Fact sheet
Energy 09
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09

HEAT PUMPS IN AGRICULTURE

Introduction

Heat pumps are used to capture solar energy, which is stored in the air, ground or water, and then delivered to a building to heat it. They can also be used for cooling by taking heat energy from a building and delivering it to the air, ground or water. Heat pumps cool by capturing energy at a certain temperature and delivering it at a higher temperature elsewhere. This occurs in a closed circuit with fluid evaporating to take in heat at one temperature, and then being compressed and condensed to release the heat at another temperature in a condenser, before being expanded in readiness for the evaporation and a repeat of the cycle.

Heat pumps capture energy in the air, ground or water and deliver it to buildings.

Coefficient of performance

The process requires energy to drive it (typically electricity to run the compressor). However, for each unit of energy to drive the process, more units are captured and delivered. The ratio of energy delivered to energy input is referred to as the coefficient of performance (COP). Some typical values for the different sources are shown in **Table 1**. The COP of heat pumps is greater if the temperature difference between source and delivery temperatures is less. This explains why a ground source heat pump is more efficient over a heating season than an air-source heat pump, which extracts energy from the air that is often at lower temperatures than the ground (**Table 2**). A COP of 4 represents a production of 4kWh of heat at the condenser for an input of 1kWh of electricity at the compressor.

Table 1: Coefficient of performance.

Source of heat	Source temperature	COP
Air	0-5	3.5
Ground	5-10	4
Water	12	4.5

Table 2: Pros and cons of each type of system.

Type of system	Advantages	Disadvantages
Air source	Can be used anywhere. Takes up little space. Cheaper.	Not as efficient. Noise can be an issue. High running costs.
Ground source/closed loop	Can access heat in ground anywhere. Horizontal systems are cheaper but take up space. Borehole systems are more efficient and take up less space.	Installation costs can be high. Need a certain amount of space for ground collectors.
Water source/ open loop	Most cost efficient for very large systems as less infrastructure required. Also most efficient if tapping into deep water sources with higher temperatures.	Only possible near to a water source such as an aquifer, lake or river.

The size of the heat pump should be matched to a building's heating requirements.

Sizing

Heat pump size has to be matched to building heating requirements. The more closely this can be matched the better, as capital costs tend to go up pro rata with size (unlike gas or oil boilers for example).

The size of the collector has to be calculated accurately also to ensure that the system performs well. If the collector is too small, then it will overcool the ground and the system will struggle to achieve best efficiency. If it is too large, then it will be an unnecessary expense.

The more pipe there is in the ground, the more potential there is to collect heat. However, the ground and soil conditions affect heat exchange between the ground and the pipe (see **Tables 3** and **4**).

Similarly, a borehole loop collector will have more or less capacity to collect heat according to the geology concerned.

Table 3: Specific heat for various ground conditions.

Ground conditions	Specific heat capacity w/m	Area per kWth (m²)
Dry loose soil	10	75
Damp packed soil	20-30	38-25
Saturated sand gravel	40	19

Assumes spacing of 0.8m for loose soil and 0.5m for damp well-packed soil. Typical installation depth 0.8m to 1.5m. PE – Pipe Hard PN 10 (DN 20 or 25).

Table 4: Specific heat for other ground types.

Ground conditions	Specific heat collection capacity w/m	Loop length per kWth (m²)
Dry sediment	3	25
Shale, slate	55	14
Solid stone with high conductivity	80	9.5
Underground with high groundwater flow	100	7.5

Suppliers

There are a large number of installers in Ireland. There are over 1,000 installers across the country offering over 200 models of heat pump.

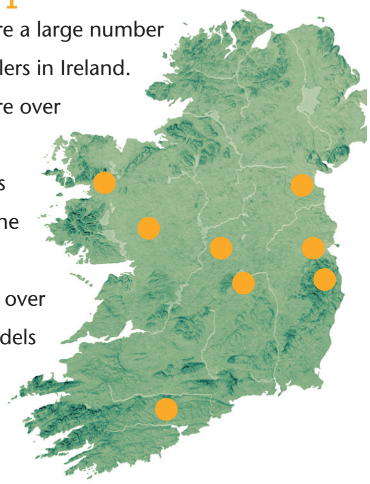


Table 5: Certain COPs to be achieved under EN 14511.

Brine/water	4
Air/water	3
Water/water	4.5
Direct evaporation	4

Standards

EN 14511 is the relevant European standard for testing heat pumps. Heat pumps should achieve a certain COP rating, as tested under EN14511 (**Table 5**).

Table 6: Financial savings for a heat pump replacing a boiler.	
Cost of gas boiler	€2,000
Cost of heat pump	€10,000
Grant for heat pump (30%)	€3,000
Price of gas kWh	5 cent
Price of electricity (c/kWh night rate)	7 cent
Heat requirement (kWh)	22,000
Gas boiler efficiency	85%
Gas input (kWh)	25,882
Heat Pump COP	4.0
Electricity input (kWh)	5,500
Boiler energy costs (25,882 x 0.05)	€1,294
Heat pump energy costs	€385
Heat pump additional costs less SSRH grant	€5,000
Heat pump annual heat savings	€989
Simple payback (years)	5.1

Table 7: Financial savings of a heat pump replacing a boiler and air conditioner.	
Cost of gas boiler	€2,000
Cost of air conditioner	€2,000
Cost of heat pump	€10,000
Grant for heat pump (30%)	€3,000
Price of gas per kWh	5 cent
Price of electricity per kWh	15 cent
Heat requirement kWh	22,000
Gas boiler efficiency	85%
Gas input kWh	25,882
Cooling requirement (kWh)	12,000
Air conditioning COP	3.0
A/C electricity input (kWh)	4,000
Heat pumps COP (heating)	4.0
Heat pumps COP (cooling)	5.0
Electricity input (kWh) (heating)	5,500
Electricity input (kWh) (cooling)	2,400
Boiler energy costs	€1,294
Air conditioning energy costs (4,000 x 0.15)	€600
Heat pump energy costs (5,500 x 0.15 + 2,400 x 0.15)	€1,185
Heat pump additional cost less grant	€3,000
Heat pump annual saving on heating and cooling	€709
Simple payback (years)	4.2

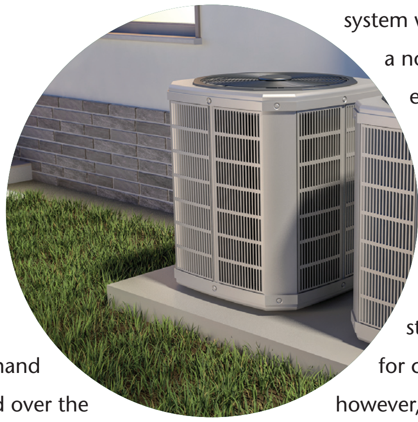
Costs

The first phase of the Support Scheme for Renewable Heat (SSRH) – an installation grant for heat pumps – opened in September 2018 and supports ground-, air- and water-source electric heat pump installations, with grant aid up to 30% of the capital outlay.

When calculating financial viability remember to factor in the offset cost of an alternative heating system, such as a gas boiler (**Table 6**) (and possibly the laying of a gas supply or installation of an oil tank – if the alternative is oil). Heat pumps look much more viable where there is a cooling demand and their capital cost can be spread over the heating and cooling savings. This results in a much faster payback. Heat pumps receive 40% funding through the Department of Agriculture, Food and the Marine (DAFM) Targeted Agricultural Modernisation Scheme (TAMS) for the poultry and pig sectors only. For further information, see: https://www.agriculture.gov.ie/farmerschemespayments/tams/.

The Scheme of Investment Aid for the Development of the Commercial Horticulture Sector offers grant aid for capital investments, which include energy-efficient and renewable energy technologies.

Heat pumps look much more viable when there is also a cooling demand as their capital cost can be spread over the heating and cooling savings (**Table 7**). This results in a much shorter payback time. However, the rate for electricity will effectively determine the payback and with a cooling system we can assume a normal electricity day rate tariff of 15 cent per kWh.



The costings assume a standard tariff for cooling; however, in some cases it is possible to manipulate the operation of a ground-source heat pump to maximise the benefit of a night-rate tariff. This will reduce the cost and shorten the payback time. If this is to be the operational strategy, then this has to be considered during the design and specification stage, to ensure the right capacity of heat pump and collector is installed.

Table 8: CO_2 savings.	
Heat requirement	20,000kWh
Fossil fuel boiler efficiency	90%
Fossil fuel input	22,222kWh
Heat pump COP	4
Electricity input	5,000kWh
Gas CO_2 emissions factor	0.204kg/kWh
Oil CO_2 emissions factor	0.257kg/kWh
Electricity CO_2 emissions factor	0.375kg CO_2/kWh
CO_2 emissions from gas (22,222 x 0.204)	4,533kg
CO_2 emissions from oil (22,222 x 0.257)	5,711kg
CO_2 emissions from heat pump (5,000 x 0.375)	1,875kg
CO_2 savings against gas	2.66 tonnes
CO_2 savings against oil	3.84 tonnes

Integration

Hot water and heating can be supplied by heat pumps.

Heat pumps can provide all the hot water and space heating requirements of a house or other building.

However, the capital cost of a system to meet the peak space heating requirement can be high and; therefore, some design strategies advocate using a top-up heater for those few occasions when maximum heating is required. Commonly, this top-up heating is supplied by an electrical emersion heater in a buffer tank or by an electric flow heater. Alternatively, a completely separate heating system could be employed to provide supplementary heating, such as a pellet room heater. Heat pumps, depending on the make and model, can struggle to make temperatures over 50-60˚C. As a consequence, it may be necessary to boost the temperature by using an electric immersion heater or a second heat exchange element heated via a supplementary source.

Ground-source heat pump systems are not suitable for directly replacing conventional water-based central heating systems, which have been designed to operate at temperatures in excess of 60˚C. If building insulation is improved, the reduced heating requirement may then be met using a lower distribution temperature. Alternatively, the radiator area can be increased. A drop in circulating temperature of 20˚C would require an increase in emitter surface of 30-40% to meet the same heat output.

The ideal, which is more readily achieved in new builds, is to have a low-temperature distribution system such as underfloor heating. Alternatives include air distribution systems or oversized radiators. Underfloor heating provides a thermal buffer, which is another advantage as this helps to reduce the possibility of the heat pump cycling on and off too often. It is also possible to introduce a buffer tank, which will achieve the same effect. Consult the manufacturer as to whether this is required for a particular installation.

Electrical requirements

Heat pumps can increase peak power requirements – particularly for a house. The ESB usually requires a 16kVA connection for a single-phase installation. The ESB typically requires a soft starter.

Planning issues

Planning permission is the responsibility of each local authority – so check with them if in doubt. Recent changes to building regulations have given exemption of planning permission to heat pumps – with restrictions on noise from air-source heat pumps. Further details are outlined below.

The two types of ground-source heat pump currently available are horizontal and vertical closed-loop systems. Each system consists of lengths of buried pipe in the ground, either in horizontal or vertical trenches. The regulations provides exemptions for both types. The only condition attached to the exemption for ground-source heat pumps is that on installation of the apparatus, there should be no more than one metre alteration to ground level. Air-source heat pumps are also exempt provided that:

- noise levels at the nearest neighbouring inhabited dwelling are <43dB(A), or <5dB(A) above background noise;
- air-source heat pumps are at least 50cm from the edge of the roof; and,
- the pump is located to the rear or behind the front wall of the house.

Further information is available at:
www.seai.ie/resources/publications/Conditional_Planning_Exemptions.pdf

Ground water

Boreholes can have an effect on groundwater and so the Environmental Protection Agency (EPA) should be consulted when considering a heat-pump system with a vertical collector system or an open-loop system.

Check with the EPA before drilling boreholes.

Design by ThinkMedia.ie

Further information

For further information please contact Barry Caslin, Teagasc, Rural Economy Development Programme at:
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The following resources are also helpful:
- www.hpa.ie/faq-s
- www.gsi.ie/en-ie/programmes-and-projects/geoenergy/activities/Pages/Geothermal-Energy-and-Ground-Source-Heat.aspx
- www.seai.ie/business-and-public-sector/business-grants-and-supports/support-scheme-renewable-heat/

www.teagasc.ie/ruraldev

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This fact sheet was produced by Barry Caslin, Teagasc, Rural Economy Development Programme.