Invest Northern Ireland

Heat Pumps

A Best Practice Guide for businesses in Northern Ireland

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The guide is structured to be as easy to use as possible, providing an introductory understanding in the “Essential” sections, but also satisfying those who wish to understand the more technical detail and develop a feasible project in the “Advanced” sections. Where an endnote is added for further explanation it is indicated by roman numerals in superscript.

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Table of Contents

List of Figures 6

A. Essential – The Basics

1. Introduction 8

1.1 What they do 9

1.2 Why we need them 9

1.3 How they save energy 10

1.4 What is CoP? 10

1.5 How they compare to other renewables 11

2. What are Heat Pumps? 12

2.1 Heat pump types 13

3. Heat Pump Sizing 16

4. Permissions Required 19

5. Financials 21

5.1 Example system costs 22

5.2 Renewable Heat Incentive 22

5.3 Calculating income and simple pay back 22

5.4 Optimising returns from heat pumps 23

6. Installation 24

7. Case Studies 26

7.1 Inishcoo House 27

7.2 Abbey Haven Nursing Home 28

B. Advanced - Feasibility

8. Site Survey 30

8.1 Introduction 31

8.2 Heat sink load 31

8.3 Calculating fabric losses 31

8.4 Establishing ventilation losses 31

8.5 Heat emitters and distribution 32

8.6 Hot water 33

8.7 Heat source resources 33

8.8 Heat pump sizing 34

9. Understanding NIE Connection **36**
10. System Performance Monitoring **38**
11. Heat Pump Technology **40**
11.1 Introduction 41
11.2 Modulating compressors 41
11.3 Enhanced vapour injection 41
11.4 Ejector enhanced vapour compression 41
11.5 Thermally driven heat pumps 41
11.6 Other improvements 43
12. System Design **44**
13. Selecting Contractors **46**
13.1 Introduction 47
13.2 Microgeneration Certification Scheme 47
13.3 Long-term company viability 47
13.4 Examples and references 47
13.5 Servicing arrangements 47
13.6 Tendering 47
14. Funding and Financial Assistance **48**
14.1 Introduction 49
14.2 Carbon Trust interest free loans 49
14.3 Venture capital funding 49
14.4 Renewable Heat Incentive 49
15. Financials **51**
15.1 Predicting income 52
15.2 Capital and annual costs 52
15.3 Pay back 52
15.4 Carbon savings 52
15.5 Total return 52
15.6 Equivalent interest 52
15.7 Cost per kWh 52
15.8 Net Present Value 53
15.9 Sensitivity analysis 53

16. Project Management **54**
16.1 Introduction 55
16.2 Site safety 55
16.3 In-house capabilities 55
16.4 Planning the project 56
GLOSSARY **58**
BIBLIOGRAPHY AND FURTHER READING **60**

This publication is not intended to be exhaustive or definitive and users of the Guide should exercise their own professional judgement when deciding whether or not to abide by it. It cannot be guaranteed that any of the material in the book is appropriate to a particular use. Readers are advised to consult all current Building Regulations, EN Standards or other applicable guidelines, Health and Safety codes, as well as up-to-date information on all materials and products.

Table of Figures and Drawings

Figure 1	Cycle at typical CoP	10
Figure 2	Scale of automation	11
Figure 3	Renewable energy comparisons	11
Figure 4	A typical electrically driven heat pump cycle	13
Figure 5	16kW single unit ASHP	13
Figure 6	GSHP; horizontal collector	14
Figure 7	GSHP; vertical collector	14
Figure 8	WSHP; closed loop river collector	15
Figure 9	Typical CoPs	15
Figure 10	Typical CoP curves for high efficiency heat pump	17
Figure 11	Permissions Require for Heat Pumps	20
Figure 12	Example system costs	22
Figure 13	Oil boiler annual cost	23
Figure 14	Heat pump annual cost	23
Figure 15	RHI payment	23
Figure 16	Inishcoo House	27
Figure 17	Rotten timbers at Inishcoo	27
Figure 18	Wool insulation	27
Figure 19	Lime render finish, heat pump at rear	28
Figure 20	Care home savings and pay back	28
Figure 21	Pay back including RHI	29
Figure 22	Typical fabric heat loss calculation	31
Figure 23	Heat Emitter Guide excerpt	32
Figure 24	Heat Emitter Guide key	32
Figure 25	Mean monthly temperatures Aldergrove	33
Figure 26	Typical relation of ground to air temperatures	34
Figure 27	Ground temperature as a function of depth	34
Figure 28	Heat pump selection procedure	35
Figure 29	NIE connection chart	37
Figure 30	Typical monitoring display	39
Figure 31	Typical TDHP system configurations	42
Figure 32	GSHP cycle	42
Figure 33	NI RHI tariff to 1st April 2014	49

A Essential - The Basics

1.0 Introduction

1.1 What they do 9
1.2 Why we need them 9
1.3 How they save energy 10
1.4 What is CoP? 10
1.5 How they compare to other renewables 11

Introduction

Typically, heat pumps serve the same purpose as a boiler but, rather than burning a fuel to produce heat, they move heat from a low-temperature heat source (ambient air, for example) and “pump” it to a higher temperature where it can be used to provide central heating or produce domestic hot water.

This is the same process as in a fridge or an air-conditioning unit. In the case of a fridge, the heat energy is pumped from the interior of the fridge to the elements at the back. Removing this heat energy makes the interior of the fridge cold and the elements at the back warm. As the elements become warmer than room temperature, the heat energy (which was originally inside the fridge) is lost into the air of the room. A heat pump heating system does exactly the same thing, though on a bigger scale, and takes its heat from a source outside the room – such as the outside air, or the ground.

In the cases of both fridge and heat pump, some additional energy must be supplied to the system to pump the heat from the low temperature to the higher temperature. There are systems that use other types of energy to achieve this – for example, gas-heated absorption fridges and heat pumps. For cooling applications, heat pumps mimic a fridge.

Heat pumps are not a new technology. In 1748 William Cullen first demonstrated artificial refrigeration. In 1855 Peter von Rittinger built the first heat pump and in 1940 Robert C Webber is credited with building the first ground source heat pump. Since 2005 more than 5.45 million heat pumps have been put into operation in Europe. In 2012 alone, over 755,000 new heat pumps were installed; the equivalent of 36 MW of heat production[1].

The growth in heat pump use over the last 15 years continues. As demand for efficient production of thermal energy grows across Northern Ireland, heat pumps will play a central role in our thermal energy mix.

A heat pump can provide heating, cooling and hot water mainly using energy from air, water or the ground. A unit that operates with a seasonal efficiency of 3 can save 66.6% of final energy, provide 100% of a building’s heating and hot water needs and cut greenhouse gas emissions for this service by roughly 50%.

Historically, budget has been the principal limiting factor when considering a heat pump installation. The advent of the Renewable Heat Incentive (RHI) changes the financial parameters.

Heat pumps are a well proven and relatively simple technology, offering the opportunity to future-proof our thermal energy production, stabilise costs and grow jobs-rich industry at home. Based on current rates of tariffs and support, and assuming future rises in energy prices, those businesses that invest capital to generate their heat using well designed renewable resources will gain a competitive advantage over those that do not. The impact of future price increases will be diluted, enabling greater cost control. Under these circumstances, heat pumps can be a secure, strategic investment opportunity for Northern Ireland business.

1.1
What they do

A heat pump is a device that provides heat energy from a source of heat to a destination called a ‘heat sink’. Heat pumps are designed to move thermal energy in the opposite direction to the direction of spontaneous heat flow (hot to cold)[ii] by absorbing heat from a cold space and releasing it to a warmer one, and vice-versa. A heat pump uses some external power to accomplish the work of transferring energy from the heat source to the heat sink.

While air conditioners and freezers are familiar examples of heat pumps, the term ‘heat pump’ is more general and applies to many heating, ventilation and air-conditioning devices used for space heating or space cooling.

Typically, systems use the air, the ground or water as the heat source and transfer the heat energy at a higher temperature to space heating, process water or hot water systems.

In a well-designed heat pump application, about 75% of the thermal energy produced should come directly from the heat source while about 25% will be the primary energy used in the process cycle.

1.2
Why we need them

Like most developed economies, Northern Ireland relies on fossil fuel derived thermal energy; primarily from oil and gas. Global demand for energy is increasing dramatically as populations grow, energy-intensive technology and economic activity flourishes, and immature economies develop. This is happening as fossil fuel reserves diminish, albeit slowly. As a consequence, competition for finite resources is increasing.

In real terms, Northern Ireland’s ‘buying power’ for energy is extremely limited and so we are exposed to ever higher prices. Furthermore, 80% of the stated fossil fuel reserves will have to remain unburnt if we are to maintain a global temperature increase rate of less than 2°C this century and negate runaway climate change. As these issues converge, the role of clean energy is enhanced.

Northern Ireland’s target is to reduce carbon emissions by 25% from 1990 levels by 2025. Based on current progress it appears unlikely that this will be achieved. Heat pumps can contribute to any future reduction strategy.

Heat pumps offer one of the most practicable solutions to the greenhouse effect. It is the only known process that recirculates environmental and waste heat back into a heat production process; offering energy efficient and environmentally friendly heating and cooling in applications ranging from domestic and commercial buildings to process industries. One key approach to improving the energy efficiency of many industrial operations is to recover every possible source of waste heat and turn them into useful outputs. To facilitate this approach, the heat pump becomes a critical heat system as it possesses the capacity to recover thermal energy, otherwise exhausted to environment, and channel it to places where this heat energy can be converted to produce useful outcomes such as producing hot water to provide heat to occupants in buildings.

Heat pumps are a key technology (although no single renewable energy technology offers a ‘silver bullet’) because they can be applied in many situations and particularly where mains gas is not available.

1.3
How they save energy

The economics of heat pumps are relatively simple. Savings and income are derived from two sources:

SAVINGS – by using the thermal energy your heat pump produces, you will buy less fossil fuel and make savings on your fuel bill. As fossil fuel prices increase, the savings you make should also increase.

INCOME – under the RHI scheme (Northern Ireland Renewable Heat Incentive) you are paid for every unit of renewable heat energy that you produce from a ground source or water source heat pump. The payment depends on the size of system you install. Until 1st April 2015, up to 20kWth[iii], you will be paid 8.9 p/kWh; between 20 and 100kWth you will receive 4.5 p/kWh; above 100kWth the rate is 1.5 p/kWh. RHI tariffs are set annually on 1st April.

1.4
What is CoP?

Traditionally, the performance of a heat pump is measured using a Coefficient of Performance (CoP). This describes the ratio of useful heat produced to the energy consumed. Most heat pumps use electrically driven motors and, in these cases, the CoP is measured against the electrical consumption. If the heat pump produces 3kWth and uses 1kWe[iv] it will have a CoP of 3/1 = 3.

A high CoP shows good performance and lower electrical consumption.

More recently, as a result of field trials[v], it has been demonstrated that CoP alone is not the best indicator of value for money. System efficiency, using the energy consumption of the entire heating system in the CoP ratio instead of the heat pump alone, gives a more useful factor when comparing systems. Unfortunately, system efficiency can only be fully established in installed systems.

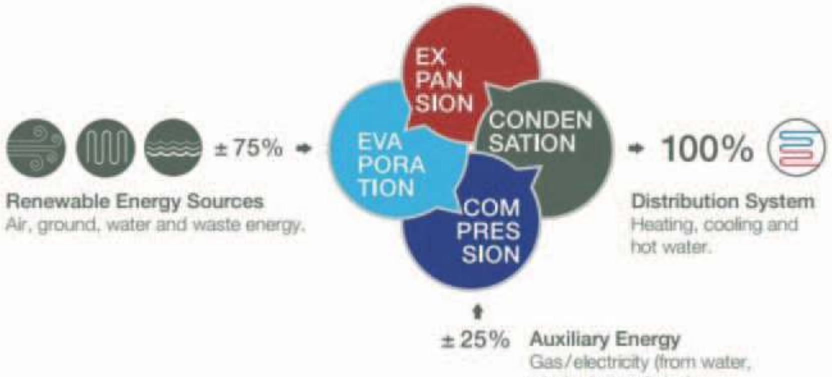


Figure 1: Cycle at typical CoP

The CoP of any heat pump system is optimised when the temperature difference between the heat source and the heat sink is as small as possible.

1.5

How they compare to other renewables

The Energy Savings Trust field trials identified that the key to successful projects was good design, good installation and good customer briefing. Unlike many heat producing systems, most heat pumps are not dependent on fuel deliveries, as they run on electricity. Similarly, many heat pump installations require minimal client intervention once they are installed and commissioned. In many installations client intervention can be removed completely when the heat pump runs on a demand basis. Because of this, heat pumps may be seen to be highly automated when compared with other systems.

Heat pumps are a mature technology, although progress continues to be made. Heat pumps require integration with other equipment or systems on site and careful design is required – especially for retrofit applications. Installation may be relatively simple (for air source heat pumps (ASHP)) or complex for many ground (GSHP) and water source heat pumps (WSHP). Once installed, heat pumps require little maintenance; normally an annual service visit will suffice. GSHPs and WSHPs are virtually silent in operation but the design for ASHPs must take account of noise. The only running costs over time are electrical consumption, annual servicing and, occasionally, replacement of the working fluid.

In summary, heat pumps are relatively simple machines with a long operational lifespan and little planned maintenance.

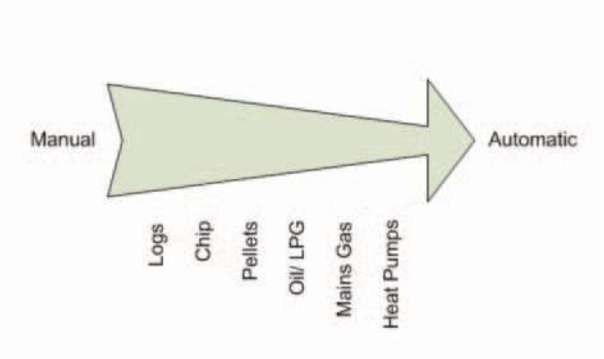


Figure 2: Scale of automation

	Heat Pump	Solar Thermal	Biomass	CHP
Technology Maturity (Low, Medium, High)	High	High	High	Medium - High
Technology Complexity (Low, Medium, High)	Medium	Low	Medium - High	High
Installation Complexity (Low, Medium, High)	Medium - Low	Low	Medium	High
Project Planning Complexity (Low, Medium, High)	Medium	Low	Medium	High
Carbon Cleanliness (Low, Medium, High)	Medium	High	Medium - Low	Fuel Specific
Project Scalability	Modular	Modular	None	None

Figure 3: Renewable energy comparisons

2.0 What are Heat Pumps?

2.1 Heat pump types 13

A heat pump works by reducing the pressure of a liquid so that it evaporates at a very low temperature. This evaporation process needs heat, which is usually sourced from the ground or the air. When the vapour is compressed from a low pressure to a higher pressure, its boiling point is raised, so that it wants to condense into a liquid again. In order to do this it needs to release the heat it has absorbed. The heat sink is the place the heat is transferred to. In most common heat pumps the compressor is electrically driven and a typical heat pump cycle is shown below. Thermally driven heat pumps are less common and covered in a later section of this guide.

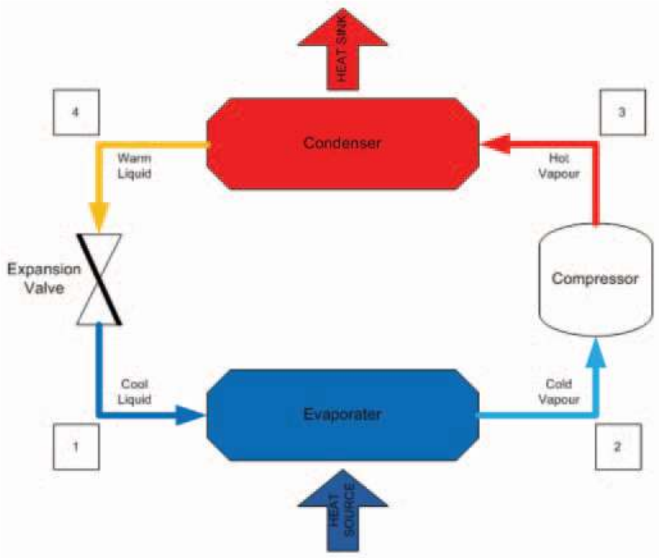


Figure 4: A typical electrically driven heat pump cycle (image courtesy of Element Consultants)

At point (1), the liquid is cooler than the heat source, so heat flows naturally from the heat source into the evaporator. This causes the liquid to evaporate. At point (2), the vapour (from the liquid) enters the compressor. This compresses the vapour, raising its pressure and increasing the temperature.

At point (3), the high-pressure vapour enters the condenser where it condenses at a higher temperature than the heat sink; thus, heat flows naturally from the condenser to the heat sink. At point (4), the high pressure liquid enters the expansion valve, which reduces the pressure to its original point, and the cycle is complete.

2.1
Heat pump types

By definition, all heat sources for a heat pump must be colder in temperature than the heat sink. Most commonly, heat pumps draw heat from the air (outside or inside air) or from the ground (groundwater or soil). However, heat pumps may also source their heat from water (ponds, rivers and boreholes) or from exhaust air, amongst others.

The majority of heat pumps are electrically powered and fall into two distinct categories; air source (ASHP) and ground source (GSHP).

An ASHP takes low grade heat from the ambient outside air, using a fan to blow air across a heat exchanger, carries out the heat pump cycle and transfers the high grade heat to the heat sink. There are commonly two types of ASHP; an ‘air to water’ heat pump and an ‘air to air’ heat pump. The former transfers the heat to a water based heat sink such as a central heating system, while the latter transfers the heat to an air heat sink such as an air heating system. Systems may be single or split units. Single units house the entire system and can be located inside or outside the building. Split units normally house the evaporator outside the building and the condenser inside; in the same way as a traditional air-conditioning unit.

Figure 5: 16kW single unit ASHP (image courtesy of Element Consultants Ltd)

Air temperatures vary seasonally and moisture content fluctuates so an air source heat pump will always be at the mercy of the climate.

The colder the air temperature, the harder the heat pump must work to lift the temperature up to what is required for heating. Below about 7°C, ice may form on the evaporator as the air is cooled, restricting the airflow and impairing performance. For this reason ASHPs always include a defrost cycle.

A common defrosting method is to extract heat from the heat sink (the house or hot water tank) and resupply it to the evaporator to melt the ice – in effect, operating the heat pump in reverse, so that the evaporator becomes the condenser and the condenser the evaporator. While this is happening, heat is being taken from the heat sink, and will temporarily lower the heat pump's CoP. An air source heat pump is likely to carry the lowest capital cost of all heat pump installations.

A GSHP takes heat from the ground. As with an ASHP, the heat can be transferred to air or water as a heat sink. The majority of installations to date use soil as the heat source but rock and groundwater are also used. The soil provides a stable temperature all year round with minor fluctuations at depths of 1m or more. The energy available in the soil is often referred to as geothermal energy; however the vast majority of the energy available in the soil at the shallow depths used for heat pumps is solar heat (i.e. heat from the sun that has been soaked up by the soil). As the temperature below the ground is higher in winter than the air temperature, GSHPs are slightly more efficient than air source heat pumps; the heat source to heat sink temperature difference is smaller. Air has a lower specific heat capacity than water, so to supply the same energy more air must be supplied to the heat pump, which in turn requires more energy. Soil based systems are referred to as 'horizontal collectors' as a series of pipes must be laid below ground, typically between 0.8 and 1.2m, to collect the heat.

The pipes are filled with a working fluid, often referred to as brine, which collects the low grade heat and brings it back to a manifold. From the manifold, the heat is transferred to the heat pump cycle via a heat exchanger, and the resulting high grade heat is transferred to the heat sink. These are referred to as 'brine to water' or 'brine to air' systems. Thus a horizontal ground source heat pump installation requires sufficient ground to accommodate the ground loops and considerable excavation and backfilling, in addition to the heat pump.

GSHPs that use rock or groundwater as the heat source collect the heat via vertical pipe loops in a borehole or series of boreholes. A vertical collector is not reliant on surface area, but rather depth. A vertical collector usually takes the form of one or more boreholes which accommodate a U-shaped plastic pipe configuration filled with brine for collecting heat. Specialist drilling equipment is required to drill to the required depth, as well as special processes and materials (such as fusion welding and bentonite grouting). Boreholes can be anywhere from 15 to 100m deep. For this reason, a vertical collector system can be considerably more expensive than a horizontal collector system.

WSHPs use the energy available in water and may be 'open' or 'closed loop'. A closed loop is similar to those discussed above where the brine constantly circulates around the collector pipe work placed in the water source. An open loop system abstracts the water from the water source, pumps the water past the heat exchanger, and returns it to the water source at a lower temperature. Surface water, such as a river, lake or the sea, can be used in either a closed or open loop system, however a closed loop system is likely to require much less maintenance.

Figure 6: GSHP; horizontal collector

(Image courtesy of EHPA)

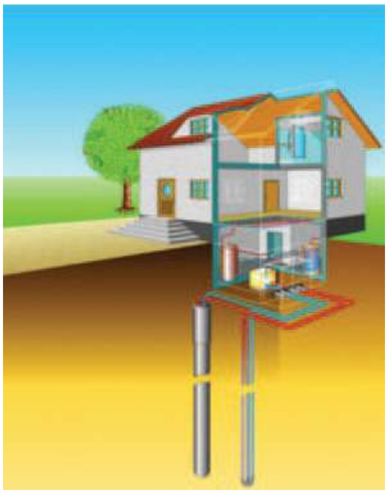


Figure 7: GSHP; vertical collector

(Image courtesy of EHPA)

Protection against debris and physical damage and obtaining the necessary permissions from the Northern Ireland Environment Agency (NIEA) and the planning authorities are also important considerations for surface water collectors. Open loop systems have the ability to pollute the environment and NIEA will require further risk assessments and method statements. In some situations an Environmental Impact Assessment could be required.

Figure 8; WSHP; closed loop river collector (Image courtesy of Dimplex, Germany)

Ground water (i.e. the water in the water table), because of its temperature, is an ideal heat source for heat pumps, however, it should be noted that water must be present in sufficient quantity so that drinking water resources are not affected. This would need to be verified using test boreholes and pumping tests. Also, when extracting from a well, the water must be re-injected downstream of the groundwater flow. The water also passes directly through the heat exchanger of the heat pump in an open-loop system; therefore the water quality (hardness, corrosivity etc.) is an important consideration.

For the common forms of heat pumps and well designed, installed and maintained systems, you may expect average CoP to be as follows:

Type	**CoP**
ASHP	**3**
GSHP	**4**
WSHP	**5**

Figure 9: Typical CoPs

Another potential heat source is an exhaust air system. These have the advantage that their heat source has a fairly constant temperature of around 20°C, but they need to be very carefully designed. They are usually installed in a *passivhaus*[vi] and in commercial applications where exhaust heat is readily available.

In addition to the electrically driven heat pumps, thermally driven heat pumps (TDHP) are now becoming mainstream. Unlike the previous heat pumps a TDHP uses heat rather than electrical energy to power the cycle. When comparing heat pumps driven by different energy sources it is appropriate to use the Primary Energy Ratio (PER); the ratio of useful heat delivered to the primary energy input. Thus, for an electrically driven heat pump, the CoP is multiplied by the efficiency of the electricity generating plant to determine the PER. In Ireland, grid electricity efficiencies may be as low as 40%, leading to a PER of 1.6 for a typical electrically driven GSHP. Where waste heat, renewable heat or gas powered heat is available, a thermally driven heat pump is likely to be comparable to or outperform an electrically driven heat pump.

Both absorption and adsorption can be used in the heat pump cycle although adsorption is less common. Gas absorption heat pumps (GAHP) are now commercially available. They are perfectly suitable for larger buildings both for renovation and in new buildings, or in areas with a weak electric grid. This technology can achieve a primary energy efficiency of 125–140% thus saving considerable amounts of energy (up to 40% on heating costs every year compared to a condensing boiler). Lower heating costs make a GAHP a cost-effective investment.

3.0 Heat Pump Sizing

Correct heat pump sizing is essential to an efficient and well-functioning system. Sizing is complex and should be undertaken by a suitably qualified technician for all systems[vii]. Heat pump sizing requires detailed knowledge of the heat source, the heat pump and the heat sink. We have already seen that the key to achieving the best CoP is to minimise the temperature difference between the heat source and the heat sink. In other words, the flow temperature from the heat pump should be as low as possible while still being capable of supplying the heat required at the heat sink. If the heat pump is over or under sized, or the flow temperature rises, performance will be negatively impacted. This can be illustrated simply by examining a typical new build space heating application.

As in any space heating application, the heat losses from the building should be minimised before attempting to design a system in either a retrofit or new building situation. The lower the heat losses, the less energy will be required to heat the building and the less power will be required from the boiler or heat pump.

Typically, an electrically driven heat pump for a space heating application will achieve its maximum CoP when delivering a flow temperature of around 35°C.

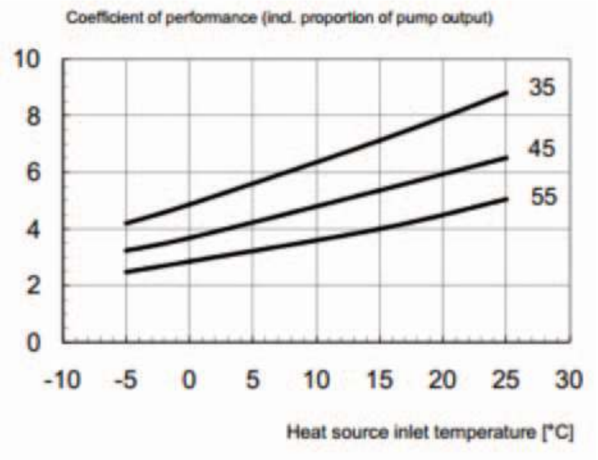


Figure 10: Typical CoP curves for high efficiency heat pump

(image courtesy Dimplex)

Flow temperatures as low as this are only suitable for low temperature heat emitters; under floor heating (UFH), oversized radiators, fan assisted radiators and fan coil units. At low flow temperatures, much less heat can be delivered to a space than at high flow temperatures.

As a typical gas fired boiler radiator system will work at 70–75°C, we can immediately see that the heat delivered at 35°C will be considerably lower. The MCS Heat Emitter Guide[viii] shows that at 35°C, standard radiators would need to be almost seven times larger to achieve the same heat output.

Clearly, to achieve a low flow temperature, low heat losses and the correctly sized heat emitters are necessary. The heat losses must be clearly identified, calculated and understood on a room by room basis. If the heat losses are higher than those used for the design, the heat will be lost more rapidly than the heat pump can replace it at 35°C flow, and the only solution will be to increase the flow temperature. The heat pump will have to work harder, use more electricity and the CoP will reduce. Similarly, if the heat pump is over sized, it will cycle (switch on and off continuously) and consume more energy.

Once the heat sink factors are established, the heat pump may be addressed. The choice of heat source will be the first consideration and this will be location dependent. A WSHP will require water; a horizontal collector GSHP, for example, is unlikely to be possible unless plenty of ground is available for the collector field; ASHPs can be installed in almost all locations.

For a heat pump designed to meet the entire space heating load, the system will be designed to meet the space heating requirement down to the local outside design temperature of -3°C. Manufacturers of heat pumps supply characteristic curves for each heat pump on which the heating capacity in relation to outside temperature may be plotted. These curves are used to select the correct capacity heat pump for the application.

Once the heat pump has been sized, the rest of the system may be designed. For an ASHP this will simply be the hydraulic connections and layout. For a GSHP or WSHP the collector field must also be designed. In each case the heat abstraction capacity of the heat source medium must be obtained. For a horizontal collector GSHP this will be the thermal capacity of the soil; for a vertical collector, the thermal capacity of the rock and for a WSHP the thermal capacity of the water. From the abstraction capacity of the heat source the collector field can be designed; the length, size and spacing of collector pipe work together with the necessary pumping power will be specified.

In each case more specific installation detail may also be required.

In summary the following factors are paramount:

- The building heat losses must be minimised and carefully calculated.
- The heat emitters must be designed for lowest temperature flow possible.
- The heat distribution system must be designed prior to sizing the heat pump.
- The heat source is established.
- The heat pump capacity is determined using the characteristic curves.
- The collector field is designed.

NIE will dictate the size of heat pump that may be connected to the grid. When a heat pump starts it creates high torque in the motor that in turn pulls high amperage. Utility companies do not like this fluctuation on the network and limit both the size of heat pump and the number of starts per hour that may take place. Therefore it is important to engage with the utility supplier at an early stage, if possible, to determine the maximum size available. Heat pumps are produced in both single and three phase models. Typically, up to 16kW with a soft start mechanism may be connected to a single phase supply. If the size of heat pump that you require is greater than that allowed by the utility, a system using a heat pump for most of the heat and an alternative heat source for the remainder (a bivalent system) is common.

4.0 Permissions Required

Permitted development rights are given to some non-domestic microgeneration equipment (ground and water source heat pump installations) under Class C of Schedule 3 of the General Development Order[ix]. Certain exceptions are made including the collector field size; distance from boundary; distance from road; plant height; area occupied and protected areas and buildings. ASHPs are not covered by this permitted development.

However, if the installation is within the curtilage of a dwelling house, ASHPs may qualify for permitted development under Class G of Schedule 1 of the General Development Order[x]. Again there are exceptions generally in line with those mentioned above. Although the ASHP must be used to provide heat for use within the curtilage of the dwelling house, it does not need to be used for the dwelling house itself.

Neither ASHPs nor horizontal collector GSHPs are likely to require further permission.

Vertical collector (VC) systems and open loop (OL) systems will require various other consents and some fees may be payable. The following matrix is not exhaustive and consultation may lead to further requirements.

	GSHP VC CL	**WSHP VC OL**	**WSHP HC CL**
Inform GSNI	X	X	
Inform/Consult NIEA	X	X	X
NIEA Abstraction Licence		X	
NIEA Discharge Licence		X	
Consult Rivers Agency			X

Figure 11: Permissions Require for Heat Pumps

The Geological Survey of Northern Ireland[xi] must be notified of any proposed borehole. The NIEA must also be consulted[xii]. For open loop systems an abstraction licence will be required and a discharge consent may be required. For a WSHP closed loop system in a lake or river, Rivers Agency should be consulted.

5.0 Financials

5.1 The principal legal provisions 22
5.2 Underpinning regulation and best practice 22
5.3 Approved Codes of Practice for Design (Best Practice) 22
5.4 The duties of the designer 23

5.1
Example system costs

System costs will vary widely depending on heat pump type, capacity, and installation site and installation details. Below we give example costs for typical installations using standard, good quality equipment, Microgeneration Certification Scheme (MCS) registered installers, and installed in a standard configuration with good access.

The cost of designing, supplying and installing a heat pump system as a turnkey package is subject to the same inflationary pressure (especially on fuel, insurance, labour costs etc.) as any other capital project.

Size (kWth)	ASHP (£)	GSHP (£)
10	8,000	12,000
20	14,000	20,000
40	20,000	28,000
60	30,000	40,000

Figure 12: Example system costs

(Heat Pump & Collector only: site specific)

5.2
Renewable Heat Incentive

The Renewable Heat Incentive (RHI) is a government environmental programme that provides financial incentives to increase the uptake of renewable heat. It provides subsidies to eligible, non-domestic renewable heat generators and producers of biomethane based in the UK and Northern Ireland, payable for the life of the installation or up to a maximum of 20 years. The Northern Ireland RHI policy and tariff rates are set by the Department of Enterprise, Trade and Investment (DETI). Ofgem administer this scheme on behalf of DETI. The primary objective for the RHI is to increase the uptake of renewable heat to 10% by 2020. The 10% target for renewable heat equates to 1.6TWh (or an additional 1.3TWh when considering existing levels). This target was included in the Strategic Energy Framework and an interim target of four per cent renewable heat by 2015 has been included in the Programme for Government. In addition to achieving the set target, it is expected that the RHI will have a number of other wider benefits in terms of fuel security, lower emissions and ‘green jobs’.

In the context of the scheme, a non-domestic installation is a renewable heat unit that supplies large-scale industrial heating right down to small community heating projects. This includes small businesses, hospitals, schools and so on, as well as district heating schemes (for example where one boiler serves multiple homes).

The RHI provides financial support for renewable heat technologies for the lifetime of the installation (to a maximum of 20 years). Payments will be made on a quarterly basis and determined by the actual heat output of the system; therefore heat meters will be required for each installation.

Under the Renewable Heat Incentive Scheme Regulations (Northern Ireland) 2012, the RHI tariffs must be adjusted annually in line with the retail price index (RPI) for the previous calendar year. DETI must make the necessary calculations and publish the revised tariffs and Ofgem, as administrators of the scheme, must take account of the tariff changes and ensure they are applied.

Under Phase 1 of the scheme (currently in place) only GSHPs and WSHPs that transfer heat to water are supported. Gas driven heat pumps are also eligible. Reversible heat pumps are also eligible but only the heat produced will receive support. ASHPs are expected to be supported in Phase 2 of the scheme; expected to be launched in 2014.

The RHI tariffs are subject to banding; different renewable technologies of differing sizes receive a different tariff. Until 1st April 2015 heat pumps receive 8.9p/kWh for installations up to 20kWth, 4.5 p/kWh up to 100kWth and 1.5 p/kWh for installations greater than 100kWth. All heat pumps under 45kWth must be certified under the MCS scheme. The RHI scheme will be subject to review in 2014/15.

5.3
Calculating income and simple pay back

In March 2014, a typical commercial unit price for electricity was 14 p/kWh, the RHI tariff was 8.7 p/kWh, for systems under 20kWth, and kerosene was 50.1 p/litre or approximately 5.1 p/kWh.

To calculate the income from a specific electrically powered heat pump, system you will need to know what size the system will be (to determine the RHI band), what heat it will replace and the annual cost of that heat. You will also need to know the proposed CoP of the system and the cost of your electricity. From these figures you can calculate the proposed annual saving as follows.

Assumptions:

1. You pay 14 p/kWh for your grid supplied electricity (including VAT and levys)
2. You intend to install a system < 20kWth so the tariff is 8.7 p/kWh
3. You have a 95% efficient condensing oil boiler that consumed 3,000 litres of oil last year at an average price of 50.1 p/ litre.

First, calculate the annual cost of running the oil boiler.

Oil Boiler Cost

Annual Oil Use	3,000	litres
CV Oil	10	kWh/litre
Net Heat Used	30,000	kWh
Boiler Efficiency	95	%
Gross Heat Used	31,500	kWh
Oil Cost/Litre	50.1	p/litre
Oil Price	5.01	p/kWh
Annual Cost	1,578.15	£

Figure 13: Oil boiler annual cost

Next calculate the annual cost of running the heat pump.

Heat Pump Cost

CoP	4	
Heat Used	30,000	kWh
Electricity Used	7,500	kWh
Electricity Price	14	p/kWh
Annual El. Cost	1,050.00	£

Figure 14: Heat pump annual cost

Now calculate the RHI payment.

RHI Tariff	8.7	p/kWh
Metered Heat	22,500	kWh
RHI Payment	1,957.50	£

Figure 15: RHI payment

The annual income is predicted to be £1,957.50 from the RHI, the annual savings from the heat pump are predicted to be £528.15.

Thus, from a 4kWp system, you might expect annual earnings of £2,485.

Simple pay back is the length of time that it will take for you to recover your costs. For a heat pump system the costs are the installation costs and the annual maintenance costs. As we have seen above, in most cases, the maintenance costs are simply the cost of an annual service. Thus in most cases the simple pay back, in years, will be:

$$\textbf{Simple Pay Back} = \frac{\text{Capital Cost}}{\text{(Replaced power value + NIROC value + Export value)}}$$

Thus, using the capital cost for a 20kWth system in Section 5.1, Simple Pay Back will be achieved in just over four years for this system. Note that this is a purely hypothetical example.

5.4
Optimising returns from heat pumps

Getting the best return from your heat pump system will depend on several factors. The main considerations are listed below:

1. Carry out a site survey to understand your project potential.
2. Plan the project carefully.
3. Ensure the system is professionally designed either by an MCS accredited installer or an independent consultant accredited by the heat pump manufacturer.
4. Ensure you carry out your own calculations for heat generation and pay back. Do not rely on the installer's illustrations.
5. Ensure that the installation is correctly commissioned and that you understand how it operates at handover.
6. Ensure you fully understand what you will realistically generate and get paid.
7. Ensure the system is regularly monitored and serviced post installation.

6.0 Installation

Complexity of installation will be directly relevant to the type of heat pump installed. You will depend on a good, experienced contractor.

An ASHP will be relatively simple. A single unit external machine should be located as close to the building as possible. Care should be taken to ensure that a good airflow can be maintained at all times and that the unit is not in a dip, as cold air will fall and, in still conditions, can cause the unit to freeze up. Ideally, heavily insulated district heating pipe should be installed below ground from the heat pump foundation to the internal space. A condensate drain must also be supplied at the heat pump. Once the foundation for the heat pump has cured, the unit may be placed in position. Internally, the buffer tank will be installed and pumps, pipe work and valves completed. Flushing is vitally important to the installation and detailed guidelines for the correct procedure are laid down in the MCS guidance[xiii]. The controller and sensors are connected and the system may be commissioned.

For a horizontal collector GSHP, the heat pump and buffer tank are best installed inside the building and the installation procedure for those elements will be similar to that for an ASHP. The external ground work will involve digging the collector field (normally a series of trenches) and laying a bed of sand followed by the collector loops (often Slinkys[xiv]). The Slinkys are covered with another layer of sand to protect them before carefully backfilling the trenches. At this point the ground loops must be flushed and pressure tested following MCS3005. Once complete, the ground collectors may be connected to the external manifold and internal flushing and purging should be completed. Finally the system is filled with antifreeze, the antifreeze level checked, and the system is commissioned.

For vertical collector GSHP, the process is similar except that a borehole or series of boreholes is drilled to the required depth to meet the heat pump load. High Density Polyethylene (HDPE) pipe loops are dropped down the boreholes which are then grouted in place using a bentonite grout. This ensures heat transfer. If pipes are to be joined below ground level electrofusion is used to make the joint. Above ground, a mechanical joint may be used. Once installed and connected to the manifold the same process is followed as above.

WHSPs will have different collector field installation methods depending on their design but the remainder of the installation will be similar to the methods described above.

There are many useful videos on Youtube showing heat pump installation, flushing and purging techniques. Simply search for ‘heat pump’.

7.0 Case Studies

7.1 Inishcoo House 27
7.2 Abbey Haven Nursing Home 28

7.1
Inishcoo House

Inishcoo House is a restored eighteenth century coastguard house standing alone on an uninhabited island off Burtonport, Co. Donegal used as a holiday let. The house comfortably accommodates 20 people.

Figure 16: Inishcoo House

The building was in an appalling state of disrepair; mainly due to damp. Being an eighteenth century building there is no damp proof course. At some stage in the building's history the external walls were cement rendered locking in damp. In response, the owners had dry lined the interior with a waterproof membrane, imprisoning moisture in the structure. As a result, the structural timbers had rotted away. The mass rubble walls even contained peat as a building material.

Figure 17: Rotten timbers at Inishcoo

The challenge was to specify a refurbishment that not only met building regulations and maintained a comfortable environment but also protected the building structure in a very hostile environment. The only mains service on the island is 3 phase electricity.

Element Consultants specified lime render externally so that the walls could breathe and move; a porous wool insulated dry lining internally so that moisture movement could be controlled by the hygroscopic action of the wool; and French drains to ensure water was carried away from the foundations. As an additional protection, an electro-osmotic damp proof course was installed.

Figure 18: Wool insulation

As the only mains service is electricity, all other fuels and materials must be transported to the island by boat. A heat pump system was the logical answer in a building that is not permanently occupied and, being very close to the sea has low air temperature variation. The layout of the building over four floors allows for flexible letting; where only two floors may be occupied during an overnight rental and only the ground floor for a day rental. Therefore, the building was zoned by floor. In order to protect the building structure, the internal temperature must be maintained above dew point. Rapid response by the heating system is essential to bring the relevant zone up to comfort temperature from dew point in as short a time as possible to minimise energy consumption. A low temperature under floor heating system cannot give rapid response so domestic fan assisted radiators were employed in each room. The on-board sensors in these radiators control the output to the room while a zone room thermostat shuts down the zone pump when set temperature is reached for that zone. Time clocks are provided for each zone. To ensure a temperature above dew point is maintained, an overriding room thermostat is fitted in the coldest north facing room. To ensure that the system cannot freeze, an overriding frost thermostat is also fitted.

As the building is on an unoccupied island, remote control is essential. One of the first ‘Climote’ systems is fitted to allow time and temperature control by computer from anywhere in the world.

A large hot water cylinder with an oversized heat exchanger to supply the ground floor shower room, kitchen and first floor bathroom is installed heated by the heat pump overnight at low rate night tariff. The shower room on the second floor has an electric shower to reduce the maximum hot water demand and the cylinder size.

Once the space heating load, hot water load and designs had been finalised, the heat source was addressed. Both a water source (from the sea) and an air source heat pump were considered. Although more efficient, the capital costs of the civil works for installing a water source heat pump proved too high and an air source heat pump was selected. Heat loads and predicted annual energy consumption were calculated and a 20kW system was installed. The heat pump manufacturer was informed of the hostile salt environment to ensure that the heat pump was adequately protected from the environment.

Figure 19: Lime render finish, heat pump at rear

The system has performed beyond expectations in its first year, maintaining the required temperatures at the expected cost.

Should tidal turbine technology mature, there is the potential to install a tidal turbine locally to provide renewable electricity to power both the building and the heat pump.

7.2

Abbey Haven Nursing Home

Although heat pumps are installed across the UK and Ireland in a wide variety of situations, very few have dedicated monitoring facilities. Most people will have heard of high profile installations like the Giant’s Causeway Visitor Centre and Castle Howard but few will have heard of the 180kW installation at the Riverside Hotel in Enniscorthy or the 240kW installation at the ESB distribution centre in Dublin.

The Abbey Haven Nursing Home in Boyle is a 60 bedroom care home in Co. Roscommon. The home is fitted with a Dimplex LA60TU heat pump and low surface temperature radiators as a bivalent system retaining the existing oil boiler. The heat pump produces approximately 80% of the energy required and automatically calls in the oil boiler when required at low external temperatures.

The heating system has been closely monitored for over a year to determine the operating parameters of the system.

Heat Required	180,000	kWh
Calorific Value Oil	10	kWh/litre
Litres required	18,000	litres
Boiler Efficiency	80.00	%
Gross litres required	21,600	litres
Oil cost per litre	0.60	£/litre
Oil Cost	12,960	£
Heat from Boiler	32,000	kWh
Annual Oil Cost	2,304	£
Heat from Heat Pump	128,000	kWh
SPF	3.50	
Electricity used	36,571	kWh
Electricity cost per kWh	0.16	£/kWh
Annual Electricity Cost	5,851	£
Fuel Saved	4,805	£
Installed Cost	26,500	£
Pay Back	**5.52**	**Years**

Figure 20: Care home savings and pay back

If the care home were located in Northern Ireland it would also be eligible for the RHI, leading to a pay back in just over three years.

RHI Tarriff	2.5	p/kWh
Heat delivered	128,000	kWh
Electricity Consumed	36,571	kWh
Eligible for RHI	91,429	kWh
RHI Income	3,200	£
Total Annual Savings	8,005	£
Pay Back	**3.31**	**Years**

Figure 21: Pay back including RHI

B Advanced - Feasibility

8.0 Site Survey

8.1 Introduction 31
8.2 Heat sink load 31
8.3 Calculating fabric losses 31
8.4 Establishing ventilation losses 31
8.5 Heat emitters and distribution 32
8.6 Hot water 33
8.7 Heat source resources 33
8.8 Heat pump sizing 34

8.1
Introduction

The site survey is undertaken to establish the factors affecting the feasibility of an installation. Each factor is discussed below and each will affect the final design, cost and ultimate feasibility. Indeed, any one of the factors may stop the project in its tracks.

8.2
Heat sink load

In order to size a heat pump correctly, the heat sink must be fully understood. A typical application will be the space heating of a building. The heat load of a building can be calculated by adding together the building fabric heat losses and ventilation heat losses. The fabric heat losses are the sum of the losses through each individual part of the fabric; the floor, the walls, the roof, the windows and the doors. The ventilation losses are the heat lost through ventilating the building. Where the building has more than one room, the losses are a combination of the losses from each room.

8.3
Calculating fabric losses

The rate of fabric heat loss is equivalent to the energy required to maintain the desired internal temperature (excluding ventilation). It is measured in watts per square metre per degree of temperature difference between the inside and outside temperatures (W/m^2C) and is known as the U value. Thus, if we know the area, the temperature difference and the U value for a specific building element we can calculate the heat loss for that element. Summing the heat losses gives us the load required.

A survey of the building will deliver the areas of each building element by room. Each room can be allocated a design temperature[xv]; e.g. a changing room might be designed to 21°C. The external design temperature must also be set and it is better to err on the cautious side so -3°C is reasonable although you may have a more accurate minimum external temperature for your site[xvi]. U values are provided by manufacturers of building components for most modern building materials. However, where a building element is made up of more than one component, the U value must be calculated. The Building Research Establishment provides an approved U value calculator at a cost of £50[xvii]. Alternatively, your architect or heat pump installer will be able to carry out these calculations. Once each U value is established, the fabric heat losses may be calculated.

Other software is available that calculates U values and heat losses for the Standard Assessment Procedure (SAP)[xviii]. However, the SAP software uses a whole house calculation and various assumptions and should not be used for calculating losses for heat pump installations[xix].

A typical calculation for a space is shown below with the U value (Column 1) and area (Column 2) multiplied to give the watts per centigrade (Column 3), then multiplied by the temperature difference (Column 4) to give the heat loss in watts (Column 5)

	1	2	3	4	5
	U Value	Area m²	W/C	dT (ºC)	Total
Floor	0.17	104.31	17.73	24	470.10
Wall	0.21	157.18	33.01	24	792.21
Roof	0.15	143.22	21.48	24	515.59
Windows	1.8	40.75	73.31	24	1759.35
		445.44	145.53	Watts	3537.56
				kW	3.54

Figure 22: Typical fabric heat loss calculation

8.4
Establishing ventilation losses

The ventilation heat loss in a building is due to purpose-provided ventilation by mechanical ventilation or natural ventilation and air infiltration or air leakage. Buildings should not exceed the design ventilation rates for their purpose. It is recommended that, before installing a heat pump, the design ventilation rate is established, the ventilation rate is measured by a specialist contractor[xx], and the ventilation is adjusted to match the design ventilation rate. If this policy is pursued, the design ventilation rate may be used in the heat loss calculation.

Design ventilation heat loss is established by multiplying the necessary air changes per hour (ACH)[xxi] by the room volume, dividing by 3, and multiplying by the design temperature difference as above. Thus the design ventilation heat loss for a changing room of $39m^3$ volume would be 10 ACH X 39 m^3 = 390 / 3 = 130 X 24°C = 3120 Watts.

In this example the total heat loss (adding fabric to ventilation) would be 6658 watts or a load of 6.7kW for space heating. An extra 10% loss is often allowed to mitigate any build quality issues.

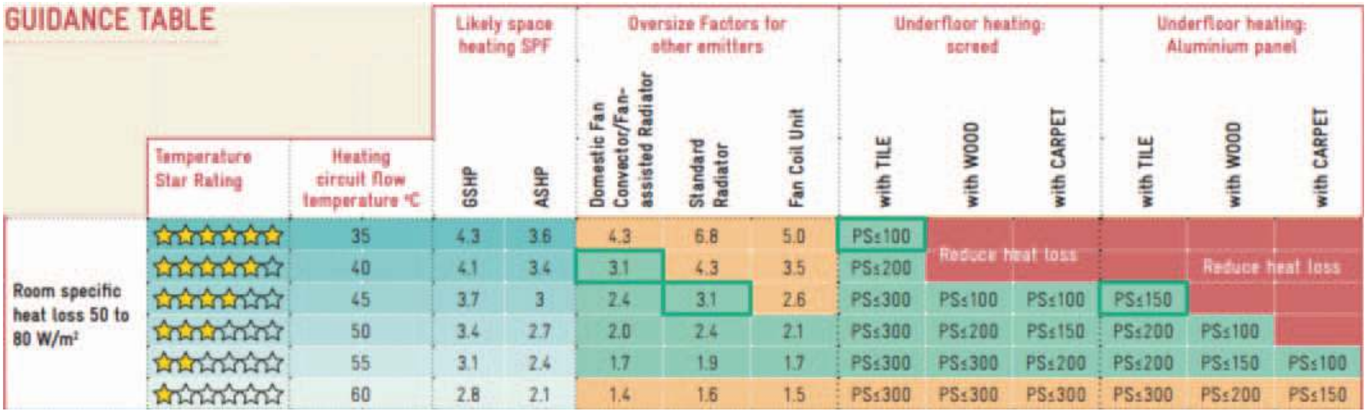
8.5
Heat emitters and distribution

As we mentioned in Section 3 above, the design of the distribution system and the heat emitters will have a profound effect on feasibility. In most cases low temperature heat emitters will be required with large bore pipe work to ensure that enough heat can reach the emitters.

In a new build, UFH is likely to be the optimum solution as low flow temperatures can be achieved. In a retrofit, the existing distribution system must be evaluated and upgraded where necessary to achieve good CoP. MCS021 – Heat Emitter Guide[xxii] presents a decision tree for assessing the efficiency of heat emitters in specific installation situations. Although not intended to be a detailed design tool, it is very useful in assessing feasibility.

The guide assesses the ability of various heat emitters to provide heat to a space based on the flow temperature and the room specific heat loss. The latter is simply the heat loss in watts divided by the floor area in square metres.

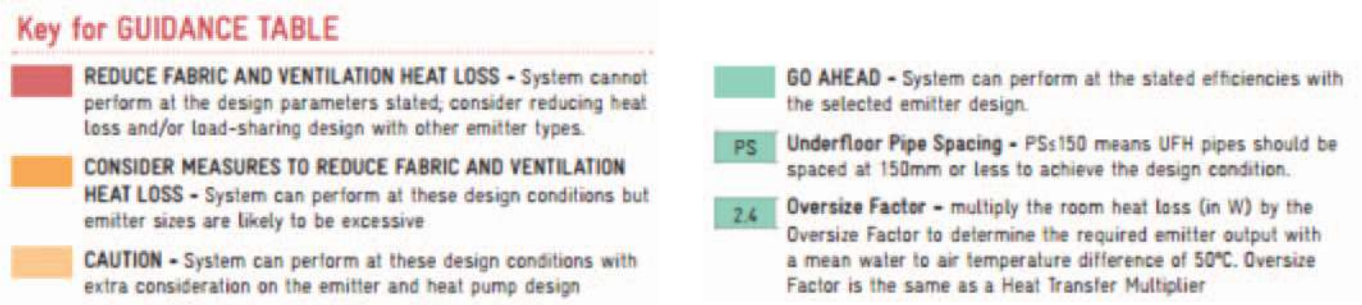
Using the worked example for the changing room, the room specific heat loss is 6658 watts / 104.3m^2 = 63.83 W/m2. This falls in the 60 to 80 W/m2 section of the guide. At 35°C the system receives 6 stars and a high seasonal CoP for both ASHP and GSHP. In the areas shaded red the system will not perform. In the areas shaded light orange the system may be able to perform but detailed extra design will be required. The system will only perform well in the green cells. For UFH maximum pipe spacing is specified, for other emitters an oversizing factor is specified.



GUIDANCE TABLE

			Likely space heating SPF		Oversize Factors for other emitters			Underfloor heating: screed			Underfloor heating: Aluminium panel		
	Temperature Star Rating	Heating circuit flow temperature °C	GSHP	ASHP	Domestic Fan Convector/Fan-assisted Radiator	Standard Radiator	Fan Coil Unit	with TILE	with WOOD	with CARPET	with TILE	with WOOD	with CARPET
Room specific heat loss 50 to 80 W/m^2	★★★★★★	35	4.3	3.6	4.3	6.8	5.0	PS≤100	Reduce heat loss		Reduce heat loss		
	★★★★★☆	40	4.1	3.4	3.1	4.3	3.5	PS≤200					
	★★★★☆☆	45	3.7	3	2.4	3.1	2.6	PS≤300	PS≤100	PS≤100	PS≤150		
	★★★☆☆☆	50	3.4	2.7	2.0	2.4	2.1	PS≤300	PS≤200	PS≤150	PS≤200	PS≤100	
	★★☆☆☆☆	55	3.1	2.4	1.7	1.9	1.7	PS≤300	PS≤300	PS≤200	PS≤200	PS≤150	PS≤100
	★☆☆☆☆☆	60	2.8	2.1	1.4	1.6	1.5	PS≤300	PS≤300	PS≤300	PS≤300	PS≤200	PS≤150

Figure 23: Heat Emitter Guide excerpt



Key for GUIDANCE TABLE

🟥 **REDUCE FABRIC AND VENTILATION HEAT LOSS -** System cannot perform at the design parameters stated; consider reducing heat loss and/or load-sharing design with other emitter types.

🟧 **CONSIDER MEASURES TO REDUCE FABRIC AND VENTILATION HEAT LOSS -** System can perform at these design conditions but emitter sizes are likely to be excessive

🟨 **CAUTION -** System can perform at these design conditions with extra consideration on the emitter and heat pump design

🟩 **GO AHEAD -** System can perform at the stated efficiencies with the selected emitter design.

PS **Underfloor Pipe Spacing -** PS≤150 means UFH pipes should be spaced at 150mm or less to achieve the design condition.

2.4 **Oversize Factor -** multiply the room heat loss (in W) by the Oversize Factor to determine the required emitter output with a mean water to air temperature difference of 50°C. Oversize Factor is the same as a Heat Transfer Multiplier

Figure 24: Heat Emitter Guide key

Using the tables at feasibility stage will allow you to assess the options available in a specific situation.

Again, taking the changing room example above, we can see that UFH with a tiled floor is possible to achieve the optimum flow temperature and efficiency.

In a new build, the space heating distribution system to the heat emitters should not prove a problem as it can be designed for the flow temperature. However, in a retrofit, where existing pipe work may not be easily accessible, within the building structure and may not be insulated, this may not be the case. If you are considering a low flow temperature in a retrofit you should consult a heating engineer to ensure the required flow rates are possible.

8.6
Hot water

We have already established that heat pumps are at their most efficient when raising the temperature from the heat source to the heat sink by the minimum difference and, preferably with a flow temperature of 35°C. Clearly, hot water is required above this temperature so producing it from a heat pump will dictate lower efficiencies.

The ability to provide sufficiently high water temperatures for stored hot water is important, both from an efficiency point of view and also to meet health and safety legislation aimed at preventing legionella. For heat pumps specified primarily for hot water production, high temperature models are able to achieve stored hot water temperatures of up to 65°C without the need for supplementary heating. These typically use refrigerants such as R290 (Propane) or R134a to achieve higher temperatures within the vapour compression cycle. Lower temperature heat pumps will require support from a supplementary heat source to reach the maximum temperature – this might be from another heat source, such as a fossil fuel boiler, or from a boost electric immersion heater.

Correct selection of the hot water cylinder with an appropriately sized heat exchanger to ensure maximum heat transfer is important, as heat pump systems usually require a larger heat exchanger surface area. This is particularly important for air source heat pumps to ensure that stored hot water temperatures can be maximised in the summer months when the heat pump output will increase due to higher ambient air temperatures. Cylinder specification for air source heat pumps therefore needs to be carefully considered in line with performance characteristics of the heat pump.

Commercial cylinders compatible with heat pumps are available in sizes up to 4,000 litres, with coil size bespoke designed to exact specification. Hybrid systems of solar thermal and heat pumps are also possible and becoming increasingly popular. Intelligent heat pump controls can optimise use of the solar energy before bringing on the heat pump compressor. The use of waste heat is also an interesting application for heat pumps. Heat pumps installed at the first supermarket in Ireland built to Passivhaus standards use the waste heat from the chiller cabinets at around 30°C, which is circulated directly through the system and used to provide hot water at 60°C for the staff canteen and washrooms, and customer toilets.

The hot water load must be calculated and added to the space heating load where hot water is required. It may be possible to mitigate the load. A common strategy in mono valent systems is to size the cylinder for the average daily hot water load and control hot water production within a low overnight electricity tariff. Whilst CoP is unaffected, cost is substantially reduced.

8.7
Heat source resources

Once your heat losses, emitters, distribution system and hot water loads have been established, you should consider the available heat source resources. The most common resource in Northern Ireland will be the ambient air. As we are close to the sea, in a temperate climate, air temperatures do not fluctuate widely through the seasons, so ASHP efficiency is relatively stable.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
4	4.4	5.7	7.7	10.5	13.3	14.7	14.5	12.5	9.8	6.2	4.7

Figure 25: Mean monthly temperatures Aldergrove

As height above sea level rises temperatures fall, so you must bear in mind that, at height, an ASHP will be less efficient. Providing that you have a location with good air circulation so that the air is constantly replenished, that the heat pump collector is not in a dip and that the proposed site is not excessively elevated above sea level, an ASHP will be a possibility.

Unlike an air source heat pump a GSHP will be less affected by seasonal variation in temperatures, leading to greater CoP.

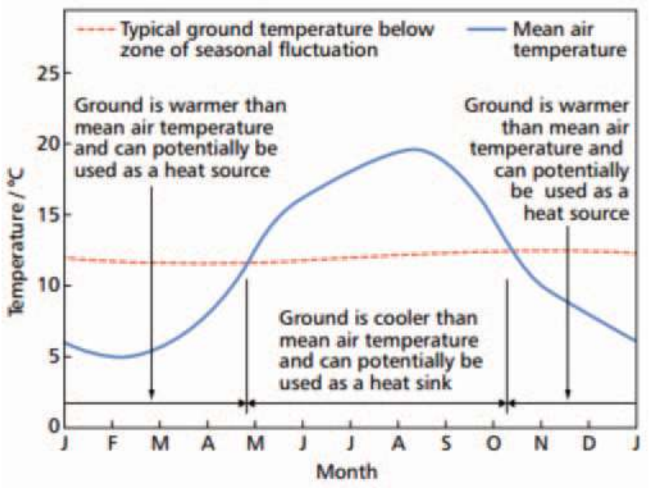


Figure 26: Typical relation of ground to air temperatures (Image courtesy of CIBSE)

The ground temperature at between 1 and 2m remains relatively constant throughout the year at between 3 and 10°C during the heating season.

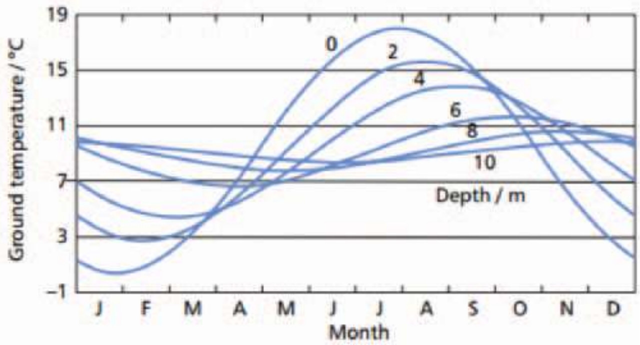


Figure 27: Ground temperature as a function of depth (Image courtesy of CIBSE)

A GSHP with a horizontal loop collector will require a considerable area of land in which to locate the collector and the correct soil qualities. The area required will be dictated by the specific heat extraction rate that, in turn, will depend on the soil characteristics. Specific heat abstraction rates vary widely depending on ground type, pipe and collector specification and FLEQ (Full Load Equivalent Run Hours). In view of the complexity of the calculations involved, these should be carried out by an MCS accredited installer[xxiii].

Where a GSHP is preferable but a horizontal loop is not possible, a vertical collector loop in a borehole may be possible. Again, this will be dependent on the heat sink load and the geology. Both will dictate the necessary borehole depth(s) and design. This is a highly specialised installation and feasibility should be investigated by an MCS accredited installer or the heat pump manufacturer.

A closed loop WSHP may be possible if you have a pond or river close to the heat sink. The quality of the heat source is dependent on both temperature fluctuation in the water and the speed of water replenishment. Thus, a pond or lake may have a large volume but, if it is shallow or has a low flow rate, it may not be suitable. Similarly, if a river is too shallow, it may not be suitable. WSHPs can have high CoPs in suitable locations. Again, this is a highly specialised installation and feasibility should be investigated by an MCS accredited installer or the heat pump manufacturer.

8.8
Heat pump sizing

Once all of the factors above have been assessed the heat pump may be sized. As mentioned in Section 3, the heat pump manufacturers' characteristic curves are used for this process. Using the changing room worked example, the heat source assessment shows that an ASHP is most suitable and that we can achieve a flow temperature of 35°C using UFH with a tiled floor finish and pipe spacing of no more than 100mm. The heat load is 6.7kW and no hot water is required.

Accurate selection of an ASHP to meet the demand at a range of outdoor air temperatures is absolutely vital. Remember that ASHP output is a function of heat source temperature and water flow temperature, so both efficiency and kW rating will decrease at colder times of the year. The capacity of the heat pump needs to be matched to the energy demand during cold periods. Figure 28 shows the heating demand as 7kW with the red line, the internal design temperature is 21°C and the ambient air design temperature is -3°C (green). The diagonal purple line intersects the heat pump output curve to give the bivalent or balance point (1°C ambient; blue line). The heat pump contributes 100% of the heating demand at this balance point.

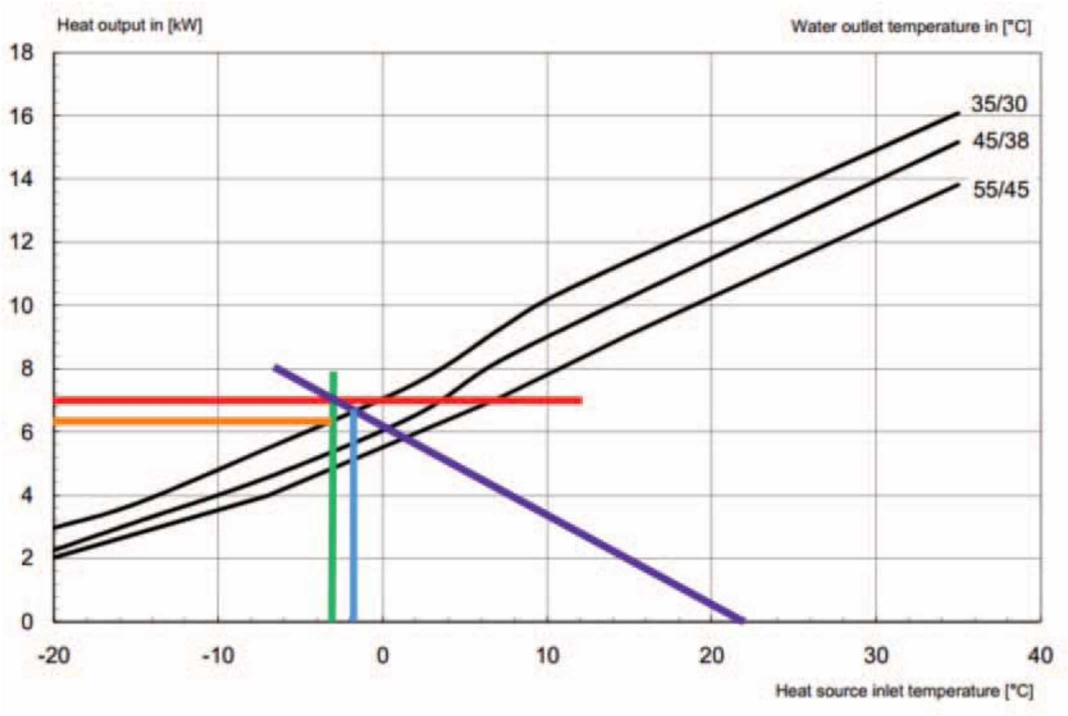


Figure 28: Heat pump selection procedure (Image courtesy of Element Consultants)

When the ambient temperature falls below the balance point, the heat demand increases, while the heat pump output falls, such that about 1.5kW of supplementary heating has to be provided (from the orange to the red line).

Thus, the changing room may be heated by this heat pump as long as an additional 1.5kW of heat are available for the lowest temperatures. Typically, in a monovalent installation, an immersion heater will take up this load when required.

Other factors that may affect the heat pump output are:

- Wind speed affecting fan on outdoor unit
- Positioning in relation to the building (dead areas)
- Orientation and shading
- Geographical height and area
- Defrost requirements.

For a GSHP or WSHP, once the supplementary heating requirement has been sized, the energy required from the ground or water is calculated and the required area and pipe length are calculated from the abstraction rate. Geographical soil specific abstraction rates are given in MIS 3005 and may be used for feasibility purposes. Other sources include consultant geologists or hydrogeologists and recorded observations from test pits. Experience from a nearby site and confirmation of consistent geology in the area is equally useful.

In order to use the tables you must first establish the FLEQ.

$$\text{FLEQ} = \frac{\text{Total energy consumption (kWh)}}{\text{Heat pump capacity (kW)}}$$

From a feasibility perspective, the total energy consumption may be derived by several methods. In a retrofit situation we can calculate the energy consumed using historical billing. In a new build situation or a situation where the heat losses are being calculated, it is well worth using the MCS spreadsheet “DHDG sizing spreadsheet @ 19&21 v1.1” available on the MCS website[xxv]. The total energy consumption will be calculated as a function of assessing the heat losses.

For example, say the changing room scenario decided to use a GSHP with horizontal pipe collectors in a clay/silt soil and the total energy consumed was 12,600kWh; the FLEQ would be 1800. Using the look up tables, the abstraction rate would be between 9 and 16W/m. Using standard collector pipework, between 800m and 400m of pipe and an area between 740m^2 and 500m^2 will be required. The importance of correctly identifying the soil abstraction capacity for practical and financial feasibility is evident.

9.0 Understanding NIE Connection

The heat pump is driven by an electric motor (unless it is a TDHP). This is an inductive load that can cause disturbances to the electricity distribution network because of high starting currents. It is a particular problem when using a single phase and can lead to flickering lights, voltage surges or ‘spikes’ (which can affect electronic equipment) and premature main fuse failure.

NIE will require full details of the heat pump that you wish to connect in advance of connection. You must apply for an alteration of your existing supply if you already have one. The details must include the compressor(s) rating, continuous operating current, starting current and number of starts per hour along with the manufacturer’s data sheet for the heat pump. Note the timescales on the list below. The entire process takes at least nine weeks and can take over a year if planning permission or wayleaves are required for infrastructure.

If this is a new supply, NIE will also require full plans. Note that you will probably apply for a night rate saver tariff, such as Economy 7, if it is available.

Connection Stages	**Action and Timescale**
Application	• Complete NIE’s connection application form and submit it along with all relevant information eg. site maps, sketches, etc.
Confirmation of Requirements	• NIE will contact you to discuss your specific requirements or identify additional information required. • This will happen five to ten working days from receipt of your application information.
Quotation	• NIE will provide you with a quote for the work involved. This will include terms and conditions. • Quotations are valid for 90 days. • Normally a quote will be provided 15 working days from receipt of all relevant information.
Acceptance of Terms	• You should sign the acceptance of terms and provide payment. • Quotations are only valid for 90 days so your payment must be received within that period.
Third Party Consents	• Some connections may require electricity equipment to be sited on other people’s land. NIE will seek permission from the landowners or other government bodies before we can proceed with your application. • This process can take between six to nine months.
Construction	• When approvals and full payment have been received NIE will contact you to agree a date for the work. • Normally construction may take between four to eight weeks from when your site is ready. This is subject to receipt of your Connection Card from your electrical contractor.

Figure 29: NIE connection chart

10.0 System Performance Monitoring

If you avail of the RHI, meters will be fitted to the system. There is a variety of system monitoring options available depending on your requirements. These range from simply recording the meter readings to full data monitoring solutions with online portals and data evaluation. From a business perspective the online portals can fulfil two functions; enabling data evaluation and providing a good marketing tool displaying the company's green credentials.

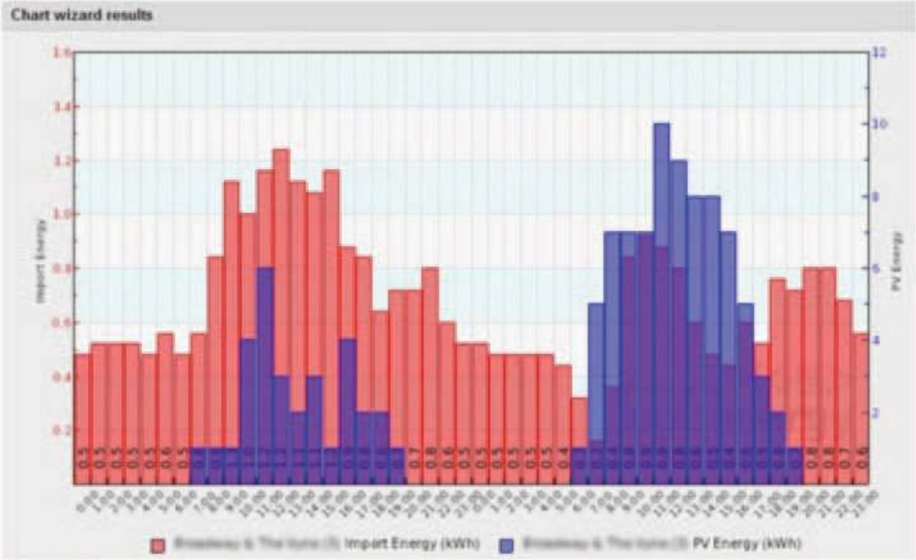


Figure 30: Typical monitoring display
(Image courtesy of Logic Energy)

A useful recent addition to the range is Logic Energy Live Monitoring[xxvii]. This system can visually display the heat generation and electrical use.

11.0 Heat Pump Technology

11.1 Introduction 41

11.2 Modulating compressors 41

11.3 Enhanced vapour injection 41

11.4 Ejector enhanced vapour compression 41

11.5 Thermally driven heat pumps 41

11.6 Other improvements 43

11.1
Introduction

Although heat pumps are a mature technology, advances are continually being achieved to drive efficiency and improve CoP. Some advances are discussed below.

Advances in compressor and refrigerant control in ASHPs have led to considerable increases in CoP. For example, the latest Dimplex LA9TU A rated heat pump can achieve a CoP of 3.4 at A0/W35[xxvii] while the older LI8MS could only achieve a CoP of 2.2 at the same temperatures.

11.2
Modulating compressors

The modulating compressor increases heating, ventilation & air conditioning system efficiency by precisely matching compressor output to the heating or cooling need which saves energy and reduces maintenance costs. Developed in 1993, the first application of this technology was in refrigerated marine containers in 1999. In 2000, the air-conditioning version of this technology was first launched in Asia. Today, over one million pieces of these compressors are working in the field all over the world in various applications and their reliability has been over 99.99%.

Capacity modulation between 10% and 100% can be achieved quickly and smoothly using a variable speed drive, meaning that it is perfect for buildings or rooms which experience widely varying loads or where precise temperature and humidity control is necessary. Furthermore, this technology can easily be applied to a variety of applications including Variable Refrigerant Flow (VRF) systems, packaged and split units.

By offering a capacity range of 10%–100%, the modulating compressor doesn't need to start and stop as often as a traditional compressor. Because of this reduction in wear and tear, the compressor has enhanced reliability and requires less maintenance.

11.3
Enhanced vapour injection

Enhanced vapour injection describes an economising operation. Economising can be accomplished by using a sub cooling circuit. This increases the refrigeration capacity and the system efficiency. The benefits provided will increase as the compression ratio increases. A heat exchanger is used to provide additional sub cooling to the refrigerant before it enters the evaporator. This sub cooling process provides the increased capacity gain measured in the system. During the sub cooling process, a certain amount of refrigerant is evaporated. This evaporated refrigerant is injected into the compressor and provides additional cooling at higher compression ratios.

The vapour injection scroll compressor is for use with an economised vapour compression cycle heat pump. This cycle offers the advantages of more heat delivered and a better CoP than with a conventional cycle. Both the heating capacity and the CoP improvement are proportional to the temperature lift and this technology offers best results at high condensing operation where capacity and efficiency are most needed. Due to this increase in capacity, it is possible to specify a smaller displacement compressor for a given heating load. Additionally the cooling provided by injection inter-stage allows the operation of the compressor over a larger envelope compared to a conventional single stage model, providing higher heat delivery temperatures at low evaporating temperatures.

11.4
Ejector enhanced vapour compression

The main advantage of the ejector may be found in the recovery of the expansion work normally wasted in throttling processes at a typical expansion valve. Use of an ejector as an expansion device by replacing the throttling valve in the vapour compression refrigeration cycle seems to be one of the efficient ways to reduce the throttling losses or the expansion irreversibility in the refrigeration/heat pump cycle. The ejector also reduces the compressor work by raising the suction pressure to a level higher than that in the evaporator leading to the improvement of CoP. Use of an ejector will give two benefits: work recovery (CoP improvement) and flash gas bypass (evaporator size reduction).

11.5
Thermally driven heat pumps

Thermally driven heat pumps (TDHP) work at three temperature levels. Driving heat is supplied at a high temperature level. Useful cold (cooling operation) or low temperature heat (heating operation) is supplied at a low temperature level. The sum of the heat supplied is released at a medium temperature level. This is the useful heat in heating operation. In cooling operation, it is usually released to the environment. However, medium and low temperature heat can also be used simultaneously for heating and cooling purposes.

In principle, all closed cycle TDHP types can be operated in heating and cooling mode. However, when we talk about TDHPs, we usually refer to absorption or adsorption heat pumps as they have the highest CoP.

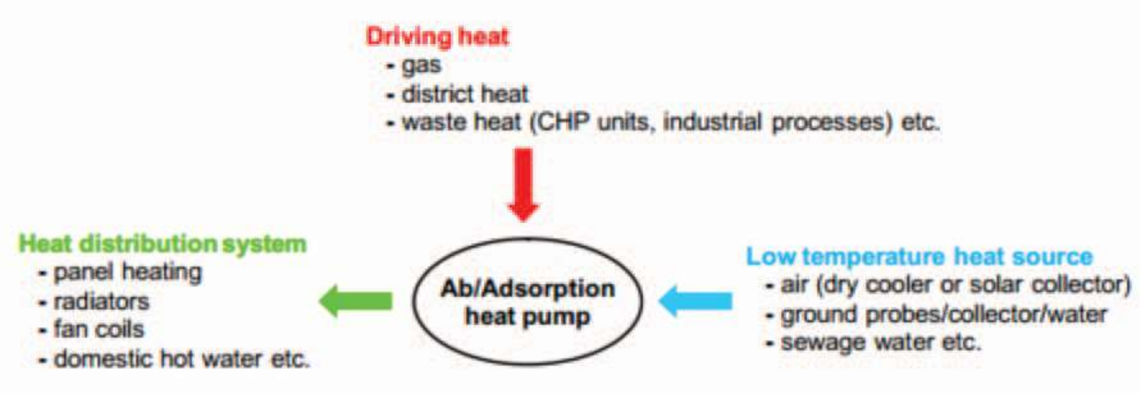


Figure 31: Typical TDHP system configurations

11.5.1
Absorption heat pumps

Just as in the conventional compression heat pump process, in the absorption heat pump process useful heat is produced by condensation of a refrigerant. Gas Absorption/Adsorption Heat Pumps (GAHP) use a combination of a carrier and refrigerant which have a natural affinity. GAHPs use heat to change the composition of the carrier and refrigerant solution and, by changing the solution state (liquid-gas-liquid), heat equating to the latent heat of vaporisation is transferred. The most common solution mixture is ammonia as the refrigerant, and water as the carrier. The diagram below demonstrates the process.

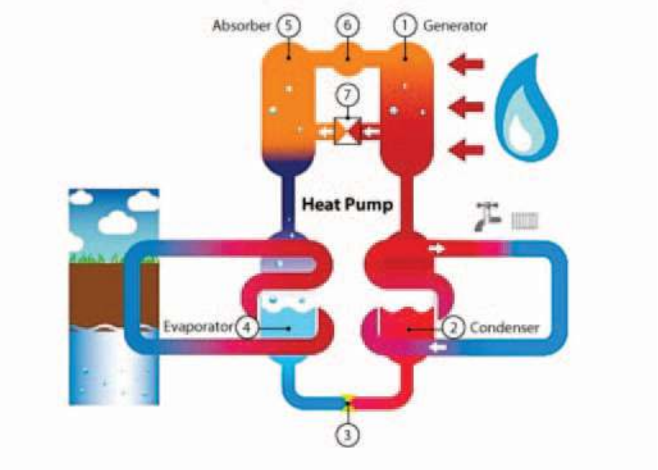


Figure 32: GSHP cycle
(Image courtesy of the Heat Pump Association

Heat is applied in the generator (1) to heat the ammonia and water solution and increase its pressure, which causes the solution to separate into strong ammonia vapour and a weak ammonia/water solution. The strong ammonia vapour is forced into the condenser (2), while the weak ammonia solution is circulated into the absorber (5) via an expansion valve which maintains pressure differential. The high temperature, high pressure ammonia vapour enters the condenser where it condenses due to the space heating/process heating media passing over the exchanger. Because the vapour has changed state and become a liquid, it effectively gives up its latent heat of vapourisation into the heating media. The ammonia liquid, still at high pressure, passes through the expansion valve (3) where the pressure is reduced downstream. The reduced pressure ammonia changes state from liquid to vapour i.e. it effectively boils and evaporates. As a result, the solution gets very cold and effectively ‘sucks’ heat from evaporator (4) heat source (air or water). If the source is ambient air or ground warmed water, the heat is from a renewable source. The ammonia vapour is now warmer but still at low pressure. In the absorber the weak ammonia solution from the generator recombines with the warmed vapour from the evaporator having just passed through a second expansion valve (7). As the ammonia vapour and weak ammonia solution recombine the vapour changes into a liquid, releasing additional heat into the system. The recombined ammonia solution is pumped (6) back to the generator where the cycle recommences.

11.5.2
Adsorption heat pumps

Unlike absorption where the refrigerant is absorbed in a liquid sorbent, in the case of adsorption the refrigerant is adsorbed in the pores of a solid sorbent. The adsorption heat pumping cycle is thermodynamically similar to the absorption cycle. It consists of the same main heat exchangers: evaporator, condenser, and a heat exchanger for adsorption and desorption. Unlike the absorption process where the liquid absorbent is pumped between absorber and desorber, adsorption is a discontinuously working process as the solid adsorbent cannot easily be moved from one vessel to the other. Adsorption and desorption can occur successively in the same vessel. However, to ensure a reasonably continuous useful heating or cooling effect, two so-called reactors are usually used and operated in counter-phase.

11.6
Other improvements

Environmental drivers are phasing out the traditional heat pump working fluids. In the EU CFCs were phased out in 1996 and HCFCs will be phased out by 2020. HFCs are the current alternative but blends and natural working fluids such as CO2 are being developed. More detail on working fluids is available on the Heat Pump Centre website[xxix].

12.0 System Design

Even for an ASHP, system design is a complex process with significant expertise required to match heat sources, heat pumps and heat sinks. It would seem sensible to leave system design to the appropriately qualified professional. For systems below 45kWth an MCS accredited contractor should suffice, but you should follow the recommendations in Section 13.

For systems greater than 45kWth you should contact the heat pump manufacturers directly and ask them to recommend a contractor or, for more complex systems, become involved in the design themselves.

13.0 Selecting Contractors

13.1 Introduction 47
13.2 Microgeneration Certification Scheme 47
13.3 Long-term company viability 47
13.4 Examples and references 47
13.5 Servicing arrangements 47
13.6 Tendering 47

13.1
Introduction

Although, a well-designed and well-installed heat pump system should require minimal intervention over its lifetime, when you install a heat pump you are entering into a long- term arrangement. You expect the heat pump to be operational for 20 years so it is logical that you will require the company that installs the system to be operating throughout that lifetime to solve any problems that might occur. Whilst you cannot guarantee that the company will always be there for you, there are some steps that you can take to protect yourself. The Green Home website provides a useful checklist of 'Questions to ask installers'[xxx].

13.2
Microgeneration Certification Scheme

The Microgeneration Certification Scheme (MCS)[xxxi] is an internationally recognised quality assurance scheme, supported by the government. MCS certifies microgeneration technologies and products used to produce electricity and heat from renewable sources.

MCS itself is a BS EN ISO/IEC 17065:2012 Scheme and was launched in 2008. MCS also certifies installation companies to ensure the microgeneration products have been installed and commissioned to the highest standard for the consumer. The certification is based on a set of installer standards and product scheme requirements.

MCS covers heat pump generating technologies with a capacity of up to 45kWth. All installations of heat pumps up to 45kWth must be installed by an MCS registered installer using MCS registered equipment to be eligible for government incentives.

The MCS should give the consumer some peace of mind as the scheme places quality standards on both equipment and installation. However, it would be naïve to think that no company operating under the scheme ever failed to meet those standards so it would be wise to put other checks in place.

13.3
Long-term company viability

In today's electronic information age, it is relatively simple to gather information about a company. You will be making a sizeable investment and you should ensure that the company is financially sound and has some organisational depth should they suffer manpower issues in the future. Any company that has traded for a couple of years will have made financial returns which are available from Companies House for a small fee[xxxii]. Ask companies how they are structured and how they will manage if one of their key people drops out. Ask for this information to be included in any tender (see Section 13.6).

13.4
Examples and references

Any company that has a good track record will be more than happy to provide you with references and examples of work it has carried out. Don't be afraid to ask for at least three examples. You need to see work that is similar to the work you are asking to be carried out. Check the references you have been given; go and visit the sites and talk to the site managers. Ask them searching questions to ensure you have a full understanding of any problems that have occurred and how they might affect you. Ask for this information to be included in any tender (see Section 13.6).

13.5
Servicing arrangements

An annual service is envisaged so that any issues are addressed and any possible issues are foreseen. The efficiency of the system is dependent on it operating correctly so an annual service including a visual and electrical inspection should be included in the contract. Ask for this information to be included in any tender (See below).

13.6
Tendering

Preparing a tender document and putting the work out to tender allows you to get everything that you require down on paper. The great advantage of this method of getting prices is that all the tenderers will be pricing for the work that you specify and not for what they think you want. This does not mean that you have to specify the nuts and bolts of the system. On the contrary, it is quite common for a tender to ask the tenderer to design and specify a system for a specific site, show his calculations and explain why he has chosen that system for that site. The tender can then require the tenderer to supply other items such as MCS Certification, financial information, references, servicing arrangements, payment details etc.

All tenders issued for heat pump systems should include a section ensuring that the contractor is responsible for completing all regulatory approval and certification, especially any required for payment of the RHI. The final payment for the job should be linked to the final approvals. Tenders are usually written by quantity surveyors or independent consultants.

14.0 Funding and Financial Assistance

14.1 Introduction 49

14.2 Carbon Trust interest free loans 49

14.3 Venture capital funding 49

14.4 Renewable Heat Incentive 49

14.1
Introduction

In the current environment, with the demise of the banks, as we have historically understood their function, funding is a fast moving and changing field. Traditional bank funding has become difficult to secure; in the case of some specific banks, funding is all but absent. Some banks continue to lend for renewable energy ventures but they are looking for excellent returns and security.

Therefore, it is all the more important that you thoroughly investigate the financial variations of the scheme and have a well-prepared business plan and a thorough understanding of the scheme before approaching a funding source.

14.2
Carbon Trust interest free loans

The Carbon Trust continues to make four year, interest free loans[xxxiii] available to all Northern Ireland businesses excluding some agricultural or fisheries businesses; incorporated businesses must have been trading for 12 months and non-incorporated businesses for 36 months. The loans are unsecured and government funded. Loans are available from £3,000–£400,000 based on the quantity of carbon emissions saved by the project.

The Carbon Trust supplies an online calculator for estimating the carbon savings and subsequent loan that might be made available at **http://www.carbontrust.com/media/47185/calculator-max-loan.xls**

Note that DETI is currently conducting a review to establish whether an installation that has received support from a Carbon Trust Loan is eligible for the RHI.

14.3
Venture capital funding

Venture capital funding should be considered as an alternative to bank lending. Often, if a loan is available, decision making, paper work and issuing of the loan will be considerably simpler than the bank system. However, you must bear in mind that any venture capital financing company will be looking for a good return and an exit strategy. They may be less flexible than banks if things go wrong. Among others, current players in the market are Nationwide Corporate Finance Ltd[xxxiv] and Portman Asset Finance[xxxv].

14.4
Renewable Heat Incentive

The RHI provides financial support for renewable heat technologies for the lifetime of the installation (to a maximum of 20 years). Payments will be made on a quarterly basis and determined by the actual heat output of the system, therefore heat meters will be required for each installation.

Under the Renewable Heat Incentive Scheme Regulations (Northern Ireland) 2012, the RHI tariffs must be adjusted annually in line with the RPI for the previous calendar year. DETI must make the necessary calculations and publish the revised tariffs and Ofgem, as administrators of the scheme, must take account of the tariff changes and ensure they are applied.

The tables below detail the tariffs at 1 April 2014. These tariffs have been adjusted in line with RPI. The increase in the RPI for the calendar year 2013 was 2.7%. The tariffs are therefore increasing by this amount, with the resulting figure being rounded, in line with regulations, to the nearest tenth of a penny, with any twentieth of a penny being rounded upwards.

Size Range	NI RHI Tariff (pence per kWh)	Length of Tariff
Less than 20kWth	8.9	20 years
20kWh and above, up to but not including 100kWh	4.5	20 years
100kWh and above	1.5	20 years

Figure 33: NI RHI tariff to 1st April 2015

In order to avail of the RHI your installation must meet the eligibility criteria; detailed guidance is given on the Ofgem website[xxxvi]. A summary is given below:

- GSHP and WSHPs only; ASHP expected to be added in Phase 2.
- Plant commissioned after 15th July 2009 and new at time of installation.
- Applicant must be the owner of the system.
- Use must be eligible: for space, water or process heating within a permanent building or outside a building for drying and/or cleaning on a commercial basis.
- Heat must be delivered by steam or water (not air).
- Installer must be MCS accredited for installations up to 45kWth.
- No public grant money may be used for the equipment purchase or installation costs.
- The metering arrangements must be correct.
- The installation may not heat a single home; district heating schemes may be eligible.

- Heat pump must be specified on load design conditions.
- Heat pump must have a CoP of at least 2.9.
- Heat source must be naturally occurring and no more than 500m below the earth surface.

The heat metering requirements are very specific and laid out in detail in Chapter 7 of the Guidance. It is imperative that these are correct; many early applications failed because of substandard metering arrangements.

Once part of the scheme, participants will need to comply with a number of ongoing obligations such as regular submission of heat data, meter readings and fuel data. Participants will also be expected to maintain their heating equipment and meters, and report any significant changes to their installation or heat uses to Ofgem. Participants will be required to make annual declarations to Ofgem confirming their compliance, and may be selected for audits and/or a site inspection. Failure to comply with ongoing obligations (including notification of a change of ownership of an accredited installation) may lead to Ofgem taking compliance action against a participant.

15.0 Financials

15.1 Predicting income 52
15.2 Capital and annual costs 52
15.3 Pay back 52
15.4 Carbon savings 52
15.5 Total return 52
15.6 Equivalent interest 52
15.7 Cost per kWh 52
15.8 Net Present Value 53
15.9 Sensitivity Analysis 53

The following list of financial tools will allow you carry out most of the financial predictions required for analysing the investment. When combined with a short-term and long-term cash flow you will have all you require for approaching a bank for financing.

15.1
Predicting income

In Section 5.3 we established a method for predicting income from a heat pump installation. Heat pumps installed in Northern Ireland can earn income in two ways; replaced heating energy and from the RHI. This replacement, combined with the maximum RHI payment is the most cost-effective method of installation and will usually lead to the fastest pay back.

It is essential that you establish the predicted income as accurately as possible. In order to do this you must have an accurate description of the heat load. For example, although the fuel consumption details for the last year are useful as an estimate, they will not take account of variations in heating load from a cold year to a warm year. Similarly, if your boiler is old, it may be very inefficient. If it is, you will burn much more fuel than necessary and your energy consumption prediction will be too high.

You must establish your heating load and predicted energy consumption accurately to get accurate predicted income figures for a feasibility study. For space heating, the MCS spreadsheets will suffice.

15.2
Capital and annual costs

Capital costs will be specific to the installation. Installation and system types vary widely and prices vary accordingly. GSHPs, with their ground works, will be considerably more expensive than ASHPs. Similarly the most modern, high CoP, systems will be more expensive than less technologically advanced pumps. Installation prices for all but ASHPs will be site specific. In each case, quotations should be received from at least three reputable contractors.

The only planned maintenance is an annual service.

15.3
Pay back

Section 5.3 described how to calculate simple pay back. To calculate pay back allowing for annual costs we need to include the amortised cost of the annual service over say a 20 year life span. In this case the equation will be:

$$\textbf{Pay Back=} \frac{\text{Total Capital Cost}}{\text{(Annual Income) x (1- (Annual Cost / Annual Income)}}$$

This equation may be expanded to allow inflation and utility inflation to be added to the variables.

15.4
Carbon savings

The Carbon Trust publishes Carbon Conversion Factors online[xxxvii]. The document includes an embedded spreadsheet to enable you to calculate carbon emissions from grid generated electricity. In the changing room example above, the heat pump is predicted to replace 31,500kWh of burning oil. Using the 2013 spreadsheet this equates to 7734kgCO_2.

15.5
Total return

The total return on investment is straightforward. It tells the investor the percentage gain or loss on an asset based upon his purchase price. To calculate total return, divide the selling value of the investments plus any income received by its total cost. In essence, this works out to capital gains plus dividends as a percentage of the money you laid out to buy the investment.

$$\textbf{Total Return =} \frac{\text{Total Income}}{\text{Total Cost}}$$

15.6
Equivalent interest

The equivalent interest rate is the actual annual rate of return that you receive on an investment over the life of an investment when it is compounded. Thus, any competing investment would need to be able to exceed the Equivalent Interest Rate. It may be calculated by the equation:

$$\textbf{Equivalent Interest Rate} = \text{((Total Return^(1/Lifetime))-1) X 100}$$

15.7
Cost per kWh

Of the financial indicators, cost per kWh is one of the most useful. If you are trying to compare the relative merits of different schemes or technologies you can compare the cost per kWh of each to see which has the lowest cost per unit of energy generated. This may be useful for comparing, say, a heat pump and a biomass boiler or for varying heat pump sizes. It may be calculated by the equation:

$$\textbf{Cost / kWh} = \frac{(\text{Lifetime Costs / Lifetime Generation})}{\text{X } 100}$$

15.8
Net Present Value

Net Present Value (NPV) is a formula used to determine the present value of an investment by the discounted sum of all cash flows received from and expended during the project. The NPV tells you what the investment is worth to you today. To calculate the NPV you need to know all of the cash outflows and incomes for the project lifetime along with the discount rate. The discount rate is the interest rate that you expect to apply over the lifetime of the project and the amount by which a future receipt or expenditure will be discounted to bring it to present value. The current UK government discount rate is 3.5%. NPV may be calculated by the equation:

$$\textbf{NPV=} \quad -C_o + \frac{C_1}{(1+r)} + \frac{C_2}{(1+r)^2} + \cdots + \frac{C_T}{(1+r)^T}$$

Where $-C_0$ is the initial investment, C_1 is the cash flow in year one, r is the discount rate and T is time (in years).

We should note that no allowance has been made for utility rate inflation or inflation. Both of these factors will considerably increase the NPV.

15.9
Sensitivity analysis

A sensitivity analysis allows you to adjust certain parameters in your financial calculations to see what effect it will have on the outcome. For instance, you might wish to examine what happens to your pay back if the cost of electricity rises by 10%.

The simplest way to execute sensitivity analyses is to use one of the freely available sensitivity analysis add-in toolkits for Excel available on the internet.

16.0 Project Management

16.1 Introduction 55
16.2 Site safety 55
16.3 In-house capabilities 55
16.4 Planning the project 56

16.1
Introduction

The project management procedure can be simplified by using the tender process. Tenders should be used to ensure that as much of the responsibility for the job as possible is placed on the contractor. Tenders are normally written by quantity surveyors or independent consultants.

16.2
Site safety

The Health and Safety at Work Act 1974 is supported by more specific legislation such as the Management of Health and Safety at Work Regulations (MHSWR) 1999. Construction and design specific legislation e.g. the Construction (Design Management) Regulations 2007[xxxviii], ensure the design of safe systems of work. These regulations apply to health and safety management and require the identification and elimination of hazards during all phases of design and construction, during operation, maintenance and eventual decommissioning.

The legal responsibilities of the designer are now extremely onerous, furthermore it is a legal responsibility of the client to ensure that the designer understands and is made aware of their legal duties as a designer. This becomes a particular problem when foreign contractors are employed.

All those who work in the construction industry have their part to play looking after their own health and safety and in improving the industry's health and safety record.

A CDM client[xxxix] is someone who is having construction or building work carried out, unless they are a domestic client. A domestic client is someone who lives, or will live, in the premises where the work is carried out.
The premises must not relate to any trade, business or other undertaking. Although a domestic client does not have duties under CDM, those who work for them on construction projects will.

On all projects clients will need to:

- Check competence and resources of all appointees.
- Ensure there are suitable management arrangements for the project welfare facilities.
- Allow sufficient time and resources for all stages.
- Provide pre-construction information to designers and contractors.

Where projects are notifiable under CDM 2007, clients must also:

- Appoint a CDM co-ordinator.
- Appoint a principal contractor.
- Make sure that construction work does not start unless a construction phase plan is in place and there are adequate welfare facilities on site.
- Provide information relating to the health and safety file to the CDM co-ordinator.
- Retain and provide access to the health and safety file.

A notifiable project is one where there is more than 30 days on site or more than 500 man days of resource involved. Before you give the go ahead to start on site you should have complied with the CDM requirement to appoint a competent contractor.

The Management of Health and Safety at Work Regulations 1999 impose a duty of care on the client to ensure that all systems of work are safe and that employees are safe, insofar as is reasonably practical.

The installations should therefore be subject to

- Provision and Use of Work Equipment Regulations 1999 (PUWER)
- Electrical safety
- Control of Substances Hazardous to Health 2003 (COSSH)

Hazard identification and risk assessments will be required at the very least and thus CE marked for the systems[xl].

Assess the route that will be taken to carry equipment and materials from the entrance to the site to the place of work . Consider areas where access requirements and working patterns may conflict and assess the solution. Once a plan is in place, make a risk assessment of the entire plan and adjust as necessary.

16.3
In-house capabilities

Having read this guide and carried out the site assessment you should have a fairly good understanding of what is required. You should also have an idea of what type and size of system you might install. It may be that your business has the ability, in-house, to carry out the planning and preparation for the work.

However, both the design and the preparation of a tender by a competent third party are likely to be money well spent. If you choose to use in-house resources, you must also ensure that the capability is available to carry out the project management as a priority. Issues in construction projects normally require instant answers to resolve them.

16.4
Planning the project

Each project will be different so no two project plans will be the same, but certain factors will be common to all projects.

Business work patterns; you will want to arrange the installation so that it has the minimum impact on your daily trading activity. For GSHPs and WSHPs weather will be a deciding factor when it comes to civil works. Thunderstorms and heavy rain will prevent work progressing and installation is likely to be seasonal.

For any work where pipes are laid underground, which could include both ground source and water source heat pump systems, particular care should be taken to identify and avoid damage to any underground installations through digging trenches or boring holes, including:

- Any filling, sealing, or other treatments used on contaminated land,
- Drainage systems, including field drains, sustainable urban drainage systems, sewers, and wastewater treatment systems,
- Fuel feed systems, such as pipes from oil storage tanks,
- Any measures to protect from radon gas, methane gas and carbon dioxide.

For ground or water source heating systems, particular care should be taken to avoid moisture damage to the building:

- Pipes or fixings that penetrate the external walls should be properly weather protected to prevent the ingress of rainwater or dampness, for instance by caulking small gaps around pipes and in a way that any moisture collecting on a pipe in a cavity is shed to the outside of a wall.
- Pipes or fixings that penetrate the walls should be installed in a way that does not adversely affect any existing damp proof, waterproof or breather membranes - if a membrane is damaged or disturbed, it should be reinstated.
- Installations should not cause bridging of the damp proof course: for an outdoor unit installed close to an external wall at ground level, provision should be made to keep the gap beside the unit clear of debris, such as a lightweight protective cage.
- Condensation produced by the heat pump should be disposed of to drainage systems:
    - for outdoor heat pumps, the condensate should be diverted to a mains drain or soakaway, through an insulated pipe to limit the risk of freezing,
    - for indoor units the condensate can be drained into the same drainage system as the sink or washing machine. The system should be protected by a trap to prevent unwanted smells.

Installations should not interfere with measures used to comply with the ventilation standard: if draught-proofing measures are used to limit the risk of frost damage to an indoor unit located in a garage, permanent ventilators should be installed to compensate for the loss of uncontrolled air infiltration.

Care must also be taken not to interfere with the ventilation of any combustion appliances. If the heat pump is near a fixed combustion appliance, there must be adequate ventilation for both appliances and if the heat pump is near a boiler flue, the fan must not interfere with the safe removal of the products of combustion.

When planning the project you should set specific milestones. The milestones will depend on the size and type of project. For a GSHP project you might use the installation of the collector field as a milestone whereas for smaller systems and ASHPs that will not be relevant.

Once milestones have been identified a full timetable may be drawn up.

Glossary

AUP	Average Unit Price
AUV	Average Unit Value
BREEAM	BRE Environmental Assessment Method; a method of assessing, rating and certifying the sustainability of buildings.
BS 7671	Requirements for electrical installations
Carbon Savings	In this case the amount of carbon saved by replacing grid electricity with Solar PV generation.
Cost per kWh	The cost of an investment per unit of energy generated over its lifetime.
DETI	Department of Enterprise, Trade & Investment
BS EN ISO/IEC 17065:2012	Conformity assessment - Requirements for bodies certifying products, processes and services
Equivalent Interest	The actual annual rate of return that you receive on an investment over the life of an investment when it is compounded.
kWh	kilowatt hour; the standard unit of measurement for energy consumption
kWth	kilowatt thermal; A unit of heat-supply capacity used to measure the potential output from a heating plant.
MCS	Microgeneration Certification Scheme
Net Present Value	Tells you what an investment is worth to you today.
NIE	Northern Ireland Electricity Limited owns and manages the electricity transmission and distribution assets in Northern Ireland; it is owned by the Electricity Supply Board in Ireland.
OFGEM	Office of Gas & Electricity Markets is the government regulator for the electricity and downstream natural gas markets in the UK.
SAP	Standard Assessment Procedure; to demonstrate compliance with UK Building Regulations
SBEM	Simplified Building Energy Model; to demonstrate compliance with UK Building Regulations
Sensitivity Analysis	Allows you to perform ‘what if’ scenarios on your financial predictions.
Simple Pay Back	The period of time taken to recover your costs on an investment.
Total Return	The percentage gain or loss on an investment over the time it is held.

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[i] EHPA – Heat Pump Report - 2013

[ii] http://theory.uwinnipeg.ca/mod_tech/node79.html

[iii] kWth = kilowatt thermal energy

[iv] kWe = kilowatt electrical energy

[v] EST – Heat Pump Field Trails 2010 - 2013

[vi] refers to a rigorous, voluntary standard for energy efficiency in a building, reducing its ecological footprint.

[vii] MCS accredited or certified as competent by the heat pump manufacturer

[viii] MCS021 – Heat Emitter Guide v 1.0 2013

[ix] http://www.legislation.gov.uk/nisr/2013/96/schedule/3/made

[x] http://www.legislation.gov.uk/nisr/2014/31/made

[xi] GSNI "Borehole and Water Well Drilling"

[xii] www.doeni.gov.uk/niea/grg_002_final.pdf

[xiii] MIS3005

[xiv] Slinkys are coiled ground loop collectors

[xv] Design temperature from CIBSE AM14 Non domestic hot water heating systems

[xvi] Design temperature from CIBSE AM14 Non domestic hot water heating systems for Aldergrove Low Thermal Inertia building.

[xvii] http://projects.bre.co.uk/uvalues/

[xviii] https://www.gov.uk/standard-assessment-procedure

[xix] See MCS Guidance

[xx] Follow CIBSE TM23: testing buildings for Air Leakage

[xxi] See CIBSE Guide A

[xxii] http://regulations.completepicture.co.uk/pdf/Mcs/MCS%20021%20Heat%20Emitter%20Guide%20Issue%201.0%2016-12-13.pdf

[xxiii] The full calculations and methodology are given in MIS3005.

[xxiv] MIS_3005_Supplementary_Information_1_-_MCS_022_-_Ground_loop_sizing_tables_2011-09-02_v1.0

[xxv] http://www.microgenerationcertification.org/mcs-standards/reference-materials/heat-pump-reference-materials

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[xxviii] Air temperature 0°C, water flow temperature 35°C

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[xxxvii] http://www.carbontrust.com/media/18223/ctl153_conversion_factors.pdf

[xxxviii] http://www.hse.gov.uk/construction/cdm.htm

[xxxvix] As defined in The Construction (Design and Management) Regulations 2007 (CDM)

[xl] CE marking is a key indicator of a product's compliance with EU legislation. See www.gov.uk/ce-marking

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