Improving the Welsh Dairy Supply Chain

Heat pumps for dairy farms

Cronfa Amaethyddol Ewrop ar gyfer Datblygu Gwledig: Ewrop yn Buddsoddi mewn Ardaloedd Gwledig
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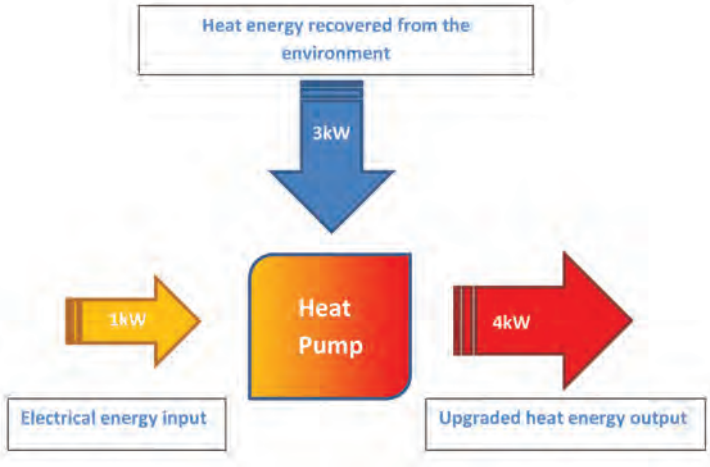
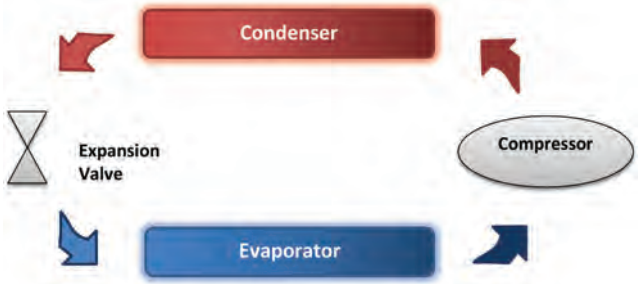
Heat pumps for dairy farms

A heat pump is basically a refrigeration system which is configured so that the heat from the hot coil is put to good use and the cold coil gathers energy from a waste or free energy source – usually the ground or ambient air. By transferring heat energy from a cold area to a warmer area it 'upgrades' the temperature thus making the energy useful for water or space heating. Its main economic advantage is that for every unit (kW) of energy it uses, it provides between 3 and 5 units (kW) of upgraded heat energy.



How does a heat pump work?

A heat pump uses a similar principle to a household refrigerator, except in reverse. The refrigerant used in a heat pump boils at -20°C, enabling useful energy to be absorbed at low temperatures. This gas is then compressed by an electric motor-driven compressor. The compression increases the pressure and temperature of the gas, thus allowing heat to be transferred through a heat exchanger where it condenses to a liquid. The liquid is released through an expansion valve which produces a temperature and pressure drop and the process starts again.



Some heat pumps employ the use of a buffer tank system as a heat store. The heat pump is only involved with heating and maintaining the water temperature in the tank which can then be used for space heating and hot water demands. This provides a 'buffer' or 'cushion' of hot water which can be used when required.

Hot water 'buffer' tank or thermal store

Heat recovery units (HRU) are a form of heat pump that use warm milk as a heat source in the milk cooling refrigeration system as the pump. To learn more about HRU's please refer to the 'Heat recovery units' (HRU) booklet.

Heat pump heats the water in the thermal store only

Type of heat pump
There are three main categories of heat pump:

- Ground Source Heat Pump (GSHP)
- Air Source Heat Pump (ASHP)
- Water Source Heat Pump (WSHP)

Ground Source Heat Pump (GSHP)
As the name suggests, energy is collected from the earth through the evaporator coil. Ground temperatures at 1m to 100m depth remain fairly constant between 8°C-12°C with the sun maintaining the energy within the mass of land throughout the year.

All closed loop systems operate by passing a fluid through polyethylene pipework similar to a water pipe.

Pipes are laid either in a:

Horizontal trench typically 1m-2m deep, 1m wide and up to 200m long. Multiple trenches may radiate out from a central manifold to absorb the sun's radiation in a field or paddock.

Vertical borehole drilled into the underlying rock to a depth of 70m to 200m. This is 2-3 times more expensive than a horizontal trench and is used where land area is at a premium.

Air Source Heat Pump (ASHP)
An air source heat pump replaces the ground collector with a finned coil evaporator and a fan. Ambient air is blown over the evaporator which absorbs the heat in the air.

These heat pumps are cheaper than GSHP but they suffer from the problem that their heat source is not at a constant temperature. Ambient air gets colder in winter which reduces heat yield and efficiency. Of course this happens just at the time when most heat is needed. Because of this these systems may need a back up in the coldest conditions.

Low Temperature Air Scource Heat Pumps (LT-ASHP)
These produce 'low grade' heat and can only heat water to around 60°C:

High Temperature Air Source Heat Pumps (HT-ASHP)
These produce hot water to a temperature of around 80°C and can be used as a direct replacement for a traditional water heater or boiler system, although they are less efficient than LT-ASHP.

Water Source Heat Pump (WSHP)
Water source heat pumps capture heat from a water course or lake. Water course temperature is more stable than air, but less stable than the ground, so it's an intermediate solution in terms of efficiency.

Coefficient of Performance (COP)

The COP of a heat pump is a measure of its efficiency. A COP of 4 means that 1 kWh electrical input produces 4 kWh of useful heat at the condenser coil. Typical COP for a GSHP would be between 4 - 5 and for an ASHP typical COP would be between 3 - 6. Clearly air source heat pump COP's are at their lowest during cold conditions.

Type	Typical seasonal COP
GSHP	4 to 5
ASHP	3 to 6
WSHP	3.5 to 4.5

The table above shows typical efficiencies for heat pumps giving temperatures around 50°C – 60°C. It is not practical or efficient to obtain temperatures of around 90°C, which is what's required for circulation and tank washing. This means that they are only suitable for preheating water.

Applications

Heat pumps are used for space and water heating. The output stability of GSHP is best suited for space heating as the heating output must be sustained during the coldest conditions. ASHP are more suited to water heating and perform better in warmer weather, and of course hot water is required for washing throughout the year, even in the summer.

Renewable Heat Incentive (RHI)

Ground source and water source heat pumps attract the Governments Renewable Heat Incentive (RHI) subsidy. Current rates (September 2013) are 3.5p/kWh for installations over 100kW and 4.8p/kWh for installations less than 100kW. Payments can be claimed for system installations completed after 15th July 2009. Air source heat pumps are expected to be included from April 2014.