Designed by the renowned Italian architect, Renzo Piano, Il Vulcano Buono (The Good Volcano) was inspired by Mount Vesuvius and includes over 250 heat pumps for heating, cooling and hot water provision.

Source: Clivet

Heat Pumps

Heat pumps provide heating, cooling and sanitary hot water for residential, commercial and industrial applications. They convert ambient energy from air (aerothermal), ground (geothermal) and water (hydrothermal) but also excess heat from buildings and processes to useful heat. This conversion is done via the refrigerant cycle, which is also used in refrigerators and air conditioning systems. Heat pump technology is efficient and mature. Typical capacities range from 2-20kW for single family buildings, up to 100kW for multi-dwelling residential applications and even higher capacities for commercial applications. Industrial and district heating heat pumps reach capacities of several MW. Operating the unit when surplus electricity is available and storing that surplus energy in the form of heat provides significant demand response capacity to the electric system and enables the integration of a larger share of renewable electricity.

Highest efficiency is reached when heating and cooling is needed at the same time.

Low-Carbon Technology

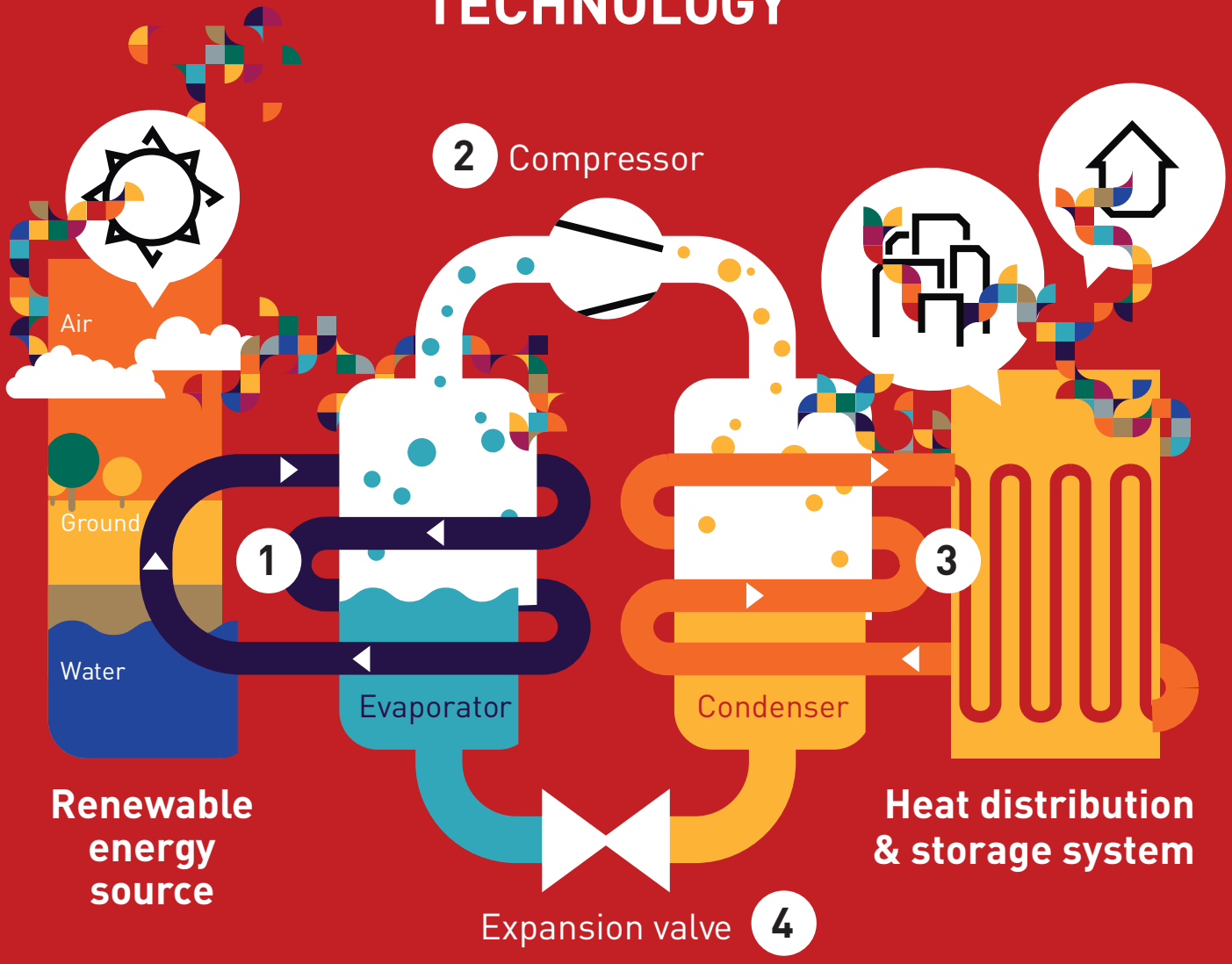
A heat pump system consists of a heat source, the heat pump unit and a system to distribute heating and cooling. Among several possible concepts, the electric compression cycle is most common. The heat pump works as follows: **(1) a transfer fluid (refrigerant)** is exposed to the energy source, where it evaporates and thus cools the source. Using a **compressor (2)**, the refrigerant vapour is compressed and its temperature increased. In the next step **(3)**, the high temperature – high pressure vapour – is fed into a heat exchanger where the energy is transferred to a distribution system. The vapour cools down and condenses. After the pressure is released in an **expansion valve (4)**, the liquid is exposed to the heat source again and the cycle is closed.

Heat pumps always provide heating and cooling at the same time. In the heating mode, outdoor ambient energy is the heat source and the building/process is the heat sink. In the cooling mode, the building/process is cooled down using the outside as heat sink. Highest efficiency is reached when heating and cooling is needed at the same time.

DID YOU KNOW?

Heat pumps help reduce air pollution: in China, the administration of Beijing has started a replacement program to eliminate oil and coal boilers in order to tackle the air pollution; 160,000 units have been replaced in 2016 and the program will continue in 2017 with expansion plans to neighbouring provinces.

HEAT PUMP TECHNOLOGY



1. In 2016, every day, about **2,700** new heat pumps were installed in Europe (annual sales of close to 1,000,000)

2. **18.6%** of all Europe's heating and cooling is derived from renewable energy, **10%** of which comes from heat pumps.

5. A heat pump + photovoltaic + battery home energy system can provide heating, cooling and hot water, **day and night.**

6. Heat pump induced growth in the efficient electrification of heating and cooling, will not lead to a significant increase in total electricity demand.

Installed heat pumps in Europe save nearly x2 the CO_2 emissions of Statoil – any year.

3. In 2017, the total installed heat pump stock will exceed **10 million** installed units (compared to approx. 119 million buildings).

4. Heat pumps provide demand side flexibility: all heat pumps in operation by end of 2015 could provide **298 GWh** of storage capacity.

7. France, Italy and Sweden are the **top 3 markets** for heat pumps in Europe with huge growth potential in important markets like Spain, Germany, and Poland.

8. The heat pump stock is expected to double by 2030, making ambient heat the **most important renewable energy** after biomass.

9. Heat pumps can be used in industry. The technical potential in applications such as food processing, drying, chemicals or textiles is estimated at **174 TWh.**

10. A total of **61 million** heat pumps is needed to replace the energy coming from Russian gas.

Sources: EHPA , Eurostat Shares, Fraunhofer Institute, IRENA, Viessmann

1. Shift subsidies from fossil fuels to low/no emission technologies.

Subsidies for fossil fuels prevail across the EU, keeping operation costs artificially low. With the investment costs of greener solutions still higher, the additional costs are rarely recovered over the useful life of the installation.

2. Include heating based on fossil energy (as well as transport) under ETS to put a price on the negative environmental impact of using them.

There is no price signal influencing the negative environmental impact from burning fossil energy in the heating sector. Electricity is covered by the European Trading Scheme (ETS), but combustion-based heating is not covered. Correct a mismatch in taxation between electricity and fossil energy.

3. Provide standard investment packages for companies, cities and citizens to gain benefits.

While you can find financing solutions for buying a new car, the banking sector does not facilitate investing in new heating solutions, distribution infrastructure and building systems that would lower energy consumption.

4. Facilitate and simplify replacement of existing boilers with no-emission solutions.

Current heating solutions benefit from decades of optimization and standardization. For the installer, this is business as usual: the basic like-for-like replacement, fault-forgiving and recognized by the client as working. This ease of installation has yet to be achieved for "2050-ready" replacement solutions to come faster to market.

5. Standardize green renovation packages for buildings across Europe.

If a heating system fails, a fast replacement is required, but in such "distressed purchase" situations the suggested replacement is rarely the best long-term solution. Standardized green renovation packages including financing and (if needed) an upgrade of the building envelope must become the *modus operandi* in the renovation sector.

Martin Forsén

President of the European Heat Pump Association

Is Europe going fast enough in moving towards a more decarbonised society?

Clearly not! We are only starting to scratch the surface. We need to go much faster in making heating and cooling in Europe more sustainable. The electricity sector has made some progress and the need to electrify the energy sector is slowly but steadily gaining ground. We need brave decisions to favor cleaner "2050-ready" technologies for their deployment in the market.

What steps are needed to create the political framework and support scheme?

I believe in strict eco-design requirements in combination with measures that make polluting technologies economically less attractive. One solution is the introduction of a price signal for the use of carbon, such as a cap-and-trade system, or more likely now as a carbon base price.

We need a paradigm shift in the transport and heating sector. The lighting sector is a leading example on how a change of paradigm enforced by legislation may lead to tremendous energy savings. The road transport and heating sector need a similar shift. The small incremental improvements that are still seen in these sectors are not enough.

Technologies that contribute to making the necessary transition are proven and available. Policy-makers need to move away from traditional technologies by implementing stronger regulations. Support schemes may speed up the process in individual markets for making new technologies economically interesting, but it will be even more important to stop fossil fuel subsidies.

Where do we stand today in decarbonising heating and cooling in Europe?

The carbon footprint of the heating sector in most of Europe is immense and the transformation of the heating sector in Europe remains very slow. In the UK, there are around 1.6 million gas boilers installed annually and only a minor fraction of the boiler market consists of heat pumps and oth-

er carbon-lean systems. It is time to reassess the heating sector and introduce regulation to report the sector's carbon footprint. If it does not decline fast enough, additional and stricter measures are needed to improve the situation. National targets should also be fixed to comply with the Paris CoP21 agreement. This is not difficult, nor controversial.

We know what needs to be done to fulfill what we have already agreed upon, but this will mean inevitably that we need to abandon traditional technologies. Sweden is a good example of how this can be done. Since 1990, greenhouse gas emissions related to heating in buildings have been reduced by 90% by an almost complete phase out of fossil fuels. The transformation of the heating sector has been realised by the broad introduction of heat pumps and fuel shift in the district heating sector. Today, more than 50% of all single family houses are equipped with a heat pump and the market share for heat pumps in new construction exceeds 80%.

Heat pumps are central to the decarbonisation of the heating and cooling sector.

What role do you see for heat pump technologies in this context?

Heat pumps are central to the decarbonisation of the heating sector. Heat pumps are unique in the sense that they reduce greenhouse gas emissions, improve energy efficiency and increase the integration and use of renewable energy. And they can provide both heating and cooling at the same time, which makes the technology particularly interesting for commercial and industrial applications. Heat pumps can therefore play an important balancing role in electricity grids with ever increasing share of intermittent renewable electricity.

What is the biggest obstacle limiting the deployment of heat pumps?

We need to continue disseminating information and training installers. As sales continue to pick up, economies of scale will contribute to more competition and cost reductions. The biggest obstacle right now is the low prices of fossil fuels, the high price of electricity and the significant price difference between heat pumps and gas boilers for retrofitting applications. As long as gas is not greening at significantly higher speeds, every new gas boiler means a lost opportunity for substantial greenhouse gas reductions. We need to find more efficient ways to address the end consumers that are in need of replacements and we need the policy-makers to recognise fully what needs to be done. I am confident that heat pumps will be a key integrator technology for the energy transformation of the heating sector. The only question is how long until the major markets in Europe really take off.

ehpa european heat pump association

INDUSTRIAL
Norway

In 2009, the growing population of Drammen led to a reconstruction of the heating system in order to meet the growing heat demand. Realizing that the 8˚C averaging fjord temperature throughout the year is an ideal heat source for water source heat pumps, the heating company of Drammen switched from fossil fuels to renewable heat generation. With an installed capacity of 13.2 MW from heat pump and 30 MW from fossil fuel, the system meets the heat demand of a community of 63,000 people and its businesses. Operating for nearly 4 years, the heat pump has reached the mark of 200 GWh of successful heat generation.

RESIDENTIAL
Sweden

Sickla Strand is located in Nacka, a community south of Stockholm. In a renovation project, 330 apartments were connected to a new 900 kW ground coupled heat pump (600kW of capacity is provided by geothermal wells, 300kW from electricity). Using a mono energetic system design, most of the energy demand is covered by the large heat pump, with peak demand being covered by electric resistant heaters. The use of ventilation systems has greatly reduced energy losses. An investment of 25 million SEK leads to savings of 2.5 million SEK/year and a payback time of 10 years.

COMMERCIAL
Italy

Developed in 2009, the "Volcano Buono"mall in Naples consists of a central food court,shops, restaurants, hotels, residential spaces, a collegeand a cultural center with a total useful area of 16,000 m^2. All thermal energy supplied to the Vulcano is 100% renewable, and for the most part produced locally. A central heating and cooling plant with three heat pumps and 64 borehole heat exchangers (each 300 meters deep) provides sustainable heating and cooling, and allows wasteheat to be recovered locally. The heat pump solution substantially reduces the need for installed cooling capacity, and eliminates the need for dry air liquid coolers. This creates more attractive surroundings, and allows more efficient use of buildings.

This multipurpose complex is sourced by renewable energy from water and the air (WLHP System) and includes over 250 heat pumps: 9 rooftop air-to-air heat pumps + 54 rooftop water-to-air heat pumps + over 240 ventilation and air handling units + 4 water-to-water heat pumps + 2 super silent chillers + over 150 water-to-air heat pumps.

(Left) District heating heat pumps. Source: Star Refrigeration
(Middle) Residential buildings in Sickla Strand. Source: Arild Vågen
(Right) The Good Volcano shopping mall. Source: Clivet