Moor Heating Air Source Heat Pump Case Study

This case study is based on an air source heat pump installed by Solarwall for Annette Hudpseth and Neil Bye. They live in a four bedroom maisonette above a shop in Castleton. The building is around 100 years old and has sandstone walls with no cavities. It has double glazing and loft insulation, to the current standard. The maisonette was separated from the shop in the 1970s.

The heat pump is a Mitsubishi Ecodan W85. Output for this model ranges between 3 kW and 9 kW. A heat pump works by taking energy from an external source, in this case the air outside of the house, so this is a renewable source of energy. This heat pump model can continue to operate with an air temperature as low as -15 °C. Electricity is used to upgrade the heat energy to a higher temperature in the form of hot water. This is stored in a new Dimplex EC-Eau hot water cylinder with a capacity of 210 litres. This feeds the radiators for central heating and provides domestic hot water.

Reasons for choosing an air source heat pump

The previous system was an oil fired boiler providing central heating via radiators and hot water. Gas is not available in the village. The main reason for wanting to change the system was environmental, to reduce carbon dioxide outputs from their home.

A biomass pellet boiler was initially considered but disadvantages became apparent. Access to deliver pellets was not easy, the work involved in moving bags of pellets was considered to be too much and a pellet boiler would require a large shiny metal flue at the rear of the property. This would be readily seen from nearby higher ground.

A ground source heat pump was considered but the garden area is limited. There would also be disruption to the area used for vegetable growing so after full discussion that option was also counted out.

Photovoltaic panels to generate electricity were fitted to the south facing roof two years ago. This means that some of the electricity to run the heat pump is from a renewable source, although it will be very difficult to estimate how much.

The decision to go ahead with Solarwall was made after the receipt of a quotation from another company, British Eco. The quotation was the same but they proposed using existing radiators where possible and charging extra if it was decided that some should be replaced. The quotation from Solarwall included replacement of all the existing radiators for reasons described below.

Running Cost and Energy Use Calculations

The quotation from Solarwall includes detailed figures for both central heating and hot water. Heating and hot water demand are estimated using a standard method taking into account characteristics of the building, with assumptions on room temperatures and occupancy. Electricity inputs and therefore running costs and CO_2 outputs are based on a standard set of assumptions for the performance of the heat pump.

The quotation includes the electricity required to provide space heating and hot water from the heat pump, as well as to operate the pumps to circulate hot water for each type of output and to run the supplementary immersion heater for about 55 hours per year. The ratio between energy output as heat and electricity requirement is the co-efficient of performance for the heat pump. This varies with ambient external temperature and internal heating system flow temperature. An industry standard average is used in the calculations. A summary of the calculations without the breakdown of electricity used for different purposes is given in Table 1. The quotation from

Solarwall also includes estimated energy requirements and costs for running the old oil fired boiler. These are shown in Table 2.

Table 1 A summary of the energy requirements and running costs for the heat pump system

Total annual energy requirement of dwelling for heating and hot water	15 923 kWh
Total annual energy consumption by the Heat Pump System	5 668 kWh
Assumed electricity price (including standing charge)	14 p kWh^{-1}
Total annual running cost for the Heat Pump System	£793.52
Factor for calculating CO_2 emissions for electricity from the UK grid	0.519 kg kWh^{-1}
Total annual CO_2 emissions from producing the electricity to run the system	2 942 kg

Table 2 A summary of the energy requirements and running costs for the old oil fired system

Total annual energy requirement of dwelling for heating and hot water	15 923 kWh
Boiler efficiency for space and water heating	86%
Total annual energy provided by oil	18 515 kWh
Price for energy content of oil	6.5 p kWh^{-1}
Total annual fuel cost for the oil fired boiler	£1 203.46
Factor for calculating CO_2 emissions for oil	0.274 kg kWh^{-1}
Total annual CO_2 emissions from oil to run the system	5 073 kg

Although not provided in the Solarwall quotation it is possible to calculate the volume of oil required to provide the 18,515 kWh of energy. As the energy content of oil is 10 kWh $litre^{-1}$, this gives an annual oil requirement of 1,852 litres. Actual oil consumption in 2012-2013 was about 1,700 litres which amounts to 92% of the theoretical oil requirement, but this period included an exceptionally long and relatively cold winter. If the heat pump performs as expected and there is no change in demand for heating and hot water the actual electricity required in a comparable year would be approximately 5,200 kWh, which would cost about £ 728. Some of the electricity will be provided by the photovoltaic panels so actual operating costs will be lower than in the model and hopefully winters will be less extreme.

Installation Costs and Grants

The total system cost £11,077 complete with all components and installation. This was offset by a Renewable Heating Premium Payment under the RHPP Community Scheme through the Moor Heating Project of £2,000. Annual Renewable Heating Incentive payments will be made for 7 years from 2014 at a rate of 7.3 p kWh^{-1} based on the annual energy requirement calculations given above.   The RHPP community grant payment will be deducted from the total RHI payments, with the deduction spread over the 7 years.

The Installation

The heat pump is attached to an external wall. Normally this is permitted development and so does not require planning permission. Castleton is a Conservation Area, so the planning department of the North York Moors National Park Authority had to be consulted; they had no objections so the installation could go ahead.

Scaffolding was required to attach the heat pump to the rear wall at first floor level adjacent to the bathroom window. Anti-vibration pads were fitted to prevent vibration travelling through the wall.

Plate 1 Rear view of the maisonette with the heat pump on the wall and photovoltaic panels just visible on the roof. The heat pump would not be visible at any distance from the building.

Much more work was required inside the house. Heat pump systems run at a lower temperature than conventional oil or gas central heating systems so the radiator area needs to be larger and the pipes need to have a greater cross sectional area to provide the required water volume.

The existing 7 radiators were removed and replaced with 10 radiators. All of the new radiators are double panel convector radiators, fitted with thermostatic radiator valves, except for the hall where the thermostat is located. The existing 15 mm diameter pipes were replaced with 22 mm diameter pipes, with 15 mm pipe-work offshoots to each of the radiators. Most of the pipes are under the floor but there are some that run up in the corners of rooms. It is possible to pay extra to embed pipes in walls but Annette and Neil decided against this. The pipes can be painted to blend in with the paint on the walls. This has already been done for some of them. Boxing them in would also be a possibility.

The new heat store cylinder and ancillary equipment replaced the original hot water cylinder in the airing cupboard. This should be located as close as possible to the heat pump. Although the airing cupboard is one floor up and in the centre of the house this was considered satisfactory by the installers.

Installation would normally be expected to take three days but in this case five working days were required. The work was made more complex than normal by the presence of multiple pipes from previous heating systems, some dating back to before the splitting of the property. Initially Solarwall had asked Annette and Neil to be present to participate in final decision making on the position of pipes and radiators, but the disturbance was too great and they decided to go away to a hotel for the middle period of the work, once decisions had been made.

They were impressed by the installation team who were always polite and considerate – a refreshing change from previous experiences. The only problem that arose during the installation was damage to the stair carpet when taking away one of the old radiators. Replacement will be covered by Solarwall's insurance.

Plate 2 The heat pump adjacent to the bathroom window. All external pipes are well insulated.

Plate 3 One of the new double convector radiators with thermostatic radiator valve.

Living with an air source heat pump

The system was up and running in the first week of June. It ran well for 24 days then Solarwall came to check everything and make any necessary adjustments to maximise efficiency of operation. This was the 'handover', the final stage of the installation.

A heat pump operates more efficiently at lower water temperatures. It was initially set at 39 °C, but Annette asked for it to set a bit higher at the handover so this was increased by 2 °C to 41 °C. Instead of getting warmer it became colder. Solarwall returned the day after a phone call and found the problem was an air lock in the heat pump. This was easily fixed. No further problems are anticipated. The system will require an annual service to keep it running smoothly. Solarwall can do this for £99 a year. The glycol that transfers the heat will need replacing every 5th service at an additional cost of £150.

Plate 4 The water temperature controller on the hot water cylinder.

The system has a combined 7 day programmer and thermostat. This is wireless and is kept in the hall. Because a heat pump operates at a lower temperature than a conventional central heating system radiators are warm rather than hot. Owners often set the system to come on earlier than would normally be the case with a conventional system and can have it off during the day if the family is out of the home. However for those who are at home most of the day it should be more economical to have the heat pump on at all times, but with varying room thermostat settings. In this case a day time temperature of 18 °C and a night time temperature of 12 °C have been selected. When bedrooms are not in use their temperatures can be further reduced by using the thermostatic radiator valves. Annette and Neil prefer not to overheat their home for environmental and other reasons and will continue to wear pullovers in the winter when required. So far the system has only been used for hot water heating.

There is a boost switch that can be used to operate the 3 kW immersion heater built into the cylinder if more heat or hot water is required than can be delivered by the heat pump. This has not been used yet and probably will not be required. The immersion heater also comes on briefly each day to heat the water to 65 °C to kill any *Legionella* bacteria that are the cause of Legionnaires' disease.

Storage space in the airing cupboard has been sacrificed for the larger cylinder and ancillary equipment, but this is felt to be a minor inconvenience.

Plate 5 The hot water storage cylinder and ancillary components in the former airing cupboard.

Outside the house it is possible to hear the heat pump when the pump is on but it is quieter than the noise from the vent of the old oil fired boiler. Nothing can be heard from inside the house. There is now no smell of oil in the back garden, which there used to be when the boiler started up.

The real test of the system will come in the winter but Annette and Neil feel well prepared. If you have any questions on their system you can contact them on 01287 660067.

Sources of further information

Solarwall, the installation company

www.solarwall.co.uk

Information on Ecodan Heat Pumps from the manufacturers

http://domesticheating.mitsubishielectric.co.uk/about_ecodan

Basic information on air source heat pumps from the Energy Saving Trust

www.energysavingtrust.org.uk/Generating-energy/Choosing-a-renewable-technology/Air-source-heat-pumps

Information on getting the most from air source heat pumps and monitoring energy consumption from the Energy Saving Trust

www.energysavingtrust.org.uk/Generating-energy/Choosing-a-renewable-technology/Air-source-heat-pumps/Getting-the-most-out-of-your-heat-pump#3

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