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Federation of European Heating, Ventilation and Air Conditioning Associations

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Regulations for buildings, products and procedures are needed to reach EU 20-20-20 target

- An interview with **Mr. PAUL HODSON** of the European Commission

Theme of the issue:

Heat Pump Market and Technology

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General Executive: Süleyman Bulak

Editor-in-chief: Olli Seppänen
E-mail: oseppanen@rehva.eu

Associate Editor: Stefano Corgnati, Italy
E-mail: stefano.corgnati@polito.it

Editorial Assistant: Cynthia Despradel

Guest Editor: Prof. Michael Schmidt
E-mail: michael.schmidt@ige.uni-stuttgart.de

ADVERTISEMENTS
Ms Cynthia Despradel
E-mail: cd@rehva.eu

SUBSCRIPTIONS and CHANGES OF ADDRESSES
REHVA OFFICE:
Washington Street 40
1050 Brussels, Belgium
Tel: 32-2-5141171, Fax: 32-2-5129062
www.rehva.eu – E-mail: info@rehva.eu

PUBLISHER
Sektorel Fuarcılık A.Ş (Inc.)
Balmumcu, Barbaros Bulvarı,
Bahar Sok, Karanfil Ap.
Beşiktaş İstanbul Türkiye
Tel: 90-212-2758359
Fax: 90-212-2749273
www. teknikyayincilik.com

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Guest Editor: Professor Dr. **Maria Todorovic** from University of Belgrade. Email: deresmt@eunet.rs

Heat pumps
– one of the key solutions for the heat supply

Michael Schmidt
professor, President of REHVA

The building sector, i.e. the operation of our buildings, is still the biggest consumer sector for energy in Europe. With a share of 40% of the total energy consumption it is much bigger than that for all kinds of transportation and all industrial manufacturing.

The building sector is dominated by existing buildings. The yearly volume of new buildings is less than 1% of the volume of existing buildings. It is an undisputed goal for Europe to drastically reduce the total energy consumption and to increase the share of renewable energy. If we all together want to achieve these goals, we have to take the necessary steps in the building sector and we have to take them primarily on the existing buildings. This will result in a huge volume of refurbishment projects. In the end we are heading for "nearly Zero Energy Buildings", the so called nZEB`s. Refurbishments down to that level need concepts for the building itself, i.e. the insulation and the tightness, and for the building services systems, i.e. for the heating, cooling and ventilation. The optimal solution for each building will need a case by case development of the appropriate concept. A lot of different solutions are possible, a lot of different components are and will be available.

Heat pumps are a very promising component for the heat supply. They offer the chance to reduce the demand for final energy. The achievable seasonal coefficient of performance (SCOP) is the determining factor. It is not only depending on the temperature levels on the heat source side and on the thermal system side, but on construction and running parameters of the heat pump itself. On the heat source side we discuss different sources such as outside air, what has the advantage of being available everywhere but the disadvantage of low temperatures in winter. This then makes combinations with solar energy interesting. On the heat pump itself, developments of capacity controlled compressors are very promising to improve the SCOP. All these new heat pump concepts need appropriate and agreed testing procedures. With those it will be possible to identify the energetic advantages. This is very important in view of necessary design data and furthermore in view of trustful performance data, what is vital for consumer information's in the market.

We in REHVA have no doubt that, from the engineering point of view, all the above mentioned goals can be achieved. The necessary know how is available from the European engineers. 3E

The Commission plans to expand Ecodesign regulations also to new HVAC products

European Commission, Directorate-General for Energy has launched an open call for tenders on 25/08/2012, with subject framework contracts for the provision of preparatory studies, review studies and technical assistance – call no. 2012/S 163-270653.

The framework contract is divided into three lots. The first one deals with preparatory studies and related technical assistance on specific product groups listed in the Ecodesign working plans adopted under the Ecodesign Directive. The following products are mentioned in the call, as priority product groups listed in the second and subsequent Ecodesign working plans, such as, but not limited to:

- window products,
- steam boilers (< 50 MW),
- power cables,
- enterprises' servers, storage and ancillary equipment,
- smart appliances/meters,
- wine storage appliances (c.f. Ecodesign Regulation 643/2009).
- positive displacement pumps,
- fractional horsepower motors under 200 W,
- heating controls,
- lighting controls/systems,
- thermal insulation products for buildings,
- power-generating equipment.

The tenders or requests to participate must be sent by 31.10.2012 and must meet the formal requirements described in the call text. This means that the studies may start early next year. The maximum duration of the contracts based on the tenders is four years, but as the earlier studies have typically been completed within two years from the start, this will mean that the preparation of EU regulations could start in early 2015, so the first regulations based on the new studies may enter into force in the beginning of 2017.

The call text and other relevant information can be found at http://ted.europa.eu/udl?uri=TED:NOTICE:270653-2012:TEXT:EN:HTML. This information contains a lot of legal and administrative information, but gives also a clear indication about the approaching activities important especially to product manufacturers. It also includes a list of high priority product families subject to preparatory Ecodesign studies. These studies may already within three-four years result in obligatory requirements for products included in the studies.

JR

Ecodesign – Lot 20 "Local room heating products", final report is now available at www.ecoheater.org

The study defined the local room heating products as de-centralised space heating stand alone devices that convert electricity, gaseous or liquid fuels directly into heat and then distribute it to provide heat indoors. These devices can be portable or installed in the building.

"The study showed that there was scope to set Minimum Energy Performance Standards (MEPS) for residential gas/liquid fuel flued heater/fires, and non-residential warm air and radiant heaters. Most of the design improvements for electric heaters for residential use are related to controls (often the extended product) and not the product itself as the Joule effect is almost 100% efficient. Scenarios representing the implementation of policy recommendation (BC 1, BC 2, BC 7, BC 8a and BC 8b), least life cycle costs (LLCC) and Best-Available-Technologies (BAT) in the EU were projected over the period 2011-2035 to quantify the improvements that can be achieved with respect to the 'BAU' and 'Pragmatic BaU' scenarios. As non-residential heating products require professional engineers and technicians to dimension and design the systems, relevant product information requirements were thought to be more effective than simplified energy labels. Two approaches were proposed for a combined energy label for all the residential heaters using different energy sources."

The extract from the conclusions of the report:
– Preparatory Studies for Ecodesign Requirements of EuPs (III)
– ENER Lot 20 – Local Room Heating Products
– Task 8: Scenario, policy, impact and sensitivity analysis

Mr. **Shailendra Mudgal**, Dr. **Adrian Tan**,
Mr. **Sandeep Pahal**, Mr. **Alvaro de Prado Trigo**,
BIO Intelligence Service

Aqua – Therm Moscow 2013 is your gateway to the Russian HVAC&pool market!

XVII International exhibition for heating, water supply, sanitary equipment, air conditioning, ventilation and pools, organized by Reed Exhibitions and ITE. It will take place on February 5 – 8, 2013 at Crocus Expo.

Aqua – Therm Moscow is the leading event in Russia in the industry of heating, water supply, sanitary technologies, air conditioning, ventilation and the equipment for pools, saunas and spa. With total space of 31 000 sqm Aqua – Therm Moscow 2012 brought together more than 570 exhibitors from 30 countries. The exhibition carries out special projects highlighting the profile sectors of the exposition.

'NEW ENERGY' is a project devoted to energy-saving technologies and production solutions that are based on non-conventional renewable energy sources, designed for companies that are using innovative energy-saving and energy-efficient systems and making efforts to meet strict international requirements for environmental safety.

'*Climate Control Equipment and Technologies'* sector is called to unite all professionals who offer solutions in field of stationary and portable climate regulation for open and closed spaces.

Dedicated section '*World of Water and Spa'* is giving opportunity to all companies, which are in pool and pool equipment industry, to mark out their achievements and to take part in national competition for the best swimming pool – The Pool of the Year holding in frames of the exhibition Aqua-Therm Moscow.

Aqua – Therm Moscow is the key business platform for demonstration of the latest industry novelties of international and Russian manufacturers. Participants of the show will represent a wide spectrum of products and technologies.

The list of exhibitors 2013 is available on official web-site: http://www.aquatherm-moscow.ru/en

KGH – The 43rd International HVAC&R Congress and exhibition

Belgrade, 5 – 7 December 2012

This year's, the 43rd international congress is dedicated to the current topics from broad HVAC&R field, primarily focusing on buildings as main energy consumers and the use of renewable sources and the most up-to-date products used wish is to promote the exchange of information on new building materials that affect the building energy demands as well to present the most up-to-date building structures and their architectural designs in compliance with thermal performance, which are the preconditions for energy efficient behaviour of buildings. The topics include refrigerants which substitute conventional ones that are being phased out due to their environmental impact. The district heating and cooling systems remain the inevitable topic of this gathering of HVAC&R professionals.

The second congress day dedicated to the student program, which has already become traditional and is intended for students and the youngest generation of those who select to engage in HVAC&R profession as well as in other specialties directly associated with HVAC&R systems in buildings. The topics of student papers include the general HVAC&R topics as well as the topics suggested in this announcement. Among the papers to be presented in the congress, the best ones will be selected to be published in the journal and to be presented at international student conferences and meetings.

For more information, please visit www.kgh-kongres.org/kongres/

Thomas E. Watson P.E., Fellow Life Member, ASHRAE president 2012-13.
Chief engineer, Daikin McQuay, Staunton, Va. Bachelor of Science in mechanical engineering from Virginia Tech in 1966 and a Master of Science in mechanical engineering from West Virginia University in 1969. His past service with ASHRAE includes chair, Members Council and Technology Council, President-Elect Advisory Committee, the Strategies for a Global Environment Ad Hoc Committee and the Advocacy Committee; and vice chair of the Vision 2020 Ad Hoc Committee. He also served as a member of the Advanced Energy Design Guide Steering Committee.

Broadening ASHRAE´s Horizons
– *the presidential theme for 2012-13*

Thomas E. Watson was installed as president of ASHRAE for 2012-13. His presidential theme is *Broadening ASHRAE's Horizons*, which emphasizes the role of ASHRAE members as leaders in the application of sustainable design and practices in our communities worldwide.

In his Presidential address during the annual meeting, Mr. Watson explains what he means with his theme:

- You cannot separate the technology and the applications of technology from the people of ASHRAE and their communities. So many members serving on technical committees and on standards committees have developed the technology of our industry through the years. Now we must broaden its application as we strive to serve additional communities.

Our technology needs to consider many issues: climate, culture, how people think about air conditioning, how they use it, and the economic environment. In my hometown, and in every one of your communities, there are economic issues. We need to consider our resources, the technical education of the people, and the infrastructure available to us.

When it comes to technology, we need to keep the users in mind. We need to keep it simple. Do we really need those latest technologies in all cases? Do we need super-sophisticated solutions? Do we need complicated buildings? We need to focus on impact, making sure the advanced technology is used throughout the life of the building, not just installed as showpiece to win an award, then not used. We need to have buildings that remain viable for years to come. We need to use innovation that works. An important issue for our industry is providing simple, affordable solutions. We need to use global expertise to meet local needs. 3E

EU uses the "Low energy buildings" to push construction sector back to growth

Construction is a crucial sector for the European economy, generating almost 10% of EU GDP and providing 20 million jobs, mainly in micro and small enterprises. Competitiveness in the construction sector can significantly influence the development of the overall economy. Buildings' energy performance and resource efficiency in manufacturing, transport and the use of products to construct buildings and infrastructures have an important impact on Europeans' quality of life. The competitiveness of construction companies is therefore an important issue, not only for growth and employment in general but also to ensure the sector's sustainability.

Low energy buildings with high CO_2 and energy cost saving potential still have a limited market uptake, despite their economic and environmental advantages. Construction comprises of more than 10% of total employment in the EU. Therefore, to promote the construction sector as a driving force in the creation of jobs and for sustained growth for the economy in general, the European Commission tabled July 31 st a strategy to boost the sector. Its main lines include stimulating favorable investment conditions, in particular in the renovation and maintenance of buildings, including:

- encourage the take up of the package of up to €120 billion in loans available from the European Investment Bank (EIB) as part of June's *Pact for Growth and Employment*
- boost innovation and improve worker's qualifications by promoting mobility
- improve resource efficiency, by promoting mutual recognition of sustainable construction systems in the EU
- provide standard design codes of practice to construction companies making it easier for them to work in other Member States
- foster the global position of European construction enterprises to stimulate good performances and sustainable standards in third countries.

See the whole document "**Strategy for the sustainable competitiveness of the construction sector and its enterprises**" at http://ec.europa.eu/enterprise/newsroom/cf/_getdocument.cfm?doc_id=7616

Increasing research on Zero Energy Buildings

Nearly zero-energy buildings are required by the Energy Performance Buildings Directive (2010). Article 9 states that Member States shall ensure that after the end of 2020, all new buildings are nearly zero- energy buildings; and after the end of 2018, new buildings occupied and owned by public authorities are nearly zero-energy buildings. This requirement has created lot of activities in research and development in Europe. The trend towards zero energy building is worldwide. REHVA Journal has collected some information of the research units which are specially focusing on zero energy buildings – **READ THE ARTICLE AT:** **www.rehva.eu/en/rehva-european-hvac-journal**

The European Commission has also contracted a consortium (Ecofys, Politecnico di Milano and University of Wuppertal, with various national subcontractors) to define common principles for nearly-zero energy buildings under the EPBD. See more info in the next issue in December.

Indoor climate in low energy buildings – main topic in Healthy Buildings Conference 2012

The Healthy Buildings 2012 conference 8–12 July 2012 in Brisbane, Australia (www.hb2012.org) attracted 680 participants from 43 countries, with the largest delegations (apart from the host country – Australia), from China, Korea, Japan and USA. Healthy Buildings and Indoor Air are the flagship conferences of the International Society of Indoor Air Quality and Climate – ISIAQ. Professor **Jarek Kurnitski**, a member of REHVA Board of Directors attended the conference and highlights some of the results of the Conference focusing on Indoor Air Quality and Climate in low energy buildings in his summary of the conference – **READ THE SUMMARY AT:** **www.rehva.eu/en/rehva-european-hvac-journal**

Energy Efficiency Directive adopted

The European Parliament adopted the compromised Energy Efficiency Directive on September 11th with 632 votes. The previous issue of REHVA Journal summarizes the main requirements of the Directive – **READ THE DETAILS AT:** **http://ec.europa.eu/energy/efficiency/eed/eed_en.htm**

The Municipal House where the Farewell Congress Night-Out – dinner will take place.

High number of submitted abstracts to REHVA CLIMA 2013 Congress predicts a great success

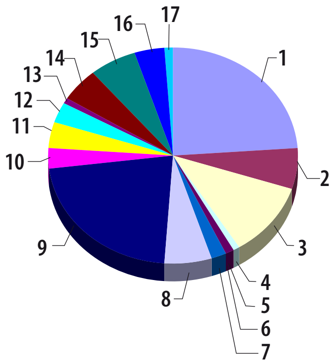
In June 2013, Prague will host one of the most significant professional events of the year focused on heating, ventilation and air conditioning in buildings – the REHVA Congress CLIMA 2013. The Congress will be the 11th REHVA international Congress in a row and, integrating also in the programme the IAQVEC, the 8th Conference on Indoor Air Quality, Ventilation and Energy Conservation in Buildings. Professor Karel Kabele, the president of the Clima 2013 Congress is glad to announce that "*more than 850 experts from 60 countries submitted their abstracts for presentations at the conference with theme, Energy Efficient, Smart and Healthy Buildings*".

The Clima 2013 conference will have a significant participation outside Europe, especially from Japan and USA as the distribution of abstracts indicates.

The CLIMA2013 puts a great emphasis on contributions that will address those skilled in this art. Therefore, the Congress Programme includes presentations of contributions, posters, workshops, as well as an additional expert lessons such as the ASHRAE Course entitled "*High Performance Building Design: Applications and Future Trends*", for example.

The Topic distribution of abstracts on 21.07.2012 (total of 928 abstracts).

1. Energy Efficient Heating, Cooling and Ventilation of Buildings, 24%
2. Renewable and High Efficient Energy Sources, 6%
3. Advanced Heating, Cooling, Ventilation and Air Conditioning Systems for Buildings, 11%
4. Energy Efficient Domestic Hot Water Supply Systems, 1%
5. Sanitary Systems - Hygiene of Domestic Water Supply Systems, Efficient Use of Potable Water, Environmental Friendly Sewage Disposal, 1%
6. Advanced Technologies for Building Acoustics, 0%
7. Artificial and Day Lighting, 2%
8. Technologies for Intelligent Buildings, 6%
9. Quality of Indoor Environment, 22%
10. Building Certification Schemes, 3%
11. Integrated Building Design, 4%
12. Commissioning and Facility Management, 3%
13. HVAC Best Practise Examples, 1%
14. Directive on Energy Performance of Buildings Implementation, 5%
15. Zero Energy Buildings, 6%
16. HVAC in Historical Buildings, 4%
17. Fire Safety of the Buildings, 1%



The International Scientific Committee consisting of more than 100 leading experts of all continents guarantee a high professional level of the programme. At this moment, the interest of the industry shows that the capacity of the 20 REHVA workshops, ie. expert lessons organised by our industrial partners within the framework of the Congress CLIMA 2013, as well as within the framework of the REHVA projects (Task Force) have been almost used up, which workshops were primarily aimed at solutions of up-to-date issues of the implementation of the EU Directive on the Energy Performance of Buildings and associated problems in the technological development. A special theme connected with historical traditions of Prague deals with problems of historical buildings, which should be pointed out certainly.

Reputed keynote speakers invited from the expert community recognised worldwide will open each of four Congress days. The Congress will be held under a patronage of important industry partners, as well social organisations and in co-operation with partners that represent the top in this art. Among REHVA CLIMA2013 Congress partners can be mentioned, for example, the ASHRAE - a professional organisation with 118 years history associating 50 000 professionals worldwide, the SHASE – a Japanese organisation with more than 80 years tradition and more than 20 000 members and the ISHRAE, professional partner from India, as well as the IIR, AIVC, AHRI and a number of other professional organisations.

Register now at www.clima2013.org

International Society of Indoor Air Quality and Climate (ISIAQ) elected new president

Dr Pawel Wargocki, Technical University of Denmark, President of International Society of Indoor Air Quality and Climate for 2012-2014.

ISIAQ elected new president for the next two year term in its annual meeting during the Healthy Buildings Conference in Brisbane, Australia. ISIAQ is an international, independent, multidisciplinary, scientific, non-profit organization whose purpose is to support the creation of healthy, comfortable and productive indoor environments. ISIAQ is the publisher of International Indoor Air Journal, the authority of the indoor air sciences. Its major conferences Healthy Buildings and Indoor Air attract about thousand experts from all over the world. Some highlights of the Healthy Buildings 2012 Conference are presented in this and the future issues of the REHVA journal.

REHVA journal had an opportunity to have the new president of ISIAQ respond to some important questions on the future developments of indoor air technology and sciences.

What are the biggest challenges for indoor air research?

- There are certainly many challenges but let me name few. We should much better acknowledge the interactions between different parameters indoors and interaction with outdoor environment as well as differences in the requirements regarding IEQ between people. So far most of the research has mainly been focused on the impact of single parameters on humans but we are constantly exposed to influences from different factors, rarely or never from the single factor. As for the latter we should make our buildings more flexible so that we can much better control the environment and alter it so our needs are met. Individual/personal control of IEQ and inclusions of behavioral aspects and adaptation in the design are probably the way forward.

ISIAQ in short

Mission of ISIAQ

ISIAQ is an international, independent, multidisciplinary, scientific, non-profit organization whose purpose is to support the creation of healthy, comfortable and productive indoor environments. This is achievable by advancing the science and technology of indoor air quality and climate as it relates to indoor environmental design, construction, operation and maintenance, air quality measurement and health sciences. To make this vision real ISIAQ creates a meeting point for disciplines involved in indoor air sciences and practice from medicine to engineering. This is accomplished by supporting the international Indoor Air and Healthy Buildings conferences, by promoting scientific development and practical applications through Scientific and Technical Committees, by disseminating knowledge through the Indoor Air journal, the Newsletter and the homepage of ISIAQ, by communicating and outreach through specific courses, internet based lectures on practical and scientific issues.

Future conferences

Already next year ISIAQ will take very active role in disseminating science through scientific conferences and meetings. In June 2013 in Basel ISIAQ together with two societies dealing with exposure analysis, ISEE (International Society for Environmental Epidemiology) and ISES (International Society of Exposure Science) will co-organize the congress on Environment and Health – Bridging South, North, East and West in Basel. In October 2013 ISIAQ will co-sponsor ASHRAE's IAQ 2013 congress on Environmental Health in Low Energy Buildings organized in Vancouver, Canada. ISIAQ will of course as usual also be present at CLIMA 2013 congress in Prague organized by REHVA. The next ISIAQ's flagship congress Indoor Air will be held in July of 2014 in Hong Kong (www.indoorair2014.org) while another flagship congress Healthy Buildings in 2015. The host for Healthy Buildings 2015 is yet unknown and ISIAQ is looking for the potential organizers of this event; the Call for Letters of Interests is due February 1, 2013 and can be found on ISIAQ's webpage.

Membership in ISAQ

ISIAQ Members receive discount on registration for the events co-organized and co-sponsored by the Society, and all who join the ISIAQ flagship congresses become members of ISIAQ and can enjoy members' benefits. These benefits among others include receiving Indoor Air journal as well as access to previous publications and reports which are also available on-line in the electronic form on ISIAQ's webpage. The Members can also actively participate in the Scientific and Technical Committees which work on essential scientific and practical topics relevant to indoor air sciences with objective to develop tutorials and guidelines, and even future policy papers. More on how one can become member of ISIAQ can be found on the Society's webpage.

Board of directors

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More information concerning ISIAQ can be found at www.isiaq.org

What are the biggest risks in the indoor environment of European buildings?

- I feel that the biggest risk is that too much emphasis is placed on energy especially in the so called low energy buildings, zero energy buildings or green buildings. We see for example that building certification schemes do not award many credits for high IEQ; they can be traded for credits in other categories not related to indoor environment and still the buildings can receive the top certificate. Sometimes I feel that in the quest for the most efficient building technologies that use as little energy as possible we simply forget that the buildings are not constructed to save energy but to promote high quality of life and furthermore to promote working performance and/or learning.

What are the most important actions EU should take to improve the indoor environment in buildings?

- I think that the EU should mandate that IEQ is not compromised in all policies related with buildings and built environment especially these which concern reduction in energy use. This has been nicely articulated in EPBD 2002. Besides I feel that EU should put much more strict requirements on source control both as regards ambient air as well as regards products used in indoor environments, not only building materials and furnishing but also for all type of equipment and consumer products. Consumers should be aware of the risks taken when they buy different products similarly as when they buy food. Consumers should have the choice to select products which emissions do not create health risks. It should be mandated that the air that we breathe and is used for ventilation must be treated so that it does not endanger health, similarly as drinking water.

What do you like to accomplish during your term as president of ISIAQ?

- Well, we do as the Society have many ambitious goals. Among others we want to establish much closer collaboration with the exposure sciences and practice, create on-line courses and tutorials and have much stronger impact on the creation of codes and regulations regarding IEQ by e.g. publishing policy papers. We will be working towards achieving these goals during my term. Let me put more pragmatic though also ambitious goal. ISIAQ has got nearly 900 members and I hope that during my term we will be able to welcome the thousandth member.

Interview with Mr. Paul Hodson of the European Commission

As the Head of the European Commission's energy efficiency unit Mr. Hodson is in a key position to offer valuable insights into how the EU energy policy is being implemented in the construction sector. His unit is in charge of most important pieces of legislation to improve the energy efficiency of European buildings such as the Energy Performance Buildings Directive, Ecodesign of Energy Using Products Directive, the Energy Labelling Directive, and the Energy Efficiency Directive. REHVA Journal was pleased to get an interview from Mr. Hodson.

Questions by Prof. Olli Seppänen, Editor-in Chief, REHVA Journal

What are the most important EU regulations to improve the energy efficiency of buildings and what is their role? How do they integrate to avoid double regulations?

– With buildings being responsible for close to 40% of European energy use and greenhouse gas emissions, all EU regulations addressing energy efficiency impact the building sector, either directly or indirectly.

Paul Hodson is head of the European Commission's energy efficiency unit.
He previously worked for the Commission on renewable energy; urban transport; and as a speechwriter.

Before joining the Commission, he was head of transport policy at Manchester City Council and transport policy manager at Reading Borough Council.

He began his career in the Inner Cities Unit of the UK's National Council for Voluntary Organisations. He has a degree in history from Cambridge University and a masters in urban planning from Oxford Polytechnic.

The Energy Performance of Buildings Directive (EPBD[1]) directly targets the energy efficiency of buildings. The main objective of the Directive is to ensure the establishment, at national level, of a comprehensive framework for improving the energy performance of residential and non-residential buildings through the setting of minimum energy performance requirements for new and existing buildings, for technical building systems and for building elements. The Directive ensures transparency by mandating energy performance certificates (EPCs) and their display in public buildings. The EPBD also looks at the future with requirements for nearly zero-energy buildings by the end of the decade.

The Directives on Ecodesign (ED[2]) and Energy Labelling (ELD[3]) cover product groups relevant for the energy performance of buildings including heating products, motors, fans and lighting.

While the EPBD requires Member States to set requirements at system level and does not prescribe the level of the requirements (except for the fact that they have to be cost-optimal), the ED and the ELD address specific product groups and, in case of the ED, set specific minimum requirements.

In the future, more Ecodesign requirements will be adopted for products that are part of technical building systems, and possibly also part of the building envelope (e.g. windows). The Commission services will therefore look closely at the interaction of these two pieces of legislation to ensure they are complementary.

The European Parliament and Council recently achieved a political compromise on a new Energy Efficiency Directive (EED), which also contains several measures impacting on buildings.

How does the EED complement the existing directives?

– The EPBD, the ED and the ELD promote energy efficiency on a sectoral and product specific basis. The EED takes a more comprehensive approach to achieving energy efficiency progress across the whole value chain of energy production and consumption.

It also covers some ‘gaps’ that were not addressed by the EPBD. In particular, the EED requires Member States, by April 2014, to establish long-term strategies for mobilising investment in the renovation of the national building stock. These ‘renovation roadmaps’ will become a driver for the improvement of the existing building stock and build upon the requirement of the EPBD for public buildings to have energy performance certificates.

In addition, Member States have to refurbish each year at least 3% of the floor area of buildings owned by central government – or take other measures that have an equivalent impact. This is a step forward from the EPBD which, while having an obligation to set minimum energy performance requirements for existing buildings undergoing major renovation, does not set any renovation targets.

Under the EED Member States have to establish energy efficiency obligations, requiring energy distributors or retailers to achieve a defined quantity of energy savings among their customers by 2020 – or again, to adopt other schemes with the same impact. Many of the measures to be implemented under this requirement will focus on the energy performance of existing buildings.

Finally, the EED will provide an important impetus to the deployment of the most efficient products, for example through the requirement for central government authorities to purchase only the most efficient equipment, meaning the highest classes under the Energy Labelling Directive or the benchmark levels established under the Ecodesign Directive.

How do you assess these pieces of legislation in the light of the EU targets? Can you record sufficient progress - especially in the light of the economic crisis - to ensure that the energy and climate targets by 2020 and beyond are met?

– From our 2011 analysis it emerged that the EU is not on track to reach its 20% energy efficiency objective in 2020. The EED is a step forward to close this gap and bring us back on track again, although the compromise reached in July is still a few percentage points below the 20% target.

However, much relies on the ambition of the Member States when transposing the Directive into national law. It is therefore too early to answer your question. We have agreed with the Member States to review progress

1 Directive 2010/31/EU of the European Parliament and of the council of 19 May 2010 on the energy performance of buildings (recast).

2 Directive 2009/125/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for the setting of Ecodesign requirements for energy-using products.

3 Directive 2010/30/EU of the European Parliament and of the Council of 19 May 2010 on the indication by labelling and standard product information of the consumption of energy and other resources by energy-related products (Text with EEA relevance).

in April 2014 – if necessary accompanied by complementary proposals from the Commission.

What role does the Commission assign to heat pumps in improving the energy efficiency of buildings? Do you have any quantitative assessment on this impact?

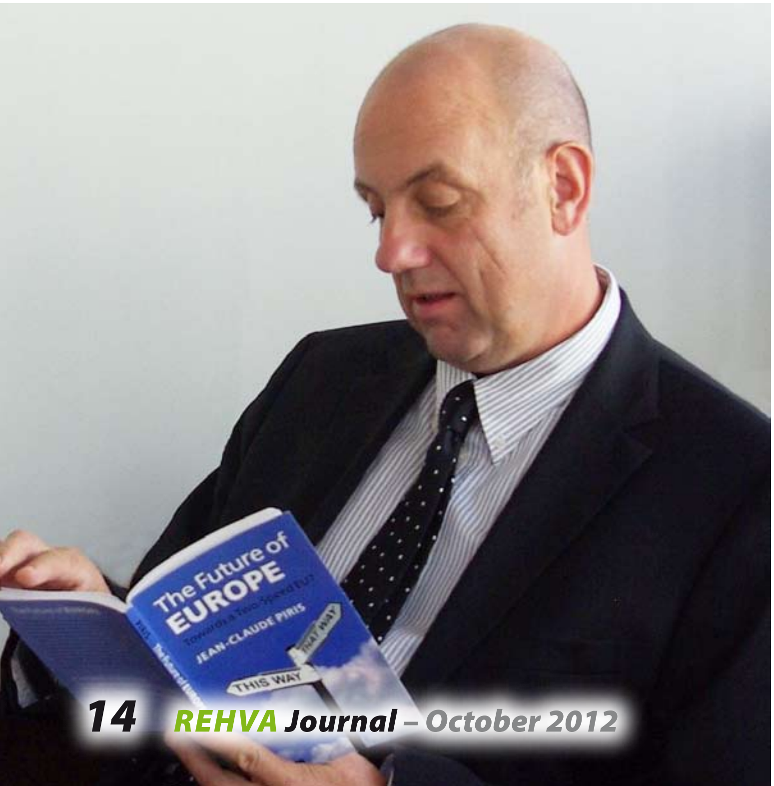
– Article 6 of the EPBD requires Member States to ensure that high-efficiency alternative systems, including heat pumps, are considered for new buildings. This means that, before a new construction starts, the technical, environmental and economic feasibility of such systems must have been assessed and taken into account.

Today, the opportunity to implement heat pumps depends largely on this feasibility assessment which is typically undertaken on a case by case basis and a local level. Therefore, it is difficult to make a quantitative assessment of the impact heat pumps will have in the future.

Nevertheless, I am convinced that these systems will become more important, especially in the move towards nearly-zero energy buildings.

Will we see Ecodesign Lot 1 (Boilers) and Lot 2 (Water heaters) to be finalised by the time this journal goes to print? (Sept 21st)

– The proposals for Ecodesign and energy labelling of heaters (including boilers), water heaters and related products have been in World Trade Organisation consultation until August 2012. We have also re-consulted Member State experts on some significant new elements introduced as a result of consideration within the Commission.



As you will be aware, there are a number of industry, consumer and environmental associations involved; these stakeholders have differing views on many aspects of the proposals. As a contribution to finalising the remaining crucial aspect, the energy label of boilers, the Commission will consult a selection of these stakeholders again in early September 2012.

Formal adoption by the Commission and the approval by Member States and the European Parliament will be the next steps. We aim to publish the Ecodesign and energy labelling Regulations for heaters, water heaters and related products in the Official Journal of the European Union in February 2013.

Which measures are planned to ensure compliance with the above named pieces of legislation - i.e. energy efficiency in buildings, real efficiency of declared heat generators.

– For the EPBD recast, the transposition deadline was 9 July 2012. The Commission is checking national provisions notified by the Member States, to see whether they comply with the Directive. If necessary, we will start infringement procedures where this is not the case.

Member States themselves are responsible for ensuring compliance by market actors. In this context, it is important to note that the role and the quality of energy performance certificates and inspection schemes have been strengthened by the EPBD, e.g. by requiring an independent control system at the national level. The Commission services intend to launch a study on the effectiveness of these provisions, in order to increase our knowledge of their practical implementation and of their real impact on consumers' practices.

With respect to compliance with Ecodesign and energy labelling implementation measures, also here the Member States are in the frontline. The 'New Legislative Framework' puts in place a comprehensive system of market surveillance, under which Member States' authorities (including customs) have to ensure adequate compliance checks on the market. The Commission will continue to support national authorities with this task, for example by facilitating joint surveillance actions. I also believe that industry has an important role to play in this context, for example by cooperating with national authorities, by sharing expertise regarding product testing and of course by manufacturing compliant products. Only with joint efforts can we ensure that the rules are properly implemented and complied with.

Independent testing of heat pumps is needed for reliable COP

Heat pumps offer a high potential to rapidly increase the proportion of renewable energy share within total heating energy consumption. Due to their built in multiplication effect, by using environmental heat sources the supplied energy is transformed into more thermal energy. This factor is called the Coefficient of Performance or COP. How is this factor determined? What has to be considered when comparing performance ratings? Can a high rate of performance always be trusted? This article illustrates how various factors have to be included in testing and how the testing has to be performed to get reliable results.

Bernd Klein
Dipl. -Ing., University of Stuttgart, IGE Prüfstelle HLK, Testing Centre at the Institute of Building Energy, Pfaffenwaldring 6a, D-70569 Stuttgart, Germany, Head of the Department for Heat Pump and Home Ventilation Testing,
e-mail bernd.klein@hlk-stuttgart.de.

The basis for comparison

The determination of performance rates for heat pumps is largely standardised throughout Europe on the basis of the EN 14511. This defines standardised conditions for testing electric heat pumps and determining their COP using a test rig. This involves using steady state and virtual steady state measuring points, which form the basis for the comparison of individual devices, as well as the dimensioning and design of whole systems. EN 14511 was revised in 2011 and has, for a number of years, replaced EN 255-1+2.

Environmental heat sources which can be exploited include outside air, exhaust air, ground or surface water and ground heat (brine). The heat source side is described in the standard as the external heat exchanger, which corresponds to the evaporator of the refrigeration circuit in heating case. The transfer of usable energy can be via air or water. The usable heat side is described as the internal heat exchanger. In heating case this corresponds to the condenser.

The standard defines so called nominal standard and nominal working conditions for each category of device. A device using brine as heat source and water as heat transfer for example is called a brine/water heat pump. In the case of brine/water heat pumps, the nominal standard conditions at low temperature are for brine at 0°C (B0, B = brine) and a heating water temperature of 35°C (W35, W = water). This boundary condition is abbreviated to B0W35.

If the heat transfer is via water, the temperature of the heating circuit influences the efficiency of overall heat generation. The lower this temperature level is, the higher the efficiency of the heat pump. EN 14511 specifies four temperature levels at which devices can be tested. These are distinguished according to their outlet temperatures and are defined as follows: low temperature (35°C, W35), medium temperature (45°C, W45), high temperature (55°C, W55) and very high temperature (65°C, W65). The efficiency of the heat pump however, depends on the mean condensation temperature. Therefore the input temperature which depends on the mass flow rate of the water must also be specified. These are set at the nominal standard point, where the mass flow rate set to produce a 5 K temperature difference on the heating side.

If the heat transfer is via air, a uniform input air temperature of 20°C (A20, A = air) in the condenser is used. The air output is governed by the volume flow rate, which in turn is determined by the internal fan.

A further important influence on the efficiency of heat pumps is the temperature of the heat source. The higher this temperature level is, the higher the efficiency of the heat pump. In this case the standard also offers a variety of temperature levels, categorised by the input temperature at the evaporator. Seasonal variations are minimised using ground or water heat sources. For brine there are three temperature categories: –5°C (B-5), 0°C (B0), and +5°C (B5). For water as the heat source, two categories are defined: 10°C (W10) and 15°C (W15). The largest temperature span is available when using outside air as a heat source, where 12°C (A12), 7°C (A7), 2°C (A2), –7°C (A-7), and –15°C (A-15) are defined as source

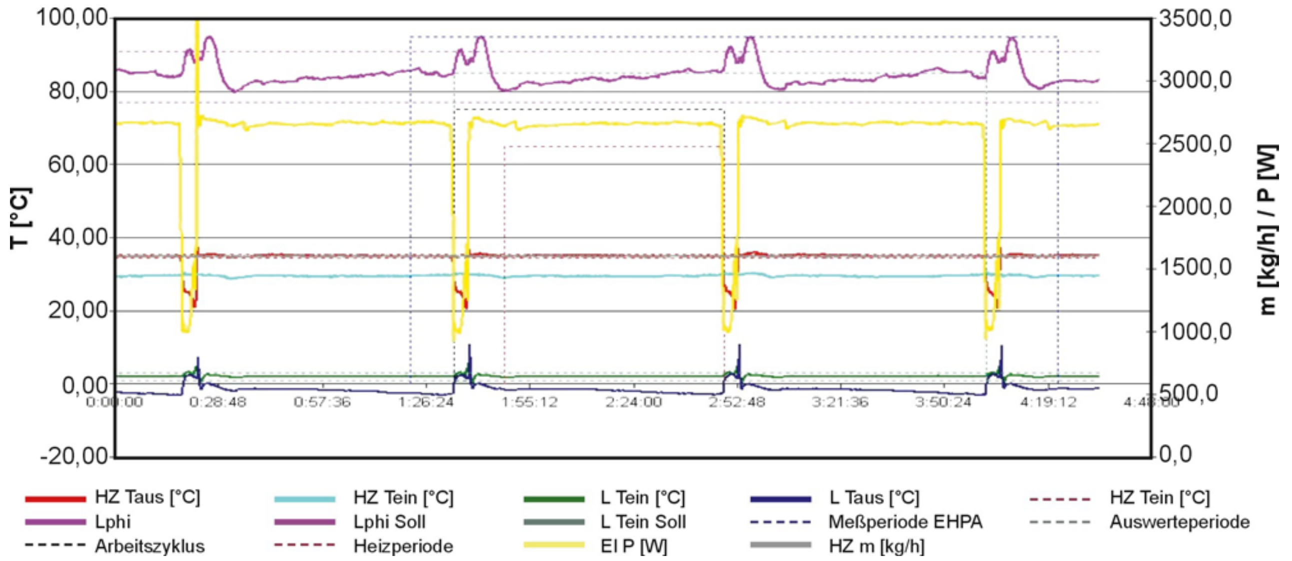


Figure 1. Diagramme of an air/water heat pump with defrosting cycles.

Figure 2. Ice build-up on an evaporator.

temperatures. If exhaust air is the heat source, a standardised temperature of 20°C (A20) is used.

As a matter of principle, the lower the difference in temperatures between the heat source and the output side is, the higher the COP of the device in question. So naturally, the COP of an air/water heat pump at A7W35 is much higher than at A-7W55 and care must be taken to ensure COP ratings are compared under the same border conditions!

Icing of Air/Water heat pumps

The evaporators on heat pumps using air as a heat source can freeze at low source temperatures depending on the humidity of the air. These devices therefore have to provide periodic defrost cycles in order to free the evaporator of ice. These usually work with a reversal of the normal process, temporarily delivering heat for defrosting from the heating circuit. The energy required for this process is taken into account when determining the COP and results in a reduced rating. During testing according to the standard, the device operates over a four hour period, and depending on the number of defrosting cycles completed in this time, the COP is calculated across one or more cycles. As the ice build-up and the number of defrost cycles are heavily dependent on the humidity of the air, this parameter has also been specified for each temperature level. Typically freezing occurs at testing points below A7 and devices can normally be run ice free above A7. The COP rating reduction through defrosting cycles is in the region of 0.3…1.0 depending on the efficiency of the defrosting algorithm employed (**Figure 1**, **Figure 2**).

Correction for the pumps and fans

A further aspect to be considered when determining the COP is the power consumption of circulation pumps and fans. Some devices have hydraulic circulation pumps integrated into their design, whilst others are delivered without a pump. If this was disregarded, devices with integral pumps would be at a disadvantage due to their higher consumption of electrical energy. In order to allow for this the standard includes a correction for the pump. The basis for this is the assumption that only the capacity necessary to overcome the device's internal pressure loss should be ascribed to the device itself. The correction is based on the measurement of the hydraulic capacity and on its conversion, using a virtual pump or fan efficiency factor, into an equivalent electrical input. This is then either added to the electrical energy consumption value, or subtracted from it. Correction for the pump and fans affects the COP up to 0.3.

Additional standards

Other than EN 14511, further standards can be applied in the testing of heat pumps. EN 12102, for example, specifies conditions for sound measurements, and describes the relevant geometric boundary conditions supplementary to the working points laid out in EN 14511.

EN 15879 describes the boundary conditions for the testing of direct evaporation heat pumps. The cooling medium evaporates directly in a pipe buried beneath the ground. During testing this evaporator pipe lies in a brine tank at specified temperatures.

EN 14825 describes the determination of a seasonal coefficient of performance (SCOP) for brine/water, water/water, air/water and air/air heat pumps. Based on a linear relationship of heating load, supply temperature and outside temperature, the standard defines per cent loads and supply temperatures for different outside temperatures. To determine the SCOP, the standard, apart from allowing the selection of a temperature level, provides a choice of three climate zones: cold (c, T_{design} = –22°C), medium (m, T_{design} = –10°C), and warm (m, T_{design} = 2°C). Furthermore a bivalence point must be defined up to which the unaided heat pump must cover the heating load. According to the chosen boundary conditions the device is now tested on the basis of EN 14511 at different per cent loads. This standard is particularly significant for testing devices using outside air as their heat source, as in this case the heating requirements of a building at diminishing heat source temperatures increase, while both the efficiency and capacity of the heat pump decrease.

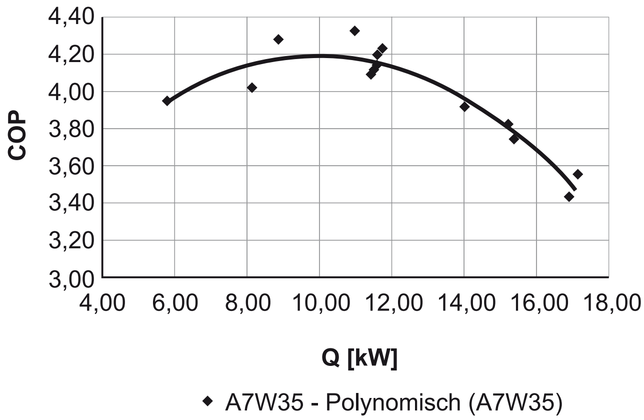


Figure 3. COP of a modulation air/water heat pump at A7W35 plotted against heat output.

Also the advantages of output-regulated devices become more apparent. When regulating their capacity according to per cent load conditions, their efficiency usually increases (**Figure 3**).

Domestic hot water heating

EN 16147 describes the determination of performance ratings for the heating of domestic hot water, and replaces EN 255-3. The boundary conditions on the heat source side are adopted from EN 14511. On the output side daily hot water tapping profiles are used to determine the COP. These daily tapping profiles specify water withdrawal in varying quantities spread over a day, ranging from profile S (2.1 kWh/d) up to profile XXL (24.53 kWh/d). Normally the COP increases with the quantity of water used, as in this case the storage losses, which are fully incorporated in the determination of the COP, remain relatively low. For this reason the test is usually undertaken using the largest possible water usage profile, and this at the same time, makes a statement about the heat pump's performance. The cold water temperature is specified at 10°C, and for every withdrawal a minimum achieved water temperature is stipulated. If this temperature cannot be reached by the device, a direct electrical heater cuts in. The challenge is to define suitable initial test conditions, so to ensure that the energy content in the storage is the same at both the beginning and the end of the test. In opposition to the old EN 255-3 the storage losses over a 24 hour period are incorporated in the calculation of the COP, so the measured COP ratings are, in comparison, much lower. With environmental air as a heat source (A15) COP ratings are typically in the region of 2.3…2.7.

Figure 4. Test rig at the HLK test centre.

Gas powered heat pumps

EN 12309 describes the testing of gas powered absorption and adsorption heat pumps. Along with the tests on the gas side of the device, part 2 specifies the conditions for the determination of its efficiency. There are differences to EN 14511 for the test conditions in heating mode. For example testing is conducted using the volume flow rates specified by the manufacturer. On the heat usage side, there is, additional to the low temperature level of 35°C (W35), a high temperature level of 50°C (W50) specified. The ratio of extracted heating energy to the combustion energy expended provides the resulting performance rating. Typical values for an air/water heat pump operating at A7W50 are in the region of 1.5. However, here the consumption of auxiliary electrical energy, which can be extensive, is not taken into consideration.

Independent testing

The measurement of these specified values on a test rig make exacting demands on the test surroundings and on the measuring apparatus. Not all manufacturers can, or choose, to provide the necessary laboratories. Also there is often an absence of verification for distributers' claims for their products. Confidence in the accuracy of declared ratings is achieved through tests carried out at an independent testing centre, which has access to appropriate laboratories and has the necessary experience to arrive at reliable results.

The Prüfstelle HLK test centre of the Institute for Building Energy (IGE) at the University of Stuttgart has, as an independent test centre accredited according to ISO 17025, all the necessary competence to determine specified ratings under the above mentioned conditions. Electrically or gas powered brine/water, water/water or air/water heat pumps up to 70 kW heating capacity can be tested. Also domestic hot water heat pumps for all cycles can be tested (**Figure 4**).

Certification

On the basis of an independent test a certification of specific ratings is possible. The EHPA Quality Label for electrically powered heat pumps, awarded by the European Heat Pump Association is widespread. One criteria for the award of this label are performance and sound tests carried out at an independent testing centre where a minimum COP rating has to be achieved. The minimum COP for air/water heat pumps hereby is 3.1 at A2W35. The minimum COP for brine/water heat pumps is 4.3 at B0W35, for water/water heat pumps it is 5.1 at W10W35 and for direct evaporation heat pumps it is 4.3 at E4W35. Apart from the performance requirement, the device has to be delivered with a documentation in the language of the country of sale, and the availability of a service network.

Experience shows that through unreliable declarations of performance ratings, both the consumer and the image of heat pumps are repeatedly harmed when the promises of the planning phase are not fulfilled after the system is installed. One building block towards reliability is to only trust in certified performance ratings determined by independent testing centres. In this way a reliable foundation can be laid, so that together with competent system planning, the full potential of environmental heat sources can be realised. 3ε

Smart Grids *create new opportunities for heat pumps*

A low carbon future in Europe will require a more dynamic electricity system. A decarbonised grid - with high penetration of inflexible wind and nuclear - means that balancing generation and demand is not as straightforward as ramping up supply to meet demand. Instead, demand may be shaped to meet available generation. On the demand side, increasing electrification of heat and transport leads to demand peaks. The energy system of the future will have to deal with: supply / demand imbalances and increased congestion on the distribution grid.

New business opportunities are emerging to capture value through smart operation of heat pumps and other assets on the demand side - to help balance generation and demand, and to manage network congestion.

Ultimately, heat pumps will have to be 'smart' if they are to capture a share of this emerging market. In this article, we explore what it means for a heat pump to be 'smart', and where the value is in this emerging smart market.

Lindsay Sugden
PhD, Heat Pumps Research Manager
Delta Energy & Environment, 15 Great Stuart Street, Edinburgh EH3 7TS, UK
Lindsay.Sugden@delta-ee.com, +44 (0)131 625 1006

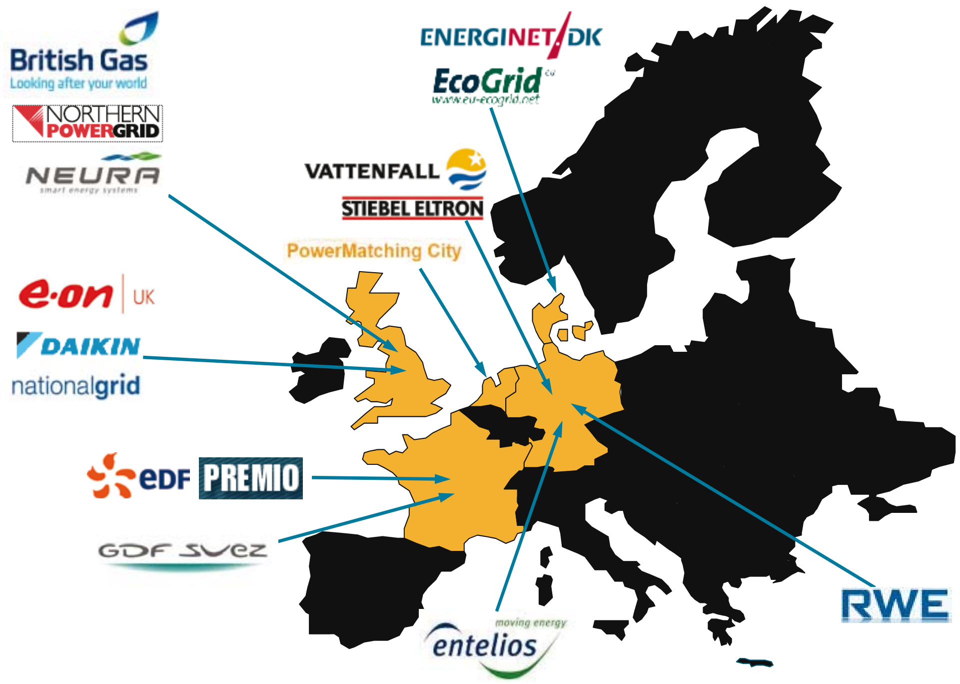


Figure 1. A wave of smart heat pump projects as tracked by Delta-ee.

An emerging smart demand market creates opportunities for heat pumps

Ultimately, heat pumps will not be playing in a "smart heat pump" market, but in a wider smart market. There is a wave of smart projects emerging in Europe, driven by interest from a large number of energy market players. All of these companies see an opportunity to capture a share of the potential market value in smart demand. Heat pumps are one technology which could enable some of this value to be captured. There are, of course, many other ways to shape demand – for example time of use price signals, home energy management systems, and 'smart' refrigerators and washing machines. But with their relatively large electrical consumption, heat pumps offer attractive opportunities to help match supply and demand – as demonstrated by the wave of smart heat pump projects shown in **Figure 1**.

Where is the value in smart demand?

The value chain for smart demand with heat pumps is still emerging and is partly dependent on future developments in electricity regulatory frameworks. The following players can capture potential value in this future market:

- **Network operators** can benefit from the avoided cost of new grid infrastructure to support demand peaks, through smart operation of heat pumps & other assets.
- **Aggregators, energy suppliers & demand response companies** can benefit from the additional value created through controlling operating times of heat pumps and other assets according to fluctuating power prices, and trading this capacity in balancing markets and other energy markets.
- **Heat pump manufacturers** can benefit from the greater market opportunities available to them if they are 'smart-ready'.
- **New market entrants:** New market opportunities for demand response 'enabling' technologies and services from, for example, companies developing communication technologies, home/building energy management systems and offering energy services.

Delta-ee is tracking this emerging sector in Europe, and highlights projects which include the use of heat pumps in 'smart' applications. Some of these projects are already commercial, but most are pilot projects which are testing key questions related to smart control of heat pumps, such as:

- How far can demand realistically be shifted?
- How will end-users respond to 3rd party control of their heating system?
- What communication and control mechanisms are most effective?
- What business models will maximise value & provide a strong customer proposition?

Learnings from these pilot projects will be critical in developing understanding of the value potential in smart heat pumps.

Smart heat pump projects in Europe

To understand what is driving these projects, and to investigate key questions about what a smart-ready heat pump is, we focus on three projects in more detail in **Table 1**. We compare three smart heat pump projects in markets where balancing supply and demand and managing grid congestion is – or will be – a significant challenge. We compare the drivers for the projects, and assess what being 'smart-ready' means for each project.

Being smart-ready will be a must-have to maximise the growth potential of heat pump markets

As seen above, there is growing recognition amongst utilities and other energy market players that smart-ready heat pumps could represent significant market value through their application in smart demand projects. Currently in the form of pilot projects and demonstrations, this could open up new value opportunities for heat pumps (**Figure 2**). Only 'smart-ready' heat pumps will be able to exploit these opportunities. The heat pump value proposition will grow towards 2020. Energy cost savings will be larger in the future as energy prices rise (depending what electric heat pumps are displacing). But the future value proposition is increased further because of the additional value associated with smart use of heat pumps in matching supply & demand – additional value which will only be captured with smart-ready heat pumps.

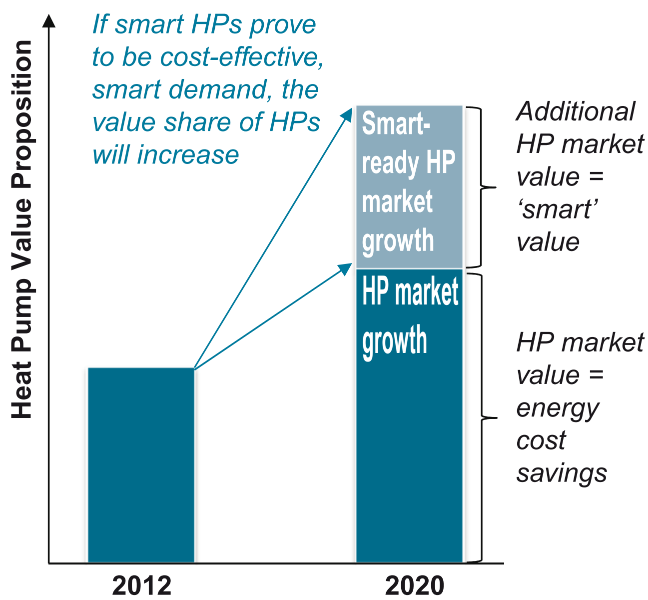


Figure 2. How will being smart-ready grow heat pump market value?

Table 1. Comparison of smart heat pump projects in Denmark, the UK and Germany.

	Denmark	UK	Germany
Companies	**Energinet.dk** (TSO)	**British Gas** (Energy supplier), **Northern Power Grid** (DNO)	**Entelios** (Demand Response company)
Project type & status	Demonstration project	Pilot which may be rolled out commercially	Commercial business
Project description	Assessing the control & communication mechanisms necessary for shifting HP operation in response to energy price signals, testing how far demand can be shifted, and assessing consumer response.	Trialling the application of smart grid solutions on the distribution grid – including HPs and other microgeneration, and assessing the consumer behaviour and network impacts.	Controlling the operation of technologies providing flexible load & energy storage (e.g. air-cond/HPs) in response to TSO signals, and selling into power markets.
End-user	Residential	Residential & small commercial	Commercial/industrial
Market context	Wind capacity is set to grow from 3 GW today to 6 GW by 2025, meeting 50% of Danish electricity demand. This will create major challenges managing supply & demand.	The UK electricity networks will need significant upgrading to accommodate the growth in wind and the projected electrification of heat & transport. Smart demand could minimise investment costs in the grid upgrade.	The increasing penetration of wind in Germany, and increased volatility of electricity prices associated with this, creates large opportunities for demand response.
Primary driver	Managing distribution grid congestion & matching supply/ demand	Managing distribution grid congestion	Matching supply/ demand
Requirements for the heat pumps involved in the project			
Communication capability of HP	2-way	2-way	2-way
Communications interface	wifi	tbc	LAN
Level of intelligence built in to the HP	None required – controls retrofitted (but retrofitting is not cost-effective for a commercial project)	Ability to accept utility signal and communicate how much consumption has been reduced	Ability to integrate with Building Energy Management system is critical
How fast should the HP respond?	As quickly as possible	As quickly as possible – certainly within 1 hour	Within 1-5 minutes of receiving the signal
How long will the HP need to shut down for?	Typically up to 2 hours	Ideally up to 4 hours	Typically up to 2 hours, but longer if possible

Being smart-ready requires built-in control & communication capabilities

As seen from analysing existing smart projects in Europe, the market has yet to decide exactly how smart a heat pump must be, and uncertainties remain – for example, currently there is no clear preference for communications interface. But there are some clear messages about what capabilities will be critical:

- **2-way communication** – to accept utility signals and be able to respond back with information on how much capacity it has available, or how long it has shut down for.
- **The ability to accept dynamic control and influence on operation** - responding to signals as fast as possible, and being able to shut down for as long as possible while minimising the impact on the end-user.

Heat pumps which can differentiate themselves in this way will be more attractive to energy market players engaging in smart markets, so ultimately will take a greater share of the heat pump (and smart) market.

High temperature multifunctional heat pump system for better over all energy efficiency

Recent years are characterized by important changes in the energy sector, which mean more efficient integrated projects focusing on innovative technologies. Current laws show that the main objectives are the reduction of energy consumption and greenhouse gases emissions and the use of renewable energy sources. The design approach has also changed: buildings should be viewed as a set, fully balanced, identifying not efficient elements, reducing heat loss, unnecessary consumption and increasing efficiency of the equipment. Manufacturers, consultant and customers plan to reduce energy consumption and reducing pollutant emissions. The climate sector moves towards the application of electrical and electronic technologies since they are: eco-sustainable products with high energy efficiency and integration with renewable energy with low CO_2 emissions and opportunity to eliminate the use of non-renewable energies.

Francesco Amato
Export Sales Manager
Thermocold Costruzioni
amato@thermocold.it

Challenges and opportunities for heat pump technology

The possible solution to work towards eco-sustainable products with high energy efficiency and integration with renewable energy is the replacement of boilers for heating and hot sanitary water production by heat pumps.

The advantages are obvious:

- Possibility of exploitation of renewable energies (air, water, geothermal);
- High efficiency (COP ever higher);
- Increase of the energy efficiency rating of buildings (A+);
- Reduction of CO_2 emissions (best performance even compared with condensing boilers);
- Reduced use of primary energy;
- Versatility of use: seasonal employment winter / summer;
- Economic benefits from taxation;
- Using where natural gas networks does not exist;
- They do not need chimneys;
- No need for places where the demands of fire fighting;
- They do not need gas supply contracts;
- Possibility to use special power rates.

But using traditional heat pumps we face, at times, a number of problems. While functioning satisfactorily in summer, have some problems, well known, in the winter:

- Reduction of heating capacity when outdoor temperature decreases;
- The need for over sizing the project;
- The high mechanical stress in case of high temperature of water with low air temperatures (increase of compression ratio with the drastic decrease in isentropic efficiency);

- Time required to eliminate the risk of legionella is greater as lower the water temperature;
- Almost always installations with standard heat pumps are complemented by traditional energy sources (boilers, electric heaters) to reach the limits of power and temperature;
- For hot sanitary water it is required a three-way valve with an additional heater in the tank (double exchange) which causes a significant loss of efficiency (performance decreases of about 7%);
- Impossibility to obtain the hot sanitary water temperature above 55°C;
- The need for buffer tank for hot water high-volume to meet the need in the morning.

By reversing the cycle on the water evaporator/condenser it is possible to supply the air conditioning users; at the same time the unit can produce hot water for sanitary use with an additional dedicated water exchanger.

The operating modes of a multifunctional unit during the whole annual period are:

- During WINTER:
  - □ Only Heat pump mode (Hot water production for heating);
  - □ Heat pump + sanitary mode (Hot water production for heating or for sanitary use with priority on sanitary circuit);
- During MIDDLE SEASONS:
  - □ Heat pump mode for hot sanitary water production;
- During SUMMER:
  - □ Only Chiller mode (Cold water production for air conditioning);
  - □ Chiller + sanitary mode (Cold water production for air conditioning and simultaneous free hot water for sanitary use).

The main advantages of the use of a multi-functional unit in place of a standard heat pump are:

- High energy efficiency;
- Dedicated exchanger for hot sanitary water production;
- No integration of electrical heater;
- Elimination of double water / water exchange;
- Free hot sanitary water during summer cycle.

Two stage multifunctional unit

In some applications high temperature hot water is required. However with the simple cycle system is not possible to reach temperatures above 65°C as reaching the outlet water temperature at 80°C would require theoretically a compression ratio of about 7 and the coolant temperature (R134a) of 140°C.

The above mentioned operating conditions is not feasible with components developed and designed so far, besides it would bring additional negative effects, such as lubrication problems, abnormal stress of the components, very low efficiency, etc.

In order to overcome these problems the only feasible solution is to split the temperature difference in a cascade of two cycles. The use of two different refrigerants allows to exploit the best performance of each refrigerant combining a wide scale of advantages.

Figure 1 represents a patented cascade cycle applied in Thermocold DUO unit.

The low-pressure cycle operates with R410a and the high-pressure cycle with R134a. The choice is optimized for winter heating application, since the R410A is a well performing with low outdoor temperature while the R134A is the refrigerant perfectly designed for high pressure and temperatures.

By a simple comparison and considering operating temperature between 55°C for condensation and –5°C for evaporation, a standard single cycle need a compression

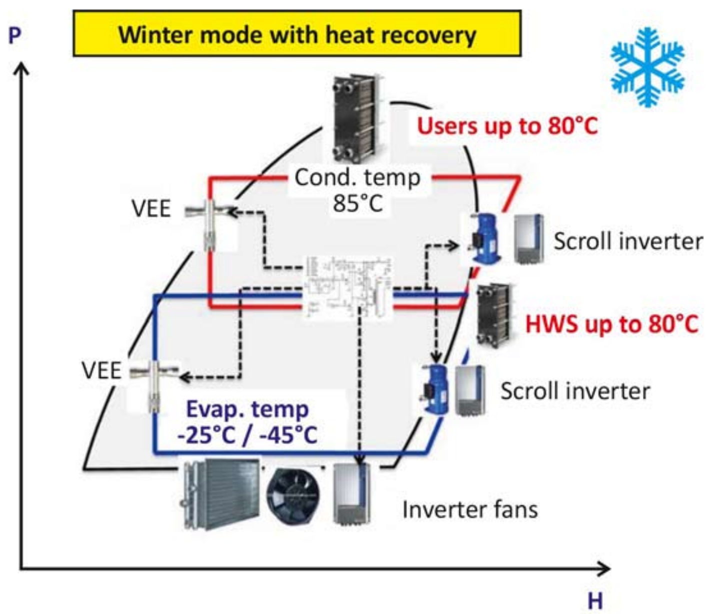


Figure 1. Thermodynamic cycle cascade cycle heat pump in pressure – enthalpy diagram.

ration about 7, while the double cycle will have a low and an high pressure cycle with a ratio between 2.5 and 3.2.

Therefore provided that all the scroll compressor exploit the highest isentropic efficiency in this range of compression ratio (2.5 – 3.5), the case of DUO® the isentropic efficiency is becoming maximum.

Furthermore mechanical stresses are directly proportional to the compression ratio. Dividing the compression into two-stages, it is possible to reduce by half the compression ratio of each of the compressors. According to the data provided by manufacturers of compressors the average lifetime of compressors operating in the "normal" conditions is 40 000 hours. The average lifetime in the double-cycle units is 60 000 hours, thus increasing the useful life of about 50% because they work better and avoiding the mechanical stress.

By considering what stated above, the combination of a cascade compression cycle with the multifunctional technology will offer an optimal solution for the actual market requirements.

High heating capacity even at low outdoor temperatures

DUO® overcomes the limitations of traditional heat pumps (strong decrease in performance with low outdoor temperature) in addition to providing winter heating, summer cooling and hot sanitary water (HOT SANITARY WATER) up to 80°C retaining a **constant heating capacity** at different outdoor temperatures down to –20°C.

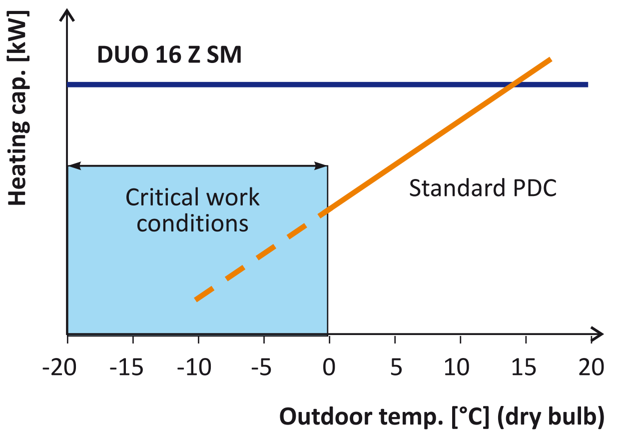


Figure 2. Constant heating capacity of DUO® heat pump system.

DUO® is a multifunctional unit where the key of this innovation is the advanced electronic system that allows to manage complex refrigeration cycles in an interactive way through a **full inverter technology** allowing to set up **different and completely independent set points** for HOT SANITARY WATER, winter heating, summer cooling and also managing with absolute fluidity the Digital Defrost System (intelligent digital technology defrost).

The use of primary energy of DUO® is both substantially lower than a methane condensing boiler and a last generation heat pump.

The two-stage DUO® units are equipped with **Full Inverter technology** to ensure maximum efficiency, much higher than traditional heat pumps. Both compressors of low and high pressure, such as fans and circulation pumps are with inverter in combination with electronic expansion valves and high-performance heat exchangers.

The two-stages next generation units are completed by the new technological defrost system: with this function, the electronic control system minimizes the number of reversing cycle in the heating mode while the unit is operating in cooling mode.

The **Digital Defrost**, used in these units, is a digital self-adaptive defrosting system able to prevent the production of frost and only allows the defrost cycle in case of real presence of frost on the coils fins.

Modulating the frequency of the inverter compressor according to the outdoor temperature keeps the evaporation temperature above the boundary conditions of frost formation, thereby reducing the number of defrost cycles, so much negative as required, in standard heat pumps.

To achieve the best possible conditions of comfort and above all for maximum energy savings, the control system has been equipped with the function of DSP (**Dynamic Set Point**), allowing temporary change of set point according to the change of outdoor temperature. With this system it can be maintained the temperature difference between indoor and outdoor by varying the set point, reducing consumption and preventing thermal shock. On the other hand it allows to decrease the set point when the thermal load increases on time.

The possibility to produce hot water at 80°C with two-cycle units offers another important advantage about the problem of Legionella. The *Legionella* bacteria reaches its maximum growth at water temperatures between 25 and 40°C. Having the opportunity to have water temperature of 80°C, it can be performed automatic cycles of sanitation, eliminating harmful bacteria, even when working with lower water temperatures.

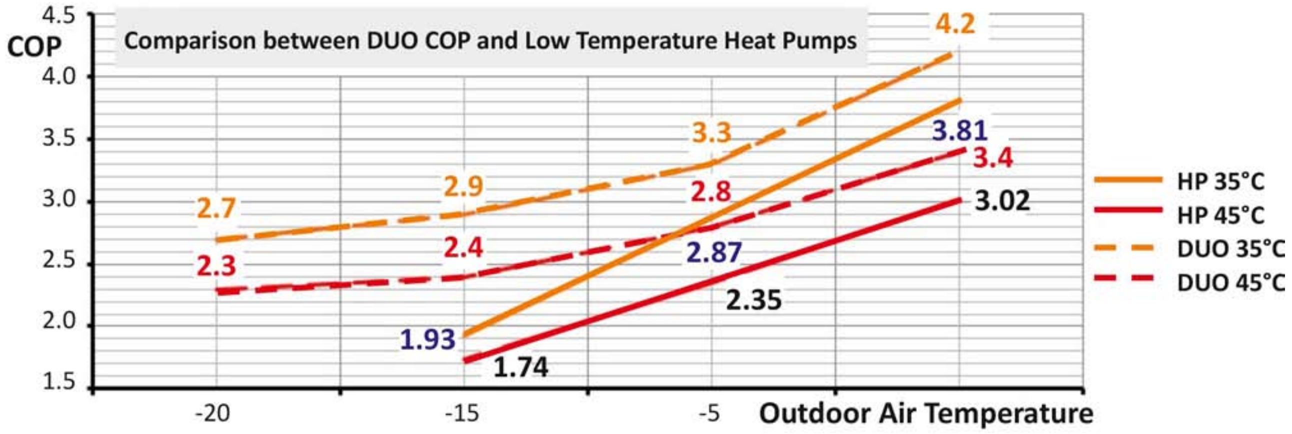


Figure 3. Comparison of COP between DUO® and standard heat pumps.

Figure 4. Split version of DUO® DUO® heat pump system.

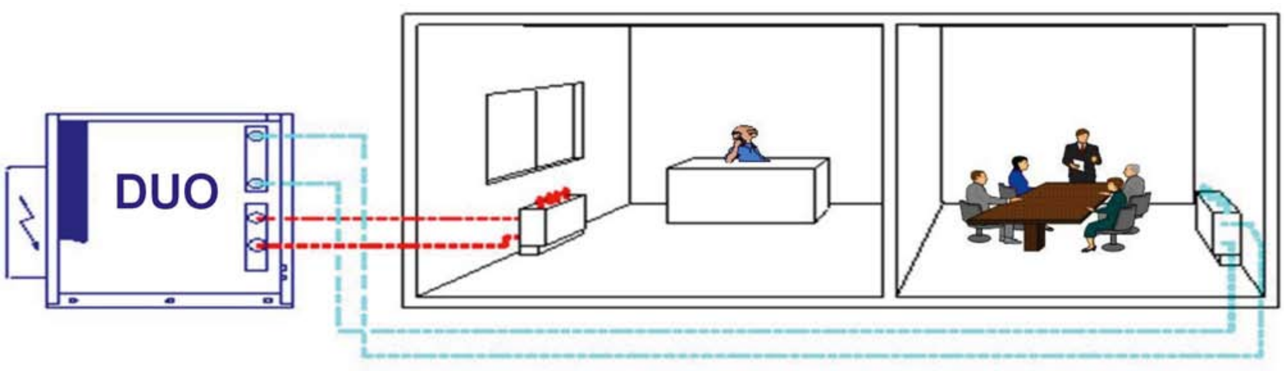


Figure 5. Four-pipe solution of double cycle DUO® heat pump system.

Multifunctional unit DUO® is available into packaged or split versions

In facilities with split versions it can be eliminated glycol regardless of outdoor temperature if the high-pressure unit is installed inside the building and the interconnection with the low pressure unit is made through refrigerant lines.

The versatility of the multifunctional units with dual thermodynamic cycle allows simultaneous heating and cooling in four-pipes solutions with the additional advantages that this system involves rationalization of energy when the thermal load is very erratic.

In conclusion energy saving is the most clean and affordable form of energy and the use of heat pump allows the achievement of targets for primary energy savings, increase of renewable energy and reduction of CO_2 emissions.

Therefore the heat pump can be regarded as a technology able to make a tangible contribution to the environmental strategies of the European Community.

The double cycle multifunctional unit DUO® combines and enhances all the merits of the traditional heat pumps (in terms of energy, reduction of pollutants, safety, availability of the fuel, etc.), without being penalized by the limits (minimum capacities at low outside temperatures, low outlet hot water temperatures, high stress on the components in extreme conditions, etc.).

The use of DUO® unit in place of a traditional plant with a boiler combined with a chiller unit, allows a considerable simplification of the plant itself and consequently an increase in reliability of the system given by the presence of a smaller number of components.

DUO® applied in residential buildings, allows to produce free hot water during the summer to all homes, allowing a large energy recovery.

Ultimately, thanks to the constancy of the thermal performance, the large choice of design flow temperature, even at very low outdoor temperatures, combined with the reliability of components not subjected to high mechanical stress, DUO® allows to overcome the prejudice that has so far accompanied the use of heat pumps as the only element of the production of hot or chilled water.

The full length version of this article is availbale at the journal website http://www.rehva.eu/en/rehva-european-hvac-journal

Capacity control of heat pumps

In Sweden the current trend is to size heat pumps much closer to full coverage of the heating demand than has been the case so far. The driver for this development is both economic and legislative (increasing electricity price, possible power rates and limits in the building code regarding installed electric power for heating). This means that heat pumps will operate at part load almost all the time and that power utilization will be very low. This is particularly the case for new, low-energy buildings and has increased the interest in variable-capacity heat pumps. The article shows the importance of adapted electric motors, drives and control for good COP aslo in part load conditions.

Per Fahlén
professor emeritus
SP Technical Research Institute of Sweden
per.fahlen@sp.se

General aspects of capacity control

Capacity control, primarily by means of Variable-Speed Drive (VSD) motors, is commonly used to improve the efficiency of operation of systems for heating, cooling and ventilation. However, before going into the specific application of heat pumps it may be pertinent to look at some of the generic aspects.

Matching of supply and demand

HVAC systems are sized to cover a planned maximum design load, e.g. at the design outdoor temperature for heating or cooling or at the design polluting load for hygienic ventilation. Normal operation is at substantially lower levels, e.g. the ventilation rate in VAV systems rarely exceeds 30% of the design flow. This means that large energy savings are possible for heating, cooling and fan energy by capacity control of the fan motor. Theoretically this means that the fan motor should be optimized for a drive power that is around 30% of the design power in pressure-controlled systems and for only 5% of the design power in future, decentralized systems[1]. Similarly, a heat pump sized for full coverage has 80-90% of the operating hours at a capacity which is less than half the design power.

Demand starts at room level and a common experience is that use is larger than actual demand. This difference tends to increase when the load factor (i.e. power utilization) goes down. It is more difficult to control a small energy supply with a large power than with a small power. One way[1, 2] to accomplish the required load matching is by variable-speed drive (VSD) of compressors, pumps and fans

Potential advantages with capacity control

Capacity control of heat pumps is interesting for several reasons. The most obvious is that reduced thermal power will lower the temperature differences in the evaporator and the condenser and thus potentially increase the coefficient of performance. Another effect is that the temperature swing in the heating or cooling system will decrease relative to the situation with on-off control. To achieve a given mean temperature of the room heater with on-off control the mean temperature during actual operation of the heat pump must be higher (lower in the case of cooling). Other examples[1, 2] of advantages with variable-speed capacity control are:

- fewer starts and longer operating times,
- reduced frosting and noise when air is used as heat source,
- possibilities to overrev the compressor and hence increase the capacity and avoid using a supplementary heat source,
- additional degrees of freedom in the control of sanitary water heaters etc.
- reduced latent cooling demand in refrigeration applications.

Variable-speed drive and motor efficiency

Although variable-speed drive of electric motors is a well-known technology it is less known, at least outside the circle of electric motor designers, that the matching of motor and controller type is critical for the end result. It is not uncommon to find retrofitted VSD equipment to existing motors that certainly deliver a reduced capacity but without substantial reduction of the drive power.

Motor torque and power requirements

A heat pump system comprises not only a compressor but also flow generators such as pumps and fans. The character of the mechanical work that these flow generators have to produce differs somewhat from that of the heat pump compressor and thus provides slightly different operating conditions for the respective motor and motor drive.

Pumps and fans

Heating and cooling systems typically use radial-type flow generators even though there may be axial fans in large systems and heat pump outdoor units. The torque requirement of this type of flow generator depends mainly on the flow character of the external system. Pressure drop has an exponential dependence on flow rate and we have the following relation (fully developed turbulent flow has $n \approx 2$):

$$\Delta p(\dot{V}) = \Delta p_0(\dot{V}_0) \cdot \left(\frac{\dot{V}}{\dot{V}_0} \right)^n \qquad \text{[Pa]}$$

where $\dot{V}_0$ is a specified reference flow rate (e.g. the design flow rate), $\dot{V}$ is an arbitrary, controlled flow rate and $1.7 < n < 2$ is the flow-related pressure drop exponent. Filters and some types of heat exchanger work in the laminar regime and hence have $n \approx 1$.

Torque is proportional to the pressure difference that the machine is working with and the power requirement $\dot{W}_p$ of pumps or fans is given by the product of torque and angular frequency ω of the rotating part. This means that the power requirement of the electric motor becomes (further details in an web-site article[1]):

$$\dot{W}_{e,p}(\omega) = \frac{1}{\eta_{e,m}(\omega) \cdot \eta_p(\omega)} \cdot \dot{W}_{p,0}(\omega_0) \cdot \left(\frac{\omega}{\omega_0} \right)^{n+1} \qquad \text{[W]}$$

Disregarding efficiency changes, the relation indicates that power as well as torque tends to zero as rotational speed (angular frequency) approaches zero. This is advantageous for the electric motor as it will start unloaded and thus have a very low starting current and this will also be advantageous from a grid perspective. Displacement type compressors, however, will have a very different torque characteristic.

Displacement compressors

Displacement compressors, e.g. piston, rotary piston, vane, Scroll and similar types, have a given transported volume V per revolution. In the case of a heat pump compressor the pressure difference will not primarily depend on the flow rate (compressor speed) but rather on the temperature difference between condenser and evaporator. The saturation pressures of the refrigerant in the condenser and evaporator, p_1 and p_2 respectively, depend directly on the condensing and evaporating temperatures t_1 and t_2. It is the temperature-related difference between condenser and evaporator that decides the torque on the compressor motor.

Fahlén[1] has shown that the torque of a displacement compressor depends primarily on the pressure ratio $\pi = p_1 / p_2$. The torque depends also on the absolute level of the evaporator pressure and therefore has a maximum at a certain inlet pressure. Depending on the operating conditions the compressor torque may vary from zero, with pressure-equalized start or the same temperature indoors and outdoors, to varying maximum torque in relation to pressure according to **Figure 1**. The power requirement of the compressor is obtained by multiplying the torque and the angular frequency (rotational speed).

Electric motors

The low efficiency of electric motors that appear in residential units has been an obstacle for achieving high seasonal performance factors. One reason for the low efficiency of ordinary asynchronous motors is that they will always draw a certain magnetizing current. No energy for useful work will be taken from the magnetic field and the magnetizing power will thus be a total loss. In particular during part-load operation this becomes significant; the magnetizing power remains more or less unaffected whereas the useful power is reduced. These effects are relatively more important for small motors than for large motors and thus the introduction of permanent magnet motors has had a tremendous impact for the development of more efficient small fans, pumps and compressors.

There are many alternative configurations for motors and motor drives but two alternatives are of special interest for small motors, the DC motor with permanent magnets and electronic commutation (EC = electronically commutated or BLDC = brushless direct current

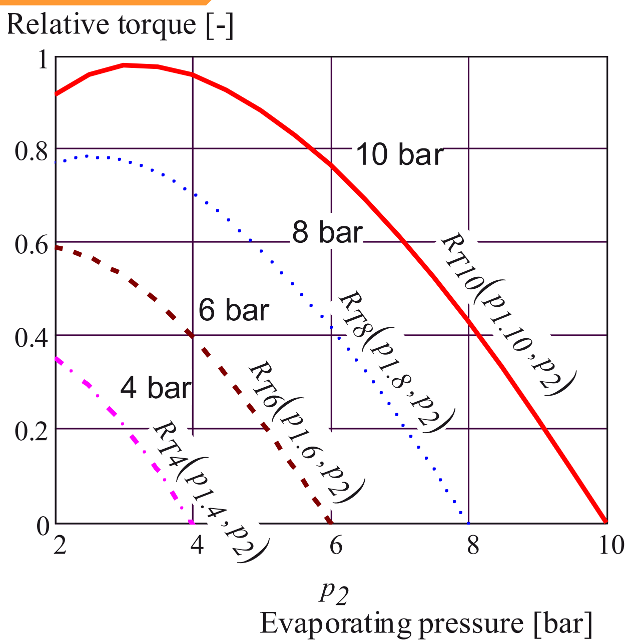


Figure 1. Relative torque T = T_{com} / $T_{com,0}$ as function of evaporating pressure p_2 with p_1 = $p_{1,0}$ = 10 bar, $p_{2,0}$ = 2 bar (see Fahlén[1]).

motor) and the synchronous AC motor with permanent magnets (PMSM = permanent magnet synchronous motor). They appear similar in their construction but the BLDC is fed by a rectangular-pulse current (pulsed DC) and the PMSM is fed by a sinusoidally varying current.

A heat pump sized for full coverage of the heating demand will deliver around 90% of the heat at a mean capacity less than half the design value and a very large part at less than 25% of the maximum motor power (varying conditions at the heat source and heat sink will make the motor power drop relatively more than the reduction in heating capacity). This implies that most operating hours will be at a very low relative capacity and to reap the full benefits of capacity control[1] it is necessary to conceive new systems[1, 3, 4] for heating, cooling and ventilation, to develop new components that can cope with large turn-down ratios while maintaining acceptable efficiency and finally to establish smart control strategies for the overall operation of the systems. As an example of recent developments at Chalmers/SP, **Figure 2** illustrates a comparison between three alternative motor topologies. The highest efficiency is provided by a new motor topology (PMSM) with matching drive and control and this prototype retains its high efficiency way down in the load range.

Heat pump application example

Figures 3 – 5 below illustrate the importance of matching the heat pump compressor control with adapted "parasitic powers" to pumps and fans while at the same time maintaining the efficiency of the electric motors.

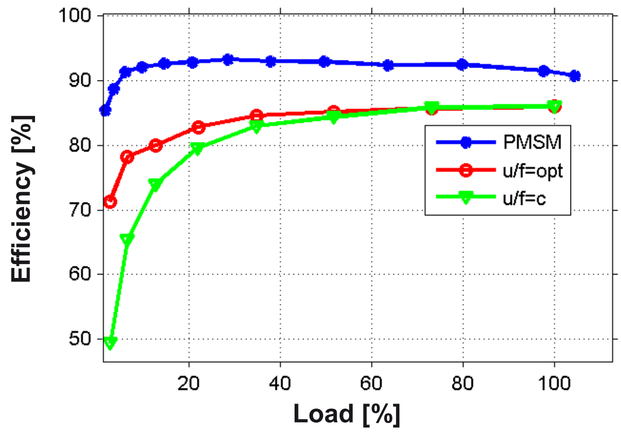


Figure 2. Comparison by Åström[4] of three alternative motor configurations. The two lower represent current state-of-the-art whereas the top curve is from a new PMSM motor developed by Åström.

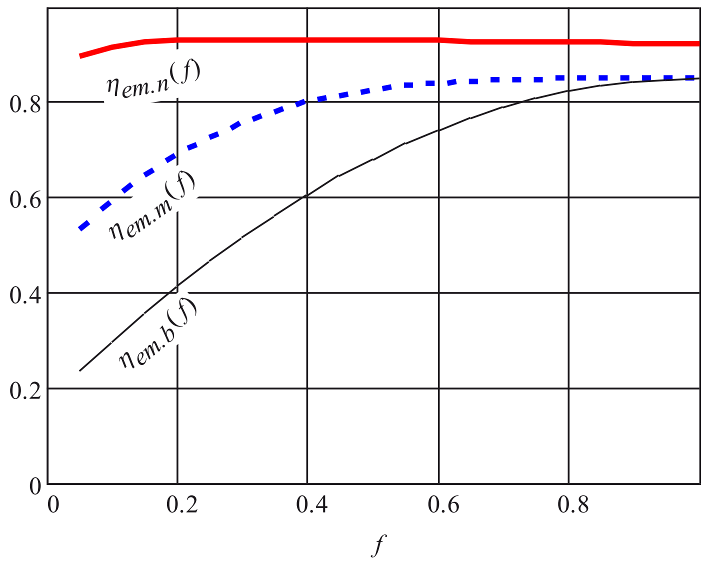


Figure 3. Motor efficiency (η_{em}) as a function of the fractional capacity (***f***). Index ***b*** represents a base case with today's standard practice, ***m*** corresponds to modern, state-of-the-art equipment and ***n*** is our newly developed concept (motor power around 1 kW).

The diagrams derive from development of a rotating air-to-air heat pump (an EU project where Chalmers and SP lead the scientific part). **Figure 3** presents a comparison of three alternative motor topologies that were used to simulate the coefficients of performance of the heat pump (COP_{hp}) and the heat pump system (COP_{hps}) respectively.

Figure 4 shows how the coefficient of performance of the heat pump system varies as function of the fractional capacity ($0 \leq f \leq 1$) at the operating condition +7°C outdoor temperature and +20°C indoor temperature. In

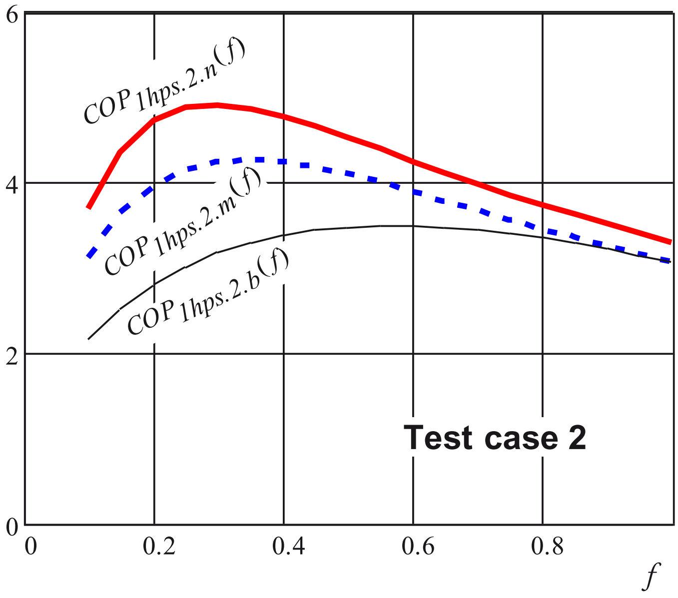


Figure 4. The coefficient of performance of the heat pump system (COP_{hps}) as function of the fractional capacity ($0 \leq f \leq 1$) for three alternative motor topologies. Powers to the evaporator and condenser fans are constant.

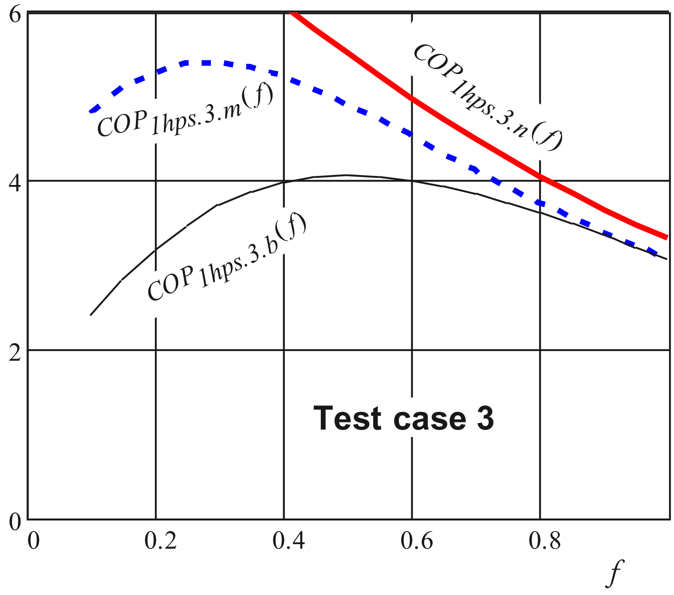


Figure 5. Coefficient of performance of the heat pump system (COP_{hps}) as function of the fractional capacity ($0 \leq f \leq 1$) for three motor topologies. Evaporator and condenser fan powers vary in relation to the relative thermal capacity.

this example the fans are uncontrolled with the implication that their powers become relatively more important in relation to the output of the heat pump. This also implies that with a sinking efficiency of the compressor motor the *COP* will not improve by much in the base case. The modern motor and our new concept, however, will provide substantial improvements.

Figure 5 provides the same comparison as **Figure 4** with the difference that also the powers of the evaporator and the condenser fans are reduced as the compressor power goes down. This also means that the air flow rates will drop in relation to the case of **Figure 4** and this will make the condensing temperature rise and the evaporating temperature drop compared to **Figure 4**. The reduction of fan powers, however, will be larger than the increase in drive power to the compressor and the end result is substantially improved part-load values for COP_{hps} in **Figure 5**. With the new motor technology, *COP* continues to increase all the way down to $f = 0.10$ and will then be an impressive 7.4!

Table 1. The heat pump system coefficient of performance of alternative system designs at 100, 50 and 20% load

(hps = heat pump system; 1-3 are the alternative system options; motor type: b = base, m = modern and n = new design).

Alternative	COP	$f = 1.0$	$f = 0.5$	$f = 0.2$
1. Constant evaporating and condensing temperature.	$COP_{1hps.1.b}$	3.1	2.4	1.4
	$COP_{1hps.1.m}$	3.1	2.8	2.2
	$COP_{1hps.1.n}$	3.3	3.2	2.8
2. Constant flow rates, constant fan powers. Decreasing temperature lift.	$COP_{1hps.2.b}$	3.1	3.5	2.8
	$COP_{1hps.2.m}$	3.1	4.1	4.0
	$COP_{1hps.2.n}$	3.3	4.5	4.7
3. Adapted flow rates, decreasing fan powers. Decreasing temperature lift.	$COP_{1hps.3.b}$	3.1	4.1	3.2
	$COP_{1hps.3.m}$	3.1	4.9	5.3
	$COP_{1hps.3.n}$	3.3	5.5	7.1

Table 1 provides an overview of the very large impact that system design, sizing and motor characteristic has on part-load performance.

Conclusion

The trend in the heat pump market is towards rising energy coverage. Higher electricity prices, the possibility of hourly tariffs and new power rates as well as new requirements in the building code affect the possibility of using electricity for peak heating (the standard alternative so far). Thus it comes natural to size all types of heat pump, ground-source systems in particular, as close to full coverage as possible by overreving the compressor on the coldest days. However, irrespective of application this article underlines the importance of adapted electric motors, drives and control.

References

See the complete list of references of the article in the html-version at www.rehva.eu -> REHVA European HVAC Journal 3E

Verified net Zero Energy Building with air source heat pumps for SME

Field measurements were conducted on a net zero energy building designed for small to medium enterprises (SMEs). Energy flow and comfort parameters were monitored. The net zero energy concept, built around air source heat pump technology, achieved a positive energy balance of 977 kWh after one year of measurements. The study was conducted in cooperation with five European research institutes.


Bart Van Reeth
Research Engineer
Daikin Europe NV
vanreeth.b@bxl.daikineurope.com


Katrien Roussel
Research Engineer
Daikin Europe NV
roussel.k@bxl.daikineurope.com


Hiroshi Aihara
Department Manager
Daikin Europe NV
aihara.h@bxl.daikineurope.com

Introduction

Since the publication of the EPBD recast (2010), much attention has been paid to nearly zero energy buildings (nZEB). As a building equipment manufacture, Daikin too has been closely following and contributing to this development. High efficiency solutions after all play an important role in the total energy picture. To this end, field measurements at a Net Zero Energy Building were


Figure 1. Interior views of the meeting room and an office.

started in March 2010 as part of an nZEB project in cooperation with major research institutions. The aim of the project is to develop an economically feasible Net Zero Energy Building concept using heat pump technology. In a first phase, current technology is being evaluated in a newly constructed building in the German Ruhr region. On the one hand, the building and its measurements are being used to study whether a net zero energy building is feasible today using an open and flexible architectural approach with high efficiency equipment. On the other hand, it is being used to demonstrate a net zero energy building in real use to customers, policy makes and consultants.

nZEB concept

Building description

The project concerns a newly constructed office building (2009) for a small to medium enterprise that is home to 15 fulltime employees. An 800-m² warehouse is connected to the north side of the 2-story office. Interior views can be seen in **Figure 1**. The entire construction is steel frame. The general building characteristics, including the climate data, are shown in **Table 1**.

Since the idea was to start with an open and flexible architectural approach, the building envelope did not target extreme insulation values, but rather a slight im-

Table 1. General building characteristics.

Location	Herten. Germany
Owner	Athoka Gmbh. Zeller Gmbh
Typology	Office and showroom + warehouse and workplace
Climate data	Heating: T_{design}: -8.6°C Cooling: T_{design}: 30.3°C
Number of floors	2
Net floor area	545 m²
Conditioned floor area	515 m²
Conditioned volume	1424 m³
Lighting level	>500 lux
Indoor temperature	Winter: 20-23°C, zone depending Summer: 24°C, with individual user control
Ventilation rate	According to EN15251, method B1.3
Envelope to volume ratio	0.66

provement in the German EnEV standard (**Table 2**), in combination with measures to reduce the loads such as controllable solar shading on the facades and windows, cool roof covering, and a free cooling option in the heat recovery ventilation system.

Table 2. Envelope technical data.

	Material	U value (W/m^2K)	EnEV reference Construction
External walls	Brickwork (insulation 14cm) + sandwich panels (insulation 10cm)	0.23 -0.25	0.28
Roof	Steel deck (insulation 20cm)	0.19	0.2
Windows	Double glazing + insulated aluminum frames	1.3	1.3
Office envelope (average)		**0.41**	

Equipment description

As a next step, high efficiency systems are used to reduce energy consumption. The primary system for heating the building is an air source heat pump, with a water circuit connected to underfloor heating. Each room has one or more piping zones for which the water volume flow is individually controlled by valves, managed by PID-controlled temperature sensors per zone. This ensures a balance between optimal comfort and energy savings. Since heat pump performance very much depends on the provided water temperature, the leaving water temperature is intelligently controlled in function of the weather. The project revealed that good knowledge of the building and its users can facilitate a perfect match between solutions used. Trying to avoid inefficient back-up heater operation in extreme winter conditions can lead to an overdimensioned design, which results in lower efficiency at low partial load operation (e.g. warmer temperatures). Therefore for this project, the choice was made to optimise the heating system for partial load efficiency, and use *combined operation* in extreme winter conditions, i.e. augmenting heating capacity using the – already present – air-to-air heat pump (designed for cooling the building, but able to run in heating mode). The building's control system was designed so the that underfloor heating remains the dominant heating system, and use of the electrical backup heater is minimised. This combined operation resulted in high seasonal efficiency. Both outdoor units of the Daikin Altherma and VRV system can be seen in **Figure 2**.

Figure 2. Daikin Altherma outdoor unit (right) and VRVIII outdoor unit (left).

As noted above, comfort cooling during the summer period is handled by an air-to-air heat pump in reversed cycle mode (VRV III). Each room has individual control of its indoor unit.

Ventilation is provided by two heat-recovery ventilation systems with a temperature exchange efficiency of 75% and an enthalpy exchange efficiency of 60-65%. The control system uses free cooling whenever possible in the summer period.

The lighting design makes use of LED and other efficient lighting technology where possible. The desks have personalised lighting to guarantee light comfort and the highest possible energy efficiency.

A Net Zero Energy Building concept may be defined as a building that is energy neutral over a period of one year: i.e., it must deliver as much energy to the supply grid as it takes from this grid. The energy saving component was handled with the previous actions; the remaining component is the addition of renewable energy sources. In this project, 27.3 kWp thin-film photovoltaic panels were installed on the roof. This system was chosen for its combination of easy installation and good response to the infrared light of the CIGS solar cells (copper indium gallium selenide). The latter is important since the research included an evaluation of the effect of Daikin's durable sun reflective coating Zeffle on the photovoltaic energy production (the results and a comparison with standard white coating can be found in paragraph "Increased PV performance"). A picture of the roof can be seen in **Figure 3**.

Figure 3. View on the roof with photovoltaic panels and standard white roof coating.

All equipment and sensors are connected to online measurement and visualisation systems that allow Daikin engineers to remotely monitor performance and comfort at the field test site.

Measurement results

Energy flows

The building and its equipment were closely monitored for a 12-month measurement period. An analysis of the energy flows shows an energy surplus for measurement year 2011-2012. The positive outcome of 977 kWh (1.8 kWh/m²) is displayed in **Table 3** and **Figure 4**. This is result includes the aspects mentioned in the European Energy Performance of Buildings Directive: heating, cooling, domestic hot water, ventilation and lighting. These measurements were conducted in cooperation with five research institutes.

Table 3. Measured energy performance of the building. All specific values are per net floor area.

	Delivered and exported energy, kWh/(m²a)	Primary energy factor, -	Primary energy use, kWh/(m²a)
Heating	14.5	2.6	37.7
DHW	1.7	2.6	4.4
Cooling (incl. server room)	5.1	2.6	13.3
Ventilation	4.3	2.6	11.2
Lighting	11.1	2.6	28.9
PV power generation	-38.5	2.6	-100.0
Total	**-1.8**		**-4.6**

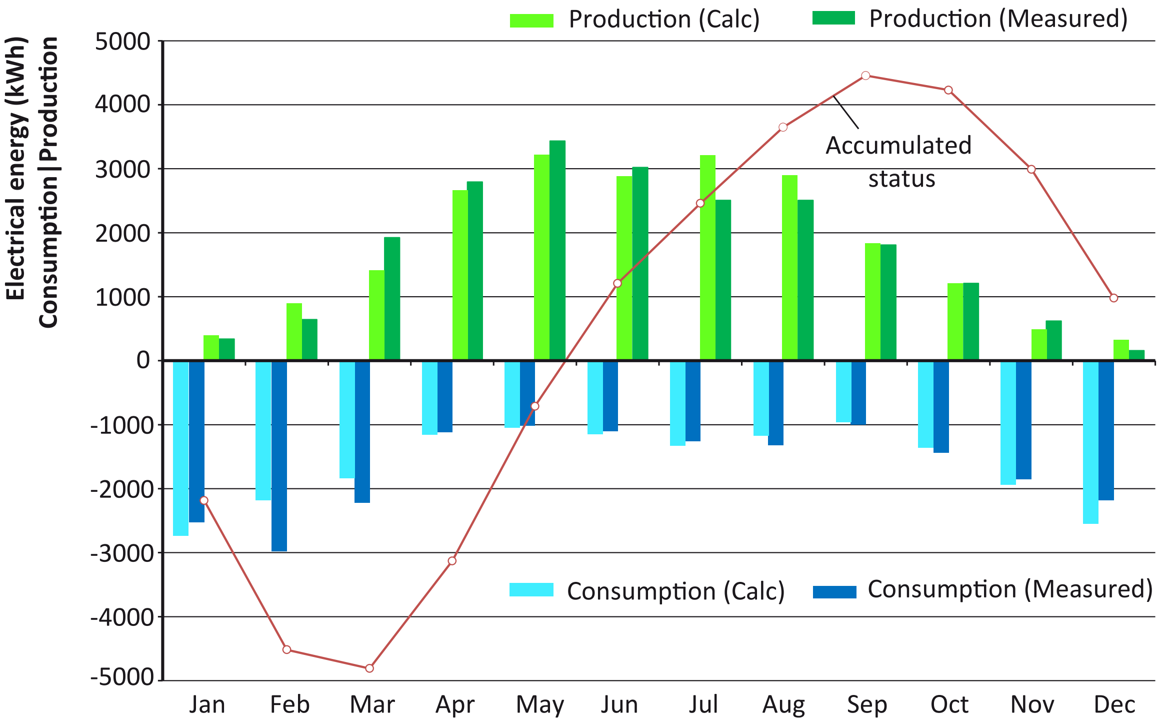


Figure 4. Yearly comparison of simulated and measured energy consumption and generation.

As can be seen in **Figure 4**, energy consumption was in line with the calculation made according to the German DIN18599 energy standard. The months of February and March deviate the most from the calculation. In March 2011, measurement had just started and the lighting control was not yet fully operational. February 2012 was a month with extreme winter conditions: –15°C as a daily minimum, compared to -8.6°C in the reference year.

Heat pumps appear to be an excellent solution for zero energy buildings. The results of the project show that the success of a zero energy project is already highly influenced in the first stage of the project: the design phase. The aim was to allow an open and flexible architectural approach in which the goal of achieving zero energy building performance would not create obstacles for the architect in the design and form of the building. This was made possible by the early integration of the technical concept into the architectural, allowing both to converge, resulting in a technically and architecturally superior building.

Increased PV performance

Daikin's durable sun reflective coating Zeffle is designed to reduce the roof temperature and be a passive measure for reducing the building's cooling demand. In this field test, a part of the roof was coated with Zeffle in order to compare it with standard white roof coating. The effect on the photovoltaic energy yield was expected to be twofold: (1) increase the solar reflection on the photovoltaic cells and thus increase the energy produced, and (2) lower the working temperature of the cells and thus increase the potential difference across the field (top in the **Figure 5**). These two aspects resulted in a measured yield increase of 11% in comparison with the standard white roof coating (graph in the **Figure 5**) [1].

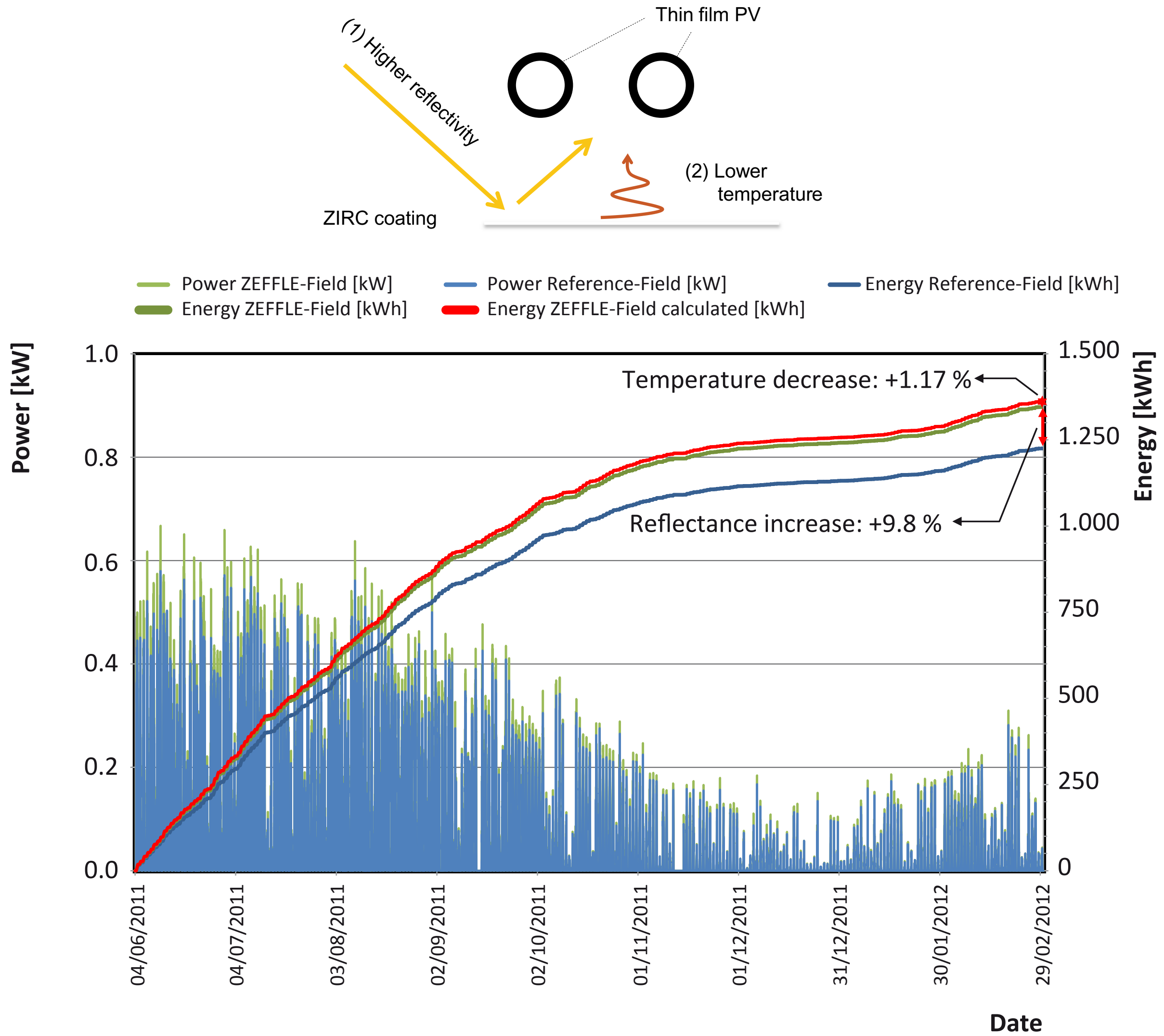


Figure 5. Principle (top) and results of measurement on yield increase of the photovoltaic system.

[1] The difference between the blue continuous line and the red continuous line gives the increased PV yield due to the Zeffle coating.

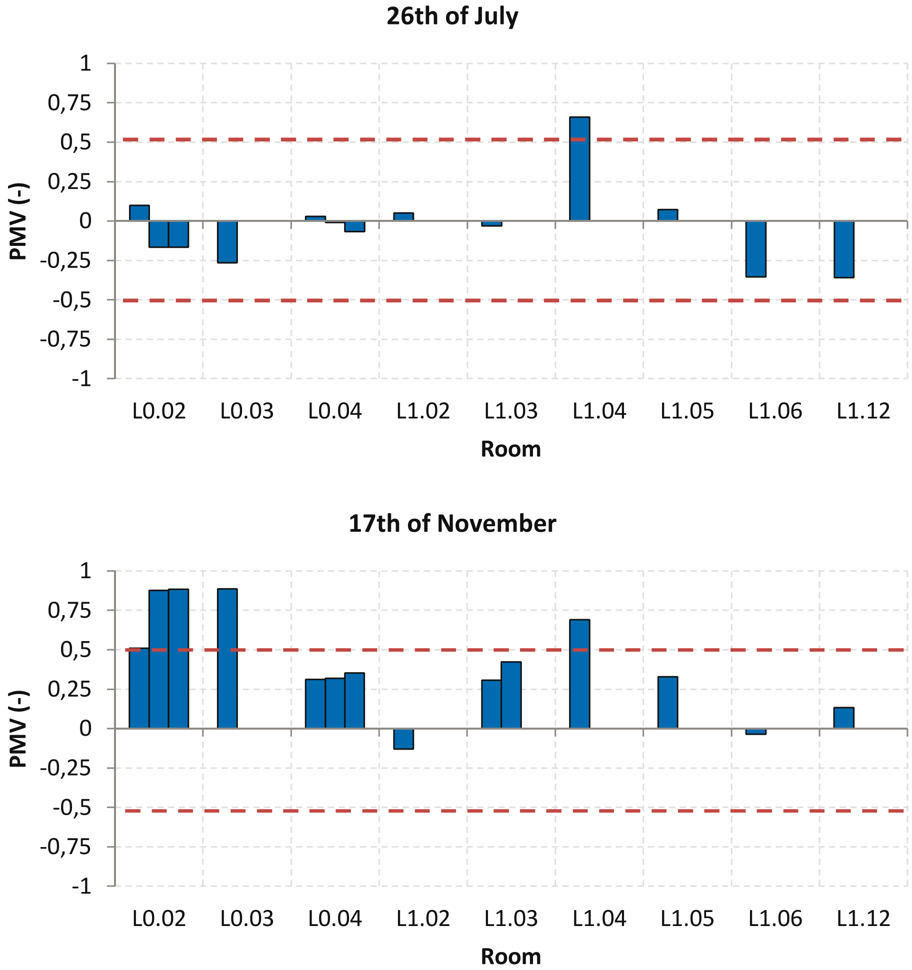


Figure 6. Results of two thermal comfort spot measurements (measured as PMV) in the summer and winter period [2].

Comfort

The project's priorities included not only energy savings but also ensuring the highest comfort levels for building users. Thermal comfort was measured as PMV (predicted mean vote). PMV is a function of room temperature (°C), partial water vapour pressure (Pa), air movement (m/s), mean radiant temperature (°C), metabolic rate per unit human surface (W/m²), human external mechanical work per human surface (W/m²) and clothing thermal insulation (m²K/W). **Figure 6** shows the results of two spot measurements in the summer and winter period [2]. The outcome falls mainly within the comfort boundaries, i.e. between -0.5 and 0.5. Room L0.02 can be seen as an exception in the winter period due to the preferred settings of the end-user.

Experience gained

After more than one year of monitoring building operation, two aspects deserve attention.

- In low energy buildings, proper product dimensioning and selection is a crucial step. Good interaction with the building owner and users prevented oversizing of equipment.
- Manual monitoring makes it possible to discover upcoming problems before these would be noticeable to the building user and result in a wasting of energy. This process could be automated.

Conclusion

The projects project shows that a net zero energy building can be achieved today with an open and flexible architectural approach, in combination with high efficiency equipment. Measurements over the one-year period show a net gain of 977 kWh, while guaranteeing comfort throughout the year.

We are presently improving the HVAC system in order to further reduce energy consumption in a next phase.

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Field test of a novel combined solar thermal and heat pump system with an ice store

Anja Loose
Institute for Thermodynamics and Thermal Engineering (ITW), Research and Testing Centre for Thermal Solar Systems (TZS), University of Stuttgart, Germany
loose@itw.uni-stuttgart.de

Harald Drück
Institute for Thermodynamics and Thermal Engineering (ITW), Research and Testing Centre for Thermal Solar Systems (TZS), University of Stuttgart, Germany

Abstract

The technological combination of solar thermal systems with heat pumps continues to be a highly topical subject in the market of sustainable domestic hot water and space heating concepts. The main background for this development is the expected increase of efficiency for both, the solar thermal system and the heat pump due to synergetic effects resulting from the mutual interaction of these two sub-systems. Solar thermal energy can be used for example to provide the heat pump with higher heat source temperatures, which is beneficial to its performance factor, while the solar collector's degree of efficiency rises simultaneously due to lower return temperatures in the solar loop when using the heat pump or an additional buffer store for this purpose as second heat sink. Nonetheless, objective performance test methods for such combined systems are not yet common standard. In this context field tests with different combined solar and heat pump systems installed in several single family houses in Germany are being performed by ITW within the project "WPSol". In this paper a novel combined solar thermal and heat pump system using an ice store for domestic hot water preparation and space heating in single family houses, in the following named solar ice store system, is presented as one selected example of the investigated system concepts. The solar ice store system consists of different types of solar thermal collectors in combination with a brine to water heat pump which utilises an ice store as only heat source. The system's functionality and the monitoring procedure are described and first results are discussed.

Introduction

During the past years, a variety of combined solar thermal and heat pump systems with different conceptual designs have appeared on the European market, claiming that higher seasonal performance factors (SPF) of the overall systems can be achieved than with traditional, separated heating systems. However, uniform and objective criteria for the evaluation of the combined solar and heat pump systems' thermal performances are not available up to now. Because of this corresponding test and assessment procedures are needed in order to be able to determine the energetic performance and the environmental impact of combined solar thermal and heat pump systems in an objective manner.

Therefore, international efforts are currently being made, e.g. within the IEA SH&C Task 44 and HPP Annex 38 "Solar and Heat Pump Systems"[1] [1]. In parallel, the research project "WPSol" (Performance testing and ecological assessment of combined solar thermal and heat pump systems) has been initiated by ITW in order to develop performance test methods for such combined systems [2], [3]. Key activities within this project are the development of a dynamic performance test procedure for heat pumps using the new heat pump test facility established at ITW, the extension of the CTSS[2] test method towards combined solar thermal and heat pump systems, the development of numerical models for specific components and TRNSYS simulations of complete

1 IEA: International Energy Agency, SH&C: Solar Heating and Cooling Programme, HPP: Heat Pump Programme.
2 CTSS: Component Testing – System Simulation; as standardised in EN 12977 series.

systems, life cycle analyses for the characterisation of ecological aspects and field tests, i.e. in-situ monitoring of combined solar thermal and heat pump systems in real building environments.

Field tests of combined solar thermal and heat pump systems

Broad field tests of separate system technologies (such as solar thermal systems and heat pump systems) have been performed already for heat pump systems only [4], [5] and for solar thermal combi systems without heat pumps [6], [7] but not yet for the combination of solar thermal and heat pump systems. Although some of these combined systems have been monitored as single cases, a systematic study for this system category is still missing. Therefore, such field tests based on in-situ monitoring are being performed within the project WPSol as well as within Task 44/Annex 38 in order to determine the thermal performance of combined solar thermal and heat pump systems under real operating conditions.

The aim of this monitoring is on the one hand the detection of installation errors, optimisation of the operation behaviour of the entire system and controlling functions for different operation modes as well as the dimensioning of the collector field and storage capacity, etc. On the other hand, measured data are necessary for the validation of numerical simulation models of combined solar thermal and heat pump systems. The combined solar thermal and heat pump systems which are monitored within the project WPSol represent a broad spectrum of different concepts. Seven systems have been installed in Germany, at locations between Osnabrück in the north down to Füssen at the southern border to Austria. Five of these systems have already been equipped with measuring equipment and monitoring is running. In the following, one example of the systems under investigation is described in more detail.

Solar ice store system – brine/water heat pump with different types of solar thermal collectors

This system consists of an earth buried latent heat store using water/ice as the only heat source for a brine to water heat pump. The ice store is charged with the heat delivered by solar absorbers (uncovered solar collectors) on the roof which also collect heat from the surrounding air during times with no or low solar irradiation. In addition, two flat plate solar collectors are used for charging a conventional small domestic hot water store on a higher temperature level than the ice store. The two types of solar thermal collectors are connected in a parallel way and the system controller decides, which collector type is being operated at a time, depending on the temperatures in the collector loops, in the domestic hot water store and in the ice store (c.f. **Figure 1a** and **Figure 1b**).

Figure 1a. Solar thermal flat plate collectors (left), absorbers (right). [Source: ITW]

Figure 1b. Ice store. [Source: A. Bühring]

This system has been developed for two main reasons. On the one hand it intended to be an alternative for brine to water heat pumps with borehole heat exchangers at locations where borehole drilling is not possible /not allowed (e.g. due to ground water protection or other authorisations). On the other hand it has proven to be rather difficult to supply brine to water heat pumps with solar energy. With borehole heat exchanger systems regenerated e.g. with unglazed solar collectors (c.f. [8]) it is in general not feasible to store solar energy in the ground in a seasonal way, speaking about single family houses with only one or two boreholes. Especially if an aquifer is crossing a borehole, the solar heat is removed rather quickly and cannot be recovered later on. Furthermore, flat plate collectors might be damaged by condensation from air moisture due to low operation temperatures, when providing energy to the ground as additional heat sink. Another option for the integration of solar energy into a heat pump system is the direct coupling of the solar loop to the primary circuit of the heat pump without a buffer store. The problem with this approach is that especially during the space heating periods solar radiation is not always available as heat source for the heat pump.

The solar ice store system makes use of the traditional heat sources ground and ambient air and additionally couples solar energy into the system. The major difference of this system to other classical combined solar thermal and heat pump systems is the ice store that is used for storing solar thermal energy, geothermal energy and ambient energy from the air at a low temperature level in order to act as the only heat source of the heat pump (c.f. **Figure 2**).

This ice store is a concrete tank with a volume of 12 m³ filled with water and buried into the ground. Polyethylene pipes as heat exchanger loops are placed inside the store for charging and discharging (c.f. **Figure 1b**). This water or ice store, respectively, is in principle comparable to a usual cistern, but it is also used as latent heat store. As the brine to water heat pump extracts more and more heat from the water store, the water will freeze to ice. The crystallisation enthalpy available during this process is additionally available for energy storage. Due to the occurring phase change this type of water store is called an ice store. As heat transfer fluid between the ice store and the heat pump an antifreeze fluid consisting of a water/Tyfocor mixture is used (ethylene glycol basis, melting point –15°C).

Building description and technical data

In the following, technical data of the several components of the solar ice store system which is being monitored by ITW and the building description of the house in which it is installed are described:

- Single-family house, 1 flat, 2 persons; Year of construction: 2010
- Location: Louisendorf, Hessen, Germany
- Heated living area: 175 m², floor heating system
- Brine to water heat pump with capacity 6 kW and integrated 220 l domestic hot water store, COP 4.6 at B0/W35[3], refrigerant R410A, scroll compressor
- 2 x 2.25 m² solar flat plate collectors and 2 x 4 m² solar absorbers
- 12 m³ ice store (latent heat store, storage medium: water/ice)

3 COP = Coefficient of performance at operating point brine at 0°C (source temperature) /water at 35°C (sink temperature), determined according to EN 14511.

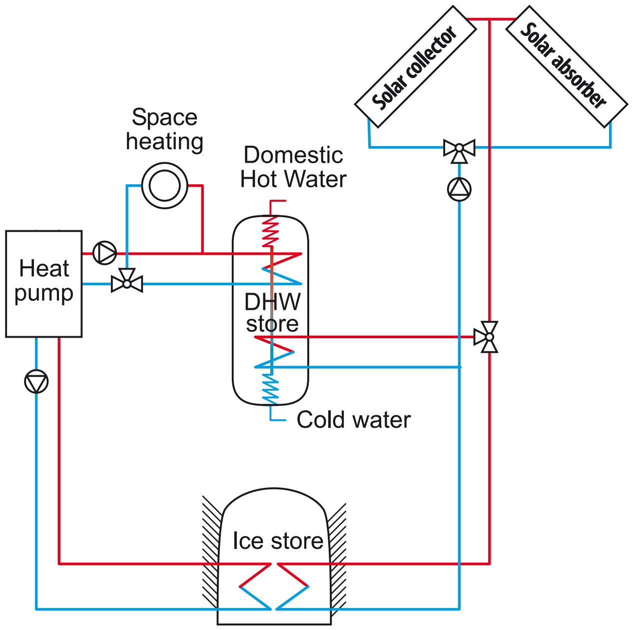

Figure 2. Simplified hydraulic scheme of the solar ice store system.

Monitoring procedure

The system is being monitored since autumn 2011. Data are collected once per minute with an *Ennovatis Smartbox* as data logger and transferred once per day via a GSM mobile connection to ITW. Pt 1000 temperature sensors are used for measuring ambient temperatures, room temperatures (boiler room) and flow and return temperatures of the three brine loops: two solar loops and ice store to heat pump loop (primary circuit of the heat pump). The solar radiation is measured with a Si cell sensor and the ambient moisture with a hygrometer. Heat meters consisting of an ultrasonic flow meter and two Pt 500 sensors each, are used for monitoring the heat flow in the space heating loop and the domestic hot water loop including circulation, recording flow and return temperatures and volume flows. Turbine-type volume flow meters are used for measuring the heat quantity in the three brine loops (two solar loops and primary circuit of the heat pump). Electricity meters are used for the determination of the electric energy consumed by the heat pump, the electric heating element included in the heat pump, the solar loop pump, space heating loop pump, the circulation pump of the primary loop of the heat pump and the controller. In addition, the status of two three-way valves and the solar loop pump is monitored by means of a simple "on/off" signal in order to track which solar collector is in operation and which store is being charged at a certain time.

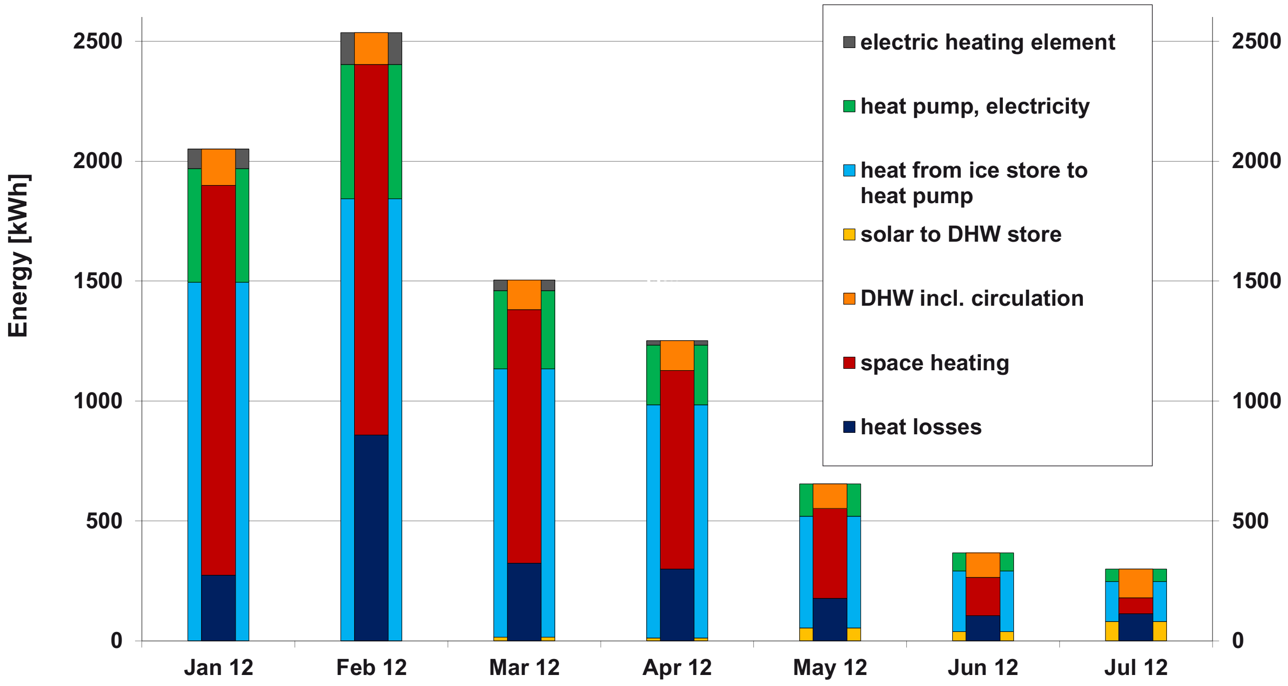

Figure 3. Monthly energy balances of the monitored solar ice store system[4].

Results

In **Figure 3**, monthly energy balances for the solar ice store system are shown in kilowatt-hours for the months January 2012 until July 2012. The central small bar of each column depicts the useful energy including heat losses. At the outer part of each column, the energy sources are displayed. They consist of solar gains from flat plate collectors to the DHW store, heat transferred from the ice store to the heat pump, electrical energy consumed by the heat pump and by the electric heating element.

The seasonal performance factor of the heat pump (SPF_{HP}) was calculated as

$$SPF_{HP} = \frac{Q_{SH} + Q_{DHW}(+Q_{losses}) - Q_{solar\ to\ DHW} - Q_{el.\ heating\ element}}{P_{el,HP}}$$

with Q_{SH} – space heating, Q_{DHW} – domestic hot water, Q_{losses} – heat losses, $Q_{solar\ to\ DHW}$ – solar energy to DHW store, $Q_{el.\ heating\ element}$ – heat delivered by electric heating element, $P_{el,\ HP}$ – electricity consumption of the heat pump. SPF_{HP} reached a value of 4.37 over the shown period of seven months, considering produced heat including heat losses, and 3.22 for produced useful heat only.

On the other hand, the thermal performance of a solar thermal system can be characterised by the fractional energy savings $f_{sav,\ prim}$ defined as the energy consumption of the solar thermal system (Q_{aux}) compared with the energy consumption of a conventional reference system using a gas boiler (Q_{ref}):

$$f_{sav,prim} = 1 - \frac{Q_{aux}}{Q_{ref}} \quad \text{with}$$

$$Q_{aux} = (P_{el,HP} + P_{el,heating\ element}) \cdot f_{PE,electricity}$$

$$Q_{ref} = (Q_{SH} + Q_{DHW} + Q_{losses,\ store}) \cdot f_{PE,gas}$$

As primary energy ratios f_{PE} factors of 1.1 for natural gas and 2.6 for the German electricity mix were used. Parasitic energies as electricity consumption of circulation pumps and controlling are not included in the value of Q_{aux}, according to EN 12976. Q_{losses} describes the heat losses of a conventional water store as a fixed value. The solar ice store system reached fractional energy savings

4 The heat meter for measuring heat from the ice store failed for February, because of which the value for this month has been calculated from the electricity consumption of the heat pump using a mean "COP" of 4.29 - (heat source + electricity)/electricity – as mean value of the neighboring months January and March.

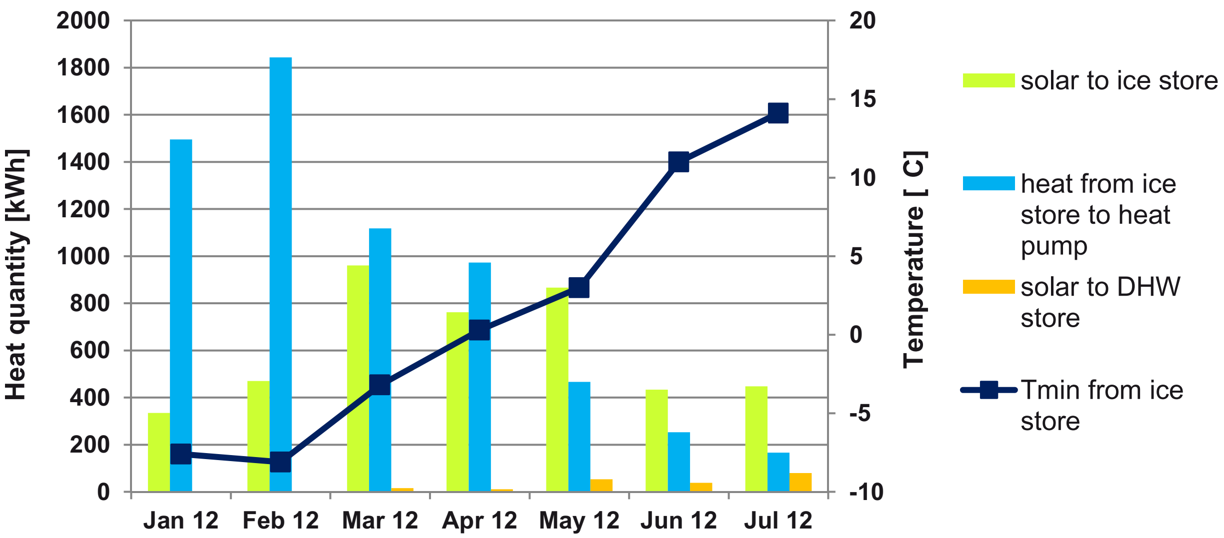

Figure 4. Solar gains transferred to the ice store and to the DHW store, heat gained by the heat pump and minimal temperatures in the ice store shown as monthly values for January – July 2012.

of 33% for the period shown above, which means that about one third less primary energy has to be used as compared to a conventional gas boiler.

In general, the solar contribution to domestic hot water preparation is rather low for this system. This is due to the splitting of the solar collector loops, allowing for either charging the DHW store by the flat plate collectors or charging the ice store with the solar absorbers only, at a certain time. Because of this the flat plate collectors are in operation only during a few hours per day, when solar irradiation is highest, i.e. at noon time. It can be recommended to change this operational mode for future system designs.

The ice store has been completely frozen during winter time and the lowest temperature measured in the brine coming from the ice store was –8.1°C in February (as flow temperature in the primary loop of the heat pump). In **Figure 4** solar gains to the ice store and to the DHW store are shown together with temperatures in the ice store and the heat from the ice store used by the heat pump. During winter time, when the ice store is colder than the surrounding earth, geothermal gains exist, while during the summer period more solar energy is transferred into the ice store than is extracted by the heat pump. In the latter case, the ice store is being regenerated by solar thermal heat and some losses occur towards the surrounding ground depending on the temperature difference between the ice store and the ground.

Conclusion

Seven combined solar thermal and heat pump systems are being monitored in a field test in Germany by ITW within the project WPSol. One of these systems, the so called "solar ice store system" with a brine/water heat pump, has been presented in this paper. Furthermore, the monitoring equipment and procedure have been described briefly and first measurement results have been shown. Monitoring is still on going, so final results cannot be presented yet. This kind of field test, in combination with appropriate laboratory performance test methods and transient system simulations, is crucial for the development of standardised performance test methods allowing for a detailed analysis and comparison of the many different system concepts available on the market.

Acknowledgement

The Project WPSol is partly funded by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit BMU) under grant number 0325967A. The authors gratefully thank for the support and carry the full responsibility of the content of this publication. Thanks are also addressed to our industrial project partners for their contributions.

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Space heating with waste heat from computer centre in the Vattenfall-head office

One of the installed (retrofitted) turbo heat pumps for heating and cooling application. The unit is speed-controlled between 16 000 - 48 000 rpm.

The EHA Energie-Handels-Gesellschaft and the Vattenfall Business Services GmbH rely on energy efficiency. These days, two ultra-modern heat pumps were installed and put into operation in the Hamburg head office of the 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 square metres floor area can be covered with the heat transfer. This project reduces the negative impact on the environment by more than 600 tons of CO_2 per annum. System design and implementation into the existing heating and air conditioning system has been performed by OCHSNER Heat Pumps. The challenge was to meet the tight temperature tolerances and the combination with the existing district heating and district cooling system.

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 300 kW of heating capacity of OCHSNER are used. Turbo compressors with magnetic bearings minimize friction loss and thus oil lubrification is no longer necessary. The drive shaft "floats" virtually in the magnetic field and reaches a speed of almost 40 000 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 a coefficient of performance (energy multiplier) of 8. This outstanding energy efficiency could be reached in an almost endless number of existing and newly built office buildings. The installation into the existing systems was carried out during the regular business. Also the sound insulation had to meet high requirements because the offices are located directly above the system.


The 50 000 square metres office building has been an architectural light-house project in its early years (1966-1969). Now it has been equipped with a light-house energy-saving system with highest energy efficiency.

OCHSNER Wärmepumpen GmbH
www.ochsner.at
daniela.edermayr@ochsner.at
htiwp@ochsner.at

HVAC&R market in Europe, the Middle East and Africa (EMEA)

Eurovent Market Intelligence (EMI), the European statistics office for the HVAC&R market, has just published the results of its studies of 2011 sales in Europe, the Middle East and Africa (EMEA), based on the data gathered among industry manufacturers. The annual data collection efforts for 2012 again produced a good harvest for EMI, with an 8% rise in participation distributed over the seven main programmes*. The air processing unit programme showed the greatest increase, from 36 participants last year to 44 in 2012, and is already expected to exceed the symbolic mark of 50 participants next year.

Yannick Lu-Cotrelle (manager of Eurovent Market Intelligence) is delighted with this expansion, because most of the launches of new programmes come from the manufacturers themselves:

"Companies are continuously seeking information about their markets, and when they can't find any source of reliable data, they turn to us and our know-how. We define the project with them, and then we immediately get to work on the programme as a whole: prospection among potential participants, management of statistics collections, organization of working meetings bringing EMI together with the manufacturers, and internal dissemination of the results. Of course, the entire process is performed in stringent compliance with European rules governing competition and in the strictest confidentiality of the data provided."

*** The seven main programmes of Eurovent Market Intelligence (EMI):**

- Fan coil units
- Liquid chilling packages
- Air processing units
- Rooftop units
- Heat exchangers
- Air filters
- Cooling towers

The year 2011, which was a soft year in the EMEA area for most markets, nonetheless confirmed the exceptional dynamism of the air processing unit market. It also highlighted the two poles of recession and growth that have marked the economy, with the collapse of the Greek and Spanish markets on the one hand, and the emergence, on the other hand, of two new "European dragons": Russia and Turkey.

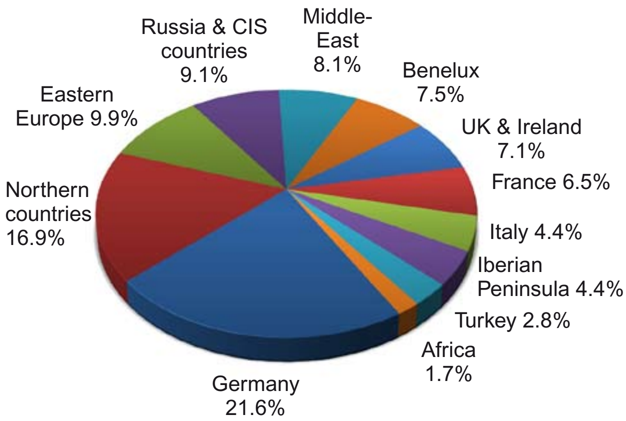
Air handling units: exceptionally dynamic

The air handling unit market is the market that has revealed itself to be the most dynamic in Europe, with 1.4 billion euros in turnover, 2010–2011 growth between 10% and 12% and projected 2012 growth exceeding 5%.

The main strongholds of this market remain in northern Europe: Germany accounts for nearly one quarter of the European market, Scandinavia one fifth, and England, the Benelux countries and Russia each have an 8% share. While the French market share stands at around 7%, southern European countries (Portugal, Italy, Greece and Spain) together account for little more than 10% of the market. The Middle East occupies a relatively minor slot in this market: its 2011 sales were barely 10% of the EMEA market; this market is dominated primarily by rooftop units that do not necessarily require the installation of air handing units.

Compared with last year, the most remarkable increases were recorded in northern Europe and Russia (and their former satellite countries), with an average 20% growth. Turkey deserves a special mention: it remains the most dynamic country, with a record growth approaching 30%. The other countries with the best results are France, Switzerland and the Benelux countries, with growth around 15%, followed by Germany and Eastern Europe, whose growth is approximately 10%. By contrast, Greece, Africa and the Middle East suffered market contractions, with declines of as much as 10% in the Iberian Peninsula. No spectacular turnaround in trends is expected in 2012 in the EMEA area as a whole, except, possibly, in the Middle East, which should see a return to growth.

Half of the air handling units sold in the EMEA zone in 2010 were those with an air flow rate equal to or below 5,000 m^3/h, while those operating at up to 15,000 m^3/h accounted for a fifth of sales. In terms of energy class, the average falls into class B, leaning towards class A for northern Europe and Switzerland, and towards class C for southern Europe and Africa.



Break down of 1.4 billion euros AHU market at EMEA zone (Europe, Middle East and Africa) in, 2010–2011.

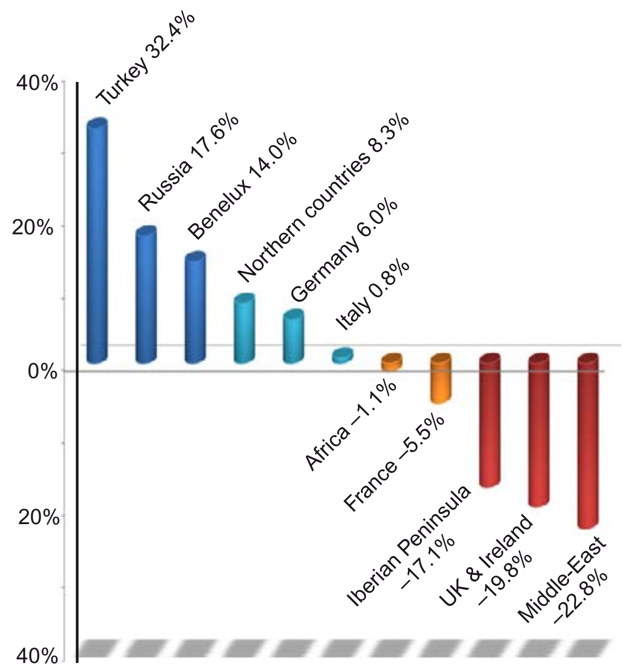
Fan coil units: a lacklustre year

The fan coil unit market underwent a slight contraction in 2011 (approximately 3%) with total EMEA sales of some 1.6 million units. European sales accounted for three quarters of the market.

In Europe, Italy kept its leadership position with nearly one third of the market, while France attained a distant second place with 13%. This year, Spain was pushed out of its third-place position by Turkey, which obtained a 7% market share, with Russia hot on its heels after securing almost 6% of the market. The 6th and 7th places were taken by Germany and the United Kingdom, respectively, each with market shares of approximately 5%. The Middle East consolidated its second place slot in the EMEA market with nearly 250,000 units sold.

Compared with 2010, the northern European countries showed the greatest dynamism with an approximate average growth of 10%; the Benelux countries increased their sales by 14% and German turnover grew by 6%. Italy had a dreary year marked by the stagnation of its market, while the French market contracted by approximately 5%. The greatest declines were recorded on the Iberian Peninsula (averaging 17%), in England (which fell by 20%) and, above all, in Greece, where the market fell 50%. By contrast, the recession spared Russia and Turkey entirely, which continued their vigorous development with respective growths of 20% and 30%. For 2012, these two countries are expected to experience a strong slowdown, while the year will again be quite a difficult one for Italy. While some improvement is foreseen for Greece and Spain, no recovery from the recession is yet envisaged.

Three quarters of the fan coil units (FCU) sold in the EMEA area are, on the whole, two-pipe units with, however, a slight difference in Turkey, which is more egalitarian, and, above all, the Ireland/United Kingdom tandem, where most of the units sold are of the 4-tube type. Regarding design, two thirds of sales are split equally between encased and unencased models. One fifth of the market is absorbed by Cassette models, and 13% by encasable units.



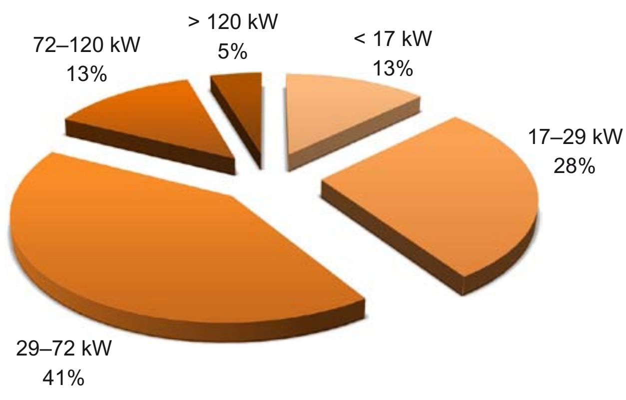
Changes in the 1.6 million units market of fancoil units at EMEA zone (Europe, Middle East and Africa) in 2011.

Rooftop units: a dynamic Middle East contrasts with an apathetic Europe

Of some 68,000 units sold in 2011, the Middle East retained its EMEA market leadership position with nearly 50,000 units sold. Africa took second place with just under 5000 units. In Europe, the main markets remained the same, with the Iberian Peninsula holding its first place slot (18%), followed by France (17%), Italy (14%) and the United Kingdom (12%), which together account for most of the rooftop units sold in Europe.

With respect to 2011, and contrary to other markets, the rooftop unit market remained dynamic with generally creditable 2010–2011 growths and further growth projected for 2012. However, this growth primarily benefited the Middle East, with increases above 30%, while in Europe the more minor markets such as Germany and the Benelux countries profited from this trend. Elsewhere, in France, Spain, Russia, Turkey and Poland, the market was quite soft, even negative; Italy came out a little better with growth close to 10%. Conversely, the market experienced serious reverses in Greece, Africa and the United Kingdom, with sales dropping as much as, or even below, 30%.

In the Middle East as in the rest of Europe, the most frequently sold rooftop units remained those with an average capacity ranging from 29 to 72 kW. However, the second market in terms of importance in the Middle East was geared mainly towards the smaller capacities below 29 kW, while in Europe that second market primarily involved large capacities above 72 kW. As regards the type of units sold, the greatest numbers were recorded, quite logically, by cooling units in the Middle East, while in Europe the reversible units (both classic and gas-powered) accounted for two thirds of sales.



Break down of the 68,000 roof top unit market based on unit capacity at EMEA zone (Europe, Middle East and Africa)

Liquid chilling packages: a sluggish 2011 for Europe, while Turkey and Russia confirmed their dynamic stride

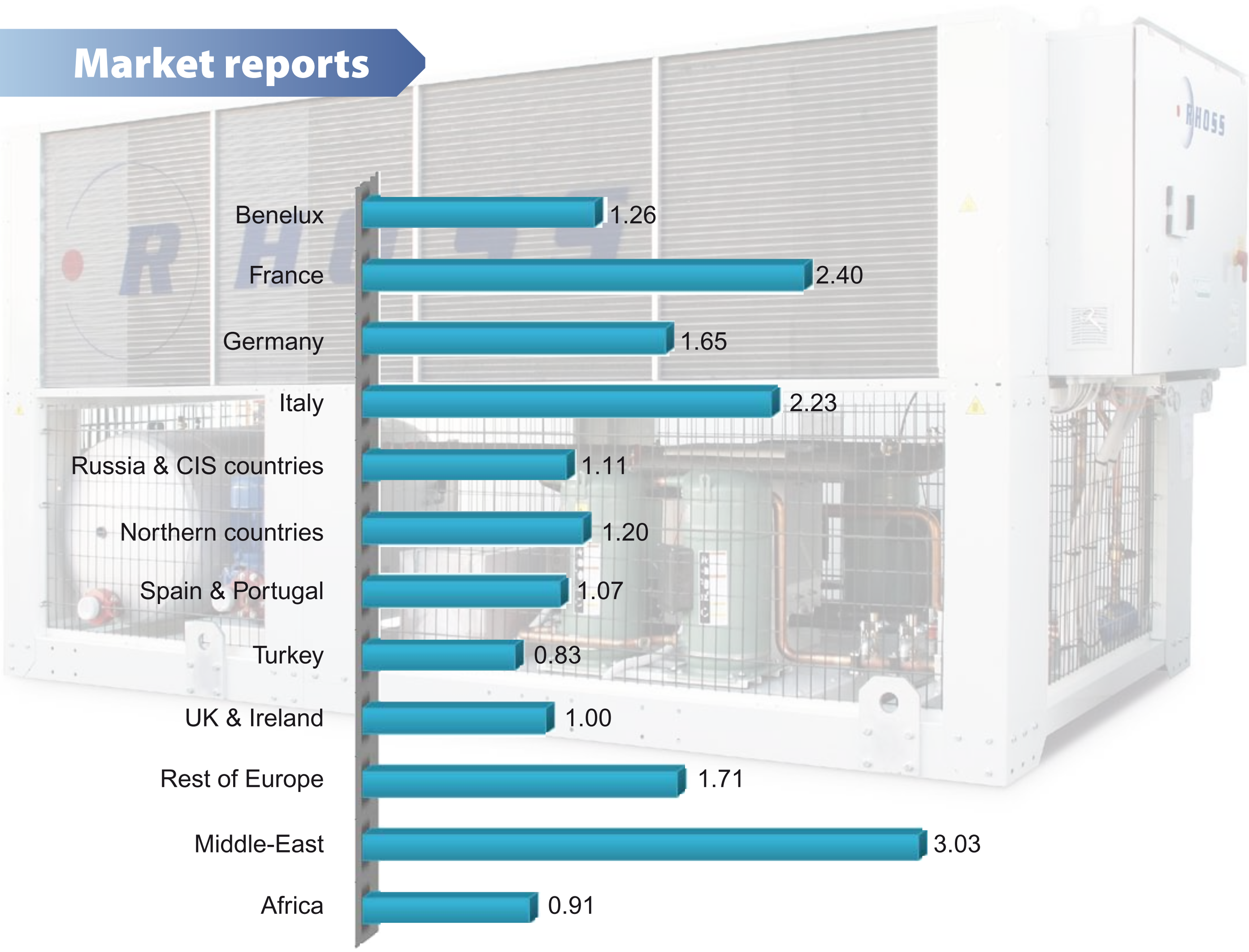
The liquid chilling package market in the EMEA zone (Europe, Middle East and Africa) attained a total volume exceeding 18 million kW in 2011, compared with 16 million in 2010. This market primarily involves the Middle East (16%), France (13%), Italy (12%) and Germany (9%).

Although sales of the smaller capacity packages (<50 kW) are traditionally concentrated in southern Europe (France, Italy, Spain), the Scandinavian and Baltic countries are also important consumers, accounting for one quarter of the European market.

In Europe, sales of medium power units (between 50 kW and 700 kW) are dominated by the trio formed by France, Italy and Germany, representing nearly half the market, followed just behind by the Benelux countries, Spain, the United Kingdom and Russia, each of which accounts for 6% to 9%. On the other hand, for high-powered units (greater than 700 kW), Turkey and Russia are on top with respective market shares of 15% and 13%, followed by the France/Germany/Italy trio, each of whose market shares ranges from 13% to 10%.

Compared to 2010, the 2011 sales of units above 50 kW stagnated in the market as a whole. This stagnation slightly affected France, Germany, the Nordic countries, the Maghreb and eastern Europe, and was more negative in the United Kingdom and Italy. The least affected countries included the Middle East, Benelux and Poland, with growth rates between 10% and 20%. As usual, Russia and Turkey managed to come out ahead with growth rates well above 20%. Conversely, significant declines were again experienced on the Iberian Peninsula (around 25%) and in Greece, where the market fell one third. Also worthy of note is Egypt, where the impact of the revolutions of 2011 strongly contracted the market and reduced it by almost two thirds, whereas it had grown by 25% between 2008 and 2011.

The forecasts for 2012 are rather mixed. They remain positive for areas which are already very dynamic such as Russia, Turkey and the Middle East, but they are clearly more lacklustre for the rest of Europe. For example, Italy, Spain and France have had quite a bad start this year, with falls ranging from 10% to 30%, respectively, which appear difficult to make up in the second quarter. Germany and the United Kingdom, which have



Break down of the liquid chilling package market in the EMEA zone (Europe, Middle East and Africa) by the total capacity in Terawatts.

seen more moderate market declines in the first quarter, should be able to maintain sales volumes almost equal to that of last year.

The factors behind the success Eurovent Market Intelligence

To begin with, one of Eurovent Market Intelligence's priority lines of action entails enriching the information available in the reports. By means of working meetings twice a year, EMI strives together with the manufacturers to improve the nature of the results provided each year and to give them greater reliability and added value.

The second factor contributing to this success is making the results available on an extranet. Extranet users log on with specific passwords and the website offers a full range of marketing tools which enable the participating company to perform tailored data extractions according to their requirements. In addition to the market results, website users can follow sales fluctuations, their market share and position with respect to their competitors and the market concentration ratio, in a real-time panel display.

Finally, manufacturers are showing a renewed interest in market information. Indeed, the programmes are open to all manufacturers who wish to participate and, in a highly volatile market context, many of them want to increase their visibility in the short and medium-term and establish strategies to obtain the greatest benefit from market opportunities.

For further information please contact:

statistics@eurovent-marketintelligence.eu or

https://www.eurovent-marketintelligence.eu/

CO_2 heat pumps in europe

market dynamics & legislative opportunities

As companies seek to find new ways to reduce their energy consumption and invest in environmentally sound technologies, more and more are turning to natural refrigerant applications. For heating cold water to high temperatures CO_2 heat pumps represent a climate and ozone friendly, energy efficient technology, gradually making clear inroads in both the residential and commercial building sectors as well as in large district heating projects across Europe. Depicting this budding market shecco shares some of the latest policy, market and technology developments relevant to CO_2 heat pumps.

Alexandra Maratou, Janaina Topley Lira, Huiting Jia & Nina Masson
shecco SPRL
Contact: nina.masson@shecco.com

CO_2 heat pump water heaters (HPWH) technology was developed in Japan over the last decade under the brand name “EcoCute” or “Eco Cute”. This type of water heater is becoming increasingly popular in many parts of the world due to the increased level of environmental awareness. As mitigating climate change becomes more pressing, applications that presently use high global warming potential (GWP) refrigerants need to be replaced with solutions like CO_2, a burgeoning trend across the HVAC&R sector.

GUIDE 2012:
Natural Refrigerants - Market Growth for Europe, shecco publications. Available also at http://guide.shecco.com/guide.php

Market potential of R744 in European countries

Part of a series of unique free publications, shecco’s “GUIDE 2012: Natural Refrigerants – Market Growth for Europe” captures a snapshot of the growing natural refrigerant market in the areas of industrial, commercial and residential heating, air conditioning and refrigeration. Based on a refrigerant survey that received more than 1338 industry expert opinions (666 from Europe), including those of heat pump manufacturers, results revealed increasing investment in CO_2 technologies and favourable market conditions for CO_2 products. For example, among the European respondents 35% currently offer CO_2-based products or services, whilst 42% of respondents stated that their future products and services would involve CO_2-based solutions. (**Figure 1&2**)

QUESTION: “Which Products & Services for Natural Refrigerants do you HAVE?”

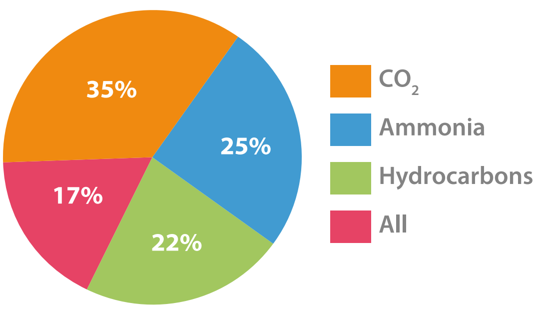


Figure 1. Market share of Natural Refrigerants Products in Europe based on 1338 industry expert opinions. [1]

QUESTION: “Which Products & Services do you PLAN TO HAVE?”

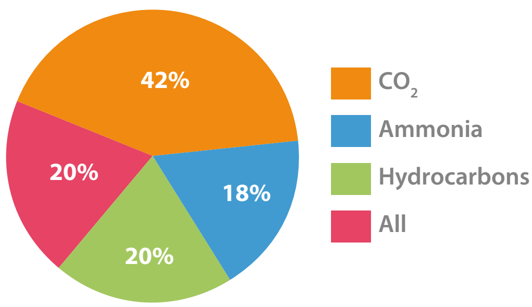


Figure 2. Market potential of Natural Refrigerants Products in Europe based on 1338 industry expert opinions. [1]

With regard to market policy conditions 63% of participants believe the business and policy climate for CO_2 in Europe to already be "rather" or "very" positive. (**Figure 3**)

QUESTION:
"How is the Business and Policy Climate evolving in your country (location of organisation)?"

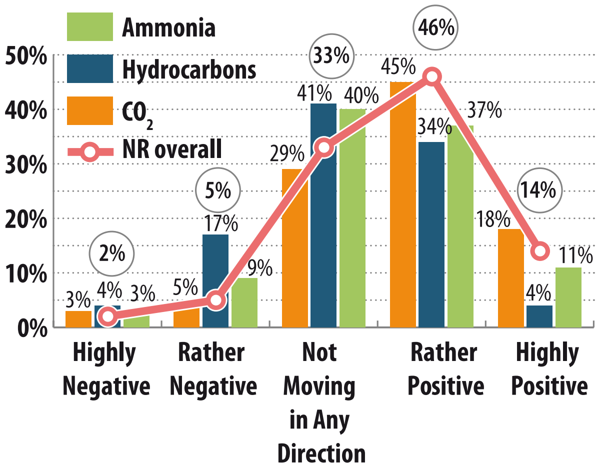


Figure 3. Market and Policy Environment of Natural Refrigerants in Europe. Responses of 1338 industry experts. [1]

Benefits of CO_2 heat pump water heaters (HPWH)

HPWHs are a relatively mature technology and have gained popularity over the past decade within the water heating industry because of their ability to deliver significantly more heat for the same amount of electricity compared to traditional electric storage water heaters (SWH).

The CO_2 heat pump water heater cycle is transcritical, operating at much higher temperatures and pressures than conventional subcritical cycles. The transcritical cycle operation provides a large continuous temperature glide and can offer a higher service temperature with limited capacity loss.

CO_2 heat pumps installations in commercial applications in Europe

Today most of the CO_2 heat pumps are designed for Domestic Water Heating (DWH), with Japanese companies like Panasonic, Daikin, DENSO, Sanden, Itomic and Mitsubishi some of the most active promoters of the technology. Whilst the Japanese market can be considered mature, CO_2 heat pumps represent a niche market in Europe. However, more and more Japanese companies are entering the European market, redesigning their CO_2 heat pumps to fit the European way of life, climate, housing structures as well as EU and national energy and safety standards.

Local CO_2 heat pump manufacturers are also emerging, with companies like Stiebel, enEX, ICS, Thermea, Kylma, CTC, JCA, and Viessmann adding CO_2 heat pumps to their product ranges.

Outside the domestic market, commercial real estate owners are beginning to see CO_2 heat pumps as a promising, high performance option for high temperature sanitary hot water for hotels, restaurants, hospitals, schools and other public buildings. Evidence of this can be seen in some most recent examples of commercial applications of CO_2 heat pumps in Europe:

Denmark: A large scale 100% renewable energy project that provides the Danish city of Marstal with a large-scale district heating system incorporates a 1.5 MW thermally CO_2 driven heat pump. The project, developed with a grant from the EU's Seventh Framework Programme (FP7), includes a solar plant, a combined heat and power (CHP) system, an Organic Rankine Cycle (ORC) Unit and a 75 000 m³ pit for heat storage, with the CO_2 heat pump moving energy to the energy storage pit.

Ireland: Ecocute Innovation and Design Limited (Ecocute Ltd) has installed an air to water transcritical CO_2 heat pump (TCHP) water heating system to supplement the O'Donovan's Hotel's existing solar thermal system. The Hotel's domestic hot water is now supplied by a 25 kW transcritical CO_2 heat pump that can operate at a seasonal performance factor of 3.2 when generating hot water at 75°C in Irish ambient conditions of 9.4°C air temperature and 10°C water inlet temperature.

Also in Ireland, the Cúil Dídin Residential and Nursing Care Facility in Tralee county Kerry has installed a transcritical CO_2 heat pump to supply hot water for the laundry facilities, kitchens and for the care of the residents. The new CO_2 heat pump can produce 2 500 litres of hot water per night at 90°C, which is able to meet the hot water demand 24 hours a day. Overall, cost savings of 70-80% are expected.

France: A McDonald's in France installed a CO_2 heat pump produced by Panasonic to comply with the energy and emission reduction priorities for new and existing buildings in the French government's Grenelle

Environment project (Grenelle de l'environnement). The CO_2 heat pump is able to reach a high pressure of 130 bars (most other heat pumps that can only reach 15 bars) providing comfort cooling.

Switzerland: In 2011, thermea. Energiesysteme installed a high-temperature heat pump thermeco2 at the campus of the University of Applied Sciences South Westphalia. The heat pump uses low-temperature waste heat from the ventilation and refrigeration plant and supplies the university canteen with hot water and heating. With a total heating capacity of 45 kW, the thermeco2 heat pump reaches high performance values (COP) even with a temperature lift of about 65°C. The COP values of 3.0 and 3.5 measured by the manufacturer surpassed values predicted by thermea.

Building regulations in EU Member States underpin trend towards sanitary hot water heat pumps

The year 2011 saw a trend towards sanitary hot water heat pumps - an application most suitable for R744: according to latest statistics by the European Heat Pump Association sales of sanitary hot water heat pumps have close to doubled in 2011 compared to 2010 levels reaching about 48 000 units.

This trend is underpinned by new building codes and regulations adopted in different EU Member States, regulations that typically place a ceiling on primary energy consumption of buildings or require the integration of renewable energy. Sanitary hot water heat pumps provide a straightforward means to integrate renewable energy sources (RES) and reduce primary energy consumption in buildings.

This is the case in France for example where the 2012 Thermal Regulation (Réglementation Thermique 2012 - RT2012) was launched at the end of 2010, replacing 2005 Thermal Regulations (RT2005). In general, all new building constructions must achieve average primary energy consumption of less than 50 kWh/m²/year for heating, domestic hot water, cooling, lighting and auxiliary equipment (e.g. fans and pumps) compared to the average of 150 kWh/m²/year required by RT2005.

This trend is expected to continue in the long term as more and more national governments in the EU are expected to adopt building codes and regulations that encompass similar requirements and accommodate the requirements of the recast EU Energy Performance of Buildings Directive agreed back in 2010.

For example the amendment of the Energy Saving Ordinance ("Energieeinsparverordnung - EnEV") that regulates energy performance for new and existing buildings in Germany is underway and is expected to raise current requirements further. The Ordinance sets requirements regarding primary energy demand, taking into account both insulation of the building envelope and the energy efficiency of equipment used for heating, sanitary hot water etc.

The Joint Research Centre estimates that by 2020 heating and cooling will represent the highest sectoral share in the gross final energy consumption, of 48% (http://ec.europa.eu/dgs/jrc/downloads/jrc_reference_report_2011_reap.pdf). Within this context and as the EU moves towards low or zero energy buildings that encompass minimal space heating requirements, sanitary hot water and energy efficient technologies for its provision are set to become all the more important.

Conclusion

Growing environmental awareness coupled with more stringent European building codes and regulations have provided a strong boost to environmentally friendly heating and cooling solutions. Since the revival of CO_2 as a refrigerant, started almost 20 years ago in Europe, there has been a strong development of new technology, with CO_2 now widely recognised an attractive and competitive alternative refrigerant to the synthetic fluids in heat pump applications.

Reference:

[1] GUIDE 2012: Natural Refrigerants - Market Growth for Europe, shecco publications. Available also at http://guide.shecco.com/guide.php

European Heat Pump Association predicts market recovery in 2012

The European heat pump sector continued to experience a challenging market environment during 2011. After two years of negative growth, heat pump sales in 2011 finished on par with 2010 results.

Thomas Nowak
Secretary General, European Heat Pump Association
thomas.nowak@ehpa.org

Whilst it may be too early to speak of a turnaround, the underlying trend during the first half of 2012 suggests a market in recovery. Growth rates were highest in the developing markets, however these smaller markets were not strong enough to overcompensate for the stagnation or even decline in the larger, more established European markets. In terms of absolute volume sales, Italy, France and Sweden were once again the leaders in 2011 (see **Figure 1**).

Key factors curtailing growth remain largely unchanged: low consumer confidence continues to hinder investment decisions and the availability of credit remains limited. As a consequence, no recovery of the construction sector is foreseen in the near future: the overall outlook remains bleak, with a slight silver lining in residential construction, albeit from a low level and thus insufficient to give any great impetus to heat pump sales. These factors affect all technologies that play a role in the decarbonisation and greening of heating and cooling, and may eventually place the attainment of the European Unions 2020 targets on GHG emission and the use of renewable energy at risk.

A slower than expected growth of heat pump sales will also negatively affect potential improvements in the overall energy efficiency. Unfortunately the scope for government intervention, now more critical than ever, is even more limited than in 2010. Even stricter budgetary constraints, at both European and national level have lead to incentives and support schemes being curtailed or withdrawn completely in most countries. The discovery of new of gas fields, the exploration of shale gas, and the recently inaugurated Northstream pipeline have eased the pressure on gas prices and have thus brought the operating costs of gas boilers closer to those of heat pumps. In parallel, electricity prices have further increased in many countries, often resulting from the fact that most countries feed-in tariffs are financed via the end consumer. It seems somewhat unfortunate, that the potential of a technology that integrates renewables into the heating sector in a very efficient manner is limited because of efforts to increase the share of renewables in electricity production.

An examination of the contribution of individual markets to overall heat pump sales highlights the fact that many of the traditionally larger growth markets have now reached maturity. Notably Sweden and Norway have seen a decline in demand in recent times, while sales

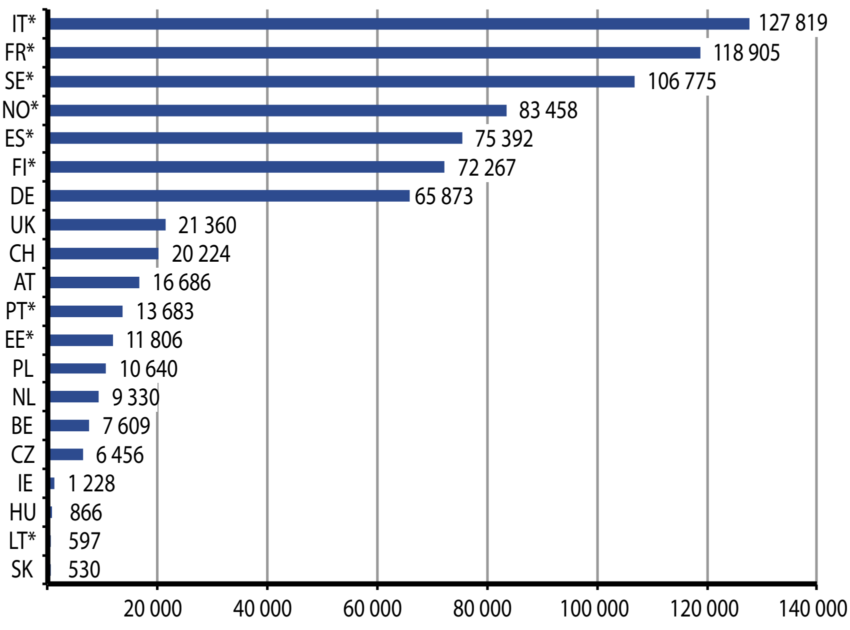


Figure 1. Sales of heat pumps in 20 European markets in 2011.

in Austria and Switzerland have levelled out. Other markets such as France, the Netherlands, Germany and Finland that showed the largest decline in 2010, recovered in 2011. Their contribution to the overall European total ensured that sales in 2011 were on a par with 2010. Growth continues in most of the developing and smaller markets lead by Belgium, Poland, the Netherlands, Lithuania, the UK and Estonia. In terms of energy source, the trend towards aerothermal energy is pronounced in most markets. It accounts for most of the market growth and reflects the cost consciousness of consumers. Improved performance and reliability characterise the air source units on the market today, and these solutions are proving to be ideal in hybrid applications, e.g. in combination with small gas boilers. In addition, industry is now rising to the challenge through an increased R&D focus on developing more cost-competitive, efficient and compact air source systems, that provide superior ease of use in both the new construction and the renovation sectors.

In applications where both heating and cooling is required, heat pumps are increasing their penetration, as they are the only technology that can deliver both of these dual functions from within a single unit, and in so doing provide unrivalled energy and cost efficiency.

Sales of 771 504 units in 2011 have positive impact on the environmental footprint of heating: they integrate 5.72 TWh of renewable energy into the mix, save 1.33 Mt of greenhouse gas emissions and reduce energy demand for final and primary energy by 7.32 TWh and 3.37 TWh, respectively. More than 4.5 million heat pumps have been sold since 2005 (see **Figure 2**). This installed base saves 43.95 TWh of final energy and 18.44 TWh of primary energy, they produce 34.89 TWh of renewable energy from the air, water and the ground and are responsible for the abatement of 8.13 Mt of Greenhouse gas emissions (GHG). The positive impact of the installed heat pump base will even improve in the future as a result of a more efficient and greener electricity production. Eurostat data for 2010 indicates an average efficiency of power production (eta) of 45.5%.

The industry has an annual turnover (incl. VAT) of more than 6 100 million Euro and ensures more than 35 000 jobs.

Industry estimates for 2012 (based on sales data for the first six months) are slightly positive. The market environment is still difficult, but the framework conditions are improving. All energy related new legislation acknowledges heat pump technology as being efficient and using renewable energy. Heat pumps are also an indispensable part of the planned smart grids infrastructure balancing supply and demand. Industry efforts results in ever more reliable, cost efficient and easy to install solutions for nearly all application fields.

For more information: Mr. Thomas Nowak,
Secretary General, European Heat Pump Association
+32 (2) 400 10 17, thomas.nowak@ehpa.org

ehpa european heat pump association

The Brussels based European Heat Pump Association EEIG (EHPA) represents the majority of the European heat pump industry. It has currently 97 members from all parts of the industry's value chain: heat pump and component manufacturers, research institutes, universities, testing labs and energy agencies. Its key goal is to promote awareness and proper deployment of heat pump technology in the European market place for residential, commercial and industrial application. EHPA coordinates the European Quality label for heat pumps and the EUCERT education and training scheme for heat pump installers. It compiles the annual sales statistics and market outlook. For more information, please visit: www.ehpa.org.

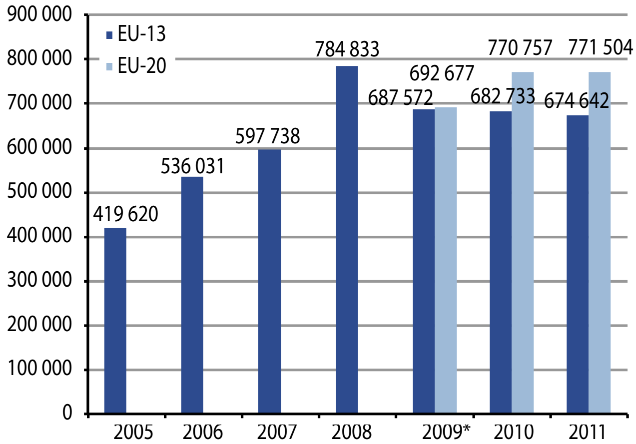


Figure 2. Development of heat pump sales 2005 to 2011: the total stock exceeds 4.5 million units.

Japan, historical culture coexisting with high technology.

Inside view into the Japanese heat pump market

Known for its contradictory image between historical culture and high technology, Japan has been leading the world of innovation in numerous and various fields for decades. In order to understand the success of the Japanese economy, Government and manufacturers are always working very closely, joining their forces and efforts through various programs in order to achieve the best efficiency to ensure a better future. A concrete example in the field of heat pumps is the foundation of the Heat Pump and Thermal Storage Technology Center of Japan (HPTCJ) in 1986 by the Japanese Government. By gathering all actors of this industry, the country enhances technologies as well as end users awareness.

Sylvain Gillaux
Sales & Marketing Manager
Living & Environment Systems
SANDEN Manufacturing Europe
s.gillaux@sanden-europe.com

Fukushima accident speeds up the development

Time has gone by since Tohoku earthquake in 2011, but some of its consequences might be unclear for our readers today. By the end of the 90's, the Japanese Government engaged a program to reduce their dependency on gas. Their idea was to strengthen electricity oriented consumption by simultaneously increasing electricity generation from nuclear power plants and strongly promoting energy efficient electrical solutions.

18 months after disaster, it is still difficult to determine a clear long term direction regarding nuclear power plants in Japan. **But for sure, in continuity with the implication of Japan in the Kyoto Protocol, energy efficient products are more than ever being promoted**.

Structure of the thermal comfort market

In the field of thermal comfort it is obvious that markets are driven by climatic characteristics. In Japan, climate is predominantly temperate but strong variations can be observed: from humid continental in the north to subtropical in the south of the archipelago.

Both heating and cooling are necessary for end users. As a consequence, air to air reversible heat pumps are extremely popular, with yearly sales of more than 8.2 million units, especially considering a total amount of approximately 57 million dwellings.

This market has been established for many years, especially thanks to always increasing performances, but their products don't show big differences compared to the ones known in western countries such as on the North American market for instance.

Relating to its geopolitical strategy to reduce Japanese dependence on fossil fuel and to promote high energy efficiency systems, the government decided to study the potential impact of expanding heat pumps use to other fields. Two fields, which were dominated by non electrical appliances, were identified: domestic water heating all over the country as well as space heating for the coldest regions.

Domestic water heating programme

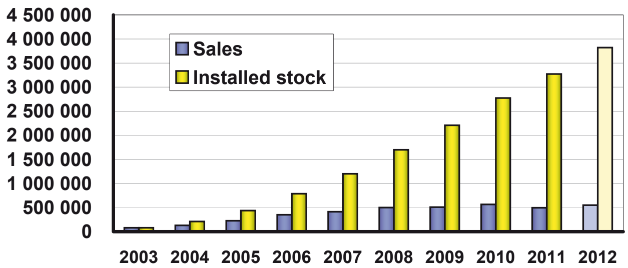
Back in 1995, the Central Research Institute of Electric Power Industry (CRIEPI) and TEPCO (Tokyo Electric Power Company) started a research of domestic water heating systems. Compared to the average Western European domestic hot water (DHW) usage, the average Japanese DHW usage is much higher in daily consumption. Japanese people's habit of taking hot baths, among others, brings the average consumption per dwelling and per day up to around 420 liters of DHW at 85°C. It represented about 34% of the total domestic energy consumption at that time.

An innovative solution was proposed to both ensure the necessary comfort and reduce the energy consumption significantly: utilizing CO_2 as a refrigerant for heat pumps.

The Japanese government, which was closely involved with this study since the beginning, decided to incorporate it into its CO_2 reduction program under the Kyoto Protocol. It was given the name of "Ecocute", which means that it provides hot water ("cute" or "kyuto" in Japanese) in an ecological and economical way ("eco").

It is important to underline that **this program focused on a full life cycle analysis from the beginning, instead of just concentrating on energy efficiency**. The result of this long term strategy is the choice of carbon dioxide refrigerant which was rarely commercialized back then, but proven as a greener choice. In addition of being natural, CO_2 is an ODP free (Ozone Depletion Potential = 0), low GWP (Global Warming Potential = 1) and neither toxic nor flammable refrigerant.

In 2001, the first "Ecocute" heat pumps were sold. As of today, **more than 3.5 million units have been installed in Japan**, while yearly sales have been constantly increasing, reaching more than 550 000 units sold per year, at an initial cost for end users of about 4 700€ (depending on the exchange rate). The equivalent CO_2 absorption of those installed units is more than 15 000 km² of forest.



Sales and installed stock of Ecocute (CO_2 heat pumps for DHW) in Japan since 2003.

Ground source space heating heat pumps for colder regions

Last February, HVAC&R Exhibition took place in Tokyo. It provided a good opportunity to learn about the future of space heating heat pumps. Besides well-known air-air reversible heat pumps, some ground source heat pumps (GSHP) that were specifically developed for colder regions in Japan were presented. Considering the ever increasing energy efficiency of those systems, Japan has decided to push their developments and installations in colder regions. Being aware of the existing technologies around the globe, Japanese engineers have developed products adapted to their specific needs and constraints: smaller houses, cold outdoor temperatures, very high seasonal performance factor (SPF) and **very green and safe technologies**.

In parallel, they focus on improving current state of the art features in order to keep perception as a technological leader and environmentally conscious country that contributes to reducing CO_2 emissions. Interesting concepts have been brought to the market, some of which result from the previous Government program developments: by combining top of the class compressors, heat exchangers and intelligent thermodynamic loops, some manufacturers have managed to replace HFC with CO_2, the final purpose being to propose the best SPF with a much greener refrigerant.

Again, Japan has decided to avoid focusing only on energy efficiency: it considers a full life cycle analysis in addition to regular comfort and cost considerations.

Intelligent incentive schemes

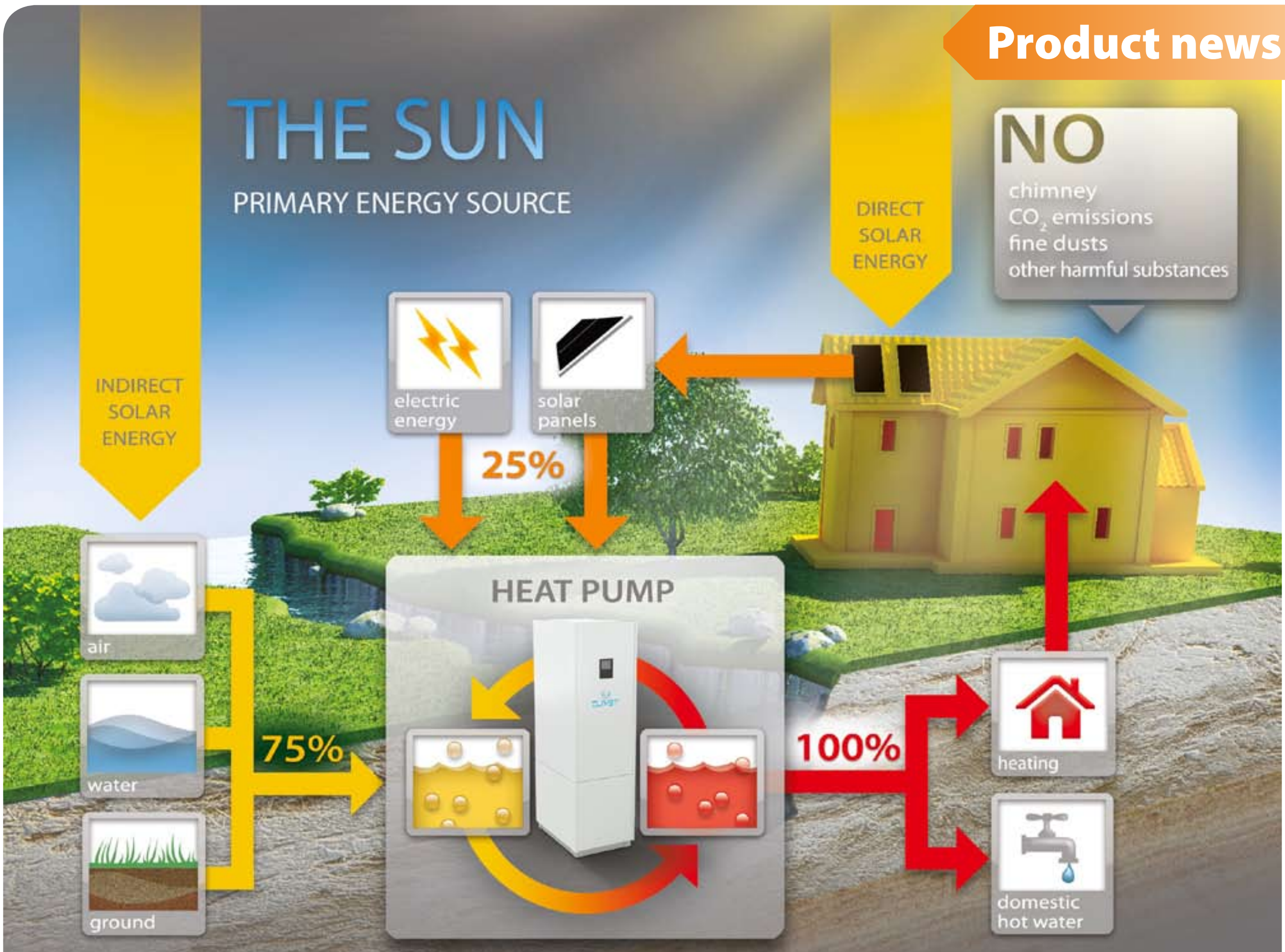
History has proven through the Ecocute program that focusing on improvement of the full life cycle analysis of systems instead of their energy efficiency only brings the best possible products to the market. However, most importantly, before reaching high sales volumes and thus reducing their cost, intelligently defined incentives have been introduced to speed up the expansion of such environmental friendly technologies.

For instance, the Ecocute program related subsidy allowed to increase yearly sales up to more than 550 000 in 2010, starting from zero. In parallel, end users prices went down in order to reach an acceptable level for end users. As a result, this subsidy program ended successfully in 2010.

As it exists in some European countries, heat pumps are eligible for subsidies under a condition by meeting predefined level of efficiency. Additional tax rebates and incentives are provided for higher efficiency products (i.e. proving their savings in terms of energy and CO_2 emissions), ground source usage and heat pumps using natural refrigerants.

Japan has an advanced vision of thermal comfort

Japanese industry has been leading the world of thermal comfort for decades. However, global competition is becoming tougher. In order to keep its number one position, it has developed a vision jointly with its Government: bringing to the market the greenest possible products. As part of this strategy, the full thermal comfort industry is now working jointly with electronics expert in order to set up standards for future smart homes.



Heat Pump systems allow the use to various heat sources and can supply both space heating and domestic hot water production.

Heat Pumps systems from Clivet for year around complete comfort

Heat pumps represent one of the most important green technologies for the future of heating, air conditioning and domestic hot water production in modern buildings, as expressed by IEA in the Technology Roadmap 2011. In this scenario, IEA forecast shows also that the contribution to this effect is roughly for 65% due to Heat Pump Technology development and that the total number of installed heat pump units in the residential sector for heating and cooling, and domestic hot water production will reach almost 3.5 billion by 2050, giving to heat pump technology a relevant place in the Heating and Cooling equipment of the future buildings. An additional important element in favor of Heat Pump Technology is: heat pumps assure not only space heating and domestic hot water production, but also cooling, and this represents, most of all in Southern Europe, a relevant amount of energy.

Bruno Bellò
President of Clivet S.p.A.

Year Round Complete Comfort Systems based on HP technology

Assumed that Heat Pumps have a key role in the future of comfort inside buildings, Clivet also believes that the future market of these equipment will be dominated by the concept of **Year Round Complete Comfort Systems.**

Components for Clivet´s ELFOSystem GAIA for "Class A" single family houses.

This approach of Year Round Complete Comfort Systems, involves a new mind set in which Comfort Systems are a single entity in which all the elements are composed by products specifically designed to interact with each other, influencing the highest level of energy efficiency in generation, distribution, emission and control. These results cannot be reached by simply assembling individual products, because, even if we are using the best individual products available on the market, their interaction cannot guarantee the same level of efficiency of a complete system where all the elements have been designed since the beginning to work and interact together.

ELFOSystem is a Year Round Complete Comfort Systems, so all its elements are specifically designed in order to interact with each other, influencing the highest level of energy efficiency in generation, distribution, emission and control. ELFOSystem is available for 3 different applications:

ELFOSystem GAIA for new single family "Class A" houses

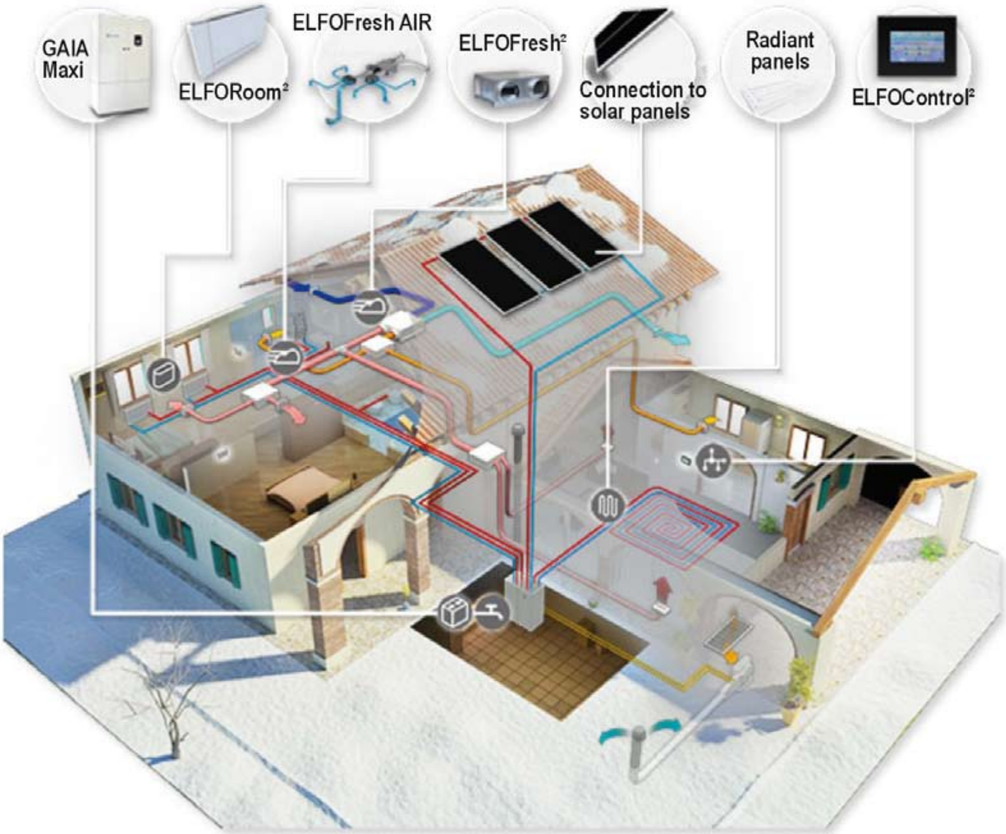
The awarded year round system ELFOSystem GAIA Edition for heating, air conditioning, domestic hot water production, air renewal and purification, which uses from 75% to 100% renewable energy for total and sustainable comfort in new single family houses.

The elements of ELFOSystem GAIA Edition are:

- GAIA, the heat pump with DC inverter technology which transfers heating and cooling energy, integrating all the components of a heating plant (including the production of hot water with 186 litre storage tanks and circulating pumps). GAIA derives 75% of its energy from the sun through heat pump technology which captures the energy contained in air, ground or water with just 25% from electricity. The unit is suitable for connection to solar panels, so that the domestic hot water can be produced with big savings. If used in combination with photovoltaic panels GAIA can become 100% renewable energy.

- ELFOFresh2, the unit for air exchange and purification with thermodynamic recovery and electronic filters (H10) can cool and heat the fresh air with minimum energy consumption. ELFOFresh2 can be integrated with ELFOFresh Air, the complete air distribution system easy to install and configurable on the web, which enhances efficiency with its low noise mechanical ventilation system.

- Distribution of hot and cold temperatures through radiant panels, radiators or ELFORoom2 fan coil



Components for Clivet´s ELFOSytem for single family houses.

units (Clivet's terminals equipped with an exclusive electric motor which drastically reduces electricity consumption compared with a traditional fan coil unit).

- ELFOControl2, the central comfort control unit that allows to control the complete system for power generation, distribution, indoor comfort and rational use of the renewable sources. This control system dialogues with the user by a touch screen and manages all the system. ELFOControl2 is able to capture the comfort requirement input by the user and automatically calculates the most proper parameters to generate the capacity required with the most efficient and convenient use of GAIA and the rest of the System. If equipped with temperature sensors for each room, it allows to define the operating conditions for each element of the system.

Clivet ELFOSystem GAIA Edition meets the most varied requirements of new and existing systems and it doesn't use gas or other fossil fuels for heating, eliminating the risk of dangerous substances in the air.

ELFOSystem GAIA Maxi for large single family houses and renovation

ELFOSystem GAIA Maxi, the new hybrid system who's heart is GAIA Maxi, a packaged unit integrating solar thermal, heat pump and condensing boiler for heating, air conditioning, and domestic hot water production of single-family houses and renovations, in particular when structural or architectural constraints don't allow any upgrade on building envelope insulation performance.

The integration in a single unit of all these elements makes GAIA Maxi the solution with the best seasonal efficiency on the market. GAIA Maxi always favors the use of renewable energy sources, dramatically reduces the connection number and the plant footprint, ensuring maximum reliability and installation speed.

As ELFOSystem GAIA Edition, also ELFOSystem GAIA Maxi can be integrated with ELFOFresh2, ELFORoom2 and ELFOControl2, providing complete all year round comfort from a unique manufacturer with more than 20 years experience in heat pump solutions focused on the occupants comfort and energy saving whilst respecting the environment.

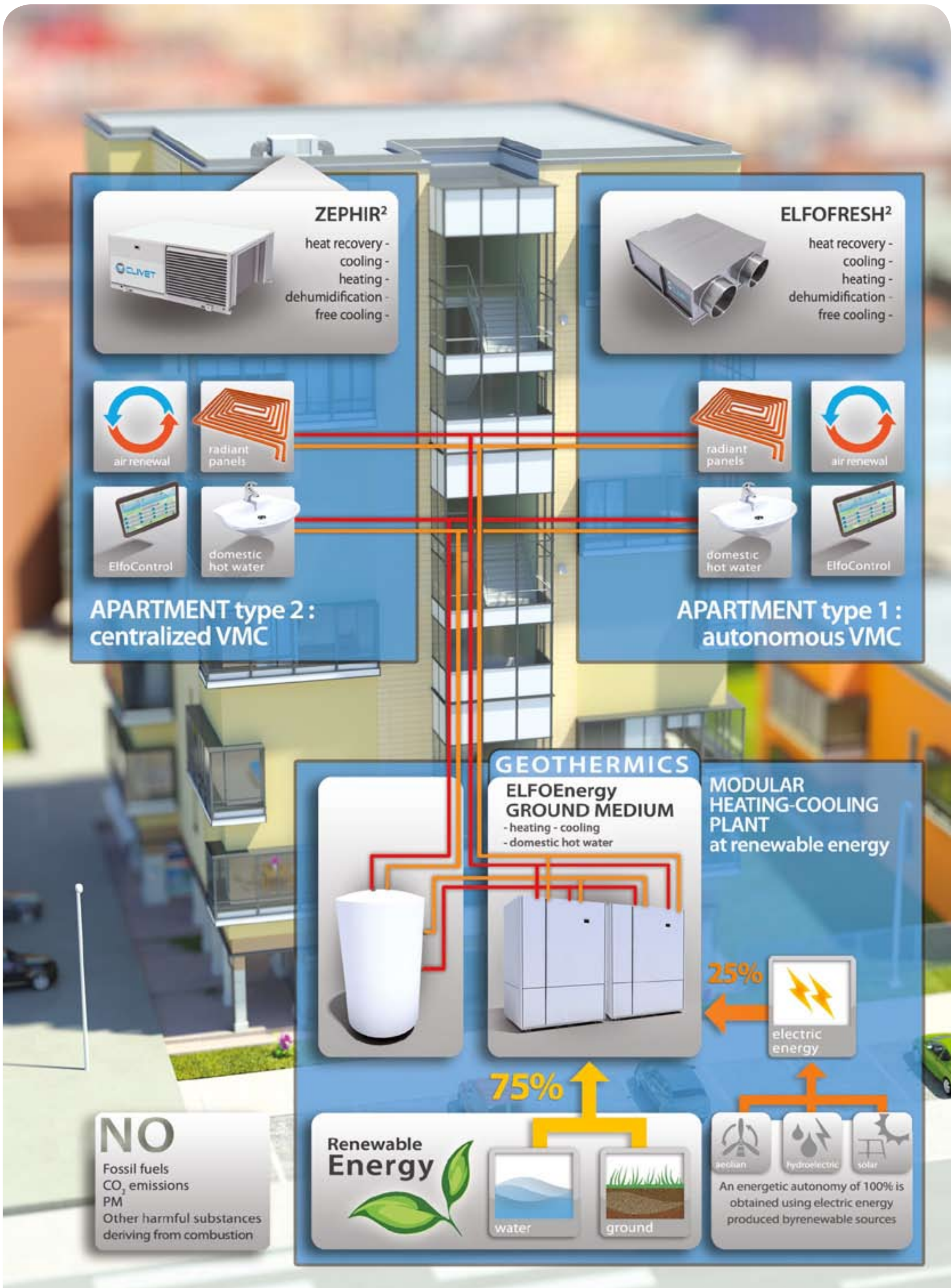
Product news

ELFOSystem BUILDING for multi-family and social housing

ELFOSystem BUILDING, the complete and intelligent renewable energy system for heating, air conditioning, domestic hot water production, air renewal and purification, ideal solution for multi-family and social housing. The heart of the complete system ELFOSystem BUILDING is ELFOEnergy Ground Medium, the new indoor water and ground source heat pump from 30 to 280 kW (COP from 5,5 to 5,9) at the top of its category for seasonal efficiency, which meets Eurovent's Class A requirements in heating and cooling mode.

The other elements of ELFOSystem BUILDING are:

- ELFOFresh2, decentralized individual packaged indoor ventilation and purification system with thermodynamic energy recovery, able to satisfy 80% of thermal need of the building,
- Zephir2, centralized indoor ventilation and purification system with energy recovery, able to satisfy 50% of thermal need of the building,
- ELFORoom2, ELFOSpace, ELFOSpace BOX2, ELFODuct (CFD, CF), the hydronic terminals with temperature control room by room, minimal design and small dimensions, variable fan speed, homogeneous temperature and low consumption,
- ELFOControl2, the new advanced control system optimizing efficiency and ensuring the correct operation in the whole living space, managing up to 12 climatic areas and 40 elements in total.



Components for Clivet´s ELFOSystem for multi-family and social housing.

Also residential applications by Clivet has proven to reach significant savings due to technology based on 20 years of experience in the commercial and industrial sectors and the collaboration with well-known groups such as McDonald's®, Bennet®, Auchan®, McArthurGlen®, IKEA®, NH Hotels®, Warner Village Cinemas®, UCI Cinemas®, Ferrari®, Microsoft® and Enel®.

For further information:
ENGLISH e-mail: export@clivet.it, tel. +39 0439 3131
GERMAN e-mail: info.de@clivet.com, tel. +49 40325957-0
PRESS e-mail: b.casagrande@clivet.it, tel. +39 0439 313235

Sensors for heat metering and the renewable heat premium payment (RHPP)

Heat metering is a megatrend for two reasons: Firstly, higher energy efficiency of a heating or cooling system and secondly, a change of behavior in terms of awareness about actual consumption of energy. In a heat pump, flow control/heat metering enables optimal control during periods of low heating load and/or production of domestic hot water. Furthermore, to facilitate a reduction in the actual consumption of heating or cooling, the actual and seasonal consumption/performance must be shown. By advocating heat metering (like the German Heizkostenverordnung making heat metering on the heating side as well as the domestic hot water side mandatory by 2014) an equal playing field for various heating and cooling technologies has been created for consumer assessment and potential Renewable subsidies.

As a hydronics expert, Grundfos supplies variable speed pumps and smart sensors for the latter and has already enabled superior energy savings for global heat pump manufacturers. Furthermore, a flow controlled system can be used for heat metering, which is the focus for the following article.

Klaus Frederiksen
Technical Key Account Manager,
GRUNDFOS Direct Sensors™.
kfrederiksen@grundfos.com

OEM Direct Sensors™ Product Family

Accuracy

In the first part of this article, the accuracies of the Grundfos Flow Sensor are listed and compared with those requested in the Energy Saving Trust (see in details www.energysavingtrust.org.uk/) RHPP, where a total maximum error on the SPF value of 10% (on a yearly basis) is allowed.

Calculating the SPF value, 4 sub-assemblies are required: a calculator (or display system), a temperature sensor pair, a flow sensor and an electrical meter.

The total error is calculated as the arithmetic sum of the maximum permissible errors of each sub-assembly:

$$SPFError = Ec + Et + Ef + Ee < 10\%$$

E_c = Maximum permissible error (MPE) calculator
E_t = MPE temperature sensor pair
E_f = MPE flow sensor
E_e = MPE electrical meter

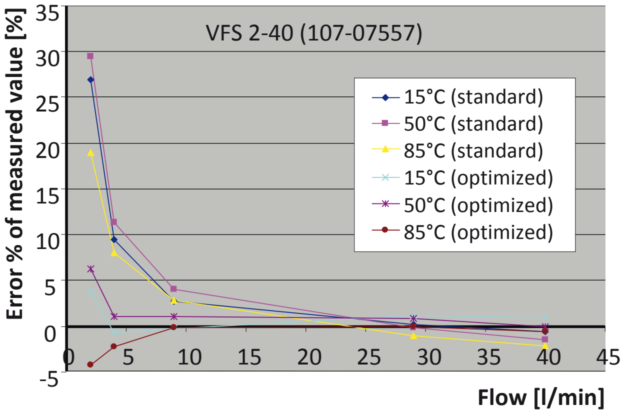
Flow

A Grundfos Flow Sensor is delivered with a maximum error of 1.5% of the full scale value as a standard for heat pump applications. As the error is a percentage of the full scale value it is necessary to consider closely which sensor range to utilize. Thus, it is clear that a 2–40 l/min range will perform better at lower flows, compared to a 5–100 l/min range.

Grundfos Direct Sensors™ has been directly involved in a project with the Danish transmission system operator (Energinet.dk) which included heat metering in 300 residential housing for a period of 1–2 years. The application scope of the project indicated that either the VFS (Vortex Flow sensor Standard) 5–100 l/min or VFS 2–40 l/min sensor would be the preferred range. The 5–100 l/min benefits from a lower pressure drop, while the 2–40 benefits from a higher accuracy - when no flow rates above 40 l/min are likely.

Experience gained by Grundfos from the first 75 installations, indicated that no flows higher than 33 l/min in the heating systems were detected. Due to the better accuracy provided, it was decided in this project to use the VFS 2–40 l/min for the remaining 225 installations.

Please see the following diagram showing accuracy of a standard VFS 2–40 l/min sensor at an independent third party institute (Danish Technological Institute) of 5 flows at 3 different temperatures (15, 50 and 85°C).



(The results presented as "standard" are obtained at a third party institute. The results presented as "optimized" are obtained in the Grundfos laboratory.)

Based on these results, an optimized VFS 2–40 l/min has been developed and tested in the Grundfos lab. These results are also shown on the chart.

It can be seen that the standard VFS 2–40 l/min sensor has an error in percentage of reading below 4% down to typically 8 l/min. To improve this according to the standard, we have optimized the VFS 2–40 l/min performance in order to perform better.

Temperature

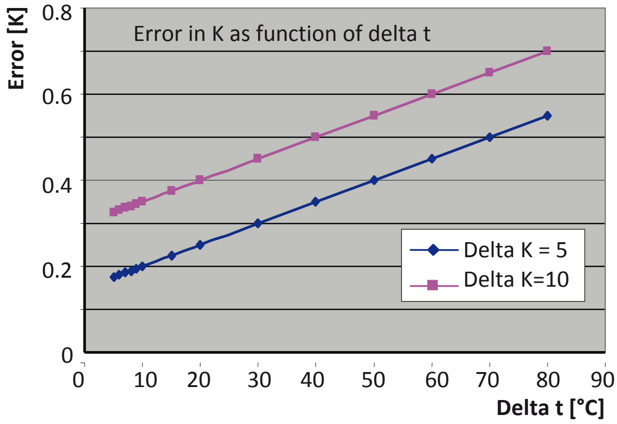
The temperature signal from the sensor has a maximum error of ±1 K in the range from 25–80°C. Looking at this, it will most likely not be enough given that a maximum error of a pair of ±2 K with a temperature difference of 5 K will account for an error of 40% of measured value.

Grundfos Direct Sensors™ have, with success, recommended that customers carry out an alignment of the temperature measurement of the 2 sensors. The recommendation is based on the fact that if the sensor pair offset is adjusted around a single point the error margin in terms of the delta measurement around this point will be considerably reduced.

In practice, this has been carried out by allowing the circulation pump to run while the heat pump is not running (or is in by-pass). Eventually, temperatures at both inlet and outlet of the heat pump will be almost the same.

Using this procedure a maximum delta T value of below 1°K is achievable.

Looking into other solutions for temperature measurements the following demands should be met acc. to EN 1434:



Calculating this in percentage of measured value a maximum error of 3.5% occurs. To meet this demand completely, a pair of Temperature sensors of accuracy <0.2°K must be utilized. There are many suitable devices such as resistance temperature detectors (RTD's), thermocouples and negative temperature coefficient thermistors (NTC's) that can meet this accuracy requirement.

Example on the calculation of the total error:

The data from above have been used to calculate the total error for 2 examples to give a more clear idea of the sensors performance in terms of the total error. In the example, the system has a flow of 30 l/min and an inlet temperature to the heating system of 65°C and 75°C respectively. The error contribution from the temperature sensor pair and flow sensor is accounted for and the total error has been calculated using the arithmetic sum of the errors.

Example 1: (30 l/min, inlet temperature 65°C, return temperature 55°C)

$E_t + E_f = (1K/10K) * 100\% + 1\% = 11\%$

Example 2: (30 l/min, inlet temperature 75°C, return temperature 55°C)

$E_t + E_f = (1K/20K) * 100\% + 0\% = 5\%$

Summary

It is important to understand that these solutions have been on the market for more than two years with substantial energy savings reaped by some of the world's largest heat pump manufacturers of air-water and ground source heat pumps. We call it Future Now, as we will continue to update our products to obtain even better accuracy of our products for present and future partner's to enable an even more efficient control of and heat metering integrated into their heat pump. ℈

Waste water as heat source of heat pump

While the heat sources air, water and ground are already well established in the heat pump market for single- and multi-family homes, their application for large industrial heat pumps is rare. A very promising **heat source** is **waste water** (**Figure 1**). The main sewer strands in all larger towns supply sufficient waste water as source of energy, which can be also used by the retrofit of sewer heat exchangers as heat source for large size heat pumps. The usage is especially economical, with more than 10,000 population equivalents. The waste water strand should have more than 0.8 meters in diameter and the users of heat have to be located in the surrounding area. A maximum distance of 200 meters is given for small heat capacities, whereas the heat pump or the user can be located up to 2 km away from the waste water strand with higher capacities.

The company OCHSNER, as project leader, carried out a **research project on waste water heat recovery**, which was funded by the Climate and Energy Fund as part of the Austrian new energy program 2020. The aim of the research project was to lay the foundations for the implementation of waste heat utilization in Austria and to investigate suitable sites for waste water utilization. The Austrian Energy Agency, the University of Agricultural Sciences, Vienna Energy and Energy Switzerland were also involved in the execution of the research project. Relevant experience was provided by Energy Switzerland as already 80 successful plants are in operation in this country. At least 5% of the heat and cooling demand of any city could be provided with the heat source waste water. The company OCHSNER produces a complete line of industrial heat pumps from 100 to 1,000 kW for use in large buildings and industrial processes (**Figure 2**).

Amstetten (**Figure 3**) illustrates once again a future-oriented philosophy with regard to innovative projects for energy savings for the purpose of avoiding climate change. The goal is to become a self-sustained community.

About OCHSNER: The company was founded in 1978 and is one of Europe's foremost heat pump manufacturers and a technology leader. http://www.ochsner.com – htiwp@ochsner.at

htiwp@ochsner.at

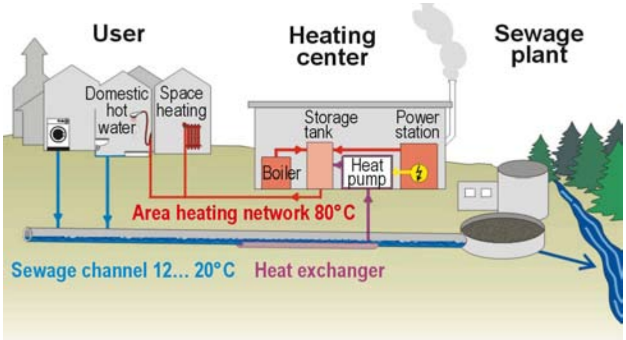


Figure 1. Principle of heat recovery from waste water with heath pump.

Figure 2. The company OCHSNER produces a complete line of industrial heat pumps from 100 to 1000 kW for use in large buildings and industrial processes with screw compressor.

Figure 3. The municipality of Amstetten, as one of the suitable locations, has been the first to realize the concrete implementation. 400 single-family homes can be heated now all over the year with the heat pump.

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* At 31th August 2012.

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- With Robur GAHP **cooling with gas is possibile too.**

type	supply	renewable energy	% renewable energy	efficiency % (G.C.V.)
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GAHP GS	natural gas/LPG	ground source	34.2	152
GAHP WS	natural gas/LPG	water source	36.3	157

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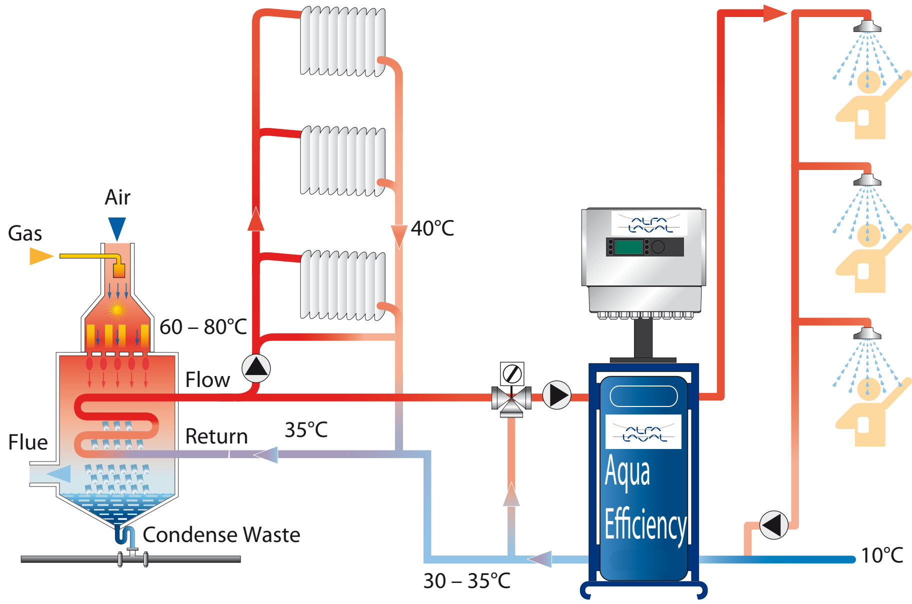


Working principle of AquaEfficiency.

AquaEfficiency – Alfa Laval's latest innovation in the area of tapwater heating for collective applications – is the most energy-efficient solution available in the market. Compared with other offerings in the market, an AquaEfficiency system can save energy up to EUR 2,200 annually which means that the pay-back period of the extra cost for an AquaEfficiency is less than one year.

Stefan LM Eriksson
Alfa Laval, manager Heating & Cooling Systems
stefanlm.eriksson@alfalaval.com

Avoiding off-peak waste

AquaEfficiency is based on Alfa Laval's well-proven 'AquaFlow 'and 'AquaStore' tapwater heaters. These systems have been equipped with new variable-speed pumps and a new, advanced system controller. The controller reacts on variations in the outgoing water temperature (within 1-2°C) and adjusts the pump speed accordingly. At every moment, the controller selects the optimum combination of pump speed and valve aperture to achieve the most effective adjustment.

Recovering condensation heat

Condensing boilers are rapidly becoming the norm for space and tapwater heating in Europe. However, with return temperatures from the heat exchangers typically in the 45-55°C range, the condensing potential is largely wasted. AquaEfficiency, therefore, uses a second sensor to monitor the return temperature and maintain it at 35°C or lower during tapping periods, which is ideal for condensing boiler heat. By recovering this heat, valuable energy can be saved.

Alfa Laval has patented this dual-sensor approach to simultaneously controlling pump speed and return temperature. AquaEfficiency really seems to be the right product introduced at the right time.

More information: www.alfalaval.com

VRV IV from Daikin - *pioneering total solution*

In developing its new VRV IV, Daikin's European Development Center has provided an overall answer to Europe's varying geographical and climate conditions, while setting the standard for cooling and heating comfort. Icing on the cake: the VRV Configurator, which allows simplified configuration and commissioning. Product Development Engineers **David Steen** and **Kevin Ampe** of Daikin's European Development Center and Mentor **Alain De Lille** of Daikin's Service department comment on this revolutionary and pioneering total solution called VRV IV.

VRV® IV

- *Variable refrigerant temperature*
- *Continuous heating via heat pump*
- *VRV configurator*
- *seasonal efficiency up to 7,53*

Q: What makes Daikin's VRV IV system so revolutionary with regard to energy efficiency?

David Steen: "Increased environmental awareness in combination with the 20/20/20 legislation inspired us to think more out of the box in order to enhance the energy efficiency of our VRV units. One of the methods we used in the new VRV IV is Variable Refrigerant Temperature. The system automatically adjusts the refrigerant temperature according to the ambient air temperature to achieve the highest efficiency, preserving optimal comfort at all times. All this is possible because of our full inverter-driven system ensuring optimal seasonal efficiency, up to an ESEER of 7.53."

Q: How did Daikin solve the problem of temperature drop in heating mode during defrost?

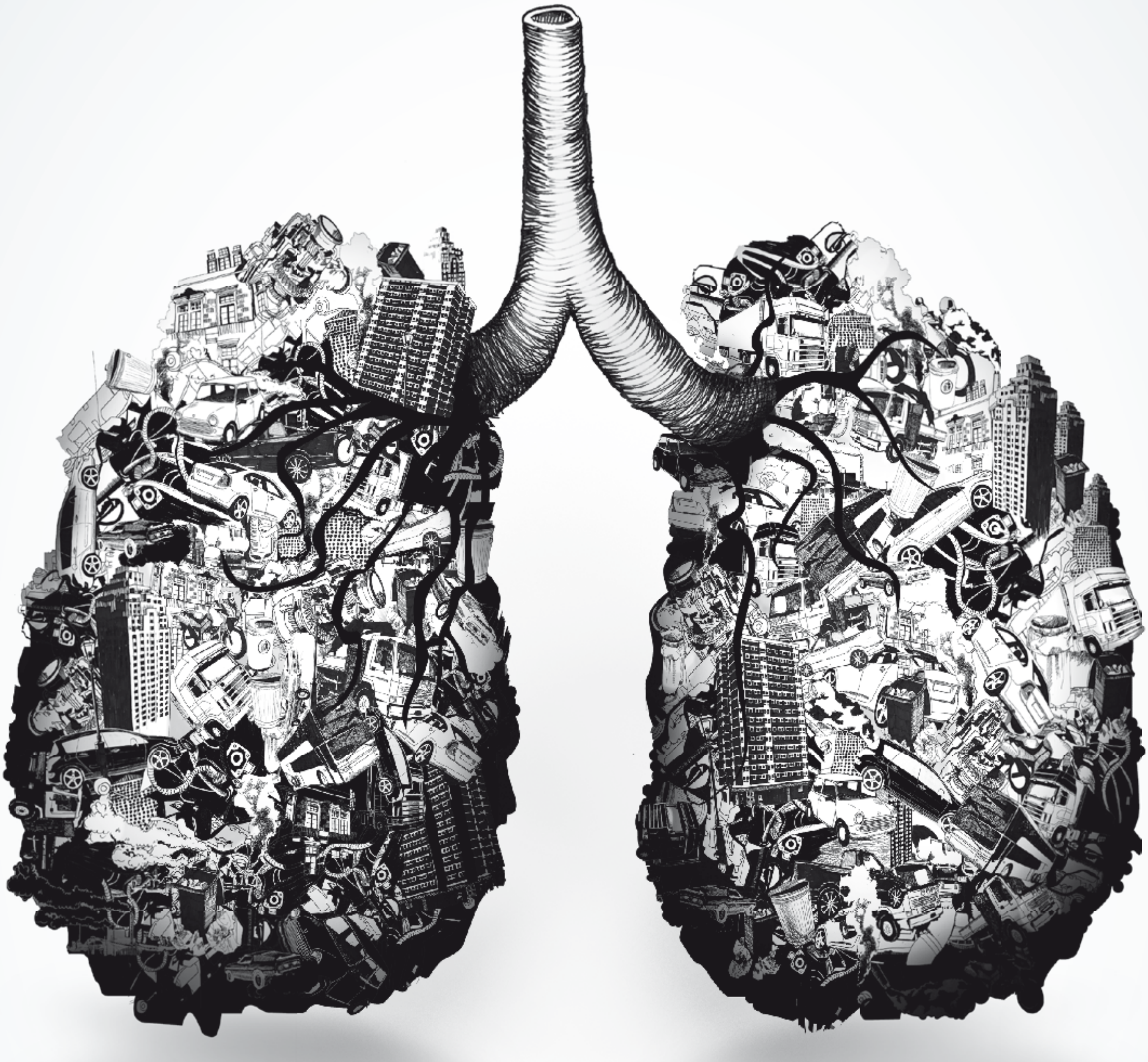
Kevin Ampe: "As is well known, during defrost operation, heating capacity is no longer delivered to the indoor units. On top of that, heat is absorbed from the indoor units – and as a consequence also from the room – since they act as an evaporator. To solve this problem, we developed a heat storage vessel, an entirely new feature for the European market, using a unique PCM (phase change material) that stores or releases energy when it changes its phase from solid to liquid and vice versa. By integrating this heat storage vessel into our system, VRV IV continues to provide heating, even during defrost, and prevents temperature drops and cold draughts inside."

Q: How does the VRV Configurator shorten the time needed for servicing and commissioning?

Alain De Lille: "Until now, commissioning was always done based on the skills and judgement of the technician. With the revolutionary new VRV Configurator, settings are done step by step using software programme. Thus, low noise or demand operation settings, ESP settings, and cooling and heating comfort settings are made easy. What's more, technicians need less time than before for commissioning!"

With the new VRV IV, Daikin not only improved the core of the VRV system, it reengineered the entire total solution. To this end, it integrated new intelligent sensors on the round flow cassette indoor unit and enabled easy energy management via the new intelligent touch manager. Finally a low temperature hydrobox was launched for highly efficient under floor heating and cooling.

Want to know more? Visit www.daikineurope.com/greatnews



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Conference Venue University of Lleida, Spain.

Innostock 2012 Conference in Spain focused on latent energy storage

Innostock 2012 is the 12th conference in the so-called Stock Conference series, starting in Seattle in 1981. The first Stock conferences were dominated by studies on energy storage in aquifers. As aquifer thermal energy storage (ATES) technology developed and matured, borehole thermal energy storage (BTES) came to dominate the conferences. The latest conferences, however, have had increasing focus on latent energy storage, such as phase change materials (PCM) and thermochemical energy storage. More than half of the Innostock conference papers dealt with latent energy storage. Several sessions were dedicated to energy storage with PCM in buildings. For the first time in the Stock conference history, electrical storage was also included in the conference programme. The next Stock conference will be called Greenstock 2015 and it will take place in Beijing, China, in May 2015.

Signhild Gehlin
Swedish HVAC Society - Society of Energy and Environmental Technology
Signhild.Gehlin@emtf.se

Professor **Marc A. Rosen**, from the University of Ontario in Canada, gave an example from his own university where a BTES system with 400 boreholes was installed six years ago. It saves 40 percent of heating costs and 16 percent of cooling costs compared to a conventional system. The biggest challenge was the initial cost, according to Rosen.

Conference proceedings from Innostock 2012 may be ordered from www.innostock2012.org

Canada has taken a decision that 50 percent of the building stock must be NZEB buildings in 20 years. One project on the way is the Drake Landing Solar Community with 52 high performance buildings reaching a solar fraction of 90 percent. The project has been so successful that Drake Landing II with 2 000 buildings is now under consideration.

Professor **Bo Nordell**, from Luleå University of Technology, has attended all Stock conferences since the start in 1981. He gave a brief overview of the development of underground thermal energy storage since the 1980s. ATES started with a small workshop in Berkeley in October 1978. The technology developed rapidly in the first two decades and is now a mature technology. However the number of persons with deep knowledge in ATES in very limited. Thermal energy storage in pits and caverns (CTES) is a marginal technology with few examples. The technique works well, but is generally too expensive. A couple of papers on CTES applications in abandoned mines and strip mines in North America were presented at Innostock. CTES can also be used for snow storage for cooling purposes.

BTES applications continue to increase worldwide and spread to new regions. According to Nordell, BTES is today a well-developed technology and few fundamentally new ideas are brought forth.

innostock 2012

The 12[th] International Conference on Energy Storage

Innostock 2012 – the 12th international conference on energy storage was held at the University of Lleida in Catalonia, Spain, in May this year. The conference gathered 330 participants from 36 countries around the world, and conference host Professor Luisa Cabeza had every reason to be pleased with the outcome.

Conference host Professor Luisa Cabeza.

An increased interest in high temperature storage with BTES has arisen lately. There is also some ongoing work on combinations of CTES and BTES, called "combistores".

Alfredo Férnandez from INGEO Investigación Geotérmica, Spain, presented the BTES project at the new IKEA retail store in Jerez de la Frontera in southwest Spain, installed in 2010. Its main design goal was to achieve a 56 ton CO_2 emission cut compared to conventional energy systems. The warm climatic conditions at the location led to an annual energy imbalance, with a heating load of 75 MWh/a compared to a cooling load of 4 100 MWh/a. The solution was a borehole field with 54 boreholes at a depth of 130 meters, covering 100 percent of the heating and 13 percent of the cooling cooling. The boreholes store free cooling in the winter and also "night cold" in the summertime.

Long term monitoring of buildings with energy storage is rare, hence there was significant interest in a German study, presented by Dr **Burkhard Sanner** of eight non-residential buildings with underground thermal energy storage for heating and cooling. The study has taken place between September 2007 and June 2012. Three BTES and five ATES systems in western Germany were included in the study. Data from the study have also been used to validate the design tool EED, with good results.

Aitor Urresti from the University of the Basque Country in Spain presented the first study of ventilated facades with PCM in the outer facades. Earlier studies of ventilated facades have focused on PCM in the inner layers. Results from the experimental study show that PCM in the outer parts of the ventilated facades increases the thermal inertia and contributed significantly to heating the building.

Justin Ningwei Chiu and **Viktoria Martin** from the Royal Institute of Technology in Sweden showed in their study of passive school buildings in Stockholm a decrease in the risk of over-heating in summer when an HVAC system with free cooling and latent heat energy storage with PCM is introduced. Simulations in TRNSYS show that comfort levels can be maintained 75 percent of the time with 40 percent less power consumption and less than half the cost of a conventional AC system. 3E

Conference proceedings from Innostock 2012 may be ordered from www.innostock2012.org

VDI- Guidelines published August – September 2012

VDI 6022/1.1 "Ventilation and indoor-air quality; Hygiene requirements for ventilation and air conditioning systems and units; Checking of ventilation and air conditioning systems"

This guideline is used as the basis of the system review as part of a hygiene initial inspection according to VDI 6022 Part 1. The goal is to issue a certificate of conformity of the respective air handling system with the requirements of VDI 6022 Part 1.

VDI 6022/4 "Ventilation and indoor-air quality; Qualification of personnel for hygiene checking's, hygiene inspections, and assessment of indoor-air quality"

This guideline describes the instruction and training in categories C, B, A, RLQ, which are necessary for the application of the other parts of the guideline series. For each category, the training target groups with entry requirements, contents and framework are presented.

VDI 2067/1 "Economic efficiency of building installations; Fundamentals and economic calculation"

The series of guidelines VDI 2067 deals with the calculation of the economic efficiency of building installations. It applies for all building types. Because the calculation of the power requirement is made step by step, the guideline is divided in several parts.

This guideline gives an overview about the complete works of the series of guidelines. The essential fundamentals and terms and definitions are explained. The standards and guidelines as well as special terms and definitions applying to the specific calculations are listed in the corresponding parts.

VDI 3803/ 4 "Air conditioning, system requirements; Air filter systems"

This guideline deals with the application of filters in air conditioning systems (A/C systems) in, e.g., residences and offices, in medical facilities, in pharmaceutical and food productions and in public buildings, service centers and commercial enterprises, schools and sports facilities.

It deals with the practical application of the technical rules DIN EN 779, DIN EN 1822 and VDI 2083 Part 3 and applies to all A/C systems for occupied areas where persons are present more than 30 days per year or more than two hours per day.

The guideline is primarily intended for use by planners, executing companies and operators of A/C systems. The requirements to be met by air filters in A/C systems primarily serve to protect the health of persons, but may also be determined by technological requirements.

This guideline adopts the technical specifications of the guideline SWKI VA101-01:2007-11.

VDI/GEFMA 3814/3.1 "Building automation and control systems (BACS); Guidance for technical building management; Planning, operation, and maintenance; Interface to facility management"

This guideline is intended to offer the user of a building an overview of basic requirements, potential and applications of building automation for technical building management. Data and information required by the facility management or building management for service processes and tasks during the use of a facility or a building are recorded, processed and archived by an integrated planning, controlling, information and archival system (computer aided facility management - CAFM).

VDI 6028/6 "Assessment criteria for Building Services; Requirements profiles and valuation criteria for building automation and control systems"

The series of guideline VDI 6028 offers a method allowing for an objective and holistic evaluation of offers for building automation. The guideline compiles technical specifications and profiles of requirements for building automation. Based on these, evaluation criteria as per VDI 6028 Part 1 are described. For a building project, lists allow selecting when and what criteria have to be observed at a given time. These lists can be supplemented by orderers' specifications in all cases. The guideline is addressed to orderers, property and technical planners, executing companies, users and operators. This guideline is only valid in conjunction with VDI 6028 Part 1.

C = VDI Ventilation Code of Practice

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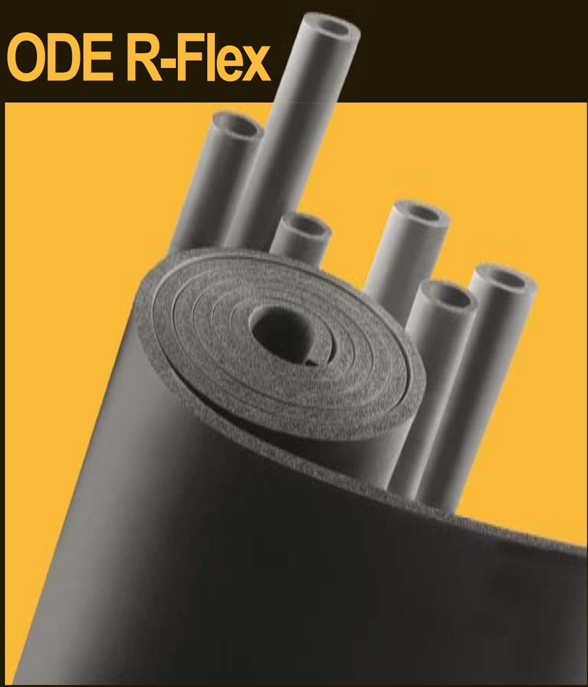

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Events & Fairs in 2012 - 2013

Fair	9 – 11 October 2012	Chillventa 2012	Nuremberg, Germany	www.chillventa.de/en/
Fair	9 – 12 October 2012	Finnbuild 2012	Helsinki, Finland	www.finnbuild.fi
	9 – 10 October 2012	The Next DHC Generation	Brussels, Belgium	www.euroheat.org
	10 – 11 October 2012	33rd AIVC Conference and 2nd TightVent Conference	Copenhagen, Denmark	www.tightvent.eu
	10 – 11 October 2012	Building Services - The CIBSE Conference & Exhibition	London, UK	www.buildingservicesevent.com
	11 October 2012	Renovate Europe Day	Brussels, Belgium	www.renovate-europe.eu
Fair	17 – 18 October 2012	CEP® Clean Energy & Passive House Expo	Budapest, Hungary	www.cep-expo.hu
	17 – 19 October 2012	15th HVAC Exhibition VVS-dagene	Lillestrøm , Norway	www.vvs-dagene.no/eng/
	17 – 19 October 2012	47th Conference of plants – "Plants for the early third millenium"	Sinaia, Romania	www.aiiro.ro
Fair	18 - 21 October 2012	Environment and energy 2012	Riga, Latvia	www.bt1.lv/bt1/ee
	19 October 2012	30th National Conference in Bologna	Bologna, Italy	www.aicaar.org
	23 – 26 October 2012	12th International Conference for Enhance Building Operations	Manchester, UK	www.icebo2012.com
	7 November 2012	Q-Day Expert Forum: Focus sul radiante 2012	Padova, Italy	www.q-rad.it/q-day
	8 – 9 November 2012	Euro-Mediterranean Energy Efficiency Forum	Monaco	www.ee-forum.eu
	12 – 14 November 2012	7th International HVAC Cold Climate Conference	Calgary, Canada	http://ashraem.confex.com/ashraem/icc12/cfp.cgi
	21 – 23 November 2012	EME3 1st World Meeting on Energy Efficiency in Buildings	Madrid, Spain	www.encuentroEME3.com
	5 – 7 December 2012	43th International congress of Heating, Air Conditioning and Refrigeration	Belgrade, Serbia	www.kgh-kongres.org/
	6 – 7 December 2012	7th International Energy Forum on Solar Building Skins	Bressanone, Italy	www.energy-forum.com

	26 – 30 January 2013	ASHRAE 2013 Winter Conference	Dallas, Texas, USA	www.ashrae.org/membership--conferences/conferences/dallas-conference
Fair	28 – 30 January 2013	AHR Expo	Dallas, Texas, USA	www.ahrexpo.com
Fair	5 – 8 February	Aqua-Therm Russia 2013	Moscow, Russia	www.aquatherm-moscow.ru/en/home/
	8 – 9 February 2013	ACRECONF	New Delhi, India	www.acreconf.org
Fair	27 Feb – 1 March 2013	World Sustainable Energy Days - the WSED 2013	Wels, Austria	www.wsed.at
Fair	7 – 9 March 2013	ACREX 2013	Mumbai, India	www.ishrae.in
Fair	12 – 16 March 2013	ISH Frankfurt	Frankfurt, Germany	www.ish.messefrankfurt.com
	8 – 10 April 2013	ISH China & CIHE	Beijing, China	www.ishc-cihe.com
	15 – 17 April 2013	3rd International Conference in Microgeneration and Related Technologies in Buildings - Microgen III	Naples, Italy	www.microgen3.eu
	9 – 11 May 2013	5th International Conference on Amonia Refrigeration Technology	Ohrid, Macedonia	www.mf.edu.mk
	27 – 28 May 2013	36th Euroheat and Power Congress	Vienna, Austria	www.ehpcongress.org
	7 – 8 June 2013	The Latest Technology in Air Conditioning and Refrigeration Industry	Milan, Italy	www.centrogalileo.it/milano/CONGRESSODIMILANO2013english.html
	16 – 19 June 2013	11th REHVA world congress Clima 2013	Prague, Czech Republic	www.clima2013.org
	22 – 26 June 2013	2013 ASHRAE Annual Conference	Denver, Colorado	www.ashrae.org/membership--conferences/conferences/ashrae-conferences/denver-2013
	26 – 28 June 2013	Central Europe towards Sustainable Building Prague 2013	Prague, Czech Republic	www.cesb.cz/en
	25 – 27 September 2013	5th International Conference Solar Air conditioning	Bad Krotzingen, Germany	www.otti.eu
	3 – 4 October 2013	Climamed 2013	Istanbul, Turkey	www.climamed2013.org
	15 – 16 October 2013	European Heat Pump Summit	Nürnberg, Germany	www.hp-summit.de
	15 – 18 October 2013	IAQ 2013 - Environmental Health in Low Energy Buildings	Vancouver, Canada	www.ashrae.org/membership--conferences/conferences/ashrae-conferences/iaq-2013
	20 – 21 October 2013	Energy Efficiency & Behaviour	Helsinki, Finland	www.behave2012.info
	24 October 2013	REHVA anniversary	Brussels, Belgium	www.rehva.eu
	4 – 8 November 2013	Interclima+Elec	Paris, France	www.interclimaelec.com

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GREAT NEWS

VRV IV SETS THE STANDARD … AGAIN

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Find out more on www.daikineurope.com/greatnews

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