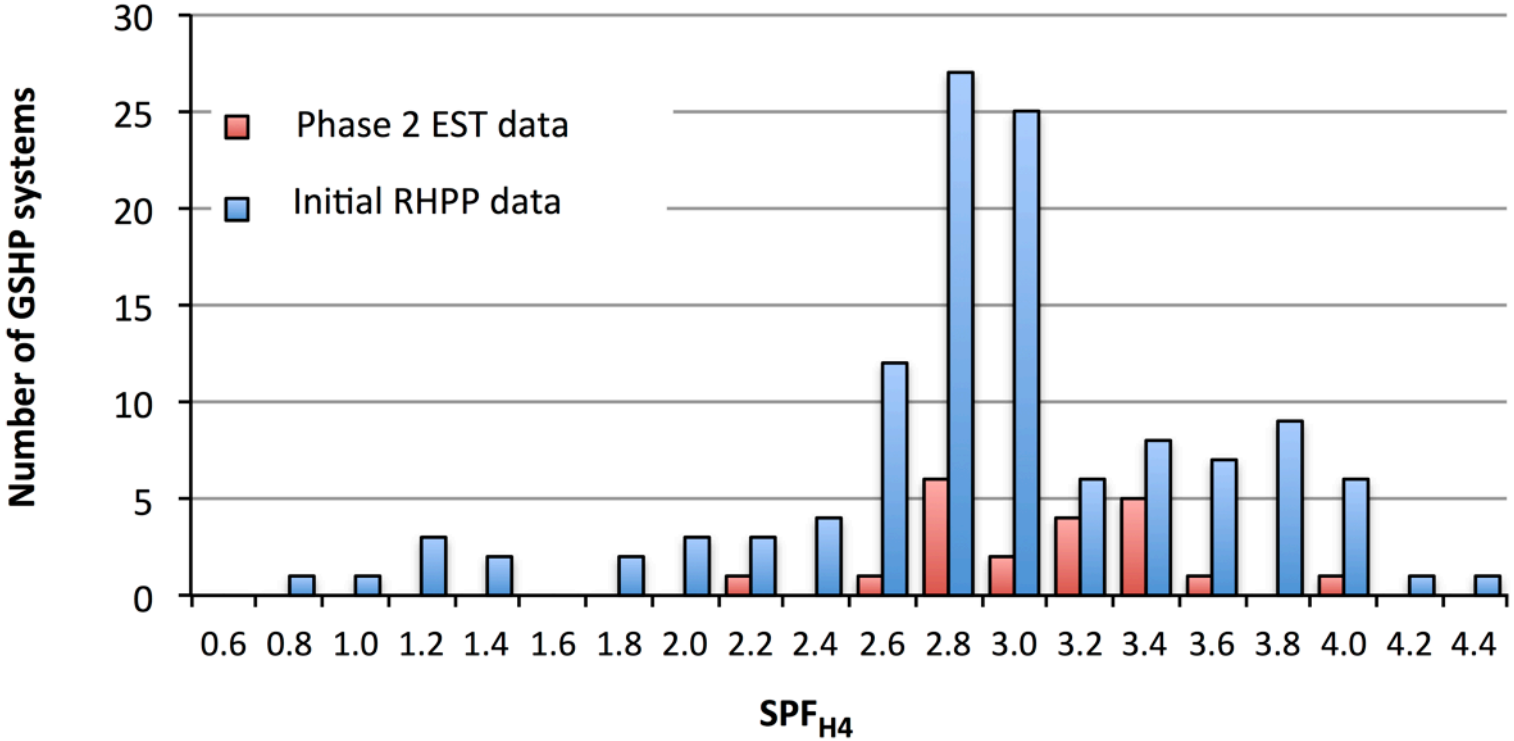
FIELD TRIAL RESULTS – PHASE 1 FINDINGS

- A number of systems with Efficiencies > 3 but some very poor performing systems
- Main technical findings
  1. Under-sizing of the heat pump
  2. Under-sizing of the ground heat exchanger
  3. Poor insulation standards (pipes and tanks)
  4. Flow temperature unnecessarily high
  5. Excessive pump usage (time control or number of pumps)
  6. Poor control
- Non-technical findings from user surveys
  - 86% satisfied with heating performance
  - Only 63% satisfied with level of support
  - Only 62% satisfied with cost savings
  - Controls not easy to understand and use
- Issues for the industry: changes to MCS standards, better training, better user support and information

FIELD TRIAL RESULTS – PHASE 2



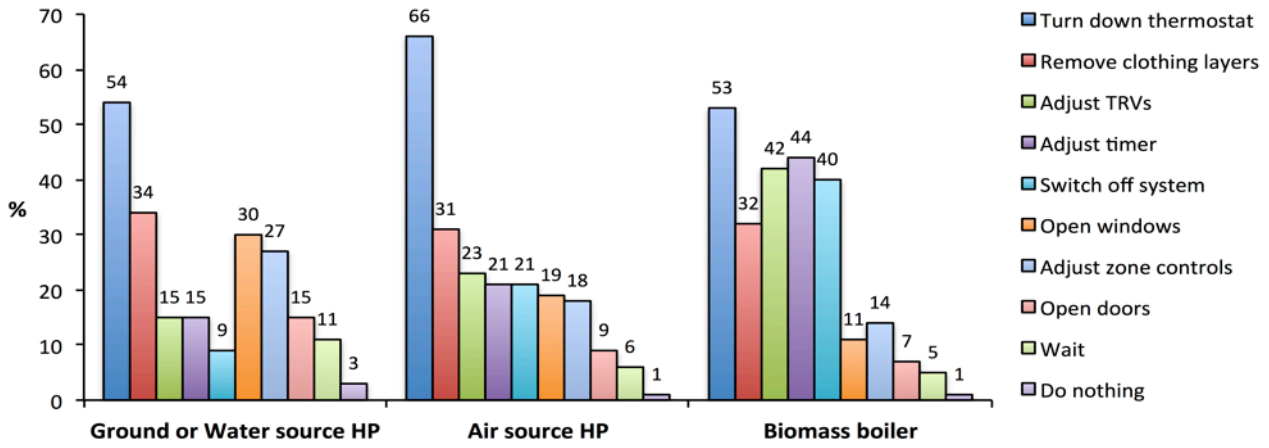
FIELD TRIAL RESULTS – RHPP 2013



- Mean SPF_4 is 2.92, System efficiency 2.74 (from 2.39)
- 84% of systems would be classed as renewable
- 85% would show carbon savings relative to gas heating
- 64% would show cost savings relative to gas. Nearly all RHPP participants saved money as initial fuel was not gas

FURTHER TECHNICAL CHALLENGES

- Performance levels are improving but still not as high as other EU trial results
- Some systems are still 'failures'
- User survey highlights some control issues
- UK Specific issues: small houses, high thermal mass, high heating temperatures?



THE OUTLOOK

- In short term:
  - RES Directive commitments are not likely to be met
  - Green Deal is not working?
  - Installers and RSLs are favouring ASHP
  - ECO is a lost opportunity
  - Buildings regs reform does not encourage renewables
- Medium and long term:
  - Heat pumps are a big part of the 2030-2050 energy strategy (in view of expected decarbonization of electricity)
  - GSHP is the most efficient heating technology – makes the most of new renewable electricity
  - Large-scale uptake will require smart grid integration and thermal storage opportunities to be addressed
  - Will the industry meet the challenges and grow through 2020-2030?

QUESTIONS

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