A Scottish demonstrator project: feasibility and design of ground source or water source heat pump systems for use in buildings owned by Scottish Canals, many of which are situated adjacent to canal waterways

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Decision process of the heat pump technology’s feasibility for Scottish Canals

To estimate the Annual heating demand (kWh) and Specific heat loss (W/m²) following data is required:
1. Floor plans or (at least) heated floor area.
2. Building fabric details or (at least) its age.
3. Details of any refurbishment.
4. Current heating system type and, if possible, its rating in kW.

Is heating required?
- Yes
  - *Annual heating demand (kWh)?
    - Low or High
      - High or Medium
        - **Specific heat loss (W/m²)?
          - High
            - Refurbishment planned?
              - Yes
                - ASHP feasible?
                  - Yes
                    - ASHP recommended
                  - No
                    - Removed from the list
              - No
                - Future work
            - Medium or Low
              - GSHP or WSHP feasible?
                - Yes
                  - Water levels and flow rate sufficient for WSHP?
                    - Yes
                      - Closed loop (HE) WSHP feasible?
                        - Yes
                          - Closed loop (HE) WSHP recommended
                        - No
                          - Open loop WSHP recommended
                    - No
                      - Horizontal GSHP collector recommended
                - No
                  - Vertical (BH) collector recommended
          - Removed from the list
    - Removed from the list
- No
  - Removed from the list
• Multi-use building cluster, currently heated with combination of electric storage and oil. Estimated Heat Demand: 50,664 kWh/year / £7,599

• Water and ground source heat pumps are options. Water, open loop taking water from the canal upstream of the lock, and ground source using boreholes. Both are doable, but more costly than an air source system

• Reducing heat loss of the building would be important prior to installing any low temperature heating system

Recommended System Type **WSHP**:  
CO₂ Emission Reduction 8,370 (kg/year)  
Running Cost Reduction 5,458 (£/year)  
Potential RHI Income 3,962 (£/year)  
System Payback Time with RHI/without 4.1/7.0 (years)  
Estimated Cost of Installation 38,228 (£)  
Cost per kg of CO₂ Reduced 0.30 (£/kg)

Recommended System Type **ASHP**:  
CO₂ Emission Reduction 8,078 (kg/year)  
Running Cost Reduction 5,268 (£/year)  
Potential RHI Income 1,413 (£/year)  
System Payback Time with RHI/without 4.4/5.5 (years)  
Estimated Cost of Installation 29,187 (£)  
Cost per kg of CO₂ Reduced 0.24 (£/kg)
Offices, customer facilities, store and plant
- Electric storage or panel heating
- Estimated Heat Demand 66,744 kWh/year / £10,012
- 268m² area and high energy costs
- A water source heat pump is an option with either an open loop or closed loop system

**Recommended System Type:** WSHP open loop
- CO₂ Emission Reduction 11,027 (kg/year)
- Running Cost Reduction 7,191 (£/year)
- Potential RHI Income 4,427 (£/year)
- System Payback Time with RHI/without 3.3/5.4 (years)
- Estimated Cost of Installation 38,559 (£)
- Cost per kg of CO₂ Reduced 0.23 (£/kg)

**Recommended System Type:** ASHP
- CO₂ Emission Reduction 10,642 (kg/year)
- Running Cost Reduction 6,940 (£/year)
- Potential RHI Income 1,862 (£/year)
- System Payback Time with RHI/without 3.4/4.3 (years)
- Estimated Cost of Installation 29,518 (£)
- Cost per kg of CO₂ Reduced 0.18 (£/kg)
Dochgarroch Maintenance Depot/Workshop

- General maintenance workshop, storage and trade work, drying area, welfare and office facilities.
- Steel framed brick with part metal cladding, refurbished in 2005, with double glazing; electric heating and hot water.
- Est. Heat Demand 52,567 kWh/year/ £7,885
- A water source heat pump is an option, with either an open loop or closed loop system. A ground source heat pump would avoid the need to cross the road with pipework, drilling boreholes instead in the yard. Equally, an ASHP system could be installed.

Recommended System Type **WSHP** open loop
- CO₂ Emission Reduction 8,925 (kg/year)
- Running Cost Reduction 5,820 (£/year)
- Potential RHI Income 2,946 (£/year)
- System Payback Time with RHI/without 3.9/5.9 (years)
- Estimated Cost of Installation **34,488** (£)
- Cost per kg of CO₂ Reduced 0.26 (£/kg)

Recommended System Type **GSHP** with boreholes
- CO₂ Emission Reduction 8,925 (kg/year)
- Running Cost Reduction 5,820 (£/year)
- Potential RHI Income 2,946 (£/year)
- System Payback Time with RHI/without 5.2/7.8 (years)
- Estimated Cost of Installation **45,626** (£)
- Cost per kg of CO₂ Reduced 0.34 (£/kg)

Recommended System Type **ASHP**
- CO₂ Emission Reduction 8,382 (kg/year)
- Running Cost Reduction 5,466 (£/year)
- Potential RHI Income 1,466 (£/year)
- System Payback Time with RHI/without 2.5/3.1 (years)
- Estimated Cost of Installation **17,125** (£)
- Cost per kg of CO₂ Reduced 0.14 (£/kg)
Caledonian Canal Centre, Café, Shop and Hotel

- Tourist destination: café/take away, commercial kitchen, office space, rented commercial retail outlet. En-suite rooms and housekeeping storage. Major refurbishment in 2018. Heating is all electric via panel heaters and hot water is provided by an LPG boiler. Estimated Heat Demand 104,612 kWh/year/ £15,691
- The site is very tight with a road between the building and the canal. There is a lock at this point of the canal which would add a level of complexity that would unfortunately make a water source option challenging and expensive. The tight nature of the site would also make it a challenge for ground source.

Recommended System Type GSHP with boreholes
CO₂ Emission Reduction 17,340 (kg/year)
Running Cost Reduction 11,308 (£/year)
Potential RHI Income 6,146 (£/year)
System Payback Time with RHI/without 4.9/7.5 years
Estimated Cost of Installation 84,668 (£)
Cost per kg of CO₂ Reduced 0.33 (£/kg)

Recommended System Type ASHP
CO₂ Emission Reduction 17,225 (kg/year)
Running Cost Reduction 11,234 (£/year)
Potential RHI Income 2,918 (£/year)
System Payback Time with RHI/without 2.8/3.5 years
Estimated Cost of Installation 39,346 (£)
Cost per kg of CO₂ Reduced 0.15 (£/kg)
Gairlochy Customer Facility

• Constructed in 2007, customer facility with toilets and showers, store, laundry and plant room. Electric heating. Estimated Heat Demand 16,048 kWh/year / £2,407

• An IDM Terra Heat WSHP was installed but was decommissioned because it didn’t meet the showers and laundry requirement.

• It is worth investigating whether the heat pump could be replaced with a more modern and therefore efficient model that would achieve the temperature and hot water demands. This would require a site visit to try and ascertain whether the water source collector system is useable and sized such that it would service a new heat pump. Meanwhile, calculation is based on full system replacement.

System Type **WSHP** open loop
- CO₂ Emission Reduction 2,841 (kg/year)
- Running Cost Reduction 1,852 (£/year)
- Potential RHI Income 999 (£/year)
- System Payback Time with RHI/without 10.0/15.4 years
- Estimated Cost of Installation 28,613 (£)
- Cost per kg of CO₂ Reduced 0.67 (£/kg)

Recommended System Type **ASHP**
- CO₂ Emission Reduction 2,745 (kg/year)
- Running Cost Reduction 1,789 (£/year)
- Potential RHI Income 447 (£/year)
- System Payback Time with RHI/without 5.1/6.4 years
- Estimated Cost of Installation 11,492 (£)
- Cost per kg of CO₂ Reduced 0.28 (£/kg)
• The Crinan Canal HQ has now moved, leaving this building currently unoccupied and due for renovation with a view to letting it out as tourist accommodation.

• The ground floor is heated by a 5 year old oil boiler. Upstairs there are electric storage heaters. Estimated Heat Demand 39,991 kWh/year / £1,919

• Good opportunity to incorporate renewable heat. Improved insulation and air tightness will create a building suitable for a low temperature heating system. Over-sized radiators can be specified to maximise system efficiency. Allowance can also be made for a plant room to house a heat pump and hot water tank.

• Ground source is an option for this building. There is limited available land for a ground collector system but plenty of space for drilling boreholes at the back.

Recommended System Type GSHP with boreholes
CO₂ Emission Reduction 9,657 (kg/year)
Running Cost Reduction 890 (£/year)
Potential RHI Income 2,583 (£/year)
System Payback Time with RHI/without 16.0/62.5 (years)
Estimated Cost of Installation 55,690 (£)
Cost per kg of CO₂ Reduced 0.38 (£/kg)

Recommended System Type ASHP
CO₂ Emission Reduction 9,524 (kg/year)
Running Cost Reduction 803 (£/year)
Potential RHI Income 1115 (£/year)
System Payback Time with RHI/without 13.0/31.0 (years)
Estimated Cost of Installation 24,895 (£)
Cost per kg of CO₂ Reduced 0.17 (£/kg)
The Boathouse, Auchinstarry, Restaurant and Hotel

- Existing dysfunctional WSHP has been decommissioned and a gas boiler installed. Estimated Heat Demand 116,650 kWh/year / £4,899

- Recommendation is to replace the heat pump system with a new water source heat pump for the following reasons: the cost of system fault-finding, repair and possible re-commissioning could be significant with no guarantee of reinstating a resilient system that remains operational; the installed system is around 15 years old and heat pump technology has improved significantly during this time; installing a new system with guarantees, within the RHI qualifying timescale, means that it could qualify for RHI payments for the next 20 years.

- Existing wet heating system with radiators seems to be in good order and already sized for a low temperature heating system. Existing gas boiler can be retained as a back-up.

- A GSHP with boreholes is also an option at this site.

<table>
<thead>
<tr>
<th>Recommended System Type</th>
<th>CO₂ Emission Reduction (kg/year)</th>
<th>Running Cost Reduction (£/year)</th>
<th>Potential RHI Income (£/year)</th>
<th>System Payback Time with RHI/without (years)</th>
<th>Estimated Cost of Installation (£)</th>
<th>Cost per kg of CO₂ Reduced (£/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>WSHP open loop</strong></td>
<td>16,176</td>
<td>738</td>
<td>6,493</td>
<td>5.6/55.0</td>
<td>40,597</td>
<td>0.17</td>
</tr>
<tr>
<td><strong>GSHP with boreholes</strong></td>
<td>16,176</td>
<td>738</td>
<td>6,493</td>
<td>9.4/92.0</td>
<td>68,272</td>
<td>0.28</td>
</tr>
<tr>
<td><strong>ASHP</strong></td>
<td>16,213</td>
<td>763</td>
<td>3,254</td>
<td>8.1/42.0</td>
<td>32,400</td>
<td>0.13</td>
</tr>
</tbody>
</table>
Scottish Canals Head Office

• 1000m² including adjacent and connected extension. Currently heated by a gas boiler (15+ years old) and wet radiator system. Additional heating and cooling is delivered via multiple air to air heat pumps and convector fan units. Estimated Heat Demand 165,055 kWh/year / £6,932

• recommendation is for open loop WSHP. The existing gas boiler would be retained as back-up. Included our calculations is the upsizing of radiators to ensure best system efficiency associated with a low temperature heat pump system.

Recommended System Type **WSHP** open loop

CO₂ Emission Reduction 22,806 (kg/year)
Running Cost Reduction 992 (£/year)
Potential RHI Income 12,978 (£/year)
System Payback Time with RHI/without **6.5/91.0** (years)
Estimated Cost of Installation **90,167** (£)
Cost per kg of CO₂ Reduced 0.26 (£/kg)

Recommended System Type **ASHP**

CO₂ Emission Reduction 21,148 (kg/year)
Running Cost Reduction -89 (£/year)
Potential RHI Income 4,605 (£/year)
System Payback Time with RHI/without **21.8/-** (years)
Estimated Cost of Installation **98,368** (£)
Cost per kg of CO₂ Reduced 0.31 (£/kg)
## Payback with RHI

**Ranking of top 10 buildings (1 = First/Top)**

<table>
<thead>
<tr>
<th>CO₂ Emission Reduction</th>
<th>System Payback Time with RHI</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Scotland SC HO</td>
</tr>
<tr>
<td>2</td>
<td>Caledonian Canal Centre</td>
</tr>
<tr>
<td>3</td>
<td>The Boathouse</td>
</tr>
<tr>
<td>4</td>
<td>Seaport Marina</td>
</tr>
<tr>
<td>5</td>
<td>Crinan Canal HQ</td>
</tr>
<tr>
<td>6</td>
<td>Dochgarroch Maint. Depot</td>
</tr>
<tr>
<td>7</td>
<td>Clachnaharry Sea Lock Office</td>
</tr>
<tr>
<td>8</td>
<td>Old Basin House</td>
</tr>
<tr>
<td>9</td>
<td>Gairlochy Customer Facility</td>
</tr>
<tr>
<td>10</td>
<td>Lowland Office / Workshop</td>
</tr>
</tbody>
</table>

**Combined Ranking Average**

<table>
<thead>
<tr>
<th>Building</th>
<th>Ranking</th>
<th>Preferred System</th>
<th>Est. current heating cost £/m²</th>
<th>Est. cost of installation £</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caledonian Canal Centre</td>
<td>1</td>
<td>ASHP</td>
<td>28</td>
<td>39,346</td>
</tr>
<tr>
<td>Seaport Marina</td>
<td>2</td>
<td>ASHP</td>
<td>37</td>
<td>29,518</td>
</tr>
<tr>
<td>Dochgarroch Maint. Depot</td>
<td>2</td>
<td>ASHP</td>
<td>41</td>
<td>17,125</td>
</tr>
<tr>
<td>Scotland SC HO</td>
<td>4</td>
<td>WSHP open</td>
<td>7</td>
<td>90,167</td>
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<tr>
<td>Gairlochy Customer Facility</td>
<td>7</td>
<td>ASHP</td>
<td>49</td>
<td>11,492</td>
</tr>
<tr>
<td>Lowland Office / Workshop</td>
<td>9</td>
<td>ASHP</td>
<td>32</td>
<td>11,737</td>
</tr>
<tr>
<td>Old Basin House</td>
<td>10</td>
<td>ASHP</td>
<td>6</td>
<td>15,380</td>
</tr>
</tbody>
</table>
## Payback with NO RHI

### Ranking of top 10 buildings (1 = First/Top)

<table>
<thead>
<tr>
<th>CO₂ Emission Reduction</th>
<th>System Payback Time - NO RHI</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Scotland SC HO</td>
<td>1 Dochgarroch Maint. Depot</td>
</tr>
<tr>
<td>2 Caledonian Canal Centre</td>
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</tr>
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<td>3 Seaport Marina</td>
</tr>
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</tr>
<tr>
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<td>5 Gairlochy Customer Facility</td>
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<td>6 Lowland Office / Workshop</td>
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<td>8 Old Basin House</td>
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<td>9 Gairlochy Customer Facility</td>
<td>9 Old Basin House</td>
</tr>
<tr>
<td>10 Lowland Office / Workshop</td>
<td>10 Scotland SC HO</td>
</tr>
</tbody>
</table>

### Ranking average CO₂ reduction & payback (NO RHI) - top 10 buildings (1 = First/Top)

<table>
<thead>
<tr>
<th>Combined Ranking Average</th>
<th>Building</th>
<th>Ranking</th>
<th>Preferred System</th>
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<td>Scotland SC HO</td>
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- The total annual carbon emission reduction if all the buildings in the top 10 had heat pumps installed would amount to 102 tonnes CO₂, over 10% of Scottish Canals total emissions.

- The project has shown the potential for water and ground source heat pumps and other renewable energy alternatives across the Scottish Canals estate and also highlighted the importance of a ‘fabric first’ approach to energy efficiency and carbon footprint reductions.

Thank you
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