The potential of industrial heat pumps

While the benefits of the use of heat pump technology in residential buildings is widely recognized, we barely find the benefits of its “big brother” mentioned in neither energy policy action plans nor in the mind of investors or potential users. We see an impressive share of heat pumps being installed in newly-built single and multi-family houses – 80% of all heat generators, for instance in Switzerland, 68% in Austria, 90% in Sweden.

The European Union as well as the National Renewable Energy Action Plans (NREAPs) stipulate the use of ambient heat by means of the heat pump technology, but as soon as you look at the figures in detail, you will mainly find statistics and potentials of family houses. The same can be found in the market reports. Figures and targets for large size heat pumps are more or less missing. I think that we could achieve the recognition of a roughly similar potential by additionally taking large buildings into account: with today’s available technology also large office buildings, apartment blocks, theatres, museums, governmental buildings, manufacturing facilities and so on could be heated with heat pumps. As we find a conglomeration of high-rise buildings in cities, we could use in many cases ground water, geothermal or air as a renewable heat source.

Energy-Commissioner Oettinger presented the Energy Efficiency Directive (EED) in July 2011: According to this paper, 3% of all public buildings should be renovated every year. (Today we see a figure below 1%). We need to fulfil this rate in order to reach the 20-20-20 goals, set in 2007.

While, when renovating family houses, upgrading insulation is an often-demanded request, we have to look for alternatives when addressing large volume buildings, historical buildings and buildings with glass façades. Almost all these buildings do not only need heating but also cooling/air conditioning. In all these cases, the building can be upgraded to a much lower energy demand by retrofitting intelligent heating & cooling systems. Heat pumps can play a major, maybe a dominant, role in this respect. When heat pumps are needed for heating and cooling at the same time, either heating or cooling energy is “for free”. We see light house reference buildings with an integrated Coefficient Of Performance (COP) of 8 – that means that with 1 kWh of electricity we can generate 8 kWh of heat. With this “energy-multiplier” of 8, we have the answer on how to minimize electricity consumption and at the same time the solution to substitute oil and gas.

Heat pumps can also be used in industrial processes in chemical, biochemical, food & beverage, mechanical and other industries to reduce energy demand for process heating by waste energy recovery. It would be worthwhile to pay more attention to all these options.

Karl Ochsner | Chairman EHPA
Industrial heat pump applications at the HP Summit in Nürnberg

The European Heat Pump Summit 2011 with its internationally orientated congress programme offered information at the highest level on the political framework in Germany and abroad, the latest research findings and technical solutions. Top speakers impressed with their concentrated know-how and delighted the attending specialists with high-quality presentations.

Topical issues in focus
The highly professional presentations at the congress both showed the way ahead for heat pumps and presented the latest progress of research and development in Europe and the rest of the world.

The Workshop ‘Industrial Heat Pump Application’, presented by the International Energy Agency (IEA), also attracted great interest. Here you can find some highlights of this workshop:

1. Industrial (High Temperature) heat pumps in Germany – Market situation, potentials and technological development
   In regard to the increasing energy prices, the goal to reduce CO₂ emissions and the need to foster the use of renewable energy sources, the research project „Potential analysis for industrial heat pumps in Germany“ aims to promote industrial applications of the heat pump technology and to support the development of high temperature heat pumps in cooperation with manufacturers.
   The presentation at the Summit gave an overview of the ongoing research project „Potential analysis for industrial heat pumps in Germany“. It is the German contribution to the IEA HPP / IETS Annex 35/13 “Application of Industrial Heat Pumps”. The first part of the presentation highlighted the actual situation of the heating and cooling demand in Germany as well as heat balances and process analyses of selected branches of industry that show high potential for the use of heat pumps. The description was followed by a detailed market analysis of current heat pump technologies and an overview of existing systems. The second part of the presentation consisted of selected case studies that were analysed and monitored in detail during the research project. Finally, in cooperation with heat pump manufacturers, innovative developments for high temperature heat pumps (up to 140 °C) were described and possible applications with regard to this high output temperature were shown.
   First conclusions of the project were:
   • Hardly any “real” industrial application of heat pumps
   • Room for improvement:
     i. Higher COP at current temperature level (70 °C)
     ii. Increase of output temperature up to around 140 °C
     iii. Use of high temperature heat sources (> 30 °C)
   • Combined facilities: heating and cooling
   • Heat pumps have to provide a strictly defined temperature (quality reasons)
   • Need for safety measures to operate and low-maintenance facilities

   Increasing concerns about energy prices and CO₂ emissions trigger industries to invest in energy efficiency. Industrial heat pumps may play a key role in this situation but, as a great part of industrial heat demand is at high temperatures (80/100 °C), current commercial machines cannot satisfy these needs because of technological limits. In this context, Electricité de France (EDF) and Johnson Controls Inc. (JCI) have developed and tested a high temperature heat pump, which is able to produce hot water up to 100 °C.
   This study deals with the experimental results of a test campaign conducted with a high temperature heat pump using R-245fa as working fluid. Firstly, the technological choices were explained, and the test bench was described. Secondly,
the test campaign was presented. The campaign was divided in two parts. In the first one, the aim target was to evaluate the performance of the heat pump with this fluid. The purpose of the second part was to test the reliability of the machine using this working fluid. The performances of the heat pumps in its operative field were characterized.

The conclusion:
• There is a big potential for heat pumps, especially at a high temperature
• Thanks to its thermodynamic, safety and economic properties, R-245fa was chosen as refrigerant
• Our prototype provided by JCI demonstrates the possibility of using R-245fa at industrial scale
• The reliability of the heat pump is demonstrated
• The prototype can theoretically reach a temperature of 120 °C and offers a promising field for more industrial applications
• A research phase on HFO refrigerant must be carried on for the future

3. Heat pumps in industrial cleaning applications
The objective of this project was to promote the use of heat pumps in energy-intensive industrial washing applications. Energy consumption in cleaning and drying applications is vast, leaving an enormous amount of waste heat to be recovered and recycled in the cleaning process. As the focus on industrial energy consumption has increased, heat pumps are becoming an interesting technology in more and more applications, including cleaning and drying. Throughout the project, a heat pump solution was developed and commissioned for a specific cleaning application at Grundfos. The designed heat pump provided heat for a single washing machine at the factory. The heat pump concept was simply an “add-on” to existing or new washing machines. Few modifications were needed to enable easy installation and high flexibility in production facilities. The specific heat pump recovered energy inside the washing machine by cooling moist exhaust air and recycling the energy into the washing water.

The field test showed that the overall energy consumption of the washer was reduced by app. 50 % (including energy consumption of motors, pumps, fans etc.). As the washers have a lot of running hours, the annual reduction in energy consumption is considerable, enabling short pay back periods.

To promote the use of heat pumps in new and existing applications, results from the analysis were summarized in a software tool. This software tool provides energy consultants, manufacturers and end-users with a quick assessment of possible heat pump solutions in different applications. Data e.g. temperature levels, heating demand, alternative heat sources and so on are implemented in the software tool, which will then offer a number of possible heat pump solutions as well as energy consumption and savings potential. By using the software tool, consultants are able to make a quick first assessment on heat pump solutions, even if they have a limited knowledge on heat pump technology.

Dr. Rainer Jakobs
Information Centre on Heat Pumps and refrigeration IZW e.V., Germany
E-mail: Jakobs@izw-online.de

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Table 1: Heat pumps in industrial washing applications

> 50 % reduction of energy consumption is expected
Ground source heat pumps in larger installations

Heating and cooling of many non-domestic buildings is done by using a combination of gas boilers and mechanical cooling (electric chillers). Increasingly often, national building codes or environmental legislation will require a significant reduction in energy usage and emissions, a request that this type of installation can not provide. Heat pumps can overcome this limitation by using the ground as a buffer, whilst providing heating and/or cooling to the building.

Over a number of years Groenholland UK Ltd. has installed a several larger heat pump installations, providing either seasonal heating or cooling or simultaneous heating and cooling to university buildings, schools, commercial offices and warehousing. All the systems are of hybrid design, whereby the heat pumps cover a large proportion (70-80 % of the running hours) of the annual heating and cooling load. Gas boilers are used for peak heating and chillers or dry coolers for peak cooling. By matching the heat pump compressor output to the buildings energy load, high efficiencies can be obtained for the base load. The annual performance of the system as a whole is good as well.

The heat pump capacity of this type of installation varies between 50 and 500 kW. Multiple heat pumps are used and usually the heat pumps have multiple compressor stages. This step type capacity approach allows adequate thermal and hydraulic control. Heating and cooling to the building is provided via a heat exchanger interface, providing complete quality control of the circulation medium over the heat pump hydraulic circuit.

The experience over the last 5 years learns that larger ground source heat pump installations are gaining in popularity as they often are the most straightforward way of implementing a sustainable energy saving technology. Another attraction is the combination of heat pumps and solar thermal, whereby excess solar heat can be used to regenerate the ground that has been cooled down in the winter period. Not only the size and cost of the ground source heat exchanger can be reduced, but it is also possible to enhance the efficiency of the system.
Special attention in designing ground source heat pump installations should be given to the matching of energy usage in the building, including the selected temperatures. In most buildings there will be a large number of running hours at low loads (both heating and cooling). Larger heat pumps may seem attractive to install, but if capacity steps cannot be reduced far enough and if pumping requirements remain high, the installation will not be efficient. End-user temperatures speak for themselves, as an unfavourable temperature selection may seem attractive from the point of view of cost-reduction on the building side, but will lead to a poor performance of the heat pumps.

An operating strategy, controls and monitoring are key to successful heat pump usage. Direct access to installations and to key operating parameters will allow both troubleshooting and optimisation of the system. Logged data will allow both the end-user and the installer of the installation insight in performance and the overall contribution of the system to the energy efficiency of the building.

Guus van Gelder | Groenholland UK Ltd.

**ECOPORT: Use of shallow groundwater for heating & cooling with heat pumps in Graz, Austria**

*Saubermacher Dienstleistungs AG build its new Headquarter south Graz, (capital of the Federal State Styria, Austria; 250.000 inhabitants). The building, located in the vicinity of the airport was equipped with two water-water heat pumps each providing a heating/cooling capacity of 73,2 kW and 60,0 kW respectively. The capacity refers to an operating point of W10/W35.*

The primary and secondary circuit are equipped with stainless steel plate heat exchangers. The installation comprises a temperature control for the storage water heater, including the activation of an additional heat producer and a solar control mode for warming up of the heating circuit water and the function ‘natural cooling’.

For covering the heating and cooling base load, a groundwater flow of circa 25 l/s at a spread of each 4 K is required. Figure 1 shows a graph of the average flow volumes (in l/s) per month for heating and cooling. Groundwater extraction and re-jection takes place in two wells of 20 m depth, completed with PVC casings and filter pipes of 600 mm diameter. Both wells are equipped with an 11 kW, frequency controlled submersible water pumps built into the bottom of the well. The horizontal distance between the production and the reinjection well is about 2 m. The water table of the shallow groundwater is approx. 10 m below ground, the water temperature is around 12 °C.

The installations area of influence was determined along the line of 1 K temperature difference to the natural groundwater temperatures covering a length of about 2,5 km in groundwater flow direction and a width of about 450 m upstream and 220 m downstream. Its proper definition is relevant for protecting the water rights of external users of groundwater in the licensing process.

A numerical flow and heat transport model was established to assess the regional influence on the groundwater temperature. This model was based on local and regional geological and hydrogeological data, including results of pumping tests to assess the transmissivity of the shallow aquifer. The aquifer is also providing drinking water. The analysis revealed that compartments of heated and cooled groundwater are expected to be drifting down the south-estern direction of the ground water flow. Long term evaluation revealed a stable ground temperure. Based on the hydrogeological investigations and the results of the groundwater model a concession for the thermal use of groundwater for a 20-year period was issued by the authorities.

After commissioning the Ecoport project served as an example for an additional 4 water-water heat pump installations with groundwater flows of some 12 to 25 l/s in the Graz area, at least two more are in preparation.

Johannes Goldbrunner | Geoteam
HVAC with a large heat pump coupled to a Borehole Thermal Energy Storage in Laborelec

Laborelec is a technical competence centre in electrical power and energy technology, part of the GDF SUEZ group. Located in Linkebeek, near Brussels (Belgium), it was built in the 1960s and consists of 7 buildings (5 wings and 2 independent buildings) with a floor space of 22,000 m².

A Master Plan was initiated to renovate the complex in an innovative and energy efficient way. Wing 2 was the first building to be inaugurated last autumn after an enlargement and heavy renovation.

The renovated wing 2

The "wing 2" of Laborelec contains 4,000 m² over 3 floors and each floor is equally separated in offices and laboratories. During the conception of this new wing, the energy consumption reduction was considered as a very important aspect. An active double façade has been foreseen with this respect. It allows the thermal bridges and other thermal issues of an old building to be wiped out. Another advantage of this type of façade is its activeness, enabling the reduction of the cooling demand in the summer time. The energy efficiency of the renovated wing 2 is, according to the Energy Performance of Buildings Directive (EPBD), expressed in an E-level: this was at the original situation E242 and is now brought back to E52, while the current requirement for such new buildings in the Flemish Region is E70.

The HVAC system

Because of the high ventilation demand in the laboratories, an all air concept has been used. This means that the cooling and heating demand inside the laboratories are met by conditioning the temperature of the supply air. In the offices, the hygienic air is supplied, while the cooling and heating demand is covered by a climate ceiling. Any equipment that needs heating is designed to run at a regime of 55°C/35°C (maximal demand). Two regimes are foreseen for the cooling: 6°C/11°C for dehumidification of the supply air and 15°C/17°C for the climate ceiling.

A reversible heat pump covers the basic heating and cooling load, with a heating capacity of 75 kW (source 3 to 0 °C) and a cooling capacity of 80 kW (source 30 to 33 °C). This source is a Borehole Thermal Energy Storage (BTES) made of 25 drillings with a depth of approximately 85 meters used for seasonal storage of thermal energy.

The implementation of such a BTES system requires specific geological conditions (e.g. no ground water flow) and implies a good knowledge and forecast of the whole building energy needs so that the annual cooling and heating loads are as much as possible in balance in order to have a stable ground temperature over the years.

Two condensing boilers with a capacity of 200 kW each and two performing chillers of 290 kW each assist the heat pump in case of peak demand. The heat pump can run in three modes:

- Heating only: in this mode, the heat pump uses the BTES to produce heating;
- Cooling only: in this mode, the heat pump uses the BTES to produce cooling;
- Heating and cooling: in this mode, the condenser and the evaporator of the heat pump exchange the energy. The BTES is not in use.

Figure 2: Laborelec drilling works

Figure 3: Heat pump installation working cycle
The BTES can also be used for free cooling. In this way, a very energy efficient cooling is foreseen because only the pump energy is needed for the cooling.

**First return of experience**

The system was commissioned in September-October 2011. After some premature problems, as in every new installation, it is now running very stable. Indeed, a good and stable Performance Factor (PF) of 4 (thermal output divided by energy consumption of the compressor and the needed pumps) in the very cold week of February 5th 2012 was observed (outside temperature between -12° C and 0°c). The PF was in fact a little lower because some small pumps that were needed in the system have not been connected to the energy meter yet. The source temperature is now about 10 °C. In that exceptionally cold period the heat pump was delivering the basic load, about 38 % of the total heat demand, and the boilers were supplying the rest.

**Objective**

The first results are in line with the objective, that the heat pump coupled with the BTES should cover approximately 60 % of the heating demand and 70 % of the cooling demand. This corresponds to a yearly energy saving of 24 % and a reduction of about 23 % of CO₂ emissions in comparison with a classical HVAC installation with condensation boilers and performing chillers in the same renovated building.

*Cathy Crunelle | Project Engineer at Laborelec*

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New heat pump system in the Vattenfall-head office

**Energy efficiency: Heating the building with waste heat and air conditioning**

The EHA (Energie-Handels-Gesellschaft) and the Vattenfall Business Services GmbH rely on energy efficiency. Last year, two ultra modern heat pumps were installed and put into operation in the head office of Vattenfall Europe AG. The system uses the waste heat of the in-house IT server rooms and computer centres. The total basic thermal load of the 13-floored building with 50,000 m² floor area can be covered by the heat transfer. This project reduces the negative impact on the environment by more than 600 tons of CO₂ per annum.

**How does it work?**

The energy is “pumped” to a temperature level of up to 45 degrees Celsius and fed into the heating system. Two highly efficient water-water heat pumps with each up to 360 kW heating capacity from OCHSNER are used. Turbo compressors with magnetic bearings minimize friction loss and thus oil lubrication is no longer necessary. The drive shaft “floats” virtually in the magnetic field and reaches a speed of 18,000 – 46,000 revolutions per minute. An intelligent control technology continuously adapts the performance of the machines on the cold and the warm side to the respective demand. Approximately 8 kWh thermal energy (warmth and cold) are produced for each electrical kWh. This corresponds to an “integrated” Coefficient Of Performance (COP, energy multiplier) of 8. The installation into the existing systems was carried out during the regular business. Since the offices are located directly above the system, also the sound insulation had to meet high requirements.

OCHSNER, as manufacturer of high performance heat pumps, offers a complete range of industrial units up to 1 MW with OVi technology. The standard heating flow temperatures go up to 65 °C and are thus suitable for retrofitting and renovation of the heating/cooling supply of large buildings.

The challenge with the Vattenfall project was to meet the narrow heat temperature tolerances of -0° and +1° Kelvin prescribed by the investor. A special hydraulic and electronic control system had to be developed to meet these requirements.

**Outcome**

This project shows how existing large volume buildings can be upgraded regarding energy efficiency and primary energy use even without insulation. Intelligent technology guarantees realisation within a short period of time and an extreme fast return on investment.
Assessment of ground samples to determine the efficiency of vertical borehole heat sources.

The use of vertical borehole heat exchanger (BHE) systems to heat and cool buildings by ground-source heat pumps is increasing in Hungary. One of the largest ground-source heat pump systems (8th largest in Europe with 18,000 m of drilling) has been installed in 2007 to provide the TELENOR office building with energy. Trial wells were used to execute geophysical borehole measurements and a Thermal Response Test (TRT) was executed to collect data for a proper system design.

Problem definition

Geothermal borehole heat exchanger (BHE) systems are increasingly used for heating and cooling of buildings in Hungary. In general, 1-3 BHEs are needed to cover smaller buildings (up to 10 kW heat demand) with energy. For bigger houses 3-7 BHEs are needed and large buildings (e.g. office buildings, schools, community buildings) may require from a few 10 to several 100 BHEs. As drilling costs have a large share in the total investment, and as properly executed wells influence the efficiency and operating cost of the system, accurate well-field design and implementation is very important. A geological analysis including a test drilling and a Thermal Response Test is recommended. As a result, the capacity of the heat exchanger can be calculated and an efficient well-field (both from a technical and an economic perspective) can be designed.

This procedure is illustrated by example of the TELENOR office building. The TELENOR company is committed to environmental solutions, and therefore decided to establish a heat pump system, taking the environmental benefits into account over the economic aspects. In the summer of 2007, it decided to meet the energy demand of its newest building from a geothermal source. A total of 180 drillings, each with a depth of 100 m were needed to provide renewable heating and cooling to the building.

Method

The thermal conductivity of the ground and the required value of the heat capacity of the given area (e.g. to 100 m depth by mathematical formulas) was to be determined by means of a Thermal Response Test (TRT). Such an approach is recommended for all larger installations (over 30 kW capacity according to standard VDI4640). Using the resulting data, both the required number of BHEs and the relative distance between the BHEs can be determined. The latter is necessary so that the boreholes do not affect each other and, thus cost-effectiveness of the installation can be ensured.

Heat absorption performance

The undisturbed ground temperature was measured before the start of the TRT. Temperature data on the whole length of the 100 m single-tube was recorded with values from 11.99 to 13.97 °C. Then the TRT was performed on a single BHE over a period of 68 hours. During the measurement, inlet & outlet fluid temperature, air temperature (Figure 4), mass flow of the circulated fluid and the heating power was recorded. The results were evaluated by the Kelvin-line source method. The so-called equivalent thermal conductivity (λ) can be calculated by the result of the thermal conductivity differential equation by means of a specific formula.

The defined equivalent thermal conductivity value (λ) was 2.8 W/mK. This reflects both a conductive heat transfer in the rock.
Figure 4: Assumable heat from surrounding of BHEs (TRT)

formations and a convective heat transfer by the ground water. The heat absorption power was 6.42 kW by water and 5.91 kW by glycol. The actual number of BHE was deducted by the sizing EED 3.0 software based on the TRT results.

Sizing and construction
Using the thermal conductivity value, the borehole geophysical measurement was performed, resulting in a computer model of the thermal geothermal system. The shallow ground in the surveyed area is mostly dry clay, marly clay, a depth of 80-100 m it also had some calcareous marly layers. Based on these data and calculations, the BHE was calculated at 180 pieces of single 40 mm BHEs with 100 m depth and 7 m distance.

Figure 5: Manifold

The energetic characteristics of the building determined the selection of the entire system: heating load (kW), the total heating load (hours), the heat pump for heating-cooling efficiency (COP/EER) and the seasonal performance factor (SPF), the total cooling load (hours), and heating-cooling peak loads.

There are three heat pumps. Each heat pump has the capacity to produce 287.4 kW heating and 321.9 kW cooling. Thus, the total capacity is 862.2 kW of heating and 965.7 kW of cooling.

Monitoring of the installed system
In order to check the capacity development the three BHEs have been equipped with temperature sensors. Sensors were integrated at four depths (10, 40, 70 and 100 m). The first monitoring point was placed in one branch of a double BHE on the first third of the borehole field. The second monitoring point was located between two boreholes (at half distance), while the third was placed at 6.6 m away from the field (Figure 2).

Thus ground temperature variations in the geological environment between the BHEs and outside the borehole field can be identified.

During the first trial run at monitoring point 1 (Figure 6), the temperature „cooled down” to 13.41 °C at 100 m depth, but recovered to 14.68 °C during the second day.

The ground temperature increased in parallel to the decreasing heating demand. In summer, the temperature was higher than 15.0 °C at 100m by the launched cooling effect.

At 70 m depth the thermometer measured 14.0 °C in undisturbed state. In the spring season, the heating temperature decreased to 9.26 °C as it can be seen on Figure 6. In the cooling mode, from the end of April onwards, the ground temperature increased to 19.30°C (beginning of July). On the 4th of August, we recorded a temperature of 16.4 °C at a depth of 70 m.

Figure 6: Telenor House BHE monitoring

During the test run (14 days), there was no temperature decrease at monitoring point 2, i.e. 3.5 m from the BHE. During heating mode, the temperature fell from 15.2 °C to 14.92 °C. At monitoring point 3 (6.6m outside the borehole field), no temperature change occurred during operations.

Summary of the results
A BHE with 180 piece boreholes, of 100 m depth each was created to provide heating and cooling to the building. It was equipped with monitoring equipment to evaluate the impact of the system on the environment. The installation can be considered successful as the ground outside the BHE is not disturbed by operations (compared to the undisturbed state of the ground). The use of TRT has thus resulted in a properly designed well-field. On a side note: the temperatures measured do match variations expected from literature.

As a result, Telenor is very satisfied with the operations of the installation.

Ádám Béla | HGD, Budapest
Dr. László Tóth | SZIE, Gödöllő
Advantages of large capacity heat pump application for heating and cooling

Large capacity heat pumps are an interesting alternative to conventional heating systems and not last since the German Federal Government has set-up the Renewable Energy/Heating Law (EEWärmeG) to promote an increased use of renewable energy. Heat pumps are a particularly efficient option to fulfil the requirements of this legislation. Wherever thermal energy is needed - be it in facility management, industry or indoor/outdoor swimming pools, energy costs are a significant factor and in many application fields, heat pumps contribute positively to their reduction. This is increasingly true for large capacity units.

The market of large capacity heat pumps is slowly developing. This type of heat pumps is mainly applied in areas with energy requirements of 300 kW thermal heat capacity and more. The ideal application for this kind of technology is found in low temperature applications and a feed in temperature need of up to 50°C. It is very appropriate for heating and cooling of larger buildings.

Large capacity heat pumps use the standard principle of electric compression heat pumps: in heating mode, thermal energy is withdrawn from a natural medium, such as water, air or the ground. This energy is transferred to the the refrigerant and useful heat is provided to the heating medium, i.e. the water in a heating system of a building or the air in air-conditioning. The efficiency of the solution depends on the delta between source and sink temperature. As the source temperature is rather stable (ground/water) or only slightly fluctuating (air) a lot of importance has to be put to a reduction of the temperature level required. As an option, a low temperature heating system which operates between 30–40 °C can be used. The large share of renewables integrated for heating results in a direct reduction of final energy and thus reduced energy cost. The less primary energy is used for the total process, the better the overall performance of the system. This value is known as the Coefficient of Performance (COP).

The Quantum compressor technology is oil-free using a magnetic bearing – thus eliminating the danger of an oil leak so that further environmental precautions are not needed. In addition, the costs for maintenance are greatly reduced due to the non-wearing magnetic bearing. This heat pumps provide capacities up to 2000 kW and achieve outstanding performance levels between 5.0 and 7.0 COP (at Bo/W35; W10/W35).

The example of the community of Krumbach (close to Augsburg; see figure 2) illustrates the application potential of high capacity heat pumps: heat pump technology has been used for years to heat the public outdoor swimming pools. In 2006 the old unit (using a piston compressor) was replaced by a new turbo compressor heat pump, resulting in an enormous reduction of the energy consumed for heating in both pools. The heat load of 686 kW is predominantly supplied from hydrothermal energy (580 kW) and only 106 KW of auxiliary electricity is needed to operate the heat pump. Comparing the new to the old system shows a cost saving of up to 60 % per year.
Innovation in the Dutch heat pump market on the 2012 VSK Trade Fair in Utrecht

After the first introduction of hybrid heat pump systems for domestic applications at the VSK Trade Fair four years ago, the market in the Netherlands continued to innovate at an even faster pace. At the 2012 VSK Trade Fair in Utrecht (NL) in February many companies presented their innovations in heat pump technology and applications. Although it is common that Dutch manufacturers are actively looking for interesting solutions for their own market, it is yet remarkable that also European and Asian companies are developing specific new products for the highly competitive Dutch housing and renovation market.

Techneco

The Dutch company Techneco presented a compact combination of solar thermal and its TOROS 3 – 10 kW heat pump, claiming a 40 % higher efficiency rate of the overall system. In the first place, the focus has been on increasing the efficiency of domestic hot water production. Especially in new buildings solar heat can also cover about 10 % of the space heating demand and by its overcapacity of solar input in summertime recover the ground source for the heat pump. A smaller ground source will thus be possible (www.techneco.nl). This combination of technologies demands an advanced control strategy in order to optimise the systems. To obtain adequate maintenance, a monitoring system is installed in combination with the control mechanism. The monitoring system is installed in such a way that the owner of the system can also visualise the performance (SPF) of the heat pump and solar collectors in detail. At the same time, extraction and rejection of geothermal energy via the ground source is measured in such a way to comply with the latest legislation on ground sources.

ECOON

New on the market is the ECOON heat pump, developed for domestic hot water, and connected to a heat distribution or district heating system. The main problem with heat distribution systems for domestic hot water are the high temperatures needed and thus the high heat losses (up to and over 50 %) and the impossibility to use a heat pump as a source for the distribution system. By the possibility of a larger temperature spread (15 – 40 °C) for the source, the ECOON heat pump can be fed directly from a low temperature distribution system, delivering up to 65 °C for the storage tank. The small size of the heat pump makes it perfectly suitable for the renovation of apartment blocks in the public housing sector (www.ecoon.nl).

NRG-Teq

As a new player on the market, NRG-Teq exposed its new range of ground source heat pumps ranging from 5 – 20 kW. The fault-free installation by the installer drew a lot of attention. This installation is made possible by the advanced software, which can control the capacity of the heating system. (www.nrgteq.nl)

Vaillant GEO Hybrid

An example of a European manufacturer who is developing products for the Dutch market is Vaillant. The company presented its GEO Hybrid heat pump, combining an air source or ground source small-capacity heat pump of 4 kW, with a gas boiler in one standard package. This small-sized wall-mounted system is developed for the Dutch renovation market but also applicable to new buildings. The standard package can be installed ‘plug and play’ and can, by means of advanced software, easily be adjusted to the building energy demand. With this remarkable low-cost solution, it can be expected that housing corporations will show much interest.
Teaming up for renewable heating and cooling

The European Technology Platform on Renewable Heating and Cooling (RHC-Platform) and Euroheat & Power, the international association representing the District Heating and Cooling sector in Europe are organizing the 2012 Conference on Renewable Heating and Cooling. This Conference will take place in Copenhagen on 26 – 27 April 2012. Denmark is the perfect host for this high-level conference, as it selected green growth as one of the top priorities of its current EU Presidency.

The event will provide the opportunity for industry executives, leading researchers and senior officials from the EU, national and local administrations to engage in and effective dialogue on the heating and cooling sector. As it is clear that several renewable energy technologies have a huge potential to satisfy heating and cooling demands in the EU, such a dialogue will certainly foster a fruitful debate.

For the registration and the preliminary programme and more information, please visit www.conference2012.eu.

ITHO-Daalderop

The Flat Energy Cube developed by ITHO-Daalderop received the prestigious VSK-Innovation Award. The concept is developed as a ‘plug-and-play’ system in order to renovate apartment blocks and terraced houses, combining a one-box heat pump, a storage tank, CO$_2$-regulated ventilation and heat recovery. A complete metering, monitoring and control system is installed in the box for future carefree operation and maintenance on distance monitoring. This concept is specially developed for housing corporations and retirement homes.

ZEN-Compact

In its latest development, ZEN focuses on something completely different namely low energy and nearly zero energy houses.

DAIKIN

Although not present at the VSK Trade Fair, last year Daikin quietly introduced a collective air source heat pump system for apartment buildings up to 50 m high. The Daikin Altherma MEGA is based upon a central VRF system with individual heat pumps per housing unit. As the heat pump can deliver water temperatures of up to 80 °C without electrical resistance heater, this system is well-fit for renovation projects where high temperature hydronic heating is present. (www.daikineurope.com)

GEA Grenco and IBK

The high temperature industrial heat pump developed by GEA-Grenco in the Netherlands won the prestigious NVKL Cool Award 2012. The GEA Grenco Energy Enhancer is an add-on heat pump, using the condensed heat of 35 °C from industrial cooling or refrigeration for process heating at temperatures of over 80 °C. A recent IEA study on industrial heat pumps under Annex 35 showed an enormous potential for this type of applications. In the Netherlands it is estimated at 20 PJ. The first types of these heat pumps were installed at Robert Wiseman’s Dairy in the UK.

At the same NVKL Award meeting the IBK company received the second prize for a similar development at a slaughterhouse for veal in the Netherlands, as described under the IEA Annex. The third prize was awarded to the Dutch company REDUSES for the development of a gas-driven heat pump (www.reduses.nl). This gas-driven heat pump is especially viable for large housing projects and office buildings in an existing energy infrastructure with a weak electricity grid and little space available for extensive ground sources.

Onno Kleefkens | Agentschap NL
Dr. Paul Rübig is chairman of the EU Integration Committee and Member of the European Parliament, and therefore directly involved in the definition of the European Union’s Energy Strategy.

During his visit of the Energiesparmesse (energy savings fair) Dr. Rübig gave a presentation on the 20-20-20 Renewable Energy Directive and Europe’s Low Carbon Strategy. He stressed the goals and opportunities of the European Union Energy Policy. Regarding this policy, the Energy Efficiency Directive will be an important part in order to reach the overall policy goals.

Increasing efficiency will not only lead to lower energy bills, it will also make the 27 Member States less dependent from energy imports, which still account for 70–80% of the total energy consumption.

The use of renewable ambient heat with heat pumps can play an important role to meet EU Energy Policy Goals. Mr. Karl Ochsner explained that the heat pump technology is not only a technology of renewable energy sources but also an important tool to improve energy efficiency.

**Is there a role for utilities in driving heat pump markets?**

Recent trends indicate a shift in European utility attitudes towards heat pumps. Traditionally utilities have not been deeply involved, but the utility landscape is changing, and the potential value of heat pumps as a tool for managing congestion on the grid, balancing supply and demand, and encouraging customer ‘stickiness’ is driving wider spread and deeper engagement from utilities. This can have a significant impact on end-user confidence in the technology, and be instrumental in expanding heat pump markets.

**Why are utilities becoming increasingly engaged in heat pumps?**

The potential value of heat pumps for utilities – energy retailers, traders and network operators – is increasingly shifting beyond simply an increase in kWh of electricity sold. The growing engagement in the heat pump market by European utilities reflects the recognition that:

- Value can be gained for energy retailers (or even traders) through controlling the operating patterns of heat pumps according to energy prices.
- Further value can be gained for the retailer – heat pumps can encourage ‘customer stickiness’ to the provider (directly where there is an attractive tariff, or indirectly through selling the customer commodities and services as a package with a tariff).
- Value can be gained for the distribution network operators through switching the heat pump on and off in response to congestion on the grid.
- Value can be gained for transmission network operators in controlling the heat pump in response to supply/demand imbalances.

**How are utilities engaging?**

Delta Energy and Environment presents highlights of how European utilities are engaging in heat pumps at different stages of market development. It addresses where there exists a value for them, and how this engagement has, or could trigger heat pump markets:
<table>
<thead>
<tr>
<th>Utility Role</th>
<th>Value for utility</th>
<th>How does it drive the heat pump market?</th>
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</thead>
<tbody>
<tr>
<td>Early Promoter</td>
<td>Value for the retailer: Vattenfall sold heat from their large HPs to customers</td>
<td>Vattenfall was an early pioneer of heat pumps, investing €42 Mio during 1979-1985 to fund over 400 HP demonstration projects – including some very large-scale heat pumps for cities. The backing of a large trusted utility was a ‘tipping point’ for the Swedish market, signalling a turn-around in consumer (&amp; installer) confidence in HP technology.</td>
</tr>
<tr>
<td>Incentivising</td>
<td>Value for the distribution network operator: Swiss DNOs can use heat pumps to manage grid congestion.</td>
<td>In Switzerland, network operators have been controlling heat pumps to avoid congestion in the grid since the early 1990s, an activity which has gone hand-in-hand with the growth of the heat pump market. 80% of the ~900 local network operators in Switzerland now offer a tariff which allows them to control heat pump operating times. In return, the customer receives a significantly cheaper electricity rate, which is typically 20-40% beneath the standard rate - a significant benefit for the customer.</td>
</tr>
</tbody>
</table>
| Facilitating, incentivising & active awareness-raising | Value for the retailer: Selling an energy services package (e.g. the heat meter & HP tariff) encourages customer stickiness
Value for the DNO: Many tariffs enable utility control of the HP (to manage congestion). | RWE and EnBW are engaged in active promotion of heat pumps, which in turn is reducing customer uncertainty and perceived risk. RWE’s ‘online heat pump forum’ is an information portal for end-users, and connects them with installers and heat pump products. EnBW offers an attractive heat pump tariff packaged with a ‘heat meter’ which allows end-users to see real heat pump performance information. Further, EnBW is funding a Fraunhofer ISE heat pump trial whose primary aim is to disseminate information on real heat pump performance to end-users. From the end-user perspective, RWE or EnBW’s engagement gives heat pumps the ‘seal of approval’, and gives confidence in heat pump performance. |
| Active player, selling product and building a supply chain | Value for the retailer: Not only is there value in increasing electricity sales, the engagement of the utilities right down the HP value chain unlocks value in selling & installing HPs, and encourages customer stickiness. | British Gas and EDF Energy are both actively involving themselves in selling & installing heat pumps. British Gas is the UK’s largest boiler installer – it has a history of acting across the whole heating value chain from provision of advice to installation, and tends to acquire rather than outsource skills and expertise in new technologies. BG acquired a heat pump installation company in 2011, ‘buying in’ heat pump expertise, and planning to mobilise and up-skill its large existing boiler installer workforce. EDF Energy has developed high profile relationships with key HP manufacturers (e.g. Daikin), and is building its brand as a ‘green-energy expert’. In contrast to British Gas, EDF Energy does not sell traditional heating products, and is focusing on pushing heat pumps. It is partnering with an installation sub-contractor to deliver its service. |

Lindsay Sugden | Senior Analyst at Delta Energy & Environment
For more information on Delta’s heat pump research, please contact Lindsay at Lindsay.Sugden@delta-ee.com
Country in focus: Austria

Heat pumps as number one heating system in the new building sector

Austrian market for heat pumps shows significant increase of 10 % in 2011

The Austrian market of heat pumps for heating purposes shows a significant increase compared to last year’s (2010) performance. The sales of space heating heat pumps show a substantial growth of 10 % in 2011. In other words, 12,000 space heating heat pumps have been installed in Austria last year.

In some Austrian federal states, the share of heat pumps of installed heat generators amount up to 69 % (Vorarlberg) and 50 % (Upper Austria). Hence, heat pumps are by far the most popular heating system in the field of newly built family houses in Austria. However, on the whole and at present, the total Austrian heating market is still considerably dominated by gas heating systems. This can be seen in Figure 2, where heat pumps can be found in second place of the heating market, followed by pellets, oil and wood log heating systems.

The prices of the mentioned heat sources have dramatically changed. For example, the heating costs for oil increased by 25 % in the heating period 2011 compared to 2010 (comparison November 2011 vs. 2010). The costs for natural gas increased by 13 % and for pellets by 7 %. The Austrian electricity costs remained more or less the same last year. Some electricity providers even reduced their prices by about 2 % in the beginning of 2012.

In total, there are 180,000 heat pumps installed in Austria. When taking a closer look at the different heat sources used by heat pumps, it shows that ambient air as a heat source is steadily gaining more importance. In 2011 air/water heat pumps, accounting for approx. 43 % of the newly installed heat pumps were the most frequently sold heat source – even more than the traditionally well-established brine/water system. The market growth of air/water systems amounts to 22 %. It is a clear proof of the high efficiency and quality of these air/water heat pumps, taking into consideration Austria’s cold and snowy winters.

National regulatory framework responsible for market decline of hot water heat pumps

As it can be seen in the pre-evaluation of the Austrian heat pump statistics, the year 2011 is also characterized by a heavy decline in sales of hot water heat pumps. Hot water heat pumps traditionally play an important role in the Austrian heat pump market because they are an exceptional cost- and eco-efficient solution for the preparation of sanitary hot water. However, as a result of national regulations in the field of the Austrian building subvention, the market for hot water heat pumps decreased by more than 1,200 units in 2011. In terms of percentages, this amounts to a decline of 22 %. In total, 4,200 hot water heat pumps were installed in Austria in 2011. The Austrian building subsidies recently demanded an obligatory combination of heating systems with solar-thermal systems. As a result, hot water heat pumps are heavily disadvantaged in their further market development and discriminated against other technologies.

The Austrian heat pump associations continuously inform opinion leaders, political decision makers and relevant institutions about the advantages and the significance of heat pumps for the environment and about the indispensable claim for an equal treatment of all renewable technologies. Despite these intensive efforts and educational approaches, it was not possible to cause a reorientation of the relevant political institutions. This is all more regrettable in Austria as heat pumps are considered a very “green technology” due to the good Austrian electricity mix. This mix shows a share of 72 % renewable energy. The CO₂ emissions amount to less than 155 g CO₂ per kWh electricity. On the basis of this eco-friendly electricity mix and the high performance figures of heat pumps (SPF), the total emissions of Greenhouse Gases (GHGs) or other air polluting emissions are close to zero.

National regulatory framework responsible for market decline of hot water heat pumps

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Chances and restraints for further development of the Austrian heat pump market

In the EU renewable energy directive, Austria has committed itself to increase the share of renewable energy sources up to 34 % until 2020. This target can be reached by the widespread installation of heat pumps. The heat pump technology can be regarded as a central pillar of the Austrian energy strategy. According to the energy targets of the Austrian environmental ministry, Austria could even reach energy autarky by 2050. In this strategy, heat pumps are again considered as the central solution in the area of space heating. Together with solar...
thermal systems, heat pumps could cover the main part of the heating energy of this sector. (Also see Karl Ochsner: EHPA newsletter Nr. 3 Sep. 2011 Energy revolution 2050 – Strategies from an Austrian perspective).

Concrete programmes for reaching these targets are already being implemented in the Austrian federal states. For example, the action plan “Energieautonomie Vorarlberg” already passed the regional state parliament and includes the following targets concerning heat pumps: The total stock of installed heat pumps should be increased by 50 % until 2020. At the moment, the market share of heat pumps already amounts to 70 % (!) in the federal state of Vorarlberg.

The regulatory frameworks often do not keep up with these visionary strategies that consider heat pumps as central renewable technology for reaching future energy and climate targets. Resulting from this current discriminatory regulatory development, not only subsidies for renewable technologies are reduced or totally cut (this is of course not Austrian-specific) but also laws and directives are adopted that hinder the further development of the heat pump market. One of these restrictions is the already mentioned obligation to combine all heating systems with solar thermal systems. Another constraint is the energy performance certificate for buildings. The energy performance certificate should provide the public with clear and easy-to-understand recommendations, making a comparison of cost-effectiveness and eco-effectiveness of different technologies implemented in buildings possible. The energy performance certificate could be an important tool for demonstrating the effectiveness of heat pumps compared to other technologies. In the new Austrian calculation methods for the energy performance certificate (OIB-Richtlinie 6), heat pumps are again discriminated compared to other technologies. In this calculation method, the Primary Energy Factor (PEF) for the electric power generation input for heat pumps is fixed at 2.62 and the CO₂-factor at 417 g per kWh electricity. Both figures are much too high compared to reality – especially for a country where the main share of electricity is produced by hydropower.

Despite the unjustified downgrading of heat pumps’ performance due to false calculation factors, this technology shows superior values compared to fossil fuels. In order to eliminate future discrimination, the activities of the heat pump associations gain more and more importance. Therefore, the two Austrian heat pump associations are developing strategies to increase the effectiveness of their activities. In one of the next issues of the EHPA newsletter, it will be reported how these strategies will be implemented.

Dr. Gerald Lutz | OCHSNER Wärmepumpen

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**Save the date! EHPA’s 5th European Heat Pump Forum and General Assembly in Milan (7 – 8 May 2012)**

The European Heat Pump Association warmly invites you to its 5th European Heat Pump Forum, which will be held in Milan this year on the 8th of May. Furthermore, it also kindly invites its members to the General Assembly that takes place on the same location one day before (7th of May)

**Tuesday | 8.5.2012 | 09:00 to 16:30 | 5th EHPA European Heat Pump Forum**

On May 8th, the EHPA organizes its 5th European Heat Pump Forum. This high level conference will focus on the European Heat Pump Market with a special angle on implementation of EU legislation in one of the growing heat pump markets with heating and cooling requirements alike: Italy. Furthermore, the development of the heat pump market in general and the heat pump technology will be largely debated. Keynote speakers from stakeholder organisations, industries and European institutions will lead the discussions. Please find the program on the next page.

**Location:** Palazzo Stelline, corso Magenta 61, Milano, Italy

The venue is easily reachable from Milano Malpensa Airport via rail (Malpensa Express to Cadorna station) or by taxi.

**Registration to the conference can be done via the form on our website:** www.ehpa.org/milano

The conference fee for EHPA members is 90 Euro + VAT, for non-EHPA members is 350 Euro + VAT.

Payment terms: www.ehpa.org/milano

**Monday | 7.5.2012 | 13:00 to 18:00 | EHPA General Assembly**

The European Heat Pump Association will hold its 2012 General Assembly on 7.5.2012 from 13:00 to 18:00 (for EHPA members only).

**Location:** Palazzo Stelline, corso Magenta 61, Milano, Italy

The venue is easily reachable from Milano Malpensa Airport via rail (Malpensa Express to Cadorna station) or by taxi.
## 5th EHPA European Heat Pump Forum Program

<table>
<thead>
<tr>
<th>Time</th>
<th>Session</th>
<th>Chair/Preparer</th>
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<tbody>
<tr>
<td>8:30</td>
<td>Welcome coffee &amp; registration</td>
<td></td>
</tr>
<tr>
<td>9:00</td>
<td>Opening of the conference</td>
<td>Karl Ochsner</td>
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<tr>
<td>9:15</td>
<td>Welcome to Italy – Welcome to Milan</td>
<td>Bruno Bello</td>
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### TRACK 1 | Heat pump market development

<table>
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<tr>
<th>Time</th>
<th>Session</th>
<th>Chair/Preparer</th>
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</thead>
<tbody>
<tr>
<td>9:30</td>
<td>Heating and cooling with heat pumps – contribution to national targets</td>
<td>Walter Grattieri</td>
</tr>
<tr>
<td>9:45</td>
<td>HVAC 2030 – the future of the European heating market</td>
<td>Krystyna Dawson</td>
</tr>
<tr>
<td>10:00</td>
<td>The Italian market – heat pumps in the Mediterranean</td>
<td>Carmine Casale</td>
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<tr>
<td>10:30</td>
<td>Questions &amp; Answers</td>
<td></td>
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<tr>
<td>10:50</td>
<td>Coffee break</td>
<td></td>
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</tbody>
</table>

### TRACK 2 | Implementing European legislation

<table>
<thead>
<tr>
<th>Time</th>
<th>Session</th>
<th>Chair/Preparer</th>
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<tbody>
<tr>
<td>11:20</td>
<td>Energy-related Products Directive: review and outlook</td>
<td>Els Baert</td>
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<tr>
<td>11:35</td>
<td>Energy Efficiency Directive: heat pumps’ contribution to mandatory targets</td>
<td>Martin Forsén</td>
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<tr>
<td>11:50</td>
<td>The future of F-gas use in Europe</td>
<td>Andrea Voigt</td>
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<tr>
<td>12:05</td>
<td>Energy of buildings: a Mediterranean perspective</td>
<td>Livio Mazzarella</td>
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<tr>
<td>12:20</td>
<td>Questions &amp; Answers</td>
<td></td>
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<tr>
<td>12:40</td>
<td>Lunch</td>
<td></td>
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### TRACK 3 | Conditions of efficient heat pump use

<table>
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<tr>
<th>Time</th>
<th>Session</th>
<th>Chair/Preparer</th>
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<tbody>
<tr>
<td>14:10</td>
<td>Are we doing enough? The need for stronger government action to avoid irreversible climate change</td>
<td>Monica Axell</td>
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<tr>
<td>14:25</td>
<td>Potential to the market – How to educate the workforce?</td>
<td>Anna Moreno</td>
</tr>
<tr>
<td>14:40</td>
<td>Heat pumps from the perspective of an Italian NGO</td>
<td>Andrea Molocchi</td>
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<tr>
<td>14:55</td>
<td>Best practice in successfully building heat pump markets</td>
<td>Peter Murphy</td>
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<tr>
<td>15:10</td>
<td>Questions &amp; Answers</td>
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<tr>
<td>15:30</td>
<td>Coffee break</td>
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### TRACK 4 | Technology developments

<table>
<thead>
<tr>
<th>Time</th>
<th>Session</th>
<th>Chair/Preparer</th>
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<tbody>
<tr>
<td>16:00</td>
<td>System design for large heating/cooling heat pumps</td>
<td>Claudio Carano</td>
</tr>
<tr>
<td>16:15</td>
<td>‘Smart’ controllable heat pumps: requirements to technology and benefits</td>
<td>Lindsay Sudgen</td>
</tr>
<tr>
<td>16:30</td>
<td>Towards 100 % renewable energy: integration of heat pump technology and photovoltaics</td>
<td>Andreas Bangheri</td>
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<tr>
<td>16:45</td>
<td>Opening up the renovation market segment – using thermally driven heat pumps</td>
<td>Luigi Tischer</td>
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<tr>
<td>17:00</td>
<td>Questions &amp; Answers</td>
<td></td>
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<tr>
<td>17:20</td>
<td>Closing remarks</td>
<td>Martin Forsén</td>
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<tr>
<td>17:30</td>
<td>End of conference</td>
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For more information, please visit our website: www.ehpa.org/milano
International Geothermal Center

A new Education, Research and Testing Facility for Heat Pump and Geothermal Technology at the International Geothermal Center in Bochum, Germany »under the microscope«

The International Geothermal Center (GZB), located in Bochum, Germany, is a globally networked center of excellence with incorporated competences from science and industry and a close involvement of administration and politics.

The 15 associated universities and public institutional members come from European and overseas countries: RWTH Aachen University, Bochum University, University of Westfalia, OWL-University of Applied Sciences, Technical University Darmstadt (all Germany), Technical University of Istanbul (Turkey), Aristotle University of Thessaloniki (Greece), Technical University Federico Santa Maria (Chile), Universidad de Chile (Chile), University of Zagreb (Croatia) and the University of Auckland (New Zealand). Further members are Governmental Organisations for mining and energy, the City of Bochum, the Energy Agency NRW and the Chamber of Commerce and Industry of the Central Ruhr Area. The organisation is open to new members from the scientific or educational sector.

The Center is administrated by the Bochum University AS. It is hosting the International Geothermal Association (IGA), consisting of 6,000 members from 70 countries and the International Office of the German Geothermal Association (GtV-BV).

With 13 Mio EUR of EU- and NRW-State fundings, university investments and industry sponsoring, GZB is now constructing one of the largest education and testing laboratories for Heat Pump and Geothermal Technologies in Europe. The new facility is going to start its operational work in September 2012.

Four main R&D units will be available for the members and partners of academies and industry.

The Energeticum comprising a Heat Pump Test and Demo Lab for Heating and Cooling Technologies and for the Implementation of further energy sources within the system. This building is entirely sensor-equipped and will be used for building climatisation technology development and -control. It is directly linked to a 10,000 m² in-situ Lab / Test field for ground-coupled heat exchangers. With GZB-owned drilling technology, new applications for subsurface heat extraction and storage may be implemented and tested under real life conditions. The 40 t pulling capacity rig is able to drill down to 1000 – 2000 m, depending on the diameter of the requested wells.

The GeoTechnicum Building as a large-scale lab with mechanical and electronic workshops for prototype development of Heat Pump-, Power Plant- and Drilling-Technology and -parts.

The Institute Building itself will be used for education purposes; lecture rooms and laboratories are open for the industry and for university courses. These courses are offered as summer schools and M.Sc. programs on geothermal energy systems and are going to start in October 2012. They are prepared and offered in cooperation with the education centers of the construction and building service industry. Besides these education topics, scientists and developers from universities and companies will have the possibility to work on joint projects under one roof.

With this broad base the GZB serves the general and educated public as a competence and information center for all subjects related to the utilisation and extraction of geothermal energy on a global scale.

Prof. Dr. Rolf Bracke | Hochschule Bochum

For further information please visit: www.geothermal-center.eu
How to determine the Seasonal Performance Factor (SPF) for the calculation of Renewable Energy Sources? – A SEPEMO project perspective

1. Introduction
The RES Directive (2009/28/EU) sets out measures and regulations concerning the use of renewable energy sources, including those used by heat pumps. Art. 2 of this Directive defines ‘renewable energy sources’ (RES), while article 5, in combination with Annex VII, describes how to calculate the share of energy from renewable sources, delivered by heat pumps. According to the Directive, the Commission is obliged to define a calculation method on how to estimate the renewable energy provided by heat pumps as well as guidelines on how the Member States (MS) are to perform data collection on renewable energy. In order to monitor renewable energy targets at EU and MS level, statistics on the contribution of renewable energy from heat pumps must be made available. DG TREN requested EUROSTAT to develop the statistical system that will allow the identification of the contribution of heat pumps to the RES targets. This includes the preparation of guidelines on how MS will estimate the Qusable and the SPF. EUROSTAT requested input from the involved industry associations - including the EHPA - on the calculation procedure to properly record the renewables share of heat pumps in energy statistics.

2. Problem definition
How to determine the Seasonal Performance Factor (SPF) for the calculation of Renewable Energy Sources? – A SEPEMO project perspective

(1)  SPF = useful energy/ energy input

putting the total energy production (heating and cooling) in relation to the total energy input. As heat pumps always produce heating and cooling at the same time, their efficiency is particularly high, when both services are needed at the same time. While the RES Directive generally covers the use of renewable energy for heating and cooling (Article 5 §1b), it only covers produced heat from heat pumps (cf. Art. 5(4): “aerothermal, geothermal and hydrothermal heat energy […] shall be taken into account”). Thus, a calculation method is only presented for the determination of heat pumps RES share in heating mode (Annex VII):

(2)  \[ E_{RES} = Q_{usable} \times (1/1-SPF) \]

(3)  where only heat pumps with SPF > 1,15 * 1/π (eta) shall be taken into account.

The IEE SEPEMO project provides a holistic approach by determining the boundary conditions for the RES calculation in heating and cooling mode (see deliverables D2.4 and D3.4 on www.sepemo.eu/deliverables). This article addresses the issues that arise from the use of the rather undefined variables in the RES directive’s calculation formula and it presents one possible approach to determine the RES contribution from heat pumps on the EU-27 level.

3. How to determine the «missing» variables Qusable and SPF?
The RES Directive did define neither the SPF nor the Qusable which lead some Member States to the conclusion that the share of RES cannot be calculated until the European Commission and/or EUROSTAT come up with suggestions on which values to use.

While it is rather simple to determine the energy demand of an individual building as well as the efficiency of a heat pump installed (see paragraph 2), resulting data cannot simply be applied to the installed heat pump stock on MS or EU level. Unfortunately no quick and easy solution exists to overcome this issue, as data on the energy demand in the building stock as well as on the performance of heat generators used – including heat pumps – is poor. Most Member States’ statistics on the building stock are not detailed enough for this purpose and if energy statistics include heat pumps, efficiency is usually not documented.

In order to present a useful yet simple method on how to proceed, industry has proposed a first solution based on available data.

The useful thermal energy (Qusable | «heat») provided to buildings is determined by using
• the number of installed HP units per energy source (as documented in the EHPA heat pump statistics),
• an estimated average installed capacity per energy source (agreed upon by industry experts from the three climate zones), and
• the average operating hours (Qusablefactor), again agreed upon by industry experts.

With regard to the seasonal efficiency, the situation is more complex, as available approaches have different targets and choose different system boundaries. In general, seasonal efficiency can be measured in the real installation, or it can be calculated based on a variety of data, including lab-tested performance for the individual unit/type. Independent of the approach, the basic procedure always remains the same as outlined in formula (i). However, depending on the system boundaries, more or less components are included in the calculation/measurement. Even though the difference in results will most likely be marginal, this is important to keep in mind when deciding which value to apply to the existing and future stock of heat pumps.

Table 1 shows a comparison of approaches to determine the seasonal performance of heat pump units. SPFHH-H4 applies to field measurements of system performance in real installations and the system boundaries chosen to determine the impact of...
system components on efficiency. EN 14511:2011, EN 16147:2012 and EN 14825:2012 apply to lab measurements of the heat pump unit performance under fixed conditions. EN 14511 is used for fixed speed, electric compression heat pumps. It is enhanced by part load conditions and climate data through EN 14825:2012. EN 15316 is used to calculate the efficiency of the whole building. While these approaches are calculating the efficiency of the whole system and its precision is deemed sufficiently close to real life data to justify its use. Using this approach is resulting in a sufficient approximation to reality. However it is not complete: There are heat pump types not covered by these standards, namely hybrids and large units. More work is necessary to fine-tune and extend the coverage of existing standards towards a more complete approach. Field surveys – based on a standard measurement approach and agreed upon system boundaries – will be necessary to support this work.

In conclusion, the SPF in the context of the RES Directive should be understood as the SCOPnet according to EN14825 for the provision of heating and the unit COP according to EN 16147 for the provision of domestic hot water. They can be applied to calculate the renewables share based on the measured unit performance and climate data input/tapping cycle, thereby ignoring the multitude of other influencing factors from user behavior to the building envelope. Data is available immediately and its precision is deemed sufficiently close to real life data to justify its use.

**4. Proposed solution & conclusion**

For the purpose of this Directive a compromise is necessary between applicability and accuracy. There are several options available:

1) **Field surveys**: Measuring a (large) number of installations could be done based on the SEPEMO methodology. They are however time-consuming and costly.

2) A combination of measurements and calculation: This approach is used in the EuP methodology for boilers, hot water production units and air conditioning units. It allows for comparison, yet it is based on primary energy and as such not usable for estimating the RES contribution.

3) **Unit performance measured according to standards**: For heat pumps, these standards are available to measure unit performance under lab conditions: EN 14511 and EN 15879 (heating mode), EN 16147 (domestic hot water production: based on a defined tapping cycle), EN 13209 (gas absorption units).

4) **Calculated seasonal efficiency based on test data**: EN14825 provides an Annex for the calculation of the Seasonal Coefficient of Performance (SCOPnet), based final energy and different climates, also integrating part load operation. It can be applied on existing measurement data.

In conclusion, the SPF in the context of the RES Directive should be understood as the SCOPnet according to EN14825 for the provision of heating and the unit COP according to EN 16147 for the provision of domestic hot water. They can be applied to calculate the renewables share based on the measured unit performance and climate data input/tapping cycle, thereby ignoring the multitude of other influencing factors from user behavior to the building envelope. Data is available immediately and its precision is deemed sufficiently close to real life data to justify its use. Using this approach is resulting in a sufficient approximation to reality. However it is not complete: There are heat pump types not covered by these standards, namely hybrids and large units. More work is necessary to fine-tune and extend the coverage of existing standards towards a more complete approach. Field surveys – based on a standard measurement approach and agreed upon system boundaries – will be necessary to support this work.

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