OPEN eco HOMES

Cambridge Carbon Footprint

Heat pumps for your home

Mon 12 Oct 2020, 7.30-9pm

Andy Hamilton	researcher/lecturer/consultant
Tom Bragg	Cambridge Carbon Footprint
Nicola Terry	CCF/consultant

Rules for the day

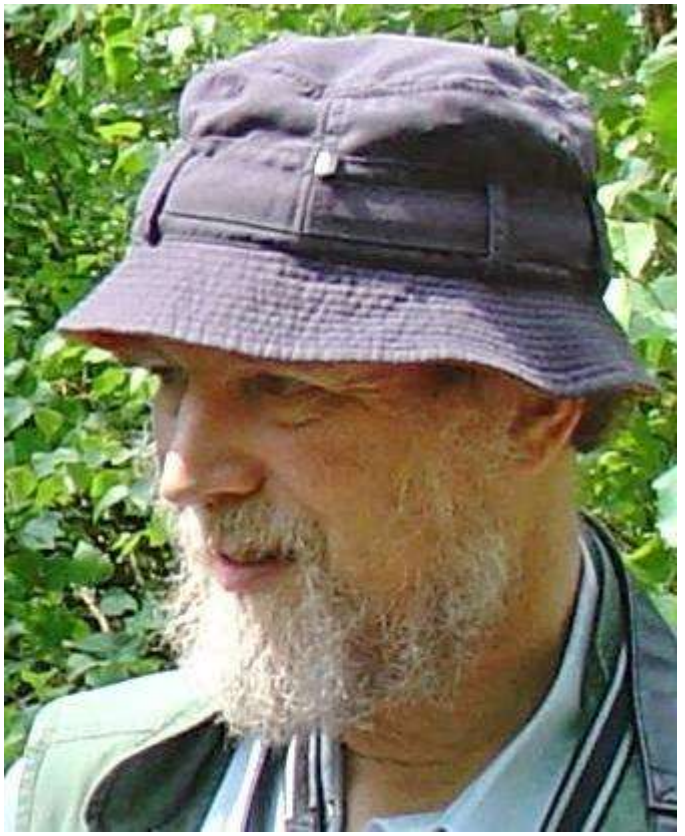
- Please keep your microphone off unless asked to contribute
- Use chat for questions
  - Nicole will monitor and interrupt Andy if needed for clarification
  - Other questions will be saved for the Q&A periods (one in the middle, the rest at the end)
- We are recording
- The slides will be available soon after the event

Why do we want a heat pump for our home

- Options for decarbonising heat in our home
  - Heat pump, hydrogen or hybrid
- Is it affordable?
  - Renewable heat incentive
  - Flexible tariffs for electricity (e.g. Octopus Agile)
- What is involved?
  - May need changes to radiators/heat emitters too
  - Efficiency depends on how you run it
    - More critical than with a gas boiler

Introducing Andy

- Carbon Co-op heat pump seminar series
- Lives in the peak district
- Has used a heat pump at home for several decades, with iterative upgrades
- Understands how they work and how to get the best out of them



Cambridge Carbon Footprint

Open Eco Homes 2020

A Heat Pump for your Home

Andy Hamilton

12th October 2020

Contact: andyham@gmail.com

Dedication

To SHELTER

- Covid eviction moratorium end - 1st October
- Shelter has launched an appeal
- https://england.shelter.org.uk/donate

Background Information

- "Heat Pumps for the home" by John Cantor, The Crowood Press Ltd., 2011, ISBN 978 1 84797 292 7
  - Currently out of print, being revised, but available as an ebook
- Also see John Cantor's Web site:- heatpumps.co.uk
- Building Research Establishment - BRE Group
  Testing and research on Heat Pump equipment, updated 2019
  - Bregroup.com/heatpumpefficieny/index.jsp

Content

- HP technical aspects
- HP performance:- CoP, Flow temp, Cycling etc
- Effective systems and their installation

Topics

- The Heat Pump Challenge
- Heat Pumps – A retrofit solution?
- The Procurement process

The Heat Pump Challenge

- Can you apply the technology?
- Can you find an installer who is able to install a effective system?
- Will your installer be motivated to install an effective system?

Heat Pumps – A retrofit solution? 1

- Poor performance of UK HPs shown in Energy Saving Trust - EST – reports
- Report 1, 2008, ASHP have average CoP of 1.8
- Report 2, 2013, ASHP Average CoP of 2.82
  - improved 2008 installations and limited to Mitsubishi Grundfoss and Daikin. No figures after 2013

Results from Mitsubishi field trail and BRE discussed later

Heat Pumps – A retrofit solution? 2

HP installation must be integrated with other retrofit techniques, such as:-

Insulation, Solar gain, Air movement, Thermal store,

Need to reduce Heat Loss to output of HP, at time of installation or later

E.g. For Semi, floor area 150 sq metres, target

- 6 kW Heat Loss, 20 degrees inside, 0 degrees outside
- 5kW output ASHP – In operation, 1 kW Electricity input

The Procurement process

1. Decide on the Heat Pump to be installed – Type, Make and model, and output size
2. Choose an Installer
3. Design the system
4. The Installation process
5. Daily operation of your HP

*** Caution!! You need to get all 5 right! ***

The Procurement process 1

Decide on the

Heat Pump

to be installed

Heat Pump Types

- Ground Source, GSHP: Suitable for new build as excavator on site.

- Water Source, WSHP: Suitable water source?
  - River Thames - London apartments,
  - The sea - Swedish airport

- Air Source, ASHP: Suitable for Retrofit
  - Air to Water: for conventional central heating
  - Air to Air: for blown air space heating

Heat Pumps - GSHP

- Ground source: Extensive excavation, or boreholes, needed to collect ground heat.
- Problems with heat collection system
- High cost - £10,000 plus
- An option for new build domestic or larger buildings
- E.g. New build care homes - Rendesco

Heat Pumps – ASHP: Air to Water

- High reliability ***potential*** as factory built
- Main unit is external

- Potential to perform well in mild climate

  Few days in the year in the UK below 3 degrees

  Warm air source? E.g. Sun trap, London underground

- Replacement for Gas Boiler - runs at lower temperature

  Cost £2,500 - £10,000

Heat Pumps – ASHP: Air to Air

ASHP is heat source for “fan heater”

- Good for “open plan” living space
- Cost from £500
- Forced Air Central Heating is possible
- Simple device – potentially reliable and efficient

Common in Canada, Australia etc. New to UK

Potential as a hybrid HP/Gas system

ASHP with Supplementary Heating

ASHP with an output less than Heat Loss at 0 degrees, supplemented by direct electric (fan heater etc),

can be more efficient than an ASHP matching Heat Loss.

E.g. Heat Loss=6kW, choose 5kW ASHP, **not** 6kW plus (BRE)

Supplementary Heating can be a Wood Stove, Fan heater, Gas fire, etc.

An Air to Air (A2A) ASHP can be used to reduce central heating gas consumption. A cheap retrofit intervention.

Tom installed an A2A ASHP in February 2020……

Air To Air

- Better COP - lower output T
- low cost, easy installation
  total £2,250, incl VAT
- <u>Could</u> be used for cooling

BUT:

- Normally only heats one room
- No RHI

Which ASHP?

- HPs come in a much wider range of performance and reliability than cars
- Japanese have invested £1 Billion in HP research – given to their manufacturers
- ASHP can be noisy
- 10 years without maintenance is possible
- Small is beautiful

Expected ASHP performance

- My 2010, 5kW Ecodan - seasonal CoP of 2.7 initially, improved to 3.6, about 4 from 2015
- Mitsubishi Field Trial, 60 ASHPs, CoPs 1.5 to 3.6
- EST 2013 average of 2.8 CoP (1.8 in 2008)
- Target CoP - 2.5 is OK, - better than 3 is good

May 2013 to May 2014, monthly, CoP 3.61 – Green Line

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MITSU ELECT

Map | Live Data | Site Details | Historic Data | Compare

3 Bedroom Detached House Rossendale, Lancashire

View the historic performance of the Ecodan system. Add and remove items from the chart using the checkboxes below.

- [x] Energy In (kWh)
- [ ] Immersion Energy In (kWh)
- [x] Energy Out (kWh)
- [ ] Flow Temperature (°C)
- [ ] Return Temperature (°C)
- [ ] Flow Rate (l/min)
- [x] Inside Temperature (°C)
- [x] Outside Temperature (°C)
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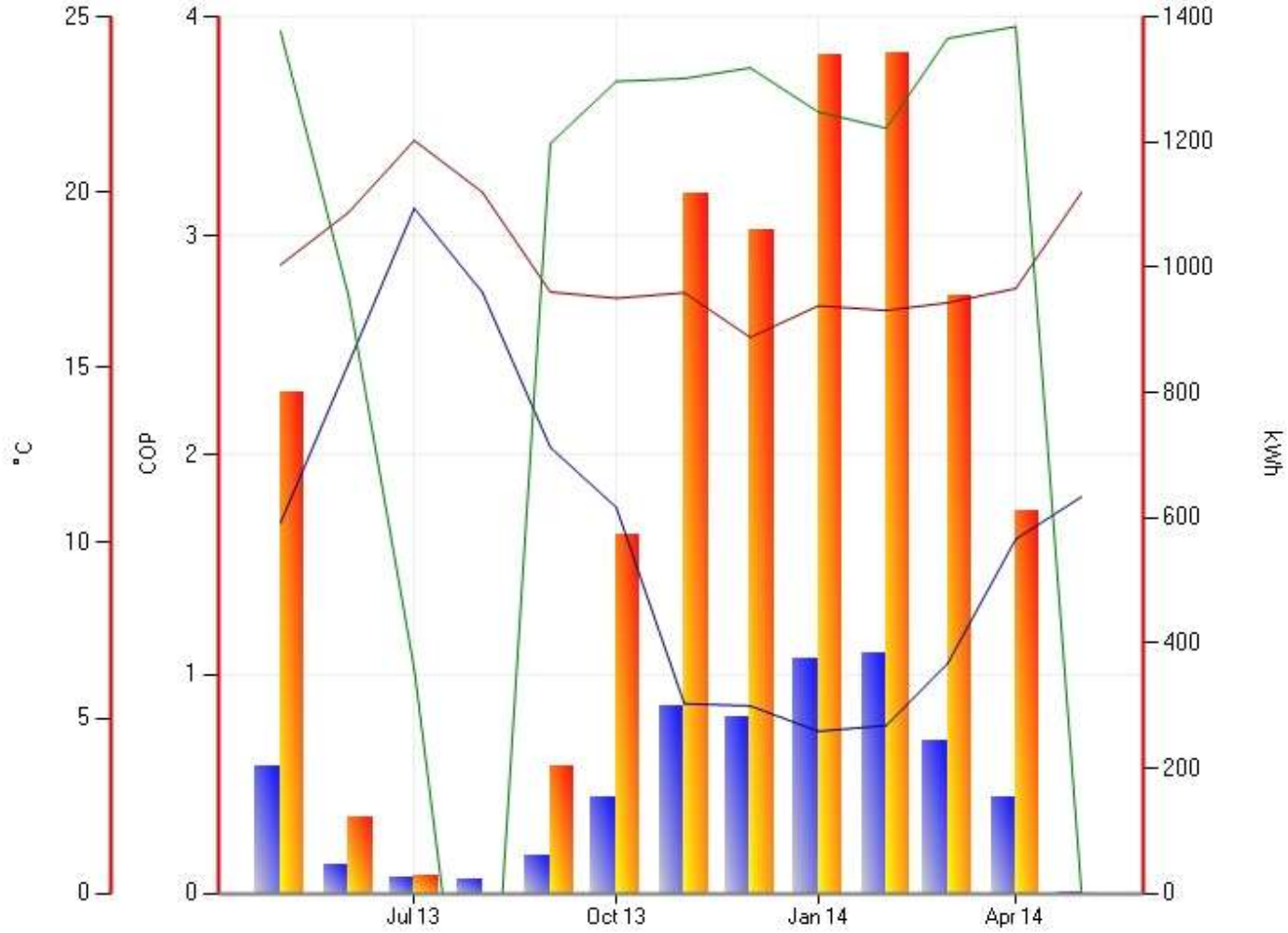
- [ ] Cylinder Temp - Top (°C)
- [ ] Cylinder Temp - Middle (°C)
- [ ] Cylinder Temp - Bottom (°C)
- [x] COP (COP)



Average COP 3.61
Total Energy Out 8112kWh
Average Outside Temp 10.3°C
Average Inside Temp 18°C

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Export Data

Group data by Minute

Export

Sizing your ASHP

- Energy Survey needed – for sizing ASHP, and planned insulation improvements
- Match output of ASHP to Heat Loss ***after improvements***
- Low ASHP output is OK as Heat Loss usually lower than calculated.
- E.g. 5kW output HP for 6kW Heat Loss
- A matched pair of ASHP can be effective

The Procurement Process 2

Choose an Installer

Choose an Installer

- Select specialist in the Make of ASHP chosen
- “Approved Installer” may not be good
- Find out who your ASHP manufacturer uses to remedy problem installations **OR**
- Select an installer who has put in a well performing system for someone you know

The Procurement Process 3

Design

Design of an efficient system

- Avoid complexity for reliability and efficiency
- Monitoring system essential for tuning system to achieve high CoP
- Low flow temperature, in radiators - 35 to 40 degrees

  ASHP Efficiency is related to Flow temp – External temp
- Low output ASHP with appropriate Heat Emitters, for efficiency

Design of Heat Emitters

- Sufficient radiators and/or under floor heating
- Under floor heating – 25 mm or larger pipes
- High output radiators: double, triple, fan assisted
- Check radiator output calcs for each room
- Small radiators for “Buffer Zones”

Design – cycling and sizing

- Performance over 2 hours of 2 ASHPs

- Next slides:- poorly set up ASHP
- Outside temp 11.9 c CoP 1.13

- Following slide:- well set up ASHP
- Outside temp 9.9 c CoP 5

Pontefract: 10 minute On-off cycles, CoP 1.13, ASHP oversized

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MITSUBISHI ELECTRIC

Map | Live Data | Site Details | Historic Data | Compare Fuels

2 Bedroom Flat Pontefract, West Yorkshire

View the historic performance of the Ecodan system. Add and remove items from the chart using the checkboxes below.

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- [ ] Return Temperature (°C)
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- [x] Inside Temperature (°C)
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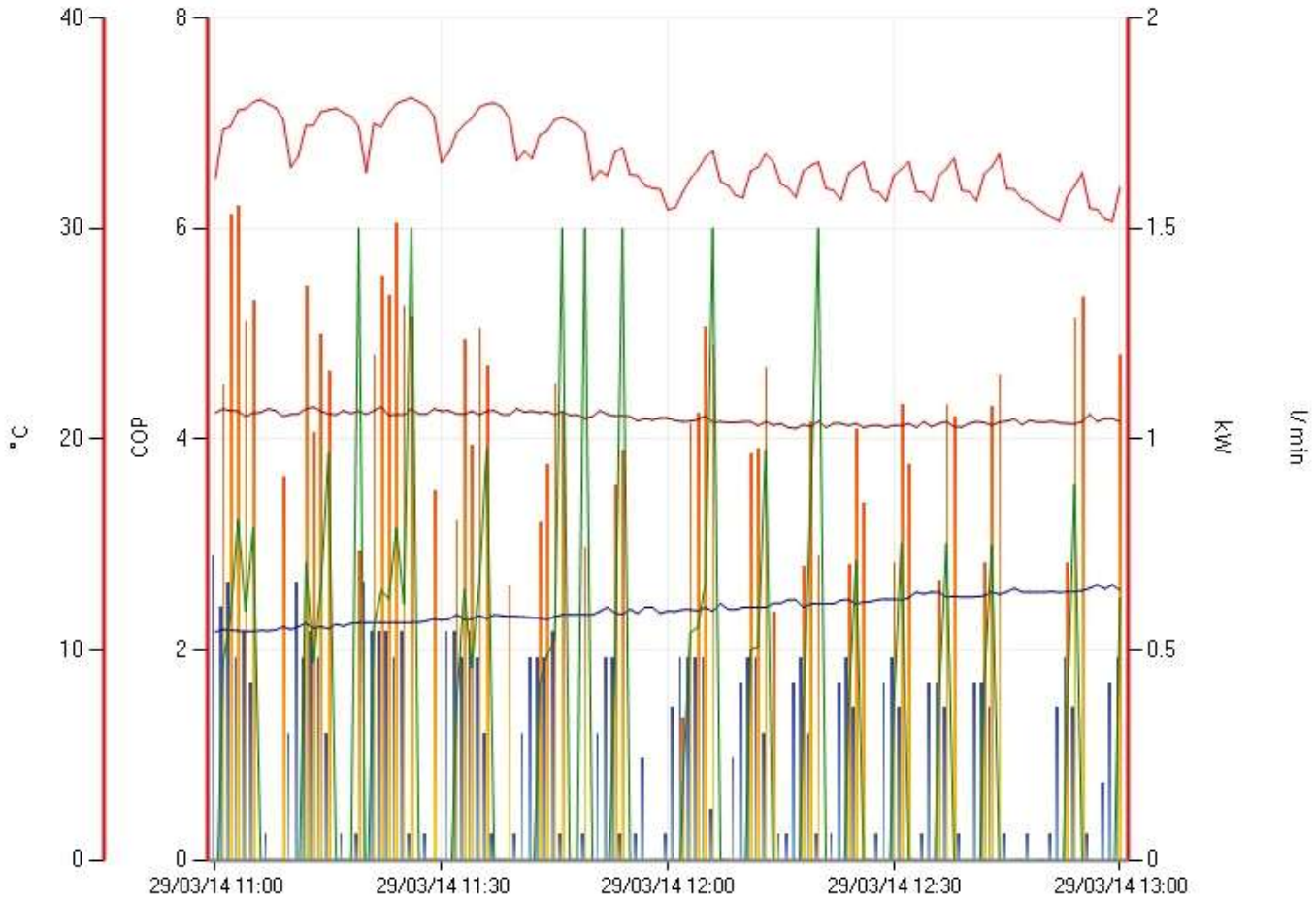
- [ ] Humidity (%RH)
- [ ] Cylinder Temp - Top (°C)
- [ ] Cylinder Temp - Middle (°C)
- [ ] Cylinder Temp - Bottom (°C)
- [x] COP (COP)

Average COP 1.13
Total Energy Out 1kWh
Average Outside Temp 11.9°C
Average Inside Temp 21°C



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Pontefract: System has CoP of 2 in winter

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MITSUBISHI ELECTRIC

Map | Live Data | Site Details | **Historic Data** | Compare Fuels

2 Bedroom Flat Pontefract, West Yorkshire

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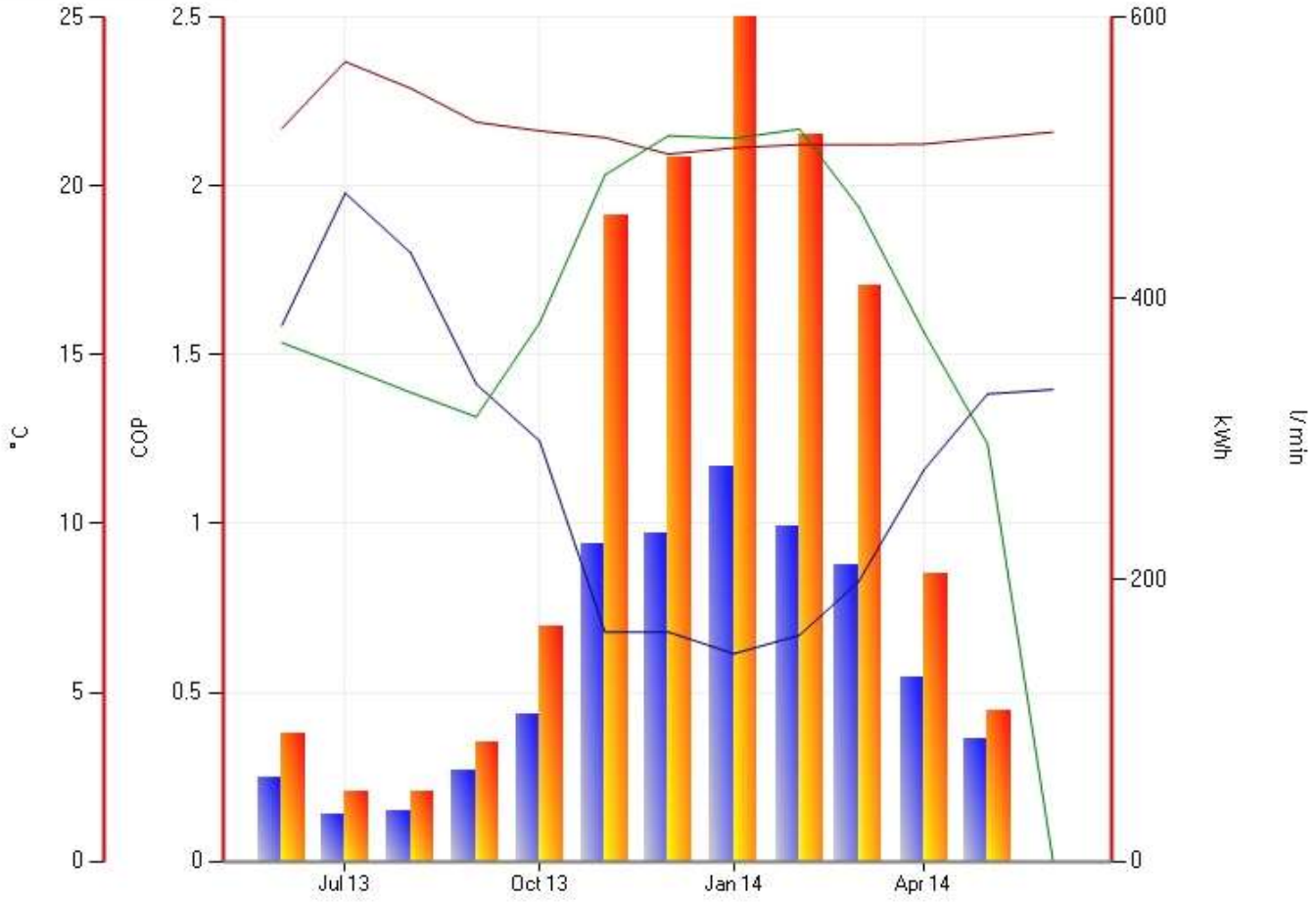

Average COP 1.9
Total Energy Out 3237kWh
Average Outside Temp 11.9°C
Average Inside Temp 21.7°C

Export Data

Group data by Minute

Export

Well sized ASHP, CoP of 5, 1kW input, output fall to 4kW and CoP fall to 4, over 2 hours

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MITSUBISHI ELECTRIC

Map | Live Data | Site Details | Historic Data | Compare Fuels

3 Bedroom Detached House Rossendale, Lancashire

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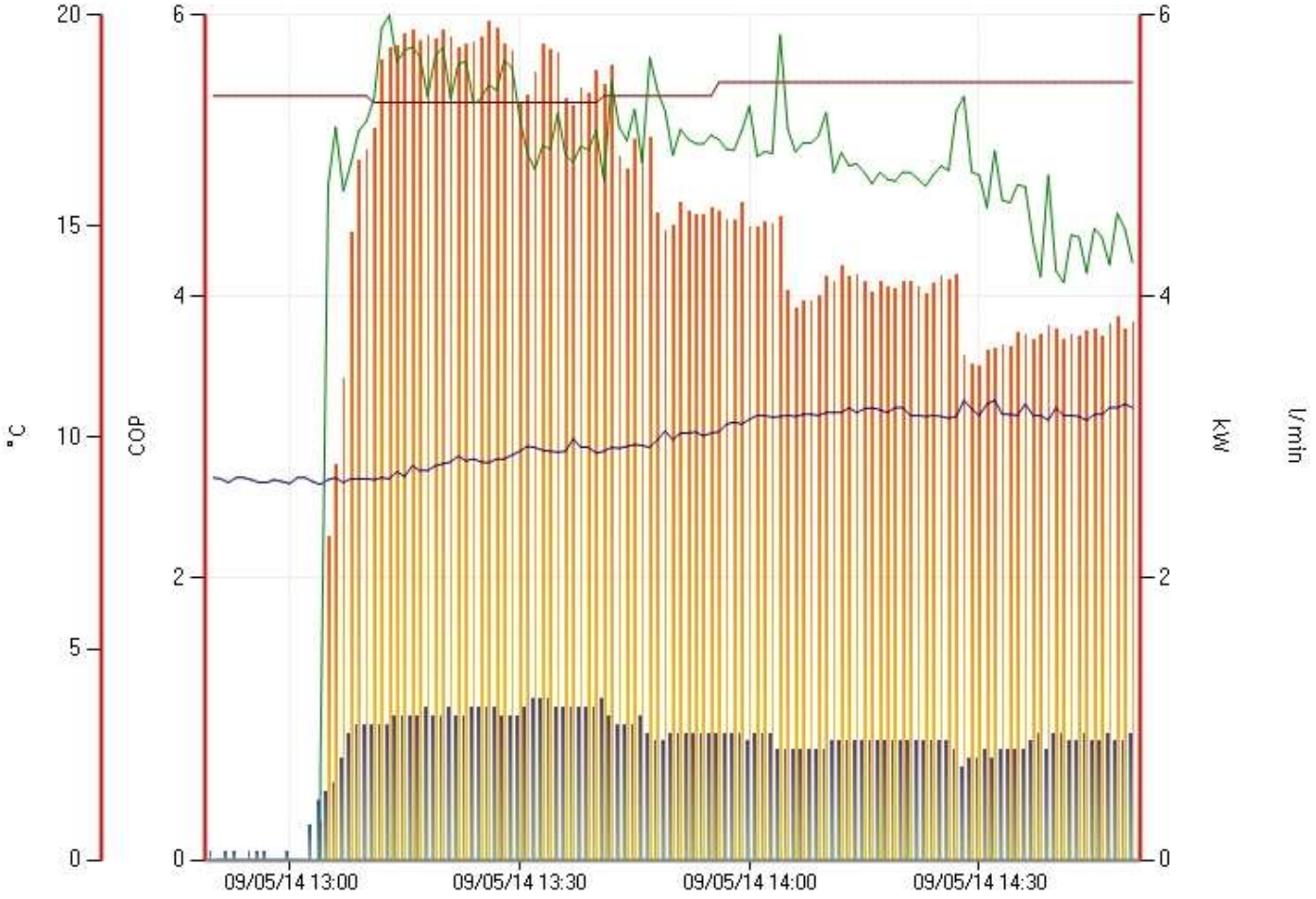
- [ ] Humidity (%RH)
- [ ] Cylinder Temp - Top (°C)
- [ ] Cylinder Temp - Middle (°C)
- [ ] Cylinder Temp - Bottom (°C)
- [x] COP (COP)

Average COP 5
Total Energy Out 8kWh
Average Outside Temp 9.9°C
Average Inside Temp 18.2°C



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Export

The Procurement Process 4

Installation

Installation

- Check quality of work, integrity of insulation etc. – take photos candidly
- Discuss issues and changes with Installer
- Written communication is a record
- Provide beverages and snacks
- If work is poor quality, you can change installers

The Procurement Process 5

Operation

Operation

- Monitor tells you the story – worth the cost
- Is the thermostat causing cycling and low CoP?
- Avoid cycling: Run on timer
  - or set on/off to 1 hour min delay if possible
- Use monitor to find out how effective your system is when working for 2, 3, or 4 hour sessions
- Cold day performance - less than 0 degrees on next slide

24 hours: 10 am to 10 am, -0.5 to -2 degrees, CoP 2.74

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MITSUBISHI ELECTRIC

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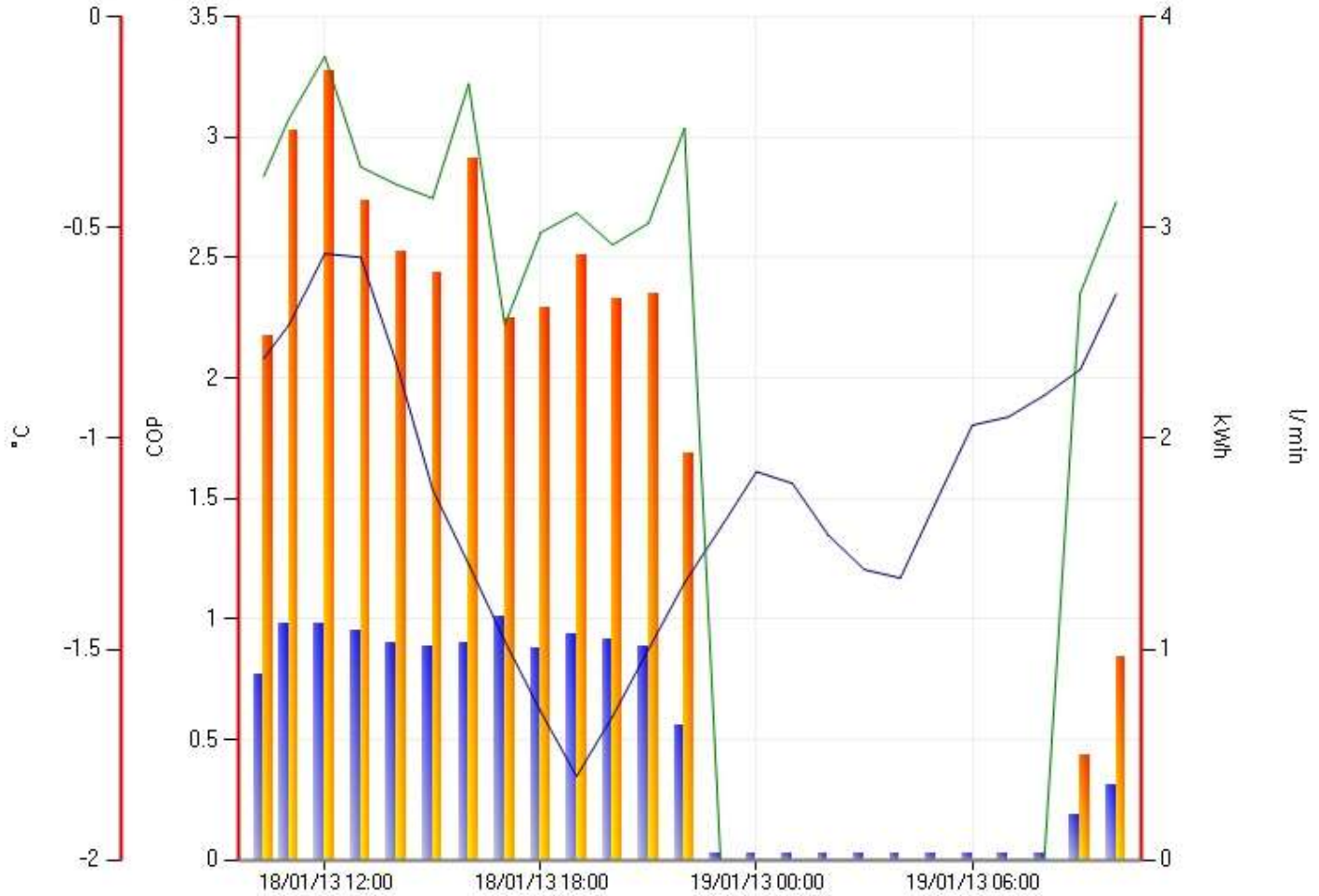
- [x] Outside Temperature (°C)
- [ ] Humidity (%RH)
- [ ] Cylinder Temp - Top (°C)
- [ ] Cylinder Temp - Middle (°C)
- [ ] Cylinder Temp - Bottom (°C)
- [x] COP (COP)

Average COP 2.74
Total Energy Out 39kWh
Average Outside Temp -1.1°C
Average Inside Temp 15.3°C



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Export

December 2015, Average temp 7.5, CoP 4.31

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MITSUBISHI ELECTRIC

Map | Live Data | Site Details | **Historic Data** | Compare Fuels

3 Bedroom Detached House Rossendale, Lancashire

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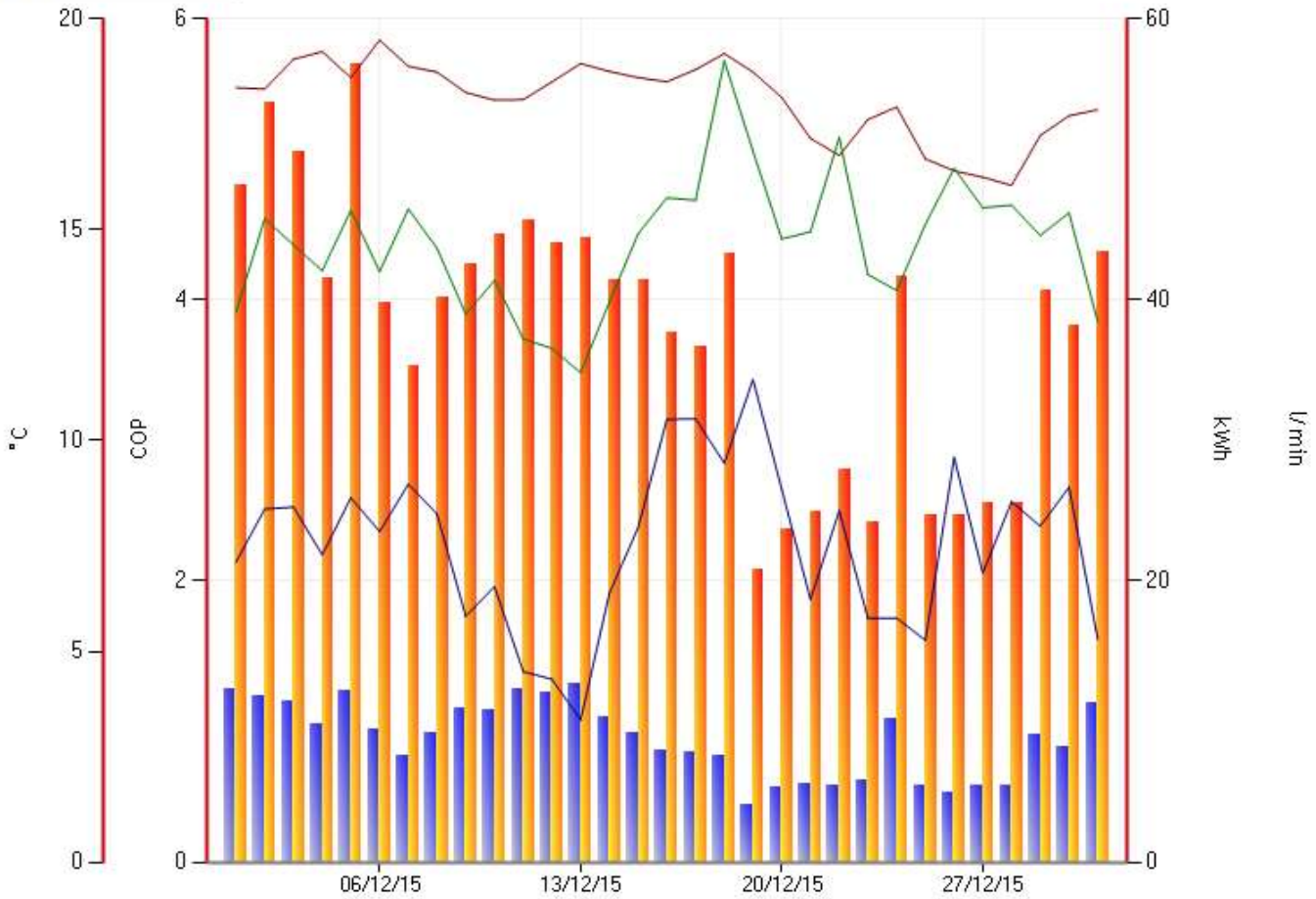
- [ ] Humidity (%RH)
- [ ] Cylinder Temp - Top (°C)
- [ ] Cylinder Temp - Middle (°C)
- [ ] Cylinder Temp - Bottom (°C)
- [x] COP (COP)

Average COP 4.31
Total Energy Out 1174kWh
Average Outside Temp 7.5°C
Average Inside Temp 18.1°C



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My thanks to the following:

- AECB members
  - John Cantor - Heat Pumps
  - Nick Parsons – Energy Survey & Retrofit insulation
  - Peter Wilkinson - Bank Nook Extension

  Also
  - World heat – Heat Pump installation
  - Mitsubishi & Trystan Lea – Heat Pump monitoring
  - Keith Trippier – Bank Nook joiner etc for 40 years
  - Prof Lubo Jankovic – for successfully applying chaos theory to Retrofit

  Contact me: andyham@gmail.com

Bank Nook 1977

Thermal Imaging Training

Cambridge Carbon Footprint

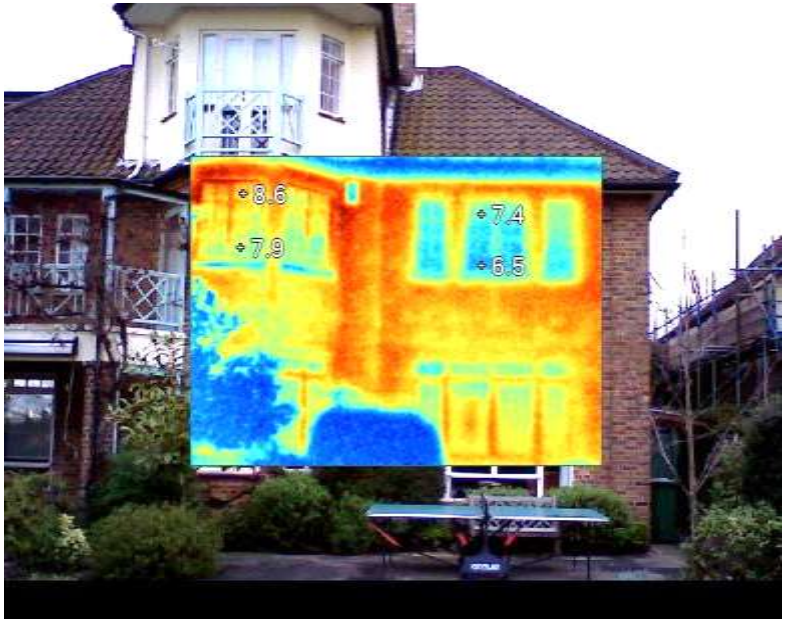
[Get trained at one of these](#) & borrow a camera:

Tue 3rd Nov, 7:30-9:00 pm

Wed 2nd Dec, 6:00-7:30 pm

Thu 14th Jan, 7:30-9:00 pm

Tue 23rd Feb, 6:00-7:30 pm



Solar Together

new **Cambridgeshire Solar Together scheme**

uses group-buying for solar panels, plus optional battery

to bring you these at lower cost.

More Online Tours & Talks

openecohomes.org/autumnseason

Please write feedback in Chat: - What did you enjoy?

- Suggestions for improvement?

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