
This version is available at https://strathprints.strath.ac.uk/35632/

Strathprints is designed to allow users to access the research output of the University of Strathclyde. Unless otherwise explicitly stated on the manuscript, Copyright © and Moral Rights for the papers on this site are retained by the individual authors and/or other copyright owners. Please check the manuscript for details of any other licences that may have been applied. You may not engage in further distribution of the material for any profitmaking activities or any commercial gain. You may freely distribute both the url (https://strathprints.strath.ac.uk/) and the content of this paper for research or private study, educational, or not-for-profit purposes without prior permission or charge.

Any correspondence concerning this service should be sent to the Strathprints administrator: strathprints@strath.ac.uk
POE + Monitoring including the 1st Scottish Passive House

paul tuohy  gavin murphy  alison cowie  gokay devici  ingo theoboldt
POE + Monitoring including the 1st Scottish Passive House

Abstract

• Project has been running since March 2011.

• Three dwellings monitored include the first Scottish Passive house, a Low Energy House (no MVHR), and a 1950s dwelling; located in Dunoon, Scotland.

• Monitoring includes: energy use; internal and external conditions (Temperatures, RH and CO2 levels inside and temperature and solar radiation outside); and systems performance (including solar hot water).

• Post occupancy evaluation (POE) carried out through inspection and questionnaire.

• Energy used, CO2 and relative humidity levels compared.

• Operation of the different ventilation schemes highlighted.

• Costs and electricity tariffs highlighted.

• Learnings identified include ventilation, heat pump, solar and auxiliary hot water services.

• Improvements to current processes are suggested.

• POE and monitoring are essential feedback for the building design and construction process.
1 – Passive House (et)  
2 – Code level 4 House (mt)  
3 – 1950s House (et)  
all-electric heating and hw
POE: Passive House

Snagging:

• MVHR intake and exhaust duct insulation
• Air Source Heat Pump winter performance
• Solar / Electric Water Heating
• Tariff

The resolution of these snags is underway.........
POE: Passive House

Snagging:

• MVHR intake and exhaust duct insulation
POE: Passive House

Snagging:

• Air Source Heat Pump winter performance

<table>
<thead>
<tr>
<th>H/P type</th>
<th>Emitter Type</th>
<th>Lowest source temp</th>
<th>Test conditions set out in EN14511</th>
<th>Highest source temp</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air to Water (Source -ambient air only)</td>
<td>UFH</td>
<td>35/a</td>
<td>Sink -7/-6 Source -35/a Sink 2/1 Source 35/30</td>
<td>7/6</td>
</tr>
<tr>
<td></td>
<td>Convect.</td>
<td>45/a</td>
<td>Sink -7/-6 Source -45/a Sink 2/1 Source 45/a</td>
<td>7/6</td>
</tr>
<tr>
<td></td>
<td>Radiator</td>
<td>55/a</td>
<td>Sink -7/-6 Source -55/a Sink 2/1 Source 55/a</td>
<td>7/6</td>
</tr>
</tbody>
</table>

Annual Coefficient of Performance - Heat Pump 2.50
Total System Performance Ratio of Heat Generator 0.40

Defrost at $T_{amb} < 6^\circ C$?

Romain Petinot
POE: Passive House

Snagging:

• Solar / Electric Water Heating – electric heater on in middle of June day?
POE: Passive House

Snagging:

• Tariffs – THTC 7p/kWh vs Standard 12p/kWh for space and water heat
CEPHEUS-SCOT: Monitoring kit
CEPHEUS-SCOT: Monitoring kit

Contact: Paul.Tuohy@strath.ac.uk
INITIAL OBSERVATIONS
COMFORT CONDITIONS – PH COOL? BUT GOOD CO2!

Dunoon CO2, RH and Temp in lounge.

Relative Humidities (lounge)

Indoor Temperatures (lounge)

Key: PH: Blue, Code4: Green, 50s: Orange

CO2 Concentrations [outdoor = 374 PPM]
COMFORT CONDITIONS – PH COOL? BUT GOOD CO2!

Dunoon CO2, RH and Temp in lounge.

Extract ventilation in code 4

Relative Humidity (lounge)

Indoor Temperatures (lounge)

Key: PH: Blue, Code4: Green, 50s: Orange

CO2 Concentrations (outdoor = 374 PPM)
COMFORT CONDITIONS – PH COOL? BUT GOOD CO2!

<table>
<thead>
<tr>
<th></th>
<th>Code Level 4</th>
<th>Passive House</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average concentration</td>
<td>1060.1 ppm</td>
<td>594.3 ppm</td>
</tr>
<tr>
<td>Maximum concentration</td>
<td>2231 ppm</td>
<td>1384 ppm</td>
</tr>
<tr>
<td>Minimum concentration</td>
<td>422 ppm</td>
<td>401 ppm</td>
</tr>
<tr>
<td>More than 900ppm</td>
<td>65.6%</td>
<td>3.4%</td>
</tr>
<tr>
<td>More than 1000ppm</td>
<td>54.7%</td>
<td>1.7%</td>
</tr>
</tbody>
</table>

Relative Humidities (lounge)

CO2 Concentrations (outdoor = 374 PPM)
Contact: Paul.Tuohy@strath.ac.uk

MONITORING OUTPUTS – Electricity use?

- Hot water tank temperatures
- RH, CO2, Solar Th, HW use also recorded
- Indoor temperatures
- Outdoor temperatures
- Electricity usage

PH - blue, LE - green, 50s - orange
Electricity summary
March – June 2011

(Eirini Moutzouri)
SOLAR THERMAL – EXPECT 55% ANNUAL CONTRIBUTION - PHPP

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>Collector sensor 1</td>
</tr>
<tr>
<td>S2</td>
<td>Store sensor</td>
</tr>
<tr>
<td>S3</td>
<td>Collector sensor 2</td>
</tr>
<tr>
<td>S4</td>
<td>Measuring sensor (optionally)</td>
</tr>
<tr>
<td>R1</td>
<td>Solar pump collector 1</td>
</tr>
<tr>
<td>R2</td>
<td>Solar pump collector 2</td>
</tr>
</tbody>
</table>

Contact: Paul.Tuohy@strath.ac.uk
Electric immersion heater controls not optimised
Electric immersion heater controls – fixed?

But still not optimised? Now 60°C 2x per day 5-6 am and pm

for Legionella?
SOLAR THERMAL – 55% ANNUAL CONTRIBUTION - PHPP

Solar system controls – if panels $6^\circ\text{C} >$ bottom tank sensor then pump is on – can flow water as cool as $15^\circ\text{C}$

**Pink** = flow from solar panel, **Purple** = return to panel from tank
Published results suggest 40% solar fraction for Solar plus Aux heating to 60°C 2x per day (Dublin climate)
CONCLUSIONS
CONCLUSIONS

• Owner very happy with Passive House
• Energy use low
• Indoor air quality good

• Snagging – learning points to be shared
• Processes can be made more robust! HP, MVHR, Solar/Aux
• Tariff

• POE and Monitoring – essential process

paul tuohy    gavin murphy    alison cowie    gokay devici    ingo theoboldt
CONCLUSIONS

• Owner very happy with Passive House
• Energy use low
• Indoor air quality good

• Snagging – learning points to be shared
• Processes can be made more robust!
  HP, MVHR, Solar/Aux
• Tariff

Standard can be made more robust!

• POE and Monitoring – essential process