Latent heating

As UK government ups the ante on going green and slashing emissions, air- and ground-source heat pumps are rearing their heads again. Brian Tinham examines the issues

Heat pumps – designed to extract energy from the air or ground and transform it into 'renewable' heating for buildings – have apparently been high on the green agenda for years. However, you wouldn't know it: the reality is that, to date, their uptake has been marginal. But that may be about to change, as the technology becomes more mainstream and as engineers increasingly understand and trust them.

So says David Matthews, chief executive of the Ground Source Heat Pump Association, and he's not alone. He talks not of thousands of installed heat pumps in the future, but of millions – possibly 250,000 by 2020 in the UK alone.

He may just be right – but for other, equally important, reasons likely to make owners of buildings, large and small, consider green heating technologies, such as heat pumps, in a new light.

Government energy policy now requires that the UK moves to source 15% of its total energy supply from renewables by 2020 (0.6% now) and reduces greenhouse gas emissions by 80% before 2050 – and by 34% against 1990 levels, ahead of 2020.

Given that heating is estimated (by the Department of Energy & Climate Change) to be responsible for 49% of energy consumed and 47% of carbon emissions, it's not difficult to see where attention is going to focus. And from that attention inevitably flows incentives. It's started already: look at February's offer, from Secretary of State for Energy & Climate Change Ed Milliband, of significant payments to "households and communities who install generating technologies, such as small wind turbines and solar panels".

Those payments, which relate to low carbon generation, kick in this month. However, Milliband says they're the blueprint "for a similar scheme, to be introduced in April 2011, to incentivise low carbon heating technologies". It's all part of his department's Renewable Heat Incentive (RHI, currently at the consultation stage), claimed by Labour as a world first and aimed at bringing about "a significant increase in the amount of locally produced green energy, as a contribution to the wider shift of the energy mix to low carbon".

Government support

Among technologies cited for support are air- and ground-source heat pumps, solar thermal, biomass boilers, renewable CHP (combined heat and power), biogas and bioliquids, and injecting biomethane into the gas grid. Importantly, from the financial perspective, it looks like government will provide support, under the Energy Act 2008, to bridge the gap between the cost of conventional versus renewable heat systems.

All of which means it's time for plant engineers to get up to date. A quick trawl through your back issues will reward you with plenty on most of the relevant technologies (more to follow in forthcoming issues), but not so much on heat pumps. That's partly because they're neither complicated, nor novel. Indeed, industrial historians point out that the equipment predates the internal combustion engine, being little more than a fridge in reverse.

As Matthews puts it: "You've got an electric motor driving a compressor that pumps refrigerant in the gas phase through a condenser, where you gain latent heat of condensation. Then there's an expansion valve that meters the liquid through an evaporator, which boils off the refrigerant and pulls in that latent heat of evaporation."

So it's simple enough and, yes, heat pumps are readily available as mass produced packaged systems, similar in size to small fridges. Today, only the ground loop (typically constructed from high grade polyethylene with fusion welded joints) is likely to be bespoke, insofar as its specification requires a local ground survey prior to the selection process.

However, there are still some facts and practicalities you need to know about. First, there's

Future developments

The next big technical improvements for heat pump projects are likely to be better latent heat stores, although these are not expected to reach the market for another five to 10 years.

David Matthews, chief executive of the Ground Source Heat Pump Association, makes the point that, while we're all familiar with latent heat storage in terms, for example, of water in the temperature range 0–100ºC, the next challenge is to construct repeatable chemical reactions with, say, salts or paraffin that exhibit useful phase changes, in order to massively reduce the physical size of heat stores.

Such developments, using what's now being termed physico-chemistry, would further improve the overall efficiency of heat pumps, by enabling extraction and storage of latent heat, when it's most available, rather than the current extraction on-demand approach.

The European Union is currently working on several approaches – in much the same way as it is funding projects on electrochemistry for batteries and reversible fuel cells, electromagnetic fields for capacitors and superconducting magnetic energy storage systems, and mechanical engineering through flywheels, compressed gas and pumped hydro storage.

efficiency – and one of the reasons for heat pumps' forecast success is that, broadly, for every kW of electrical energy used in circulating the refrigerant, you get 3–4kW of heat out (including heat recovery from the motor).

Secondly, that relates to the frequently used COP (coefficient of performance) measure and, although it's generally accepted that a well designed and installed system will run at a COP of around 3.5 (3.5:1, in terms of heat out to energy in), that's an annual average. A system's COP can vary between 8:1 (say, in September, when low level heating is needed and the ground temperature is relatively high) and 1.5:1 (when the building needs maximum heating, but the ground temperature is low).

Thirdly, as a rule of thumb, you can expect 45–50W of heat output per meter of ground loop, but that, too, is very variable. Matthews advises that it can vary from 15W in dry sandy conditions to 85W in wet clay and granite materials. "So don't put a ground loop collector under a car park, because they're not porous, so the ground dries out and system performance will go down," he says.

Fourthly, there are three main types of ground loop: horizontal, using trenches typically 2m deep (any configuration); vertical boreholes, sometimes drilled to 150m depth; and those immersed in lakes, such as the huge 5.5MW system that serves Mansfield hospital with heating and warm water.

There are also a couple of further issues to note. First, although vertical boreholes can be deep, purists will tell you that 150m doesn't tap into geothermal energy, but solar thermal energy, as the ground absorbs sunlight energy. Bit of a moot point, but worth being aware. Secondly, vertical collectors can also be designed to operate as open loop systems, rather than hermetically sealed closed loop. In the former case, your pump lifts fluid from the water table and returns it at a lower temperature, the system having captured and distributed heat. That requires permission from the Environment Agency and industry experience shows that, although efficiency can be high, design is often more complex and there may be reliability issues.

All that said, plant engineers need to know that installation and commissioning are much the same as for any HVAC (heating, ventilating and air conditioning) system. "Different manufacturers have different ways of setting up their systems, and you need to consider the BMS [building management system], but it's not rocket science," advises Matthews. "It's also simpler than gas heating installations, because you're not combusting anything, so there are fewer health and safety implications," he adds.

No one is suggesting a green future, based solely on heat pumps. Other key low carbon technologies are bound to include wind turbines, hydro turbines, wave motion energy collectors, CHP plant (including domestic), solar panel and other micro-generation systems, fuel cell equipment and biomass plants. As plant engineers, we need to be up to speed on not only the technical developments, but also their application. PE

Pointers

- Heat pumps are set to jump right up the energy-saving agenda as the government brings in funding to "shift the energy mix to low carbon"
- Heat pumps themselves are little more than simple reverse refrigerators
- Heat pumps offer very high efficiency, but variable COP (coefficient of performance), depending on several parameters
- Ground loops can be laid in trenches or inserted in deep boreholes
- This is not rocket science

Above: David Matthews, CEO of the Ground Source Heat Pump Association
Left: Simple construction techniques for ground loops, large and small