

# Heat pumps: better by nature

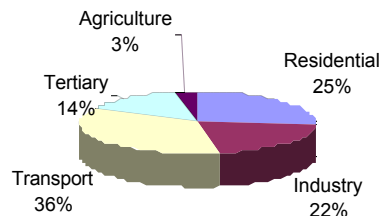
For office buildings, hospitals, swimming pools, ...

## Heat, more than 80% of our energy consumption

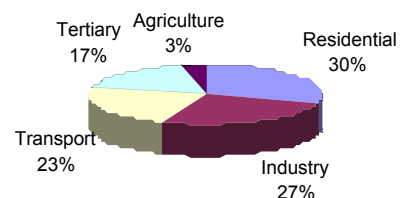
The burning of fossil fuels to meet our energy demand is resulting in the emission of vast amounts of greenhouse gases. This has attained such a level in the last decades that it poses a serious threat to our climate. Global warming has become a reality and, if not tackled urgently, it will have a dramatic effect on our lives, the lives of our children and on our planet.

Public and commercial buildings in the tertiary sector consume the equivalent of 1.5 million tonnes of oil every year for their energy needs. This represents 15% of the total primary energy consumption in Ireland. The vast majority of that energy is provided by burning fossil fuels like coal, petrol, peat, gas, etc. This results in the emission of nearly 7 million tonnes of CO<sub>2</sub>, the main contributor of greenhouse gases emissions.

**Share of total final energy consumption by sector**



**Share of energy related CO<sub>2</sub> emissions per sector**



As building owners, managers and end users, we all have a large responsibility in tackling the problem of climate change. And we can be a significant part of the solution by shifting to sustainable sources of energy and using energy more efficiently. Today, heat pumps using renewable energy sources can help us to reduce our energy consumption for heating and air-conditioning by up to 60%, with a pay-back period of five years in average.

## What is a heat pump?

A heat pump is an environmental energy technology that extracts heat from low temperature sources (air, water, ground), upgrades it to a higher temperature and releases it when it is required for space and water heating. Heat pumps can also be operated in a reverse mode for cooling purposes.

A heat pump is really a three-in-one HVAC equipment. It combines heating, cooling and air-conditioning in a economical and eco-friendly machine. They are particularly suited for buildings with a high demand

for space heating and sanitary hot water production, extensive work-in times and simultaneous need for cooling. This well established technology offers benefits to commercial buildings managers that range from increased comfort for occupants, reduced energy consumption and CO2 emissions to significant financial savings in operating and maintenance.

### Using free sources of energy

Low temperature heat sources are available everywhere around us in very large quantities from renewable energy sources: outdoor air, surface water (rivers, streams, ponds) and the ground. These sources are continuously replenished with free energy from the sun, rain and wind. In buildings equipped with a mechanical ventilation system, heat from the out-going ventilation air can also be converted to re-usable heat by means of a heat pump.

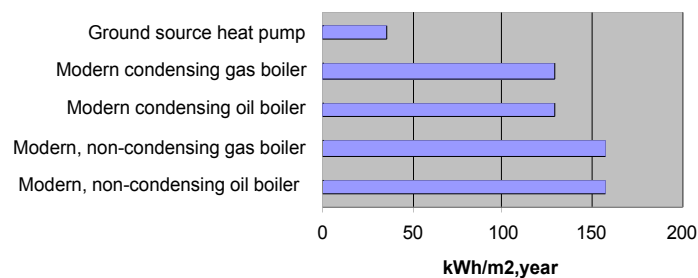
Renewable Energy is energy gained from sources in the process of which few or hardly any harmful effects on the environment occur. Renewable energy is available in inexhaustible quantities, from sources such as the sun, wind, water, biomass, geo-thermal and environmental heat.

### A total system with an unbeaten efficiency

The energy needed to drive the heat pump is generally electricity. But for every unit of electricity used, it will generate 3 to 5 units of useful heat. The ratio between the useful heat produced and the electricity used is generally referred as the 'Coefficient of Performance (COP)' to express the overall efficiency of a heat pump.

The graph below compares the energy consumption of different heating systems to supply 110 kWh of heat per square meter of floor area in a standard office building (without air-conditioning). It clearly shows that a heat pump using the ground as an energy source is three to four times more energy efficient than conventional heating systems.

**Annual energy consumption indices for heating**



In large buildings, several individual heat pumps can be placed in different zones and each can be sized to meet the needs of the space it serves. Some zones of the building may need heating at the same time as other zones need cooling. When properly integrated, a heat pump system can recover excess heat in one zone (sunny side, computer rooms, etc.) and transfer it via a water pipe loop to areas of the building requiring heating. It is therefore possible to achieve a balance between heating and cooling needs.

When the demand for heat exceeds the energy reclaimed, a central heat pump can supply the distribution loop with heat from a renewable source, generally the ground. In reverse, the same heat pump can extract excess heat from the loop and dispose of it in the ground to replenish it with heat source for further demand.

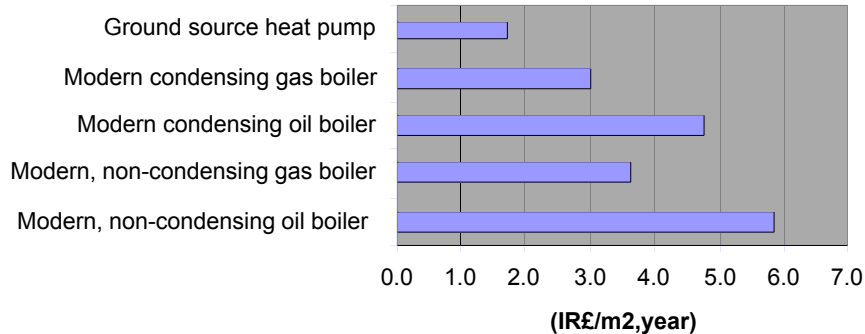
### One of the most cost-effective heating technologies

The initial cost of a heat pump is often competitive with boilers and cooling towers, and the operation costs are usually much lower. When properly designed and integrated in the building, heat pump systems can yield a simple pay-back period of five years or less when compared with conventional systems.



The graph below shows the specific energy costs for space and water heating of a typical modern office building (without air-conditioning) using different heating systems, including a ground source heat pump. Again a ground source heat pump can deliver the heat required for 70% less money than an oil boiler or 50% less than a gas boiler.

### Annual heating cost indices

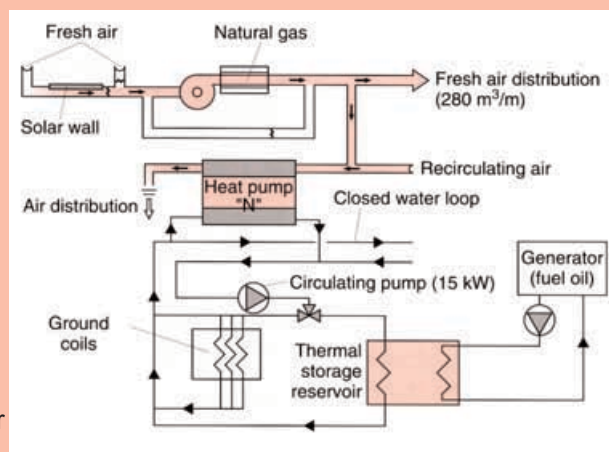


Air-source and water-source heat pump systems have maintenance costs comparable to most conventional HVAC systems, but ground-source systems appear to have significantly lower maintenance costs.

### The Saint-Hyacinthe vocational school in Canada is 40% more energy efficient with ground source heat pumps.

When designing its new buildings, Saint-Hyacinthe vocational school was highly concerned about energy efficiency and comfort. To achieve this, various techniques were implemented based on solar energy, geothermal (ground) energy, natural gas and oil. The heating and air-conditioning of the academic and recreational section (6,856 m<sup>2</sup>) of the school, constructed in 1994, is carried out by a system of 35 mixed-source water-to-air heat pumps coupled to a horizontal ground-coil heat exchanger buried in a farm field. The heat pump system is connected to a horizontal ground-coil working as a heat exchanger. It consists of a 365 metres long polyethylene pipe (diameter 32 mm) buried 1.2 metres under ground.

According to the analyses carried out by an independent company, the school's mechanical systems are no more expensive than conventional systems. The return on investment is therefore immediate. The Saint-Hyacinthe vocational school consumes only 60% of the energy normally used by similar schools, generating savings of approximately IR £24,116 or €30,021 in annual expenditure (IR£2.35/ m<sup>2</sup> or €3/m<sup>2</sup>)



## Best for the environment

Commercial and public buildings in Ireland are responsible for the emission of nearly 7 million tonnes of CO<sub>2</sub> per year (close to 20% of total CO<sub>2</sub> emissions in Ireland) due to their energy consumption. 65% of that energy consumption is for space heating, water heating and cooling.

When opting for a ground source heat pump instead of a conventional HVAC system (central boiler with or without a cooling tower), the substantial energy savings generated will result in significant reductions of CO<sub>2</sub> emissions.

But you can do even better! It is now possible in Ireland to switch to a green electricity supplier at no extra cost. By running your heat pump with green electricity, you will be able to cover your heating and cooling needs entirely with renewable energy. That means reducing CO<sub>2</sub> emissions of your building usage to the maximum, bringing a green and sustainable image to your organisation.

## Greater flexibility in design

Greater flexibility in the interior layout of the building is also possible with heat pumps. The absence of aesthetic external equipment such as cooling towers allow for greater flexibility and diversity in the architectural design of the building. This also avoids the need for roof penetration, which can cause leaks, as well as maintenance decks or architectural blinds.

Opting for a ground-source or water-source heat pump with a water-loop heat distribution system can provide other architectural benefits. The size of the ductwork can be reduced because the air handling system only provides make-up air and does not carry heat. This permits the use of pre-engineered, low-pressure ducts and allows a shallower ceiling space and lower floor-to-floor height. This gives more architectural flexibility and can reduce building costs.

## Can I add a Heat Pump to my Existing System?

Yes, you can. In Sweden, 50% of the replacement of existing heating system is done with renewable heat pumps. In most cases, the heat pump is connected to the existing central heating system and supply most of the heat required (70 to 90%). During very cold periods of the year, the existing boilers takes on and provides the higher temperatures required in the heat distribution system (above 50°C).

Such a combination is quite economical as the heat pump can be sized to meet only part (around 50 - 70%) of the maximum heat load of the building (heat required on coldest days). The rest of the heat load is met by the boiler. The initial investment of the heat pump is therefore relatively smaller and can be recouped more rapidly.

## Safer, more comfortable

Heat pumps offer improved comfort due to on-demand all year-round heating and cooling, allowing for many separate comfort zones. They are also very quiet and can be installed anywhere inside the building.

When operated with a low temperature heating system, like floor or wall heating, heat pumps can improve the quality of indoor air. It creates ideal distribution of heat throughout the room and avoid dust from being swirled, thus reducing asthma problems. This is particularly attractive in buildings of the health and care sector (hospitals, elderly homes, nurseries, etc.).

As they have fewer mechanical components, heat pumps are also more reliable, easier to service and less prone to failure. For example, in the USA, it is not uncommon to find heat pumps that were installed 30 or 40 years ago still operating effectively today.

## The Motor Tax Office building in Tralee

The new Motor Tax Office building in Tralee has been designed with sustainable energy in mind. It starts out by getting the fundamentals right with a well insulated building shell, which automatically eases the load on the heating system.

A ground source heat pump draws heat from the ground to provide space heating in winter, and deposit excess heat to assist cooling in summer months. It relies on a 5,100 metres of underground coil providing for a 2,000 m<sup>2</sup> collector area. The heat pump can generate a heat output of 130 kW with a driving force input of 35 kW, with a design coefficient of performance of 3.7 .

In addition to the ground source heat pump, an array of roof-mounted 15 m<sup>2</sup> solar collectors provides hot water for washrooms. Other energy efficient features include an automated natural ventilation system, highly energy efficient lighting and an energy management system.

An independent energy survey of the Motor Tax Building was carried out from September 2000 to May 2001. The results are highly impressive. The ground source heat pump has delivered the heat required for space heating and cooling for less than 40 kWh/m<sup>2</sup>/year. This compares favourably with the 123 kWh/m<sup>2</sup>/year consumed for heating and cooling of a 'good practice' building of the same type using conventional heating and cooling technologies.

It was estimated that the annual running cost of the Tralee Motor Tax Office for space heating and cooling and hot water production are about €1,905 lower than a 'good practice' building of similar type, and €2,984 lower than a 'typical' building of similar type.



## Millions of commercial buildings owners enjoy the benefits of heat pumps worldwide

Heat pumps are a mature technology that has proved its financial and environmental benefits worldwide. The International Energy Agency estimated that the total number of heat pumps installed in commercial buildings in the world was close to 90 million in 1996 (see table below).

Country	Total heat pump stock (IEA,1996)
Austria	4,300
Canada	158,100
Germany	5,300
UK	415,000
Japan	6,780,000
China	828,000
USA	715,750

And there is no reason why it should not happen in Ireland. We have the perfect climatic conditions and renewable resources for operating heat pumps. By using free and local sources of energy, you can reduce your dependency on imported heating fuels, whose prices are among the highest in Europe and will continue to increase.

## Who can advise me and supply me with a heat pump?

The Renewable Energy Information Office can provide you with a list of heat pump suppliers and installers, together with consultants and engineers who are familiar with energy technologies in Ireland. Contact them to discuss your situation and enquire about a preliminary design for your building.

If you want to go further, we recommend you to commission a detailed design and feasibility study for the installation of a heat pump system, specially in the case of large projects. This study can be carried out by an experience engineer or architect. Most of the heat pump suppliers provide a design service.

## The roadmap for success

Here are a few tips to ensure maximum benefits from a heat pump project:

For the system designer:

1. Incorporate it right at the beginning of the building construction or refurbishment project;
2. Carefully determine the building requirements for heating, ventilation and air-conditioning (HVAC);
3. Take into consideration the variety of needs and constraints of the different areas of the building as well as its different users;
4. Size the heat pump and associated HVAC system to match the building requirements accurately. Accurate sizing of the heat pump and design of the HVAC system will ensure lower capital and operating costs, best comfort and total security.
5. Take full advantage of the versatility of heat pump systems to ensure a high level of comfort for the building occupants, while minimising energy consumption by balancing cooling and heating needs simultaneously.

For the project developer:

6. Integrate the heat pump project into a “sustainable” energy strategy for the building whereby its energy requirements are minimised by high insulation, natural ventilation, passive solar design, ...
7. Require an official and independent certificate, or quality label, for the heat pump from the supplier ensuring minimal performance and compliance with quality standards.
8. Require proof of qualification and experience of the installer of the heat pump to ensure proper installation.
9. Require adequate warranty of equipment and make provision for its maintenance. Make sure that the heat pump operators are properly trained.

## The Renewable Energy Information Office

### Five ways to contact us:

WRITE: Renewable Energy Information Office  
Sustainable Energy Ireland  
Shinagh House  
Bandon, Co. Cork  
Ireland

TELEPHONE: our hotline – 023 42193

FAX: 023 41304

EMAIL: [renewables@reio.ie](mailto:renewables@reio.ie)

VISIT OUR WEBSITE: [www.sei.ie/reio.htm](http://www.sei.ie/reio.htm)



Sustainable Energy Ireland is a joint initiative of the Department of Public Enterprise and Forbairt. It is supported by the EU through the community Support Framework.

## I want to know more about renewable heat pumps

### Further reading

The Renewable Energy Information Office has a range of publication covering all renewable energy technologies, among which:

#### Free Factsheets available Directly from Us or Our Web Site:

- \* Wind Energy
- \* Bioenergy
  - Biomass
  - Landfill Gas
- \* Hydropower
- \* Green Electricity
- \* Renewable Energy for Buildings & Industry:
  - Passive Solar Design
  - Heat Pumps for Your Home
  - Heat Pumps for Commercial Buildings
  - Heat Pumps for the Health Sector
  - Solar Water Heaters
  - How to Heat with Wood

All these brochures can be downloaded from our website:

<http://www.sei.ie/reio.htm>

The Heat Pump Centre of the International Energy Agency has a very good range of publications on heat pumps, among which:

- \* Heat Pumps, an opportunity for reducing the greenhouse effect (1992)
- \* Heat Pumps, a better way of meet heat demand (1996)
- \* Heat Pumps, better by nature (1993)
- \* Environmental benefits of heat pumping technologies, analysis report (1999)
- \* Domestic Hot Water Heat Pumps for Residential and Commercial Buildings (1993)
- \* Commercial/institutional heat pump systems in cold climates (2000)

The IEA Heat Pump Centre Newsletter is published four times a year and is a very useful source of up-to-date information. Visit the IEA Heat Pump Centre website at: <http://www.heatpumpcentre.org>

The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) has a very good range of practical references for the design and operation of heat pumps:

- \* Ground source heat pumps – Design of geothermal systems for commercial and institutional buildings (1997)
- \* Commercial/institutional ground-source heat pump engineering manual (1995)
- \* Operating experiences with commercial ground-source heat pump (1998)

These publications can be ordered from their website <http://www.ashrae.org>, by email: [orders@ashrae.org](mailto:orders@ashrae.org) or by fax: 00 404/321-5478

#### Other publications:

Ground source heat pumps, a technology review

R H D Rawlings. The Building Services Research and Information Association, Technical Note TN 18/99

#### **RETScreen™ International:**

RETScreen provides free-of-charge software for renewable energy project analysis, including renewable heat pumps. The software can be downloaded from the Natural Resource Canada's website at <http://retscreen.gc.ca>

## Interesting websites

Renewable Energy Information Office, Irish Energy Centre:  
<http://www.sei.ie/reio.htm>

The Heat Pump Centre of the International Energy Agency:  
<http://www.heatpumpcentre.org>

CADDET, Energy Efficiency Information of the International Energy Agency:  
<http://www.caddet-ee.org> (including database with case studies)

The European Heat Pump Network:  
<http://www.ehpa.org>

Centre for Alternative Technology:  
<http://www.cat.org.uk>

UK Heat Pump Network:  
<http://www.heatpumpnet.org.uk>

The Geothermal Heat Pump Consortium (USA):  
<http://www.geoexchange.org>

The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE):  
<http://www.ashrae.org>