The Ashden Awards for sustainable energy

Kensa Engineering Ltd
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Design and manufacture of heat pumps for easy installation

Summary

Space heating represents one of the largest demands for energy in the UK, which is currently largely supplied by fossil fuels. The use of sustainable sources of energy for heating is growing to meet this demand and heat pump technology is part of the solution. A heat pump works like a refrigerator, except that it transfers heat from a renewable source outside a building to warm the interior. The external source of heat can be the ground, a body of water or the air. A heat pump is more effective than conventional electric and fossil fuel based heating because for every unit of energy used, three to four units of heat are supplied.

Kensa Engineering, founded by Richard Freeborn and Guy Cashmore in 1999, is based at the site of an old tin mine in Cornwall, where it manufactures heat pumps for installation throughout the UK. The Kensa heat pumps are unique in their level of integration and in being sold as part of a kit, including a pre-coiled 'slinky' pipe to collect heat from the ground and a manifold board providing all the plumbing connections required. This integrated kit simplifies installation and improves reliability. The result is that a Kensa heat-pump kit can be installed by a plumber or competent DIY enthusiast. Kensa provides detailed application and installation advice, and telephone support, to ensure that the process goes smoothly.

Kensa is ISO9001 approved, and also approved by BERR to both manufacture and install ground source heat pumps. It has mentored over 50 installers and takes responsibility for quality control of their work, allowing the installers' customers to qualify for grants from the Low Carbon Buildings Programme, as well as the direct customers of Kensa. It is also partnering with leading energy suppliers to offer grants to social housing providers and commercial developers. Each year their installations are delivering about 26 GWh of heat, and saving the emission of 3,600 tonnes of CO_2.

Kensa has the competence to design and make very specialised heat pumps. It has recently produced innovative heat pumps for the new Tamar class lifeboats of the RNLI. By combining this level of technical expertise with a strong management team, Kensa is raising the profile of heat pump technology throughout the UK, and is facilitating installations at an increasing rate.

The organisation

Kensa Engineering was founded in 1999 by Richard Freeborn (now Chairman) and Guy Cashmore (now Technical Director). Richard had spent two years previously developing a heat pump for heating and cooling yachts, while Guy had prior experience in heating and ventilation. Kensa's Managing Director, Simon Lomax, joined the company in May 2007 and brought with him experience in running businesses of various sizes, including one specialising in underfloor heating. Kensa employs 25 people and has now sold over 1,000 heat pumps. They recently moved to their new premises at a converted tin mine, where they have space to expand their facilities.

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Context

Over a third of UK energy consumption is for space heating, and there is room for significant growth in sustainable energy sources. Direct electrical heating is a common choice in areas that do not have mains gas available, but it is expensive and results in high carbon emissions. Heat pumps provide a more efficient way of using electricity for heating, with every unit of electricity delivering three to four units of heat. In terms of carbon emissions they are much better than oil or coal, and can even be better than natural gas, the lowest-carbon fossil fuel. Heat pumps extract heat from air, earth or water, so there is an effectively limitless heat supply. Furthermore, increased use of electricity generated from renewable sources in future will allow CO_2 emissions due to the use of heat pumps to be progressively reduced.

Heat pump technology is widely used in some other European countries, but has not had a high profile in the UK, although awareness is now growing. Kensa is one of several regional and national heat pump businesses that are experiencing rapid growth.

Technology and use

Heat pump background

A heat pump extracts low grade energy from a source outside the building in which it is installed, and concentrates this to provide heat to the inside of the building. A refrigerant is used within the heat pump to transfer and concentrate the energy, and for systems that take the heat from the ground or water, a mixture of water and antifreeze is used in the energy absorbing external loop. The heat pump itself has three main components, as shown in the diagram below:

- **Evaporator**, where the refrigerant absorbs heat from the liquid that has passed through the external source and evaporates into a gas.

- **Compressor**, which compresses the refrigerant, concentrating the energy, so that it reaches a sufficiently high temperature for the required heating demand.

- **Condenser**, where the refrigerant gives up its heat to the liquid going out to the building heating system and condenses back into a liquid.

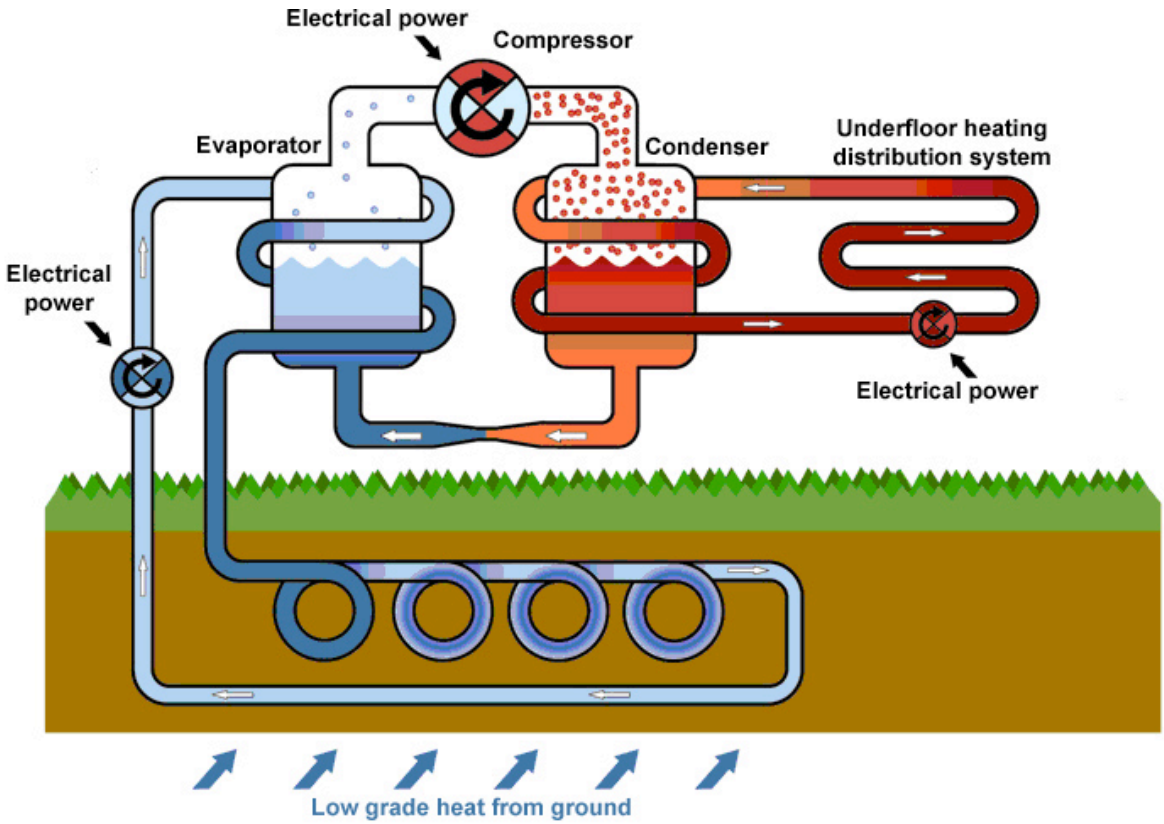

Figure 1: Ground source heat pump (courtesey of Kensa Ltd).

The diagram above shows a ground loop being used to extract heat, but water (ie. a lake or stream) can also be used as the heat source. Air can also be used as the heat source, through using a heat exchanger similar to that in an air conditioning unit. When the ground is the source of heat, the loop can be installed in a trench, usually in the form of a coiled pipe known as a ‘slinky’. If space is limited a vertical borehole can be used.

Heat pumps inherently become less efficient as the temperature difference between the evaporator and condenser increases. Underfloor heating is therefore the preferred method for distributing the heat to a building, because it requires the lowest temperature output from the heat pump. It is possible to use radiators but they must be larger than those used with a traditional heating system to remain effective at lower temperatures. It is also important that the building is well insulated, as

this reduces the temperature that the heat pump is required to deliver. Of course, good insulation gives the added benefit of reducing the overall heating requirements of the building as well.

Heat pump efficiency is expressed as the Coefficient Of Performance (COP), which indicates how much heat is supplied per unit of electricity used. Ground and water source heat pumps used for heating buildings in the UK typically have COP values between three and four (i.e. three to four units of heat are delivered for each unit of electricity used to run the system), although this will vary according to the climate and required building temperature.

The Kensa kit
One of the barriers to using heat pumps is that a range of different components are required in addition to the heat pump itself; another is that specialist installers are required to build a working system, and this is where Kensa is making a difference. Kensa is unique in selling a kit that makes the installation of a heat pump simple for a plumber or DIY enthusiast to accomplish, and reduces installation costs. The key elements of the kit are:

- **Integration of components**. The main unit not only contains the heat pump, but also the water pumps for the ground loop and the heating distribution systems. It also includes the electrical switchgear and electronic controller, which has a range of diagnostic functions. By using sensors to monitor temperature and pressure, the controller can optimise the operation of the pump and diagnose faults, should they occur. A display informs the user of the current state of the system. By integrating all these components into a single unit, Kensa is able to ensure more reliable operation and is able to provide detailed advice to installers and owners.

- **Pre-coiled slinky**. The slinky pipe used for the ground loop is actually made from a single pipe preformed into 1m coils, and a 50m slinky has 300m of piping inside it. For an installer making their own slinkies the first problem they face is that the pipes come in 100m lengths by default, resulting in a potential risk to reliability as joins are made and buried underground. The second problem is that it is often physically difficult to manipulate the lengths of pipe on site. Because Kensa orders large quantities of pipe for making slinkies they are able to buy it in the exact lengths required, so avoiding the risk of having joins buried underground. They are able to make ten pre-coiled slinkies at their factory in the time it would take an installer to make just one, and all the installer needs to do is lay the slinky in the trench they have dug and separate the coils along the bottom of the trench.

- **Manifold board**. The pipes required for the outdoor and indoor parts of a heat pump system are different diameters, and the necessary manifolds to connect them are not always easy to source, especially in the low volumes that a small installer requires. To avoid this problem Kensa supplies a ‘manifold board’, which includes all the parts required to connect the indoor and outdoor sections of the system, making installation quick and simple. The board also provides the necessary connections to fill the ground loops and purge the system of air during commissioning.

Kensa offers a range of heat pumps to cater for the domestic, commercial and industrial markets. The heat output capacities for the domestic versions range from 4 to 32 kW. The smaller heat pumps run on single-phase electricity, available in all homes, and Kensa has been able to extend its single-phase range up to 24 kW capacity by using a twin compressor design. Larger heat pumps require three-phase electricity. For installations above 32 kW, several pumps can operate in parallel. Kensa usually specifies systems to meet all winter heating requirements, rather than use top-up direct electrical heating on the coldest days, which increases running costs.

In addition to the standard range of heat pumps, Kensa also design customised larger heat pumps (up to and above 1 MW capacity) and versions for specialist applications. A recent example is the new Tamar class lifeboat of the RNLI. Each of these is fitted with a Kensa heat pump driven by the boat’s hydraulic system. These heat pumps are designed to be able to provide heating, cooling and demisting facilities, all of which may be needed on a lifeboat. For this application the heat pump has to be able to continue operating under extreme conditions and with high reliability.

Kensa has also designed an air source heat pump specifically aimed at social housing schemes and helping people escape from fuel poverty. Although the air source heat pump was originally designed by Kensa, it is now manufactured under license by another UK company.

How users pay

Kensa has four main groups of customers: housing associations, commercial property developers, installers and self-builders. 55% of kits sold so far have gone direct to clients and about half of these are doing their own installation, while the rest are using an installer. Kensa is approved under the Low Carbon Buildings Programme (LCBP), which means that its direct customers are eligible for LCBP grants. In addition, Kensa takes responsibility for quality control of the installers it has mentored, this means that the customers of these installers can also qualify for LCBP grants. Kensa provides advice on its website about applying for grants. The grant is currently 30% of the system cost including installation, with a limit of £1,200. At present the typical cost of a Kensa heat pump ranges between £450 and £1,200 per kW installed, including all plumbing and civil works required. A 25% deposit is required, with the balance payable on delivery, and discounts are given for bulk orders.

Kensa is also partnering with leading energy suppliers to provide CERT funded grants for social housing providers and commercial developers, with the amount of the grant based on the size and type of the property, the fuel it is displacing and whether the occupants are a priority group. These grants can be considerable and are designed to benefit technologies which reduce CO_2 emissions into the environment.

Training, support and quality control

Kensa takes a rigorous approach to quality control; the design of its heat pump minimises the chance of faults, and makes them simple to diagnose. Kensa is ISO9001 approved for the design and manufacture of heat pumps, and is the only business in the UK approved by BERR for both the manufacture and installation of ground source heat pumps. Every heat pump is tested for 30 minutes on a specialised automated test rig in the Kensa workshop before it is shipped to a customer. The results of these tests, including measurement of COP, are logged for future reference along with manufacturing information, so that Kensa has a complete record of each system. Kensa has also worked with its suppliers, helping them to improve the quality and reliability of their products. Every heat pump is sold with a 24 month return-to-base warranty, and any problems can be diagnosed remotely or Kensa can send an engineer to site if required.

The performance of a heat pump relies on the correct application of the technology as well as high-quality manufacture and competent installation. Kensa has therefore mentored over 50 installers through the Building Research Establishment under the (now lapsed) Clear Skies scheme, and continues to train more every year. This training includes specific training days, demonstrations and individual support. Kensa helps installers commission the heat pumps by talking them through the steps over the phone, ensuring that everything is operating correctly.

For DIY and self-build, Kensa advises the customer on the design and installation of the system, and will not sell a heat pump without evidence that the rest of the system has been properly designed. They also advise the end-user about the benefits of using an off-peak electricity tariff, and how to make the most of one when using a heat pump.

Benefits

Each heat pump typically produces 1.55 MWh/year per kW installed, and the total generation for all Kensa heat pumps sold so far is about 26 GWh/year. This results in an annual reduction in CO_2 emissions of about 3,600 tonnes.

The key benefit for most heat pump users is reduced energy bills compared to alternative heat sources, but the increased comfort of having a continuous background level of heat is also important. For people living in fuel poverty the reduced bills can make a significant difference to their finances.

Although Kensa supplies heat pumps throughout the UK, many customers are in Cornwall and the South West. This is a region in which many properties are off the mains gas grid, and therefore rely on more costly heating. Kensa's customers include housing associations that are improving the standard of their properties. In addition to the above benefits, they also appreciate the reliability of heat pumps, which are based on a proven technology and do not require the annual safety checks associated with gas or oil-fired boilers.

Kensa brings significant benefits to installers, whether they are self-builders, plumbers or property developers. Their kits are simple and quick to install and are helping to reduce the barriers to the uptake of heat pumps in the UK. Kensa provides some level of support to about 100 external jobs in the installer network, and also supports local suppliers of components and services where possible.

Potential for growth and replication

Kensa is a growing company, and expects to increase its staff from the current 25 to nearly 40 by the end of 2008. It has put in place a strong management team to oversee the company's growth, and is expecting a significant increase in sales this year.

The Kensa heat pump kit is a new approach to getting the technology used by mainstream developers and heating engineers, and is rapidly gaining acceptance. Combined with Kensa's marketing plans, the kit opens up the possibility of building a large network of small businesses capable of installing heat pumps throughout the UK.

There is huge potential for the use of heat pumps in the UK, not just in new build, but also in the refurbishment of existing housing stock, especially in millions of houses that are off the gas grid. Some older buildings are less suitable for the use of heat pumps, because of small radiators, micro-bore central heating or lack of land space for a borehole. The DTI suggested that 28,000 heat pumps could be installed by 2012, a ten-fold increase on current capacity.

Management, finance and partnerships

Richard Freeborn, co-founder of Kensa Engineering, became Chairman when Simon Lomax was recruited as Managing Director in 2007. Richard is also a director of RegenSW, the sustainable energy agency for SW England, and was the chairman of the Ground Source Heat Pump Association's Training and Standards sub-committee. Guy Cashmore, also co-founder, is the Technical Director, responsible for manufacturing, research and development. Kensa brings in further expertise through its non-executive directors, Mark Scibor-Rylski and Trevor Howard, both of who have experience with a wide range of businesses and technologies. Kensa has been financed entirely by private investment to date, has seen turnover grow considerably and is a profit-making viable company.

Key partnerships for Kensa include CSEP (Cornwall Sustainable Energy Partnership), of which they were a founding member, and Copeland compressors who manufacturer the leading edge compressors used in the Kensa heat pump. Another important partner is Mount Wellington Mine Ltd, a company set up by Richard Freeborn and Mark Scibor-Rylski to buy the mine site at which Kensa is based. Kensa rents its office and manufacturing space from this company on a long-term lease.

Kensa has helped develop a new renewable energy course at Exeter University, and has provided professional work placements for twenty University students so far, two of whom have gone on to work for Kensa's customers. Kensa staff were also actively involved in founding the UK Ground Source Heat Pump Association.

This report is based on information provided to the Ashden Awards judges by Kensa, and findings from a visit by two members of the judging team to see their work.

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