IEA **Heat Pump** CENTRE

NEWSLETTER

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Mobile Air Conditioning

DuPont Testing Validates Viable Low Global Warming Solution for Mobile Air Conditioning

Refrigerated Transportation, Energy Consumption and Food supply in China

R744 System for Heating and Cooling of Automobiles

IEA OECD heat pump centre

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In this issue

Mobile Air Conditioning

Dear readers,

This summer has been warm in southern Europe, and with many people travelling on vacation, the use of air conditioning in the cars is a blessing. The use of airconditioning, however, leads to emissions both from leakage and from the power needed for the AC. With many new regulations, the F-gas especially, car makers have a tough job to improve the AC. Some of the measures taken are reported on in this issue.

Roger Nordman
Editor

COLOPHON

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What is the future for Mobile Air Conditioning (MAC)?

For the general public, products and systems within the area of refrigeration technology are rather anonymous, even if we all benefit from chilled and frozen foods, cool air, etc. The phasing out of freon usage had a direct effect on consumers and domstic refrigerators, and now the same will be true of the F-gas directive's changes to our cars and their AC. The European F-gas directive 2006/40/EC states that the automotive industry in Europe, from 2011 until 2017, shall switch over from R 134a to refrigerants with GWP<150 . The available alternatives are carbon dioxide, flammable or combustible refrigerants, R 152a, or the invention of a new refrigerant or a new blend.

For fifteen years, carbon dioxide has been thoroughly studied and developed for MAC, and functioning systems are anticipated. High pressure, 70-120 bars, makes it difficult to contain the charge for the time required. Combustible refrigerants are not accepted by the automotive industry, which is controlled from the US and Japan, even if half a million cars in Australia have been driving legally with combustible hydrocarbons for the past ten years without any accidents occurring. Combustible fluids are cheap and market forces can take initiatives if the solutions for the future come to nothing or turn out to be costly. In the US there are perhaps ten million MAC systems using combustible refrigerants. There is official denial of this, but combustible refrigerants are sold in the US and Canada. R 152a with GWP=120, which is combustible, is studied in combination with indirect systems.

Leading chemical companies such as Honeywell, DuPont and Ineos conduct research into new refrigerants and blends. The work is discreet; it is a question of being first out, watching over patents, and offering a good level of efficiency and reasonable pressure. One suggestion is R 13I1, trifluoroiodomethane, an iodine compound, but this is expensive and is therefore mixed with something cheaper. Iodine, a halogen, occurs sparingly in the form of iodides in sea water from which it is assimilated by seaweeds, in Chilean salpeter and nitrate-bearing earth, in brines from old sea deposits and in brackish waters from salt and oil wells. A solution for producing the amounts of iodine required for the automotive industry must be found.

Cars of tomorrow must have a low fuel consumption and low CO2 emissions compared to today's. This can mean that enough heat cannot be produced for cold climates, so cooling systems must also be able to function as heat pumps.

Natural ammonia has not been tested since man's ignorance and lack of imagination put obstacles in the way. Only a few hundred grams are required, and such small quantities are not combustible nor can they poison nor injure people in a car crash. The pungent smell is an advantage, but it is unpleasant and tends to worry people. If you smell ammonia in your car, you make sure that you have the leak fixed and the cooling system works. Ammonia has lower pressure, is more efficient and cheaper than the alternatives.

A lot of work is being done on finding solutions for new MAC systems and the final word on the subject could be "open the car windows". But then you have to reintroduce vent windows and reduce speeds.

Anders Lindborg
Ammonia Partnership AB
Sweden

[1] GWP is Global Warming Potential, calculated in terms of 100-year warming potential of one kg of a gas relative to one kg of CO_2. R 134a has GWP 1300 and one kg is equivalent to 1,3 tonnes of CO_2.

Columnist

Triple Benefits: Opportunity in Mobile Air Conditioning

Rajendra Shende,
Head, OzonAction Branch,
UNEP DTIE Paris

Nearly 13 years ago the Mobile Air Conditioning (MAC) systems in developed countries made a major technology shift. Today every new MAC system in the world including developing countries uses HFC-134a as refrigerant that replaced CFC-12. It is estimated that of 450 million vehicles that operated globally in 2004 with MAC, 50 % run on CFC-12 and the remaining on HFC-134a.

MAC is probably the most 'leaky' sector among refrigeration systems as far as annual rate of emissions of the refrigerant is concerned. It is up to 25 % or more depending on the road conditions and servicing practices. Both refrigerants i.e. CFC12 and HFC 134a are powerful Greenhouse Gases (GWP 7100 and 1600 respectively). In 2003, global emissions from MAC were estimated to be 0.6 giga tons of CO_2 equivalent per year and another 0.1 giga tons of CO_2 equivalent per year due to fuel consumed for the operation of MAC.

Car manufacturers, suppliers, governments and international organisations are moving quickly to reduce direct emissions of HFC-134a from vehicle air conditioning by at least 50 % and to reduce the indirect emissions from the operation of vehicle air conditioning by at least 30 %. This is the objective of the I-MAC partnership which has been facilitated by US EPA. The European Union has banned, beginning in the year 2011, the use of HFC-134a (GWP>150) in mobile A/C units (in new 'type' automobiles) and beginning in 2017, HFC-134a will be banned from all new automobiles. It is anticipated that new air conditioning systems based on HFC-152a or carbon dioxide, and other low-GWP refrigerants which are being rapidly developed by DuPont and Honeywell will be commercialized.

The world has an unique opportunity to get economic gains by protecting the environment. The immediate need is to collaborate with developing countries and enter into partnerships to ensure that such gains are global in nature. Developing countries can avoid using obsolete MAC with HFC-134a. By forming partnerships with researchers and automobile manufacturers they can customize these energy-efficient and less ozone depleting solutions for their specific situations. Developing countries also stand to benefit from mitigation of greenhouse gas emissions, reduction of air pollution and of ozone depletion, as well as increased trade opportunities for less polluting vehicles. Recognizing this inter-relationship, OzonAction Branch of UNEP DTIE is helping developing countries make informed decisions that protect the ozone layer and at the same time safeguard the climate system through improved fuel efficiency.

The role of UNEP is to help provide automotive air conditioning system suppliers, government regulators, research and development personnel, and standards development organisations with a clear understanding of globally accepted best practices, procedures, regulations, testing/ monitoring and technology cooperation.

The MAC sector is an excellent example of how new policies could foster desirable technology change and benefit society through economic (reducing fuel consumption), environmental (reducing carbon dioxide emissions) and social (reducing air pollution and improving health) analyses. It can prove that environment and economics are not in opposite teams but on the score side of the game.

Rajendra Shende, Head,
OzonAction Branch,
UNEP DTIE Paris

Implementing the G8 Gleneagles Plan of Action Enhancing Energy Technology Collaboration with the "Plus-Five"

Alexandra Niez, IEA

The Networks of Expertise in Energy Technology (NEET) Initiative is the International Energy Agency's (IEA) response to the 2005 Gleneagles Plan of Action to:

"Raise the profile of existing research networks and encourage broader participation where appropriate; and, seek ways to improve the current arrangements of collaboration between developed and developing country participants in existing networks."

To implement the 2005 Gleneagles Plan of Action the NEET team has been engaging with the so-called "Plus-Five" countries, namely China, India, South Africa, Brazil, Mexico and also Russia, to raise their awareness of the activities of the IEA Working Parties and Implementing Agreements as well as other networks, and where this makes sense, to strengthen energy technology collaboration.

A first step: fact-finding missions

To implement its task, the NEET team, during so-called "fact-finding" missions to the "Plus-Five" countries, seeks to identify the country's main national energy technology priorities, key-players and activities. The team also presents and discusses with policy makers, business, finance, R&D institutions and universities, what was achieved through energy technology collaboration in the framework of the IEA Implementing Agreements that appear to be most relevant to the country visited.

NEET workshops in each of the "Plus-Five" countries are then set-up in such a way that the IEA Technology Network and other networks that are engaged in areas of research that are identified as relevant to the "Plus-Five" country, and who wish to open their membership to it, will have the opportunity to re-introduce the work underway in their collaborative programme. Through presentations to the national stakeholders, from the government, private sector and R&D community, the collaborative programmes will address a wide yet focused audience.

NEET workshops are an opportunity for straightforward presentations and discussions with a targeted audience on relevant issues of interest to the country. These events may ultimately lead, if found relevant by all parties, to further involvement of "Plus-Five" countries in the IEA Technology Network.

The NEET Initiative in the "Plus-Five"

Successful fact-finding missions have already taken place in South Africa in April 2006, in Brazil in September 2006 and May 2007, in China in January and in April 2007. The next planned fact-finding mission will take place in India in September 2007.

A first very successful NEET workshop took place in Johannesburg South Africa, on 20-22 February 2007, in collaboration with the South African National Energy Research Institute (SANERI). Thirteen Implementing Agreements participated in the event, and three Working Parties. During the workshop, the SANERI identified five new Implementing Agreements in which they wish to see South Africa participate. Bilateral discussions have already begun.

Following the same successful template, the NEET team is now planning a workshop in **China** end of October 2007 in collaboration with the China Coal Research Institute (CCRI) and the Ministry of Science and Technology (MOST). **The Heat Pump Centre** was identified by the NEET team and by the Chinese counterparts to be of relevance to China, and is invited to present its activities at the NEET workshop. Relevant stakeholders involved in the area of Heat Pump technologies from the government, R&D institutions and universities will be identified by the Chinese counterparts to speak or attend the session.

Another NEET workshop is planned in Brazil end of November 2007.

To know more…
For more information on the progress of the NEET Initiative in the "Plus-Five" countries please visit the website http://www.iea.org/neet and contact Dr. Alexandra Niez, NEET Project Manager at Alexandra.niez@iea.org.

IIR D2 CERTE Refrigerated Transport Sub-committee meeting in Piestany Slovakia, 31/5 - 1/6 2007

Transport of foodstuff in cooled transports.

In order to transport some types of foodstuff across borders, there are special demands on the transport and other equipment and on the temperature during transport. Foodstuffs that must comply with these demands are called ”perishable foodstuffs”. There are two groups of goods: frozen and cooled. Examples of frozen goods are ice cream and fish products, with transport temperatures of -20 °C and -18 °C respectively. Examples of cooled goods are meat products, poultry and rabbits, with maximum permissible transport temperatures of +6 °C and +4 °C respectively.

The ATP regulations

Foodstuffs that are included in the regulations described above are classed by the ATP regulations, which is a UN-based agreement. ATP is Short for ”Agreement on the International Carriage of Perishable Foodstuffs and on the Special Equipment to be used for such Carriage”. SP Technical Research Institute of Sweden is one of the European institutes that is accredited to perform type tests on cooled containers/ transports and cooling equipment.

International co-operation and ongoing issues

As has been said earlier, the ATP regulations are an agreement signed by the UN. Once a year, the representatives for the countries meet at the UN European office in Geneva to discuss and decide on new regulations. The number of countries that have signed the agreement is steadily increasing, and is at the moment 40.

Technical issues are often handled by the ”CERTE” sub-committee of the IIR (International Institute of Refrigeration). This working group is a consortium of testing laboratories and authorities that are working with certification, and a few branch organisations. The working group is a subset of IIR Group “D2 Refrigerated Transport”. The author has held the post of CERTE chairman for a number of years, and has also been the IIR representative at the annual UN meetings on a number of occasions.

The”Test Stations” group meets annually, meeting this year in Piestany in Slovakia from May 31st to June 1st. Thirty-two participants attended the meeting, and questions that were discussed included:

- Test method for type tests of multi-compartment multi-temperature vehicles. This type of vehicle, with several different sections, each with a different temperature, is increasing widely used in Europe. Today, there are no clear standards for how these vehicles should be tested. There will be a need for a method to test a cooling machine with multi-evaporators, with evaporation at many temperature levels, because of different temperatures in the different sections..

- Test method to inspect vehicles (in service) after six years.

The test method is based on the principle that the time of cool-down inside the vehicle is measured. The current testing method states only that the ambient temperature should not be less than 15 °C. The new method is based on the allowed cool-down time is a function of the surrounding temperature. This tightens up the regulations, and may in the end lead to more vehicles failing the test. However, the stricter regulation is considered reasonable by the industry if there is a reasonable transition time before the new regulation comes into force.

- Energy labelling and energy consumption for cooling machines

To improve the energy efficiency of the transport equipment, work has started on an energy labelling scheme for different transport equipment. This will be an important step for the group to monitor. One suggestion for this work was to develop a method to measure the energy consumption in cooling equipment poweredby the truck engine.

In addition to the issues described above, the Greek representative also described work in Greece on a calculation method for fuel consumption and CO_2 emissions.

SP Energy Technology
Geron Johansson
Chairman of the IIR D2 CERTE Subcommittee

General

EU heat pumps eco-label ecological criteria include the use of HFCS

National Competent Bodies in the EU for the EU Ecolabel have adopted the ecological criteria for the EU Heat Pumps Ecolabel.
The criteria permit the use of refrigerants with a global warming potential (GWP) less than 2000, which includes most HFC refrigerants. The Ecolabel will cover all types of heat pumps, with a heat capacity up to 100 kW.

Energy efficiency requirements in terms of coefficient of performance (COP) in heating mode, and energy efficiency ratio (EER) in cooling mode, will be tested in accordance with European Standard EN 14511:2004, which concerns air conditioners, liquid chilling packages and heat pumps.

If refrigerant with a GWP less than 150 are used, the required minimum energy efficiency (COP and EER) will be reduced by 15 %.

This decision recognizes that GWP alone does not satisfactorily describe the climate impact of a greenhouse gas.

Reference : http://ec.europa.eu/environment/ecolabel/pdf/heat_pumps/final_criteria.pdf
Source: www.fluorocarbons.org

Heating costs - Heat pump beats oil and gas

In Germany, the online magazine ”FOCUS online” has published a comparison of annual heating costs for five heating systems. The results clearly demonstrate the advantage of ground source heat pumps versus oil, gas, wood pellets, and thermal solar.

Annual heating costs (Status: 1 February 2007)

- New building (single-family house, 120 square meters, heat demand 50 kWh/m^{2}a)
  - Geothermal heat pump with borehole heat exchangers: 1337 Euro
  - Oil condensing boiler: 1733 Euro
  - Gas condensing boiler: 1771 Euro
  - Wood pellet boiler: 1818 Euro
  - Gas boiler plus thermal solar: 2162 Euro
- Existing building (retrofitted single-family house, built in the 1960s, 120 square meters, heat demand 100 kWh/m2a)
  - Geothermal heat pump with borehole heat exchangers: 1606 Euro
  - Wood pellet boiler: 2021 Euro
  - Oil condensing boiler: 2082 Euro
  - Gas condensing boiler: 2194 Euro
  - Gas boiler plus thermal solar: 2495 Euro

More detailed information (in German) can be found at:
http://www.focus.de/immobilien/energiesparen/heizkosten/heizkosten_aid_28214.html
Source: Ground-Reach newsletter #3

EPA helps truckers keep their cool while going green; hybrid diesel-electric trailer refrigeration units cut air pollution

(New York, N.Y.) What do chicken dinners, salmon and filet mignon have in common? They could all be found in a state-of-the-art pollution-slashing hybrid diesel-electric trailer refrigeration unit such as the one showcased by the U.S. Environmental Protection Agency (EPA) today at Pier 92. The technology allows refrigerated trucks and trailers to remain icy cold while switching from diesel power to electric power during loading and unloading, reducing diesel emissions to zero. The technology also puts a lid on fuel costs and noise. EPA’s Regional Administrator Alan J. Steinberg appeared with representatives from the New York State Energy and Research Development Authority (NYSERDA) and companies that make the technology to observe a low-polluting truck that delivered goods to a Holland America Lines cruise ship at the New York City Economic Development Corporation’s facility.

“Hybrid diesel-electric power demonstrates that businesses can go green while they keep their cool,” said Alan J. Steinberg, EPA Regional Administrator. “Refrigeration is an integral part of America’s transportation and delivery system. Thanks to EPA and our partners, businesses now have the power to shrink their environmental footprint while increasing their bottom line.”

Paving the way for cleaner and energy-efficient alternatives in the trucking industry, Shurepower LLC, Carrier Transicold, Maines Paper and Food Service, Inc., New West Technologies and Great Dane Trailers used money provided by EPA and NYSERDA to help fund the first of its kind demonstration pilot project. The original pilot project, located in a Maines Paper & Food Service, Inc. distribution facility in Conklin, N.Y., involved setting up and operating electrified loading docks and parking spaces for commercial heavy-duty diesel trucks and refrigerated trailers to power the refrigeration. The project was part of a nation-wide effort to reduce pollution from truck fleets known as EPA’s SmartWay Transport Partnership.

NYSERDA President and CEO Peter R. Smith noted that, since 2000, New York State has committed $2.55 million in cooperation with EPA and the Department of Energy in pursuing technologies to replace the nation’s petroleum use that goes to transportation. “NYSERDA projects thrive on cooperation among our federal and private partners. Through hybrid-power technology applications, we can make advances to ensure that motor freight, and especially food, is cared for in the most energy-efficient and environmentally responsive way," Smith said.

Trailer refrigeration units are the standard for preserving and cooling goods during transport and delivery. The demonstration project featured eTRU, also known as hybrid diesel-electric trailer refrigeration unit. eTRU technology enables an electrically powered source of energy from a loading dock or parking space to keep the truck's load or trailer compartments at a specific temperature without having to run the engine. The technology works by installing an electric device on a loading dock or parking space and equipping a diesel truck or refrigerated trailer with special components that connect the diesel engine to the electric power grid. Once plugged in, the diesel engine can be totally shut down, producing zero diesel emissions.

The Carrier Transicold Vector 1800 MT multi-temperature trailer refrigeration system features unique, hybrid diesel-electric technology that enables shippers effectively to regulate the temperature of multiple compartments within the trailer. It combines a diesel engine with an electrical generator to reduce air pollution and sound levels, eliminate many components and maintenance items, and increase reliability and performance. The Shurepower's electrified truck parking system is a low-cost alternative to idling that provides drivers with grid-based electricity. Maines Paper & Food Service, Inc. was a key partner in developing the project at its distribution center in Conklin, NY. New West Technologies, LLC assisted Shurepower in the project by providing engineering expertise.

EPA recognizes that various technologies, strategies and behaviours can effectively reduce long-duration idling while providing the truck driver with essential needs such as heat or air conditioning. Truck-stop electrification allows the electrical grid to supply power to truck on-board components or stationary components for heating, cooling and other needs.

Extended idling has a significant impact upon air quality. On a national scale, extended truck idling contributes, annually, 11 million tons of carbon dioxide, 200 000 tons of oxides of nitrogen and 5000 tons of particulate matter. Additionally, idling long-haul trucks consume over one billion gallons of fuel, costing over $2 billion annually.

The SmartWay Transport Partnership is an innovative program developed by EPA and the freight industry to reduce greenhouse gases and air pollution, and to promote cleaner, more efficient ground freight transportation. The Partnership provides companies with technical assistance, tools for evaluating opportunities, and help locating financing to purchase these technologies.

To learn more about EPA's SmartWay Transport Partnership, please visit: http://www.epa.gov/smartway/
Source: http://yosemite.epa.gov/opa/admpress.nsf/names/r02_2007-4-11_eTru_Diesel_Event
Contact Information: Elias Rodriguez (212) 637-3664, rodriguez.elias@epa.gov

Energy Globe 2006

The Romanian Geoexchange Society was awarded the Energy Globe 2006 national prize for the project "Romania - a clean country in a clean Europe through geoexchange technology", and one of our founding members, ASA Holding SA, was also awarded the same prize for its project: "Porsche's choice - Energy under your feet".
www.geoexchange.ro

Massachusetts sues U.S. over HVAC standards

Massachusetts' Attorney-General Martha Coakley has filed a federal lawsuit aimed at forcing the U.S. Department of Energy to adopt higher energy efficiency standards for new commercial heating, ventilation, and air conditioning systems.

Massachusetts argues that HVAC products used in schools, offices and hotels account for a significant share of energy use, and that higher efficiency standards for those systems would save the equivalent of just under 1 % of total U.S. electricity consumption until 2034. Tightening the standards alone for air conditioning products could save up to 850 TWh's over a 27-year period, thereby eliminating the need for several major power plants.

Commercial refrigeration industry ready for R744

R744 systems outperform current commercial refrigeration systems in terms of sustainability and future development potential, according to leading industry experts speaking at an international refrigeration conference

Refrigeration systems using CO_2 are already a highly convenient choice after having proved to operate successfully in commercial refrigeration test installations worldwide. This was stressed by experts from the refrigeration industry who gathered in Berlin, Germany, to discuss training, design, maintenance and safety issues for current and future systems, with particular emphasis on R744 (CO_2).

More specifically, the 150 participants, from the private and public sectors, focused on different technological options for operating CO_2 systems and requirements for a widespread use of R744 in supermarket cabinets.

"And the winners is? CO_2"

"CO_2 will be the refrigerant of the future. We want to make this quite clear." This message emerged from the presentation of Christoph Brouwers, Carrier, who highlighted the "brilliant results so far" with respect to operation of the company's CO_2OLtec technology. The new cascade system, installed in cooperation with Linde in 93 plants across Europe, has performed highly efficiently in medium and low-temperature refrigeration. The company now plans to offer complete transcritical CO_2 systems by 2010. **CO_2 a "single green fluid for all refrigeration systems"**

Following tests in a German supermarket, CO_2 cooling systems have proved to operate more energy-efficiently at low ambient temperatures of 6-13 °C than systems using R404a. This was confirmed by Samuele da Ros, Epta, who also indicated the interest of several customers in installing the CO_2 system in other supermarkets across Europe. He concluded: "Considering both environment and technology (R744 is) the best solution available today, with further improvements under development."
Source: www.R744.com

Japan to invest $1.7 billion on green cars

The government fund will help companies develop cheaper and cleaner vehicles to cut the use of fossil fuels and reduce car emissions. Japan's move follows a recent proposal to halve global greenhouse gas emissions by 2050.

The Ministry of Economy, Trade and Industry (METI) plans to spend 209 billion yen over the next five years to support the development of clean vehicle technology that would lead to a significant reduction of both fuel consumption and greenhouse gas (GHG) emissions. Under the plan, next-generation vehicles featuring innovative power trains and fuels will be awarded a grant.

Prime Minister urges global action on climate change

The initiative follows a recent proposal by Japan's Prime Minister, Shinzo Abe, to halve global emissions by 2050, without however specifying a target for Japan's own emission reductions. Abe's plan foresees a joint effort from both industrialised and developing nations and seeks to provide an international framework for the post-Kyoto Protocol era starting in 2012.
Source: www.R744.com

Climate change puts heat pumps on the political agenda?

Both the EU and the USA now have climate change at the top of their agendas. The EU has recently launched discussions on its future long-term strategy to fight global warming. The Bush administration has also put forward a proposal that is based on the principle that climate change must be addressed by "fostering both energy security and economic security, by accelerating the development and deployment of transformational clean energy technologies," the White House said in a statement.

Although there seem to be differences in the interpretation of the results that these actions may have, one thing is clear: now is the time to show the impact that heat pumps can have in helping to reduce energy demand for heating and cooling in the building sector.
See, for example, the policy papers provided by the HPC (http://www.heatpumpcentre.org) for more information.

'Megacities' to go for greener buildings

At a meeting in New York last week, 16 world cities promised to make their old buildings more energy-efficient, with the help of a $5 billion project established by the Clinton Foundation. Former US president Bill Clinton announced the new Energy Efficiency Building Retrofit Program set up by his Foundation at the C-40 Large Cities Climate Summit in New York. Under the project, 16 cities (among them London, New York, Berlin, Mexico, Rome, Bangkok, Seoul and others) will upgrade their existing buildings with more efficient heating, cooling and lightning systems to reduce energy consumption and prevent climate-gas emissions.

Five global banks (ABN Amro, Citigroup, Deutsche Bank, JPMorgan-Chase and UBS) will each provide $1 billion loans for the project, which will be paid back from the savings gained on the energy bills. Major companies such as Johnson Controls and Honeywell will manage and audit the retrofitting work.

In another partnership presented during the conference, Microsoft and the C40 Large Cities group announced that the software giant will develop tools to enable cities to monitor, compare and reduce their greenhouse-gas emissions.

Read more on
http://www.euractiv.com/en/sustainability/megacities-go-greener-buildings/article-163862

First EU Energy Strategy for Transport adopted

EU transport ministers have agreed to support more stringent legislation tackling growing emissions from transport. In the meantime, EU environmental leaders are set to convince business that an ambitious environmental policy is key to boosting Europe's competitiveness. Transport is about to be the key subject of upcoming regulations, as the EU intends to slash energy consumption by 20 % by 2020 and significantly reduce greenhouse gas emissions. This was agreed by the EU transport ministers at their last Council meeting on 8th June. Adopting the first European energy strategy addressing solely the transport sector, they called more specifically for all car manufacturers to step up efforts to make vehicle production more environmentally friendly across all model classes.

”Eco-innovations” key for EU competitiveness

To make road transport ”greener”, now accounting for 84 % of all EU transport emissions, the ministers call on the European Commission to create a regulatory framework that would significantly cut CO2 emissions from passenger cars while fostering sustainable, energy-efficient and cost-effective technologies. Future legislation, they pledge, must ensure that each individual transport mode bears the full cost of its ”ecological footprint”.
Source: www.R744.com

ADAC proves air conditioning testing feasible

Using air conditioning can increase a car's fuel consumption by up to 20 %, according to Europe's biggest automobile club. Its simple testing method confirms that measuring the AC system's fuel consumption is possible and urgently needed to minimise this additional fuel use. According to the German automobile club ADAC, an additional 2.47 to 4.15 litres / 100 km of fuel are needed to cool down a car from 31 °C to 22 °C after parking in the sun. After this first cool-down phase, the constantly operating mobile air conditioning (MAC) can increase fuel consumption by up to 2 litres/100 km. Depending on vehicle type and design of the cooling system, this could cost the driver at least an extra EUR 5-8 for an 8 hours' summer drive, with even higher fuel costs expected for less efficient systems and higher ambient temperatures.

These are key results from test cycles performed by Europe's biggest automobile club, ADAC, that have also confirmed the impact of the air conditioner's compressor design on the whole system efficiency and therefore on additional fuel consumption.
Source: www.R744.com

ASHRAE, UNEP work to reduce emissions

Two international organisations have joined forces to reduce emissions and encourage energy-efficient refrigeration and air conditioning systems and building designs. ASHRAE and the United Nations Environment Programme (UNEP), Division of Technology, Industry and Economics (DTIE), have formalized an agreement to cooperate on several technical issues, such as assessing and addressing remaining chlorofluorocarbon-based chillers. The two organisations will also promote sustainable activities in areas such as emissions reduction and energy-efficient systems and building design.
Source: Cool connections, June 2007

Ancient 'Ondol' heating systems discovered in Alaska

What are believed to be the world's oldest underfloor stone-lined-channel heating systems have been discovered in Alaska's Aleutian Islands in the U.S. The heating systems are remarkably similar to ondol, the traditional Korean indoor heating system. The word 'ondol', along with 'kimchi', is listed in the Oxford English Dictionary. The ondol heating system is widely recognised as Korean cultural property.

According to "Archaeology", a bimonthly magazine from the American Archaeological Society, the remains of houses equipped with ondol-like heating systems were found at the Amaknak Bridge excavation site in Unalaska, Alaska.

The leader of the excavation, archaeologist Richard Knecht from the University of Alaska, Fairbanks, said in an interview with the Chosun Ilbo on Monday that the team began the dig in 2003. Radiocarbon dating shows the remains are about 3000 years old.

Until now, the oldest known ondol heating systems were built 2,500 years ago by the Korean people of North Okjeo in what is now Russia's Maritime Province. The Alaskan ondol are about 500 years older, and are the first ondol discovered outside the Eurasian continent.

Professor Knecht said four ondol structures were discovered at the site. Other ondol structures were found in the area in 1997, but it was not known what they were at the time.

According to Knecht's data, the Amaknak ondol were built by digging a two- to four-meter-long ditch in the floor of the house. Flat rocks were place in a "v" shape along the walls of the ditch, which was then covered with more flat rocks. There was also a chimney to let the smoke out.

Professor Song Ki-ho of the Department of Korean History at Seoul National University looked over the Amaknak excavation report. "All ancient ondol are one-sided, meaning the underfloor heating system was placed on just one side of the room. The ondol in Amaknak also seem to be one-sided," he said.

As the ondol of North Okjeo and Amaknak are more than 5000 kilometers apart, Knecht and Song agree that the two systems seem to have been developed independently.

This theory is backed up by the fact that ondol have not been found in areas between the two locations, such as Ostrov, Sakhalin or the Kamchatka Peninsula, and because the Amanak ondol are significantly older than those of the Russian Maritime Province.
Source: http://www.teaandgossip.com/

Technology & Applications

Better compressor capacity evaluation

Most compressor manufacturers express the capacity of their compressors using the “nominal capacity” of the motor, expressed in HP (1 horsepower = 0.735 kW), which does not give precise information on the refrigerating capacity of the compressor. As far as the refrigerating capacity is concerned, the first thing to stress is that, for a given compressor, its value differs depending on the refrigerant used, due to different thermodynamic characteristics. Secondly, for a given refrigerant, two different methods are used to measure the refrigerating capacity of compressors:

- European Standard EN 12900 specifies capacity measurement for air conditioning under the following conditions: evaporation temperature: 5 °C, condensation temperature: 50 °C, superheating at the suction level: 10 °C, sub-cooling at the discharge level: 0 °C;
- ANSI/ARI Standard 500, more used in the refrigeration and air-conditioning sector, involves the following conditions: evaporation temperature: 7.2 °C, condensation temperature: 54.4 °C, superheating at the suction level: 11 °C, sub-cooling at the discharge level: 8.3 °C.

For example, the capacity evaluation of Copeland’s 17 ZR model compressors, suited for air conditioning, with R-407C as a refrigerant, gives the following results when tested in accordance with EN 12900: nominal capacity: 1.5-30 HP, refrigerating capacity: 3.8-79.4 kW; the value of 1 HP varies between 2,333 and 2,646 kW. For the same nominal capacities, capacity evaluation using ARI Standard with R-22 as a refrigerant shows, refrigerating capacities of 4.4 kW to 92 kW; the value of 1 HP varies from 2,766 to 3,066.
So, to evaluate the refrigerating capacity of a compressor, it is not possible simply to convert the motor HP into cooling kW since, in the case of the compressors cited, the result can vary by up to 31.4 %. (3.066/2.333). The standard used and the refrigerant need to be checked.
Source: Chaud Froid Plomberie, December 2006

New CO_2 chillers with integrated free cooling

Danish company ADVANSOR has launched its new “compFORT” series of air-cooled water chillers in the capacity range from 80 kW to 380 kW, covering evaporation temperatures between -10 °C and +15 °C. All compFORT products utilise carbon dioxide as the refrigerant, and are equipped with low-noise, air-cooled condensers as standard.
The units have been developed and are produced in Denmark by Advansor A/S, a new company founded in 2006 by Kim G Christensen and Torben M Hansen, both former managers at the Danish Technological Institute.
Source: www.Scanref.dk

Witzenmann presents flexible AC hose

The European market leader for flexible metallic elements has developed a highly reliable hose for R744 air-conditioning systems, featuring compact design and excellent pressure resistance. Witzenmann’s corrugated, stainless steel hoses are suitable for high and low pressure applications in CO_2 (R744) mobile air-conditioning systems. They are absolutely permeation-tight, due to the welded design. The CO_2-proof components will resist high temperature variations, operating pressure and pressure pulsations. They allow for the decoupling of vibration and engine movement between engine-fixed and chassis-fixed components, and for compensation of mounting tolerances in R744 air-conditioning systems.
Source: www.r744.com

Ongoing Annexes

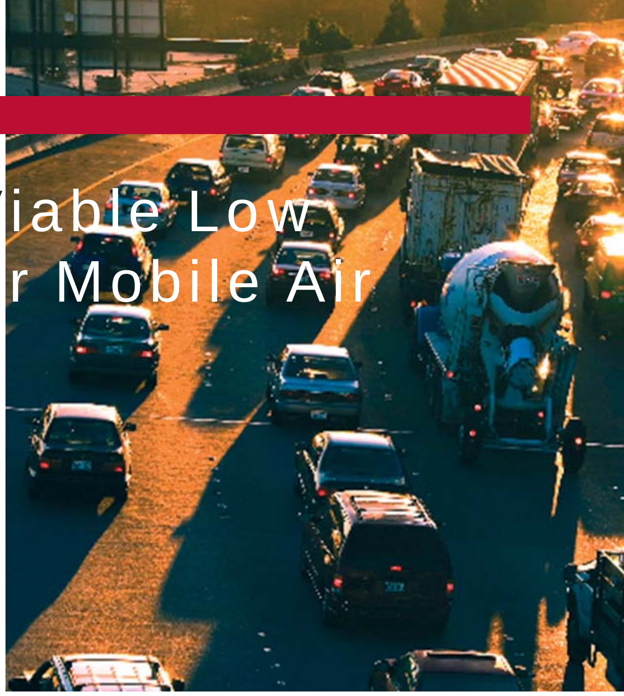
Bold text indicates Operating Agent.

Annex 29 Ground-Source Heat Pumps - Overcoming Market and Technical Barriers	29	AT, CA, JP, NO, SE, US
Annex 30 Retrofit heat pumps for buildings	30	DE, FR, NL
Annex 31 Advanced modelling and tools for analysis of energy use in supermarkets.	31	CA, DE, SE, US
Annex 32 Economical heating and cooling systems for low-energy houses.	32	CA, CH, DE, NL, SE, US, JP, AT, NO
Annex 33 Compact Heat Exchangers In Heat Pumping Equipment	33	UK, SE, US, JP

IEA Heat Pump Programme participating countries: Austria (AT), Canada (CA), France (FR), Germany (DE), Japan (JP), The Netherlands (NL), Norway (NO), Sweden (SE), Switzerland (CH), United Kingdom (UK), United States (US). All countries are members of the IEA Heat Pump Centre (HPC). Sweden is Operating Agent of the HPC.

DuPont Testing Validates Viable Low Global Warming Solution for Mobile Air Conditioning

Dr. Barbara Minor, DuPont Fluoroproducts, USA



More than 400 million cars with air conditioning systems are on the road globally.

In an effort to address global warming, the European Union (EU) enacted the F-Gas Regulation and directive that, among other restrictions, phases out the use of R-134a in mobile air conditioning (MAC) systems over the period 2011-2017. Some alternatives, like CO_2, would require significant and costly redesign to MAC systems; however, others in development, like "DP-1" from DuPont, have the potential to be more viable, cost effective replacements for R-134a, due to low global warming potential (GWP), zero ozone-depletion potential (ODP), energy efficiency and closer compatibility with current MAC systems.

Introduction

A number of regulatory initiatives have been enacted around the world to protect the environment from ozone depletion and global climate change. These actions are designed to phase-out the use of chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs) – gases that deplete the ozone layer. Due to the increasing concern over global climate change, attention has also been focused on hydrofluorocarbons (HFCs), which do not deplete the ozone layer but do have some global warming potential (GWP). Specifically, the European Union (EU) has passed a directive that will phase out the use of R-134a in MACs over the period 2011-2017 and require the use of a refrigerant with a GWP of less than 150. As a result, automobile manufacturers are working to qualify possible alternatives to R-134a, including CO_2 and "DP-1" from DuPont.

"DP-1" is a proprietary, two-component blend of non-flammable fluorine-based compounds, containing a new compound, and a refrigerant used commercially today. "DP-1" is currently undergoing extensive tests, and the results to date are very promising, suggesting that it can be a viable, low-GWP solution for MAC.

This article provides a review of the current environmental regulations, particularly within the EU, that have stimulated the development and testing of new refrigerant options. It will also discuss the automotive industry's environmental, safety, and performance requirements for an R-134a alternative and will detail key properties of "DP-1".

An Overview of Regulations

The EU proposed the F-Gas Regulation and MAC Directive in 2003 as part of its effort to implement the United Nations Framework Convention on Climate Change and its Kyoto Protocol to reduce emissions from greenhouse gases (GHGs), including carbon dioxide, methane, nitrous oxide, perfluorocarbons (PFCs), sulfur hexafluoride and hydrofluorocarbons (HFCs). R-134a, an HFC refrigerant universally used in MAC, has a GWP of 1,300. As a result, its use in MAC will be significantly curtailed over a six-year period in the EU. Specifically, the directive calls for R-134a to be phased out in MAC beginning in 2011. On January 1, 2017, it will be banned for all new vehicles. The directive also requires that next-generation replacement refrigerants have a GWP of less than 150.

Parts of the United States are also taking action to address climate change. The California Air Resources Board (CARB) recently proposed a list of possible initiatives to address climate change that includes the phase-out of R-134a from heavy equipment in 2010 and from cars in 2017. This would be in addition to steps that have already been taken to reduce greenhouse gas emissions, including MAC refrigerant emissions, from cars beginning in 2009. Ten other states (New York, New Jersey, Massachusetts, Maine, Connecticut, Vermont, Rhode Island, Washington, Oregon, and Pennsylvania) have adopted similar legislation, and it is being considered by five more (Maryland, Illinois, North Carolina, Arizona and New Mexico). These actions underscore the growing global concern over climate change and the need for a new MAC refrigerant solution.

What is Required?

As a result of the F-Gas Regulation and MAC Directive, and other similar environmental initiatives, the automotive industry has established its own timeline to ensure that it has an alternative refrigerant solution in place by 2011. Currently, the industry is testing the viability of several next generation candidates, with the goal of identifying an alternative to R-134a by mid-2007.

The automotive industry has identified three key characteristics required in the next generation MAC refrigerant. First, it must be a single, global solution that provides consistent cooling capacity in all climates and car models. Second, the new refrigerant must be cost-effective for the entire value chain and utilize existing R-134a system technology as much as possible. Finally, it should have a GWP lower than 150 and consistent with the EU F-Gas Regulation. Given variations in acceptable GWP levels over time, a GWP that is significantly below 150 would be optimal to ensure a margin of uncertainty for future changes.

There are several additional performance, safety and environmental criteria that must also be met before the industry will widely accept an alternative MAC solution. In terms of performance, the refrigerant should have cooling capacity and energy efficiency similar to R-134a or better. It must also demonstrate thermal stability, materials compatibility – specifically with the plastics and elastomers used in current MAC systems – and miscibility with polyalkylene glycol (PAG) and polyol ester (POE) lubricants. These factors will determine whether the new refrigerant will be compatible with existing R-134a system technology.

Safety is also important to qualifying a new refrigerant. The industry requires a solution that has acceptably low toxicity levels and is non-flammable. Environmental characteristics include zero ozone-depletion potential (ODP) and lower Life Cycle Climate Performance (LCCP) versus R-134a and other alternatives.

Evaluating Solutions

One early candidate under consideration as an alternative to R-134a was carbon dioxide (CO_2), largely because it has a GWP of one; however, CO_2 has several drawbacks, including significantly higher pressure and low thermodynamic efficiency. These properties would require a MAC system to operate at a higher pressure, which would add weight to the vehicle and decrease its fuel economy. It would also require extensive redesign of current MAC systems in all cars, resulting in higher costs throughout the automotive value chain and impacting manufacturers, aftermarket service and retailers, and ultimately, consumers.

Figure 1. First test car cooled with DP-1 at the 2006 European Automotive Air Conditioning Show in Frankfurt, Germany. No changes were made to the demonstration vehicle's existing R-134a MAC system in order to run on DP-1.

In November 2006, DuPont Refrigerants was first to announce it had developed a low-GWP, next generation refrigerant candidate, "DP-1", as a more practical alternative to CO_2. With vapor pressure and other properties similar to R-134a, "DP-1" registers a GWP of approximately 40 – well below the EU limit of 150. It also has zero ODP and an LCCP that is more favorable than either R-134a or CO_2, which indicates that it has the least overall impact on global warming. Additionally, "DP-1" is expected to be compatible with conventional MAC system technology with only minor modifications (see Figure 1), making it an ideal replacement for R-134a and a more cost effective alternative than CO_2. It is expected to be commercialized within the timeframe required to meet the EU F-Gas phase-out deadline for R-134a.

Performance and material compatibility tests conducted to date indicate that "DP-1" could be a viable solution for MAC. It has been evaluated for thermal stability per ASHRAE Standard 97 [1] using three tests -- refrigerant only, refrigerant with dry PAG or POE lubricant and refrigerant/lubricant and 1000 ppm water. The refrigerant and lubricant were placed in sealed glass tubes containing aluminium, copper and carbon steel coupons, and held at 175 °C for two weeks. Results demonstrate that "DP-1" is thermally stable with no significant corrosion, even when subjected to more severe conditions including temperatures at 200 °C with 30,000 ppm moisture.

"DP-1" was also tested for compatibility with plastics and elastomers used in automotive air conditioning systems. Sealed tubes containing "DP-1" and uncapped PAG lubricant were held at 100 °C for two weeks. Plastics were then inspected for weight changes after 24 hours and changes in physical appearance (Table1). Elastomers were evaluated for linear swell, weight gain and hardness using a durometer (Table 2). The tests demonstrated that "DP-1" behaved similarly with both of these materials compared to R-134a, indicating that materials used in existing MAC systems may be compatible with "DP-1".

Table 1: Plastics Compatibility

Refrigerant	Plastics	Rating	24 h Post Weight Chg. %	Physical Change
DP-1	Polyester	1	3.6	0
"	Nylon	0	-1.1	0
"	Epoxy	0	0.7	0
"	Polyethylene terephthalate	1	2.8	0 -- 1
"	Polyimide	0	0.6	0

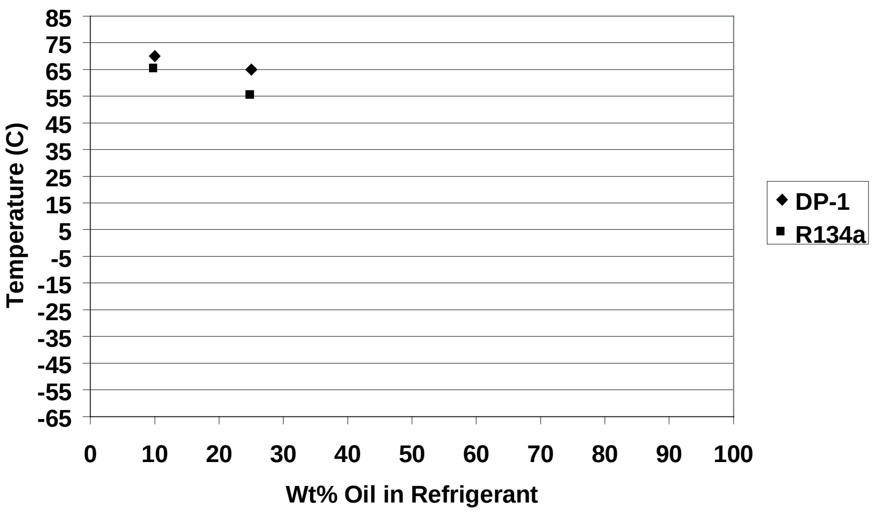
Refrigerant	Plastics	Rating	24 h Post Weight Chg. %	Physical Change
R134a	Polyester	1	4.5	0
"	Nylon	0	-1.2	0
"	Epoxy	0	0.0	0
"	Polyethylene terephthalate	1	4.2	0 -- 1
"	Polyimide	0	0.4	0

Table 2: Elastomers Compatibility

Refrigerant	Elastomers	Rating	24 h Post Linear Swell %	24 h Post Weight Gain %	24 h Post Delta Hardness
DP-1	Neoprene	0	-4.4	-2.6	3
"	HNBR	0	5.8	6.9	-5
"	NBR	0	-5.7	-1.4	3
"	EPDM	0	-3.5	-1.8	1.5
"	Silicone	0	5.4	3.8	-10
"	Butyl rubber	0	-2.3	-0.1	-1.5

Refrigerant	Elastomers		24 h Post Linear Swell %	24 h Post Weight Gain %	24 h Post Delta Hardness
R134a	Neoprene	0	-3.8	-2.4	2
"	HNBR	0 -- 1	8.6	9.8	-11.5
"	NBR	0	-1.4	1.3	-1.5
"	EPDM	0	-3.3	-1.3	0
"	Silicone	0 -- 1	1.7	2.3	-10.5
"	Butyl rubber	0	-3.1	-1.1	-2

Figure 2: Single End-Capped PAG



In all cases, "DP-1" miscibility with several PAG lubricants and a POE lubricant was similar to R-134a. Miscibility data for a single end-capped PAG and a double end-capped PAG versus R-134a are included in Figures 2 and 3. For a POE lubricant, there was complete miscibility from –40 to +65 °C.

Safety tests done on "DP-1" have had positive results. Acute toxicity tests, including Ames, Chrome AB, LC-50, cardiac sensitization and in vivo micronucleus, show acceptable toxicity (Table 3). Chronic tests, such as longer-term inhalation tests (28-day and 90-day), development tests and a first generation reproductive test (1-Gen), are in progress. "DP-1" is also non-flammable by ASHRAE Std 34 and ASTM 681 under all required leakage scenarios.

"DP-1" environmental properties include zero ODP and a GWP well below the EU F-Gas regulatory limit of 150. Additionally, it has a low LCCP compared to enhanced CO_2 and enhanced R-134a. LCCP has been used quite extensively in the mobile air conditioning industry and has become a useful tool to understand a product's total environmental impact. The LCCP model developed by Hill and Papasavva [2] was chosen for this test because it is robust and provides a sizeable volume of data. Analysis built upon this model used key assumptions and projected regional/country vehicle sales in 2017 to obtain one global LCCP value for all cars that will be built in 2017 (Figure 4). Key assumptions for the global LCCP model were as follows:

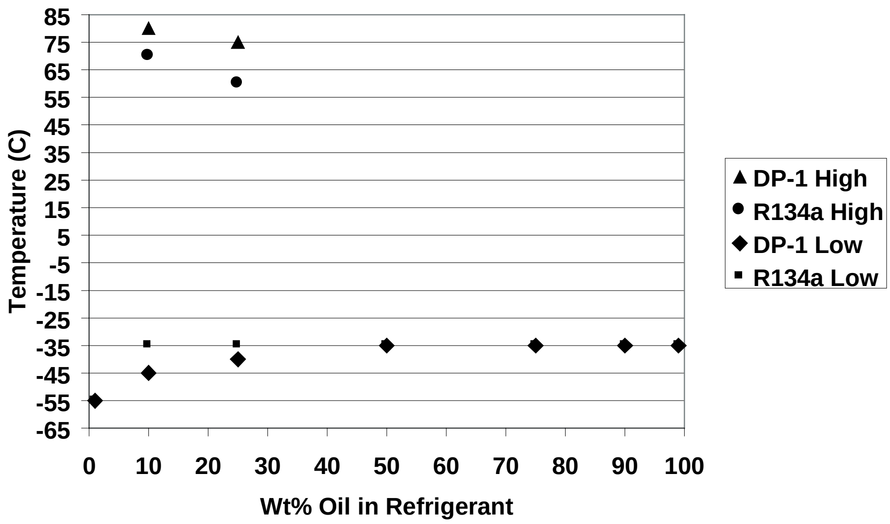


Figure 3: Double End-Capped PAG

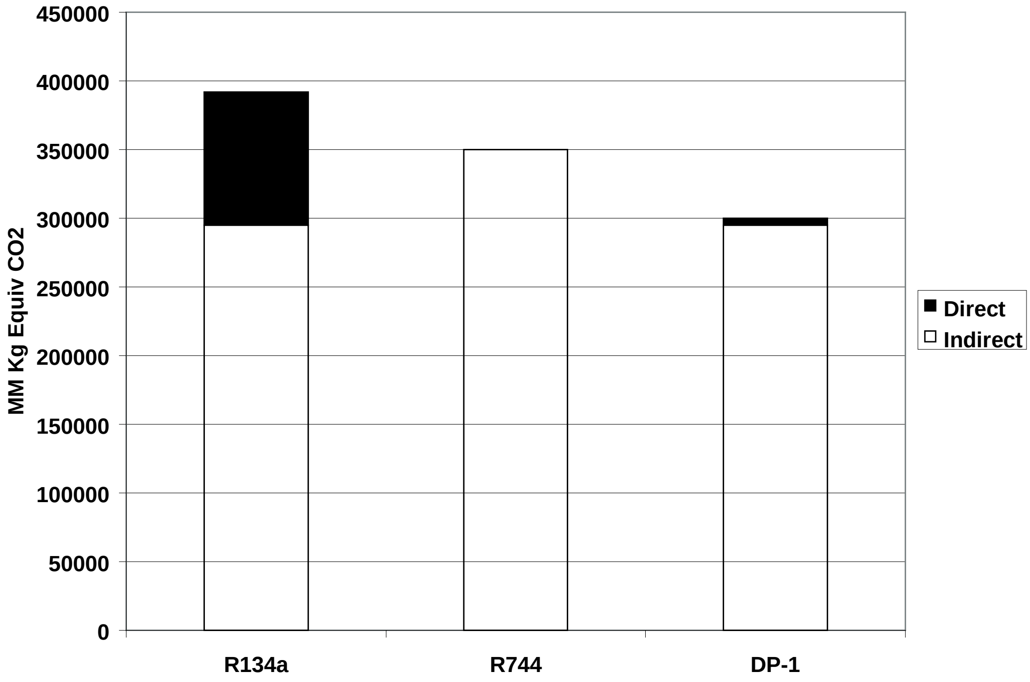
Table 3: Toxicity Test Summary

Test	Type	New Compound	R134a	R12
Ames	Acute Genetic - Mutagenic	Passed	Passed	Passed
Chrome AB	Acute Genetic - Chromosomal	Passed	Passed	Passed
LC-50 (Rat)	Acute 4 hour inhalation to 50% lethality	>750,000 ppm	>359,300 ppm	>800,000 ppm
Cardiac Sensitization	No Effect Level	25,000 ppm	50,000 ppm	40,000 ppm
Cardiac Sensitization	Threshold Level	50,000 ppm	75,000 ppm	50,000 ppm
In Vivo Micronucleus	Genetic	Passed	Passed	Passed
Full Developmental	Developmental	In progress	Passed	Passed
1-Gen	Reproductive	In progress	Passed	Passed
28-Day, 90- Day	Inhalation	In progress	90 Day No effect level 49,500 ppm	Reported 90 Day No effect level 810 ppm, 10,000 ppm

- "DP-1" energy efficiency (COP) same as R-134a
  - Manufacturing emissions same as R-134a
  - Estimated GWP of 40 compared to R-134a GWP of 1,300
- Vehicles (MAC Systems) base
  - Based on new vehicle sales in 2017 – extrapolated [3]
  - Includes cars, light commercial vehicles
  - All A/C systems (R-134a, CO_2 R-744 and "DP-1") are equipped with enhanced A/C systems
  - 100% A/C penetration in all new vehicles
  - All new cars have one single global MAC refrigerant (not only EU)
- Climatic conditions of various regions
  - Used data for climates for key cities to represent climates of major regions
  - Assumed regions to climatically match key cities

Regional LCCP CO_2 emission values were calculated by determining the number of cars within specific regions, which are estimated to be at certain climatic conditions. Regions were then combined to give a global LCCP value. Results show "DP-1" has a favorable global LCCP compared to R-134a and CO_2. Further, when compared with CO_2, "DP-1" shows improved energy efficiency that would be equivalent to 230 million gallons of fuel savings per year.

Figure 4: Projected Lifetime Global Emissions for New Cars Sold in 2017



Conclusions

As the automotive industry seeks more environmentally responsible solutions for MAC systems, DuPont is working to accelerate developments to help meet the F-Gas Regulation phase-out deadlines for R-134a with truly viable candidates that are currently being identified and extensively tested. Although CO2 is considered to be a possible replacement candidate, test results indicate that "DP-1" has the potential to be a stronger, more practical alternative to R-134a in mobile air conditioning. It has excellent environmental properties and has performed well in thermal stability tests. "DP-1" is also compatible with materials used in existing MAC systems. Therefore, it should not require significant design modifications or changes that would be necessary with CO2 alternatives. These characteristics suggest that "DP-1" will enable a cost-effective industry transition to low GWP refrigerants in a timely manner.

[i] The year 2017 was chosen for the analysis because this is the first year the MAC-Directive requires all new vehicles sold in EU to have the next generation mobile air-conditioning refrigerant.

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[1] ASHRAE Standard 97-99, "Sealed Tube Thermal Stability Test," 1999.

[2] Stella Papasavva, William Hill and Greg Major, "A Comparison of R-134a, R-134a Enhanced, R-744 and R-744 Enhanced Automotive Refrigerant Systems Based on Life Cycle," presented at MAC Summit, Washington, DC, April 13-14, 2004.

[3] Global Insights, May 2006 Automotive Sales.

Author Biography

Barbara H. Minor is an engineering fellow for refrigerants in DuPont's Fluoroproducts division, based in Wilmington, Delaware. She has more than 17 years experience in the refrigerants industry and holds more than 60 U.S. patents for refrigerants, cleaning agents and aerosol propellants. In 2002, Minor was named DuPont Scientist of the Month and was featured on the cover of Woman Engineer magazine. She is an active member of the Air Conditioning, Refrigeration and Technology Institute, serving on the ARTI-21CR Steering Committee and the Research and Technology Committee. Minor is also a member of ASHRAE and is currently chair of TC 3.1 – Refrigerants and Secondary Coolants. She is past chair of TG10.MOC – Immiscible Oil-Refrigerant Systems.

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Refrigerated Transportation, Energy Consumption and Food supply in China

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Having become the largest food production and consumption country in the world, China has a great demand for refrigerated transportation. This paper describes the general situation of refrigerated transportation, and discusses the problems of energy consumption and saving, food safety and food supply chain. The paper also summarizes current research and the developing trend of refrigerated transportation, emphasising that energy saving and food safety are the two important problems and study fields at present and in future.

Introduction

Chinese statistics indicate that the total output of all perishable foods materials reaches about 800 million tons per year, with a corresponding demand for transportation of perishable goods between provinces reaching about 250 million tons. The annual production and consumption forecasts for perishable foods are shown in Tables 1 and 2[1]. Of food expenditure, that on perishable food amounts to about 51 %. China has become the largest food producing and consuming country in the world: both account for about a quarter of corresponding world quantities, and the proportion is still rising rapidly. But the transportation volume of perishable goods makes up only half of the demand volume, and around 80 % of this kind of goods are transported by road. This paper gives a general introduction to refrigerated transport and associated problems.

Table 1: Annual Production Forecast For Major Perishable Foods in China (10^4 t)

Year	Milk	Beef	Mutton	Poultry	Aquatic products	Vegetables	Fruit	Pork	Total
2000	803.2	549.3	265.3	1273.0	4349.8	43811.82	6135.3	4250.6	61438.32
2005	906.8	681.7	325.8	1558.7	5737.4	54146.03	7410.6	4976.8	75743.83
2010	1010.5	814.1	386.3	1844.5	7125.1	64480.2	8685.9	5702.9	90049.5

Table 2: Annual Consumption Forecast For Major Perishable Foods in China (10^4 t)

Year	Aquatic products	Vegetables	Eggs	Meat	Poultry	Fruit	Total
2000	719.9	13667.7	892.4	2012.8	440.4	4680	22413.2
2005	819.7	13514.2	1101.1	2190.5	547.5	6333.3	24506.3
2010	924.8	13308	1321.9	2363.3	660.2	8095.8	26674

Refrigerated transportation and energy consumption

China is one of the largest energy consumption countries. Accompanying its rapid economy development, China faces a series of problems and huge challenges from energy and the environment. The Chinese government has set a target of a 20 % reduction in energy consumption per GDP by the end of 2010. Of this, energy saving in transport is a very important aspect.

In order to ensure the quality of perishable food in the supply chain, refrigerated transportation and logistics are a key measure. But, of course, problems of inappropriate technical operations and poor performance of equipment occur very often, resulting in perennial high energy consumption. In China, the annual consumption of gasoline in refrigerated transportation is about 500 000 tonnes, to a value of about 250 million dollars. Transport cost per ton is up to twice as high as in developed countries. The whole logistics cost accounts for 32 % of the food price (equals to twice that of ordinary goods) in developed countries, and 50 % of that in China. Because of the high cost, the vehicle manufacturers and operating companies find it difficult to make profits, and even lose money in business. On the one hand, there are not enough refrigerated transportation vehicles to satisfy the transport demands (e.g. there are only about 7000 railway refrigerated cars), but on the other hand, some consignors specify unrefrigerated vehicles instead of refrigerated ones for the transport of perishable goods in order to decrease transport cost. This definitely results in decline in product quality. In addition, the low efficiency of energy use also leads to an increase in CO_2 emissions and affects the environment.

Refrigerated transportation and food safety

Food safety is an important problem worldwide. In the food supply chain, every step or link in planning, purchasing, processing, transportation and delivery will influence food safety.

From the point of view of logistics technology of perishable foods, equipment and facilities are the important elements in guaranteeing the best quality as far as possible. Because of the lack of technical equipment, measures and infrastructure, with no real cold chain or fresh food chain, the development of Chinese agriculture and the food industry have been greatly restricted, and the loss of perishable foods in circulation after harvest is huge (e.g., 25 % to 35 % of fruit and vegetables, and 10 % to 15 % of meat and aquatic product lost in distribution). The annual total economic loss of perishable foods after harvest is more than 10000 million dollars in China. Owing to the lack of temperature legislation and weak enforcement of food sanitation law, food poisoning cases and food safety problems are increasing.

The quality and safety requirement of food is becoming stricter and stricter worldwide. At the first International Agriculture Forum in May 1999, the agriculture ministers from various countries agreed that both developed and developing countries should immediately pay attention to the following four problems: first, food safety; second, increasing financial investment in agricultural research; third, technical support for developing sustainable agriculture; fourth, WTO and international agricultural trade[2]. Many measures have been taken actively in developed countries, and great progress has been made in many aspects such as productive equipment, techniques, the best harmony with exterior environment, the traceable raw material of perishable food and the better management of interface etc.[3]. The International Food Logistics Organization, founded in 1943, has made great achievements in many aspects, including the improvement of refrigeration techniques for food and many other goods during the storage and distribution, the finding and training of appropriate persons, information exchange, research and development. It has also begun to provide all-round logistics service. Developed countries pay more attention to assessment of the performance of logistics and logistics service companies and the logistics facilities and requirements of food under low temperature, to the relation between the food refrigeration sector and the environment, and to the replacement of refrigerants and legislation in the food refrigeration sector [4-9].

The current research situation in refrigerated transportation and energy saving

In developed countries, such as the USA, the UK and some western European countries, the research and practice of refrigerated transportation have achieved great progress. 100 % of perishable foods are transported by refrigerated vehicles, containers and trucks, and 95 % of perishable foods are of good quality when delivered to the consumers. Research is mainly focused on transport conditions (e.g. temperature, humidity), weight loss, refrigerant replacement and ozone depletion, heat insulation, multi-temperature units, temperature forecasting and distribution, air flow control, etc. Since the second energy crisis, the research focus has been shifted to energy saving, and has achieved great advances. For example, body structure materials of vehicle have been changed from aluminium to stainless steel; new kinds of refrigeration compressors and new environmentally friendly refrigerants have been developed and put into practice; manual operation of refrigeration systems has been replaced by automatic digital devices and so on. Phase-change materials, liquid N2 and solid CO_2 have been tested and partly utilized in transport. The thermal conditions inside and outside the vehicle, air penetration and ventilation, internal atmosphere components, stacking pattern of packages, influence of loading and unloading time on the temperature of goods, etc. have all been studied theoretically and in practice. New analysis tools such as CFD (computational fluid dynamics), MATLAB and finite units, etc. have been utilized in research [10~26] . In 2005, after collecting views of experts and researchers worldwide, IIR listed energy saving of refrigerated transportation in its list of research priorities [27]. The Research Center for Transportation and Logistics at Guangzhou University, China, has a new test bed for refrigerated transportation conditions and energy consumption research.

Fresh food supply chain and refrigerated transportation

The food supply chain not only has the basic structure of ordinary supply chains, such as transport, storage, loading and unloading, transit, management in storehouses, picking and distribution etc. but, because fresh food supply chains handle special produce and have special requirements for quality, also has its own special structure which is shown in Figure 1.

From the figure, we can see that the fresh food supply chain can be divided into five main stages including production, transport, storage, delivery and consumption. The signifi-

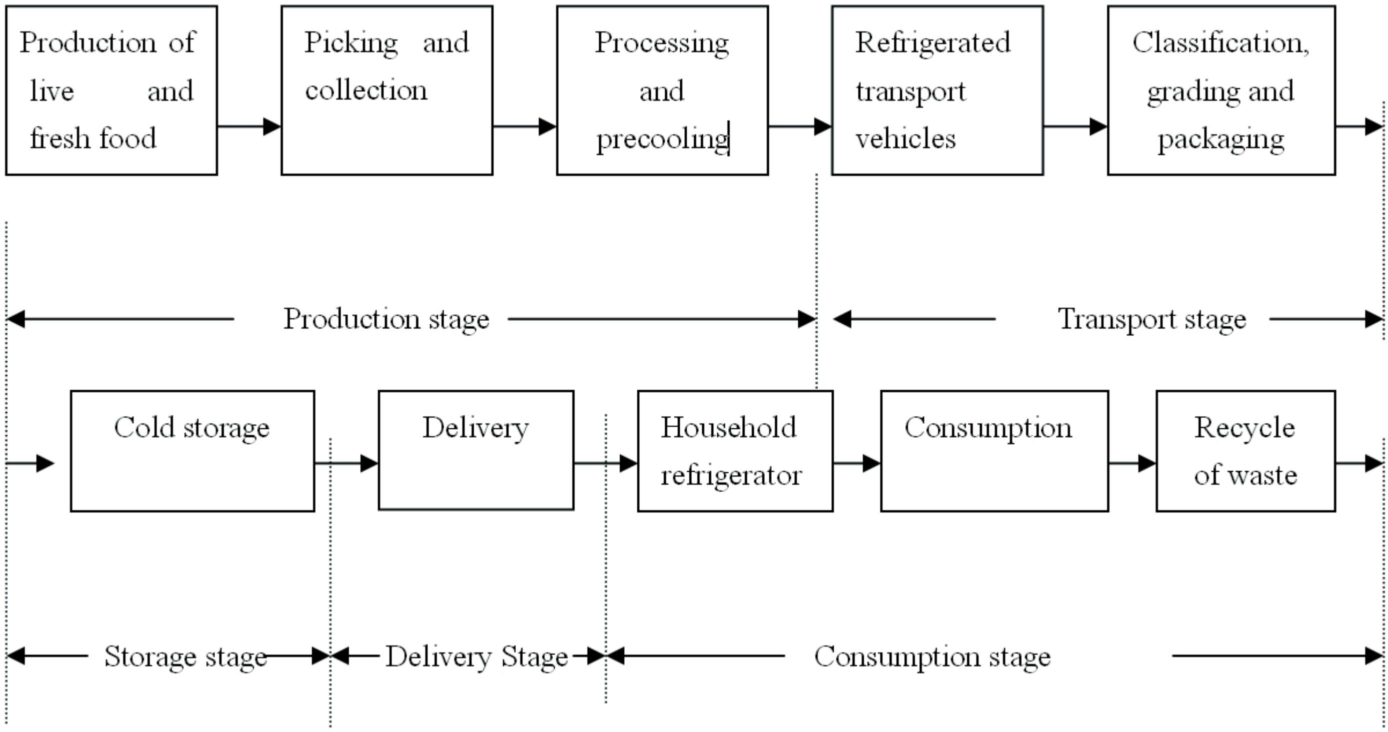

Fig. 1 structure of food supply chain

cance of each stage is different from that of a non-food supply chain.

The production stage primarily concerns the production, processing and precooling of fruit, vegetable, poultry, egg, fishery products and products made from them.

The transport stage covers the transportation of live or fresh food from the origin to storage centers or processing centers (generally bulk cold storehouses) through various refrigerated transport vehicles.

The storage stage includes such simple processes as classification, grading and packaging of food. Depending on the requirements for quality, products are stored in cold rooms at different temperatures. Delivery/unloading to the cold stores, and delivery from them, is also an important element.

The delivery stage, which uses various transport vehicles to suit the requirements of wholesalers or retailers, transports perishable food from logistics centers or delivery centers to marketing and delivery destinations, or from the refrigerators of retail stores to the household refrigerators of consumers.

The consumption stage covers the process of customers buying freight services from various marketing and delivery points, storing them in their household refrigerators and consuming them eventually. Disposal of waste after consumption may be involved.

The most obvious feature of fresh and live food is that various refrigeration and controlled environment facilities must be used to maintain the foods' freshness and condition continuously during the whole process from production to consumption. This requires the capability of every stage to be matched. If not, not only is the capability wasted, but logistics costs rises accordingly. The quality of the products will deteriorate, production of and earnings from perishable food may be restricted, and the development of agriculture and the food sector may be affected.

Conclusions

China has become the largest food producing and consuming country in the world, and there is a great demand for refrigerated transportation. But there are also many problems, such as low percentage of refrigerated transport for perishable foods, poor quality and a huge loss of food, and high cost of transport and logistics. Previous and current research has achieved great progress in refrigerated transportation Energy saving and food safety are the two important problems and study fields at present and in future

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R744 System for Heating and Cooling of Automobiles – Analysis of Heat Pumps and Hot Gas Cycle

Klaus Martin, René Rieberer, Austria

This paper describes the analysis of an air/air heat pump, a coolant/air heat pump and a hot gas cycle by means of experimental investigations and numerical simulations. All systems are based on the R744 refrigerant circuit of the air conditioning system, and they are therefore suitable for heating and cooling of the passenger cabin. It has been shown that quite large heating capacities of more than 2.4 kW can be achieved with the heat pump systems, even under unfavourable operating conditions (low compressor speed and low air flow rate). For the hot gas cycle, a maximum heating capacity of 1.1 kW was obtained at the investigated conditions.

Introduction

In the last years great progresses have been achieved in the design of efficient engines for automobiles. However, the better the engines become with respect to fuel consumption, the less waste heat is available for warming the passenger compartment. According to Renner (2002), a 2000 model year car with a fuel consumption of 3 litres/100 km has only 22% of the available energy for heating compared to a car of the year 1991. Nevertheless fast warm-up of the passenger cabin is desirable for the comfort of the passengers. Thus, the use of supplementary heaters is becoming more widespread. R744 (CO_2) heat pump systems have been investigated for this application by several authors, e.g. [1, 2]. These systems have the advantage that the components of the air conditioning system can be used, with only some minor adoptions being necessary (e.g. switching valves). It seems that refrigerant R744 is well suited for heating purpose.

The analysis of steady-state conditions is of special interest for the design and optimisation of automotive air conditioning systems. In addition, transient operating conditions (e. g. a driving cycle) are of special interest (see e.g. [6]). Within this field, numerical modelling can help to reduce the development times. To obtain reliable results, the simulation models have to be verified by means of experimental data. →

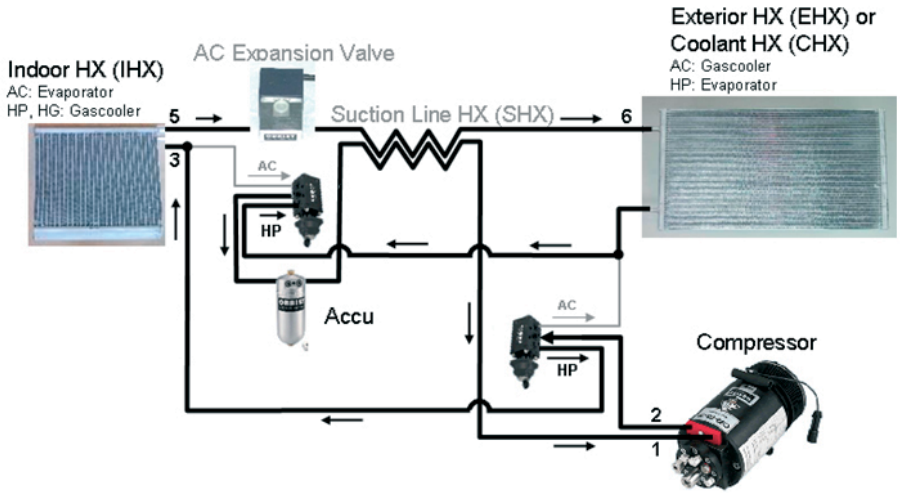
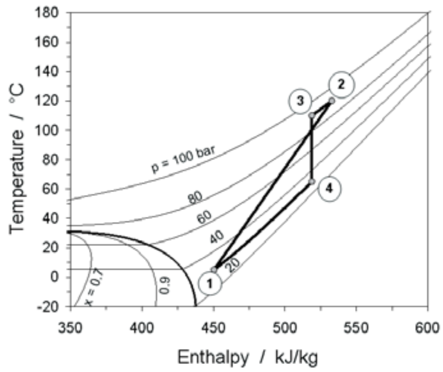


Figure 1: Flow sheet and schematic process of R744 hot gas cycle (HGC)



Investigation of the heating systems

Basics

A system with limited complexity for a heating set-up is the triangle process or what is often called the hot gas cycle (HGC) (see Fig. 1). The compressor sucks vapour and compresses the refrigerant to a high pressure (1 → 2). After heat losses (2 → 3) and expansion to a low pressure (3 → 4), the refrigerant is cooled by the air in the indoor heat exchanger (IHX, this is the evaporator in a/c mode) (4 → 1) and enters the compressor again.

The process when used as a heat pump is shown in Figure 2. There is no major difference in the process whether the heat source is the ambient air or the engine coolant. It proceeds in the following way: the compressor sucks vapour and compresses it to the high pressure (1 → 2). After heat losses (2 → 3) and heat rejection in the indoor heat exchanger (IHX) (3 → 5), the refrigerant is expanded to the low pressure and enters the two-phase region (5 → 6). In the exterior heat exchanger (EHX, either the a/c-

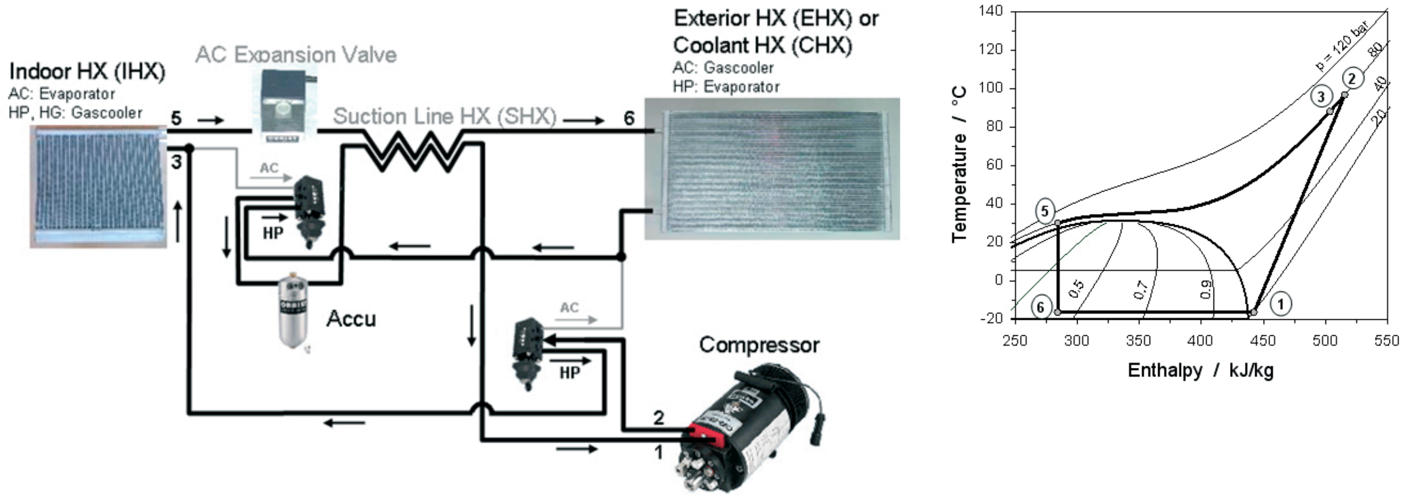


Figure 2: Flow sheet and schematic of R744 heat pump cycle

gas cooler or an additional coolant/ CO_2-heat exchanger) the refrigerant absorbs heat and evaporates (6 → 1). Afterwards, it is fed to the compressor again.

Comparison of systems

This chapter describes comparison of an air/air heat pump, a coolant/ air heat pump and a hot gas cycle by means of experiments and simulation. The systems are investigated with respect to capacity, air temperatures and COP for steady state operating conditions.

All experiments were conducted with a compressor speed of 900 rpm at an ambient temperature of 5 °C and a relative humidity of 90 % (about 2 gW/ kgdA). The test series was carried out with different air volume flow rates over the indoor heat exchanger. The compressor was operated at maximum stroke (33 cm³) during all tests. The cross-section of the expansion valve was also kept constant throughout the entire experimental investigations, even though the heating capacity is mainly influenced by the control of the expansion valve [1]. Some analysis of the influence of the expansion valve cross-section for the heat pump mode can be found in [3]. For the investigations of the air/ air heat pump, the air volume flow rate over the exterior heat exchanger was maintained constant at 1500 m³/ h; the coolant/air heat pump operated with a coolant mass flow rate of 730 kg/h and a constant coolant inlet temperature of 5 °C.

Figure 3 shows the heating capacities obtained and a comparison of measured and modelled results. As expected, the maximum capacity is achieved at the maximum air volume flow rate. The highest heating capacity of 4.2 kW can be reached with the coolant/air heat pump (HPCA). However, the operating point with the highest heating capacity will not be optimal in the vehicle, although the COP is high (see Fig. 5), because the obtainable air temperature at the indoor heat exchanger outlet and thus at the inlet into the passenger compartment is quite low (see Fig. 4), e.g. at a flow rate of 500 m³/h, the air outlet temperature is lower than 20 °C. Substantially higher temperatures can be obtained with lower air flow rates. At 100 m³/h, an air outlet

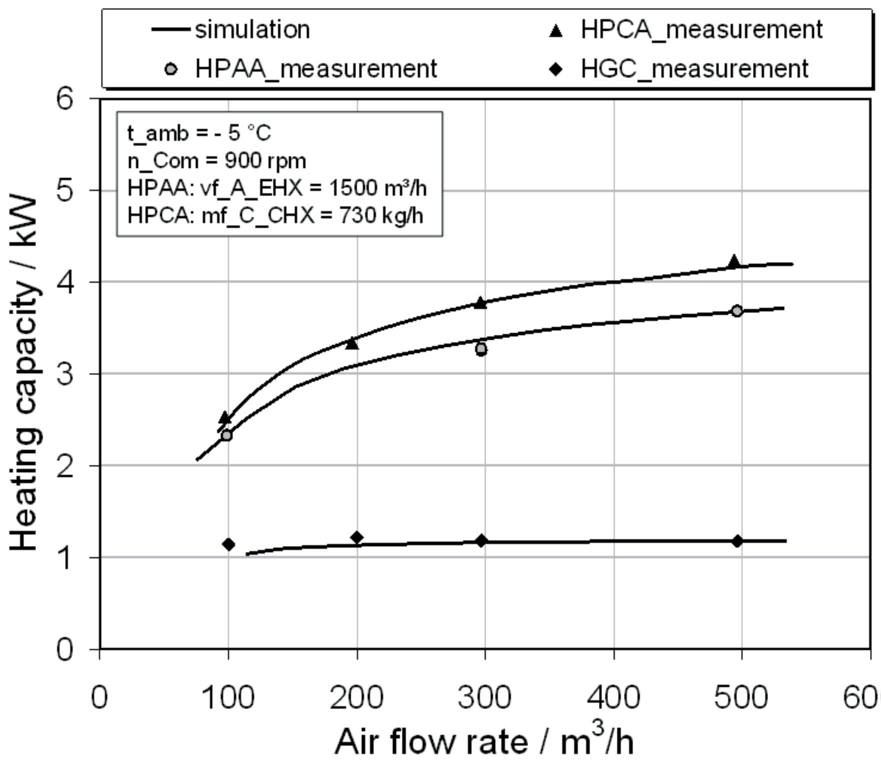


Figure 3: Heating capacity vs. IHX air volume flow rate

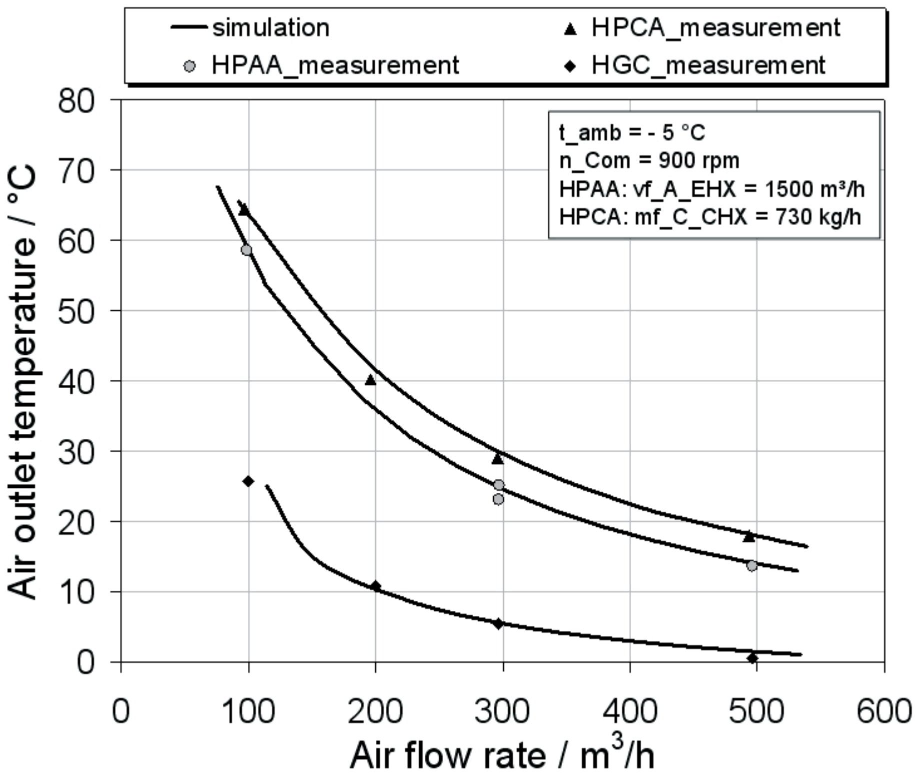


Figure 4: Air outlet temperature vs. IHX air volume flow rate

temperature of 60 °C can be achieved with the heat pump systems. Under this condition, a heating capacity of approximately 2.5 kW can be obtained.

The heating capacity of the hot gas cycle (HGC) strongly depends on the driving power of the compressor. With the compressor used in these investigations at 900 rpm, a heating capacity of 1.1 kW was obtained (see Fig. 3). The necessary driving power was 1.3 kW, which gives a COP of 0.88 (see Fig. 5). It shows that the achievable heating capacity is nearly independent of the air volume flow rate over the indoor heat exchanger over a wide range. The compressor driving power, and thus the COP, are also nearly constant, since the suction and discharge pressure are on an almost constant level over the investigated air flow rate.

The obtained COPs for the different systems are shown in Figure 5. For all systems, the maximum COP occurs with the highest air flow rates. For all the investigated operating conditions, the highest COP was that delivered by the coolant/air heat pump, with a maximum of almost 3.5 at an air flow rate of 500 m³/h. However, the COP of the air/air heat pump is only a little lower. However Schaefer et al. [5] have concluded that, for a system with a 1.9 l TDI engine, the COP of a heat pump with engine coolant as its heat source should be in the range of 1.5 to 1.8 to ensure that the engine coolant warms up within the same period of time as the basic system without a heat pump, where no heat is rejected from the coolant cycle. This COP can be reached in the region between 100 and 150 m³/h, where also suitable air temperatures are achieved (compare fig. 4).

A comparison of measured and modelled results shows that the model provides reliable results for a wide range of operating conditions (compare Figs. 3, 4, 5). For most points, the heating capacity was computed with an error less than 5 %. Therefore the air temperature at the outlet of the indoor heat exchanger could be calculated with high accuracy as well. Hence the model can be used for further steady-state calculations. Additional information on the investigation of the heating systems, especially the simulation of the transient behaviour, can be found in [6].
Although freezing of the exterior heat exchanger (evaporator) in the

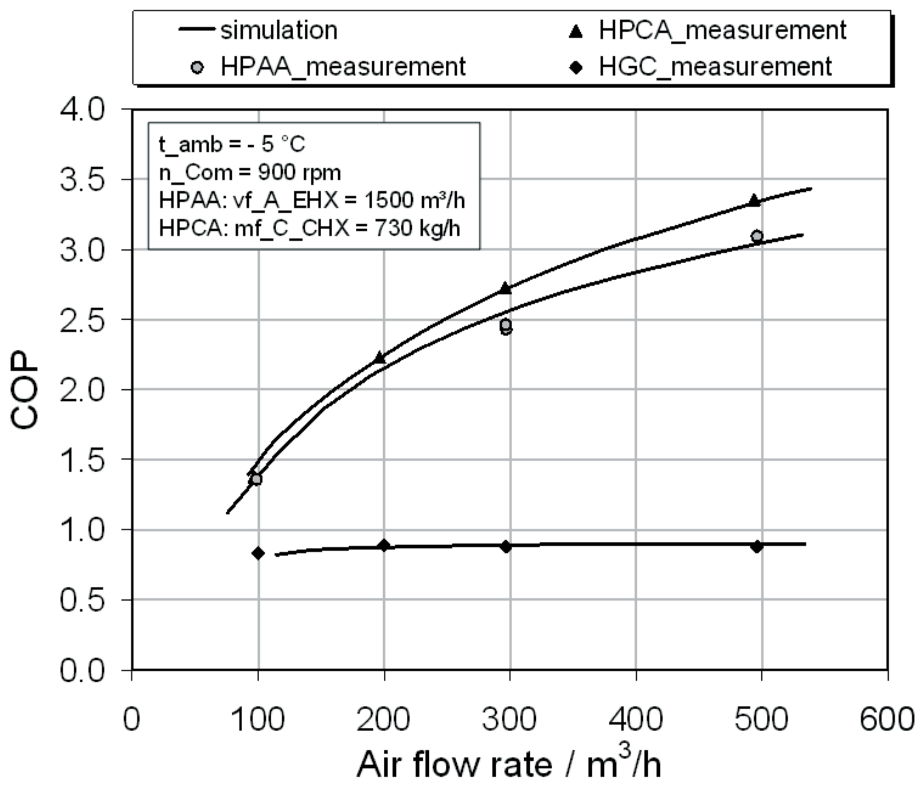


Figure 5: COP vs. IHX air volume flow rate (measurement vs. simulation)

air/air heat pump mode is not the main issue of the current work, it should be mentioned here that frosting was not a big issue for the operating points described here. However, it can be significant when the air flow rate over the exterior heat exchanger increases, or under other ambient conditions.

Conclusions

The on-going development of high-efficiency engines leads to insufficient heating capacity for the interior of the vehicles. Thus the use of supplementary heaters gains interest. A promising solution is the use of the air conditioning system with R744 refrigerant, either as a hot gas cycle or as a heat pump. A comparison of an air/air heat pump, a coolant/air heat pump and a hot gas cycle at a compressor speed of 900 rpm shows that the heat pump systems are far superior to the hot gas cycle, since the COP of the hot gas cycle is always lower than unity. With the heat pump systems, COPs higher than 3 and heating capacities higher than 3.5 kW can be reached at high air flow rates over the interior heat exchanger. However, these conditions are not favourable for the application in the car, since the air inlet temperature into the passenger compartment will be quite low. To exceed an air temperature of 40 °C, the air flow rate must be less than 200 m^3/h for the investigated heat pump systems. With the hot gas cycle, such temperatures cannot be obtained at a compressor speed of 900 rpm.

For future investigations, a detailed consideration of the transient behaviour of the refrigerant cycle seems to be of particular interest. In addition, the heating systems should be investigated within the context of the entire thermal management of the vehicle; i.e. the effect of the heating system on the coolant cycle and the engine. The verified simulation models can be used for such continuation investigations.

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Non-topical article

Analysis of heat pump systems using the arsenal research standardised monitoring methodology

Heinrich Huber, Gernot Glasner, Austria

The association of Austrian Electricity Companies has funded a project with the aim of developing, testing and evaluating a standardised monitoring methodology for heat pump systems. The results should provide a base for heat pump manufacturers, installers, energy providers, stakeholders and funding agencies.

In view of political aspirations particularly in the field of CO_2 reduction, the application of renewable energy is a central topic. Heat pumps can thus significantly contribute to a sustainable energy supply.

Monitoring was split into three parts: Part 1 included a questionnaire regarding the non-measurable data, Part 2 consisted of a system for continuous data collection and the recording of measured data, while Part 3 included the development of a data base for the administration and evaluation of the measured data.

Nine heat pumps were monitored and analysed in the project. For reasons of comparability, only direct-expansion heat pumps were chosen.

This report presents the monitoring methodology used in the arsenal research standards. The results of the first measurements - analysis of the seasonal performance factor (SPF), energy costs and TEWI (Total Equivalent Warming Impact) - are described. In addition, there is a comparison of the pollutant emissions which result from the power generation for the operation of the heat pump and the emissions of a gas or oil boiler.

Introduction

The association of Austrian Electricity Companies has funded a project with the aim of developing, testing and evaluating a standardised monitoring methodology for heat pump systems. The results should provide a basis for heat pump manufacturers, installers, energy suppliers, stakeholders and funding agencies.
Installers and heat pump manufacturers can utilise the outcome of the monitoring in various ways, such as:

- Marketing purposes for the acquisition of new customers and partners
- Optimisation of heat pump systems, e.g. new system dimensioning, new control strategies
- Development of innovations in the plant engineering and for heat pump units
- Analysis and improvement of the concurrence of different plant components and their energy efficiency in complex rigs

Various analyses for energy providers, heat pump manufacturers, installers, stakeholders and funding agencies can be made from the existing material in the data base:

- Trends of the heating energy demand of buildings and the specific heat loads for the heat pumps
- Developments of the trends of SPFs, specific heating power and extraction power from the heating source unit
- Effect of down times on the running time and the heating behaviour of the heat pump
- Provision of base data concerning the contents of funding programmes

General conditions for monitoring

Political aspirations - particularly in the field of CO_2 reduction - mean that the application of renewable energy is a central topic. Heat pumps will therefore play an important role in sustainable energy supply. Heat pumps are already common in many European countries and, according to the latest market research, the market is continuously growing. In order to assist this development, innovation, quality assurance and training are given top priority in Austria.

The quality of heat pumps relies on two factors: Firstly, the heat pump unit itself has to meet the quality demands, which are approved by the D-A-CH heat pump quality seal. Secondly, the planning, sizing and installation of the whole unit are responsible for the efficiency, functionality and customer satisfaction.

By initiating training for 'certified heat pump installers' through the Austrian Heat Pump Association (previously LGW) and arsenal research, Austria has significantly contributed in the field of education in Europe to the quality assurance of the systems. In order to document and evaluate the effects of measures taken, the implementation of long-term observations – monitoring – forms an essential part.

In the past few years monitoring has been undertaken in various forms. However, in many cases a comparison between different monitoring results is not always possible. For instance, different user habits have a significant impact on the efficiency and operation of the heat pump. For this reason, a standardised monitoring is necessary which, apart from the electrical energy consumption and the thermal yield, also documents other important data for the evaluation of the heat pump units.

Monitoring concept

The results of the monitoring act as proof for the operation and efficiency of the constructed heat pump units. The monitoring process is divided into three parts:

1. In order to collect all required data, which cannot be measured by the data entry, every installer has to fill in a form referring to the individual heat pump units.
2. In addition, the measured data is automatically recorded by a data logger and transmitted to the arsenal research monitoring server via GSM-modem.
3. In a third step, the data is evaluated and analysed by a specially developed data base.

It is important to plan the whole monitoring such that all necessary data and information which is required for a meaningful analysis is recorded.

In the course of this project, the focus was on the monitoring of heat pumps for space heating without domestic hot water preparation. However, the conception and choice of the measuring instruments also allows for the monitoring of heat pumps in combination with other heat sources such as oil, gas, biomass or solar panels, as well as heat pump monitoring for other applications such as domestic hot water production or swimming pools.

Questionnaire for heat pumps

The aim of the questionnaire is to describe the heat pump units as well as possible and to establish a consistent documentation structure for them which allows further processing in a data base. As a first step, it was therefore necessary to decide which data and information was essential.

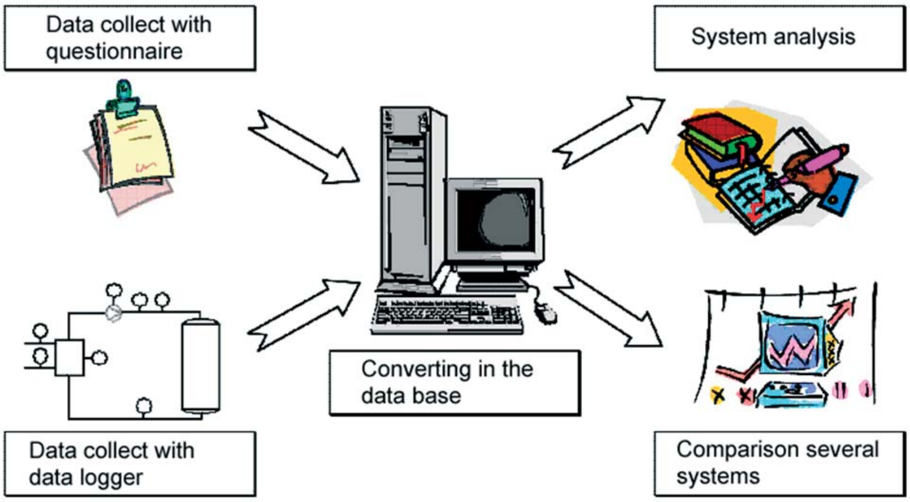
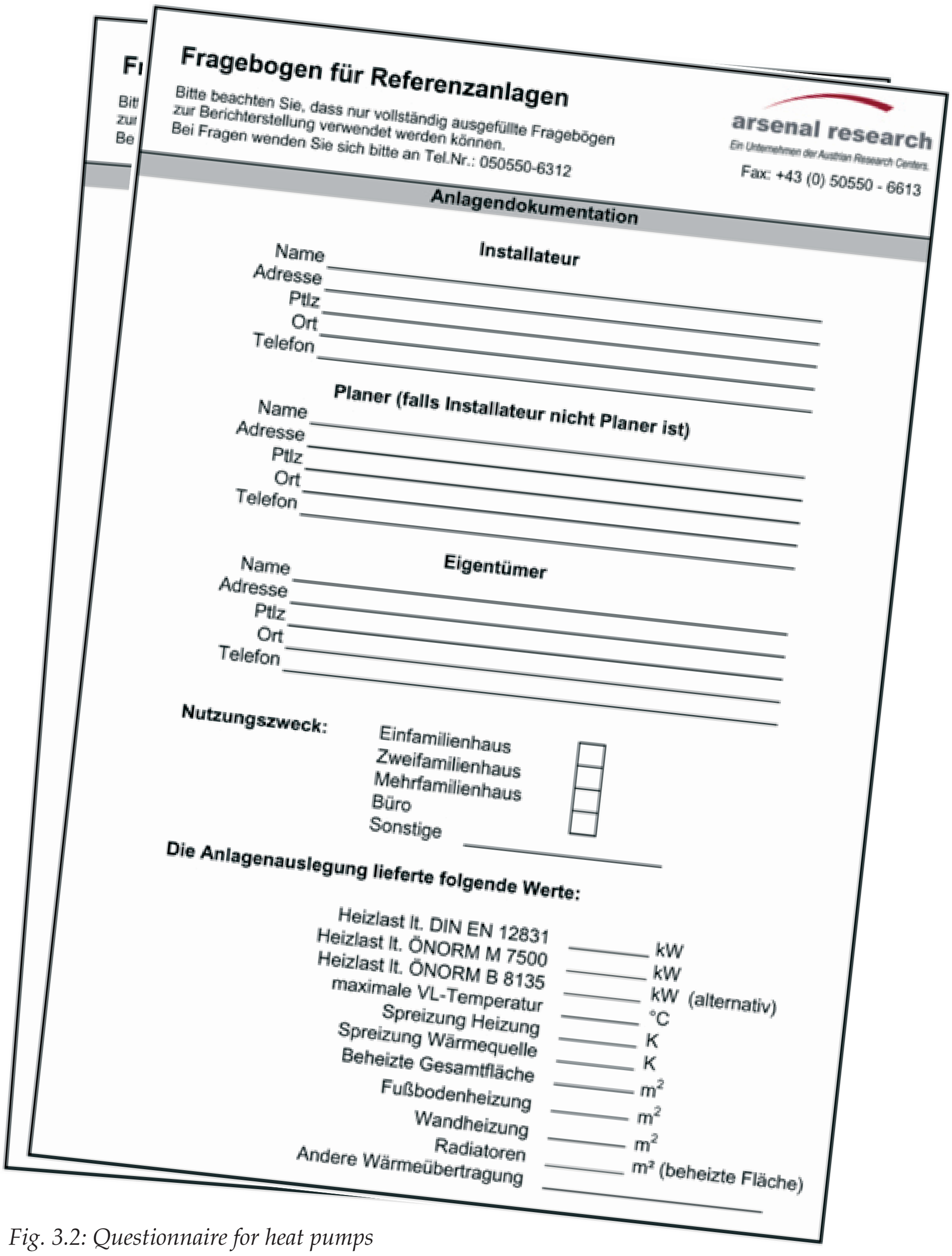


Fig. 3.1: Data flow from the data collection to the analysis



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Name
Adresse
Ptlz
Ort
Telefon

Nutzungszweck:
Einfamilienhaus
Zweifamilienhaus
Mehrfamilienhaus
Büro
Sonstige

Die Anlagenauslegung lieferte folgende Werte:
Heizlast lt. DIN EN 12831 ____ kW
Heizlast lt. ÖNORM M 7500 ____ kW
Heizlast lt. ÖNORM B 8135 ____ kW (alternativ)
maximale VL-Temperatur ____ °C
Spreizung Heizung ____ K
Spreizung Wärmequelle ____ K
Beheizte Gesamtfläche ____ m²
Fußbodenheizung ____ m²
Wandheizung ____ m²
Radiatoren ____ m² (beheizte Fläche)
Andere Wärmeübertragung ____

Fig. 3.2: Questionnaire for heat pumps

Planning the data acquisition

The monitoring of the heat pump unit has to be as efficient and as informative as possible. It must therefore be established in advance which measured data should be recorded. First of all, it is necessary to define which results the evaluation of the monitoring should deliver.

The following results are essential for further analysis:

- Energy input (power input)
- Energy output (heat supply)
- Annual, monthly and daily coefficient of performance
- Operating hours of the heat pump
- Average power input
- Average heating output
- Average operating time per day
- Operating cycles / 24 h
- External / internal temperatures
- Heat source and sink temperatures
- TEWI
- Pollutant emissions

Measuring points

Based on the preceding considerations, the measuring points have been defined. The most important measuring points are shown in the diagrams below.

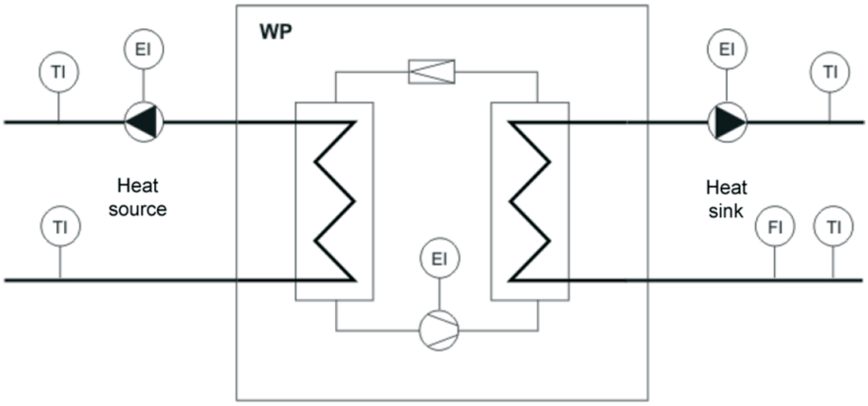

Fig. 3.3: Measuring point arrangement for water/water and brine/water heat pumps

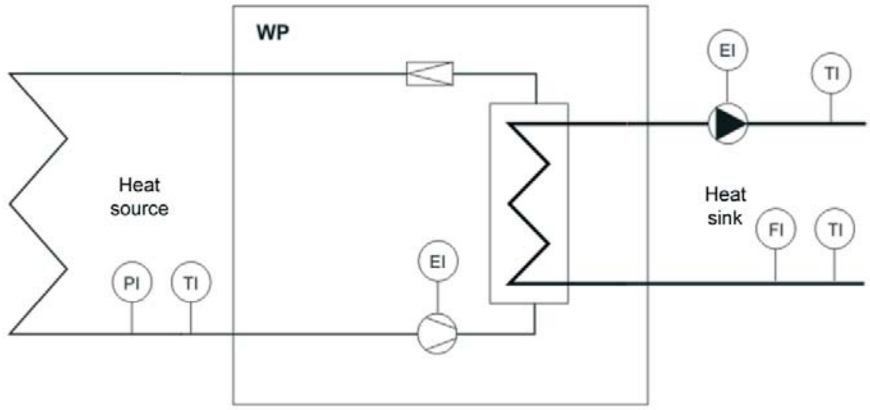

Fig 3.4: Measuring point arrangement for direct-expansion heat pumps

Carrying out the data acquisition

Measuring the required data was partially carried out using measuring devices from the installers. However, calibration and adjustment of the measuring devices was necessary (confirmation with quality seal or calibration certificate).

During the period of the data acquisition, data was measured at two-second intervals and recorded as 15-minute mean values in order to describe a meaningful trend line. The data which was also transmitted to the monitoring server has been periodically checked for errors and finally analysed at the end of a data acquisition cycle.

Analysis of heat pump units

In the course of the project, the data acquired by measurement and questionnaires had to be recorded and managed. As the measured raw data of the heat pump units cannot directly be interpreted, a conversion into information characterising the heat pump units was necessary.

For this purpose, a data base was developed and programmed to provide the list of results as described in chapter 3.2.

The main aim during the planning of the data base was to develop a mostly automated process to allow for reporting of the analysis of the heat pump units, as well as for a fast and efficient comparison of several heat pump units.

Description of the data base analysis

Evaluation of a heat pump unit

The data base generates diagrams of the relevant temperatures (Fig. 3.5), daily seasonal performance factor, the

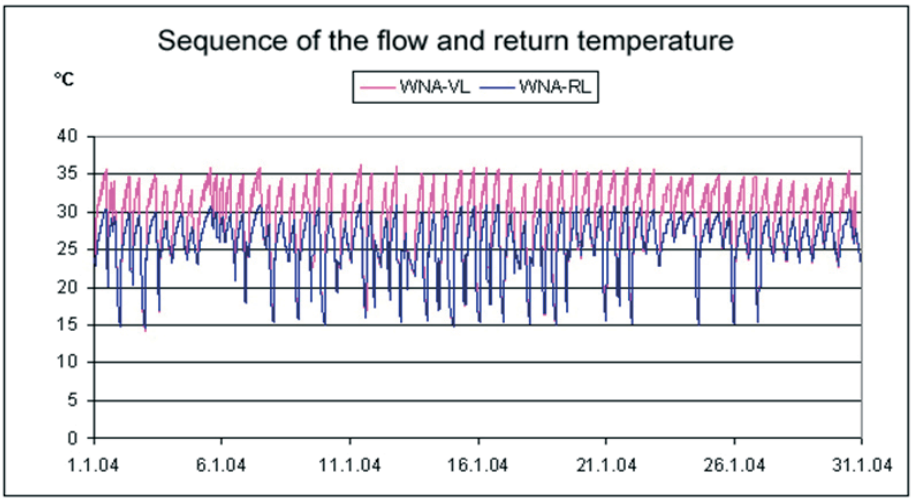

Fig. 3.5: Temperature sequence of the flow and return temperature for one month (example)

energy consumption and supplied heating energy for each month.
The annual evaluation summarises all monthly results and processes them into informative and meaningful diagrams.

Figure 3.6 shows the characteristics of energy consumption, supplied heat energy and monthly coefficients of performance.

In addition, an ecologic consideration based on Gilli [1] was carried out, where the pollutant emission of heat pumps with different types of power generation [4] is compared to the emission of gas and oil boilers (Fig. 3.7).

Finally, a calculation of the Total Equivalent Warming Impact (TEWI) of the investigated heat pump unit was performed, and the results were compared to the TEWI of oil and gas boilers according to EN 378 [3] with the leakage amounts of heat pumps from [2] (see Figure 3.8).

Evaluation of several heat pump units
For the evaluation, several heat pump units are selected for comparison. In this first project, nine direct expansion heat pumps were selected in order to establish a meaningful comparison. All heat pumps had been operational for less than three years and, apart from the "Pfaffstätt" heat pump, which uses propane as refrigerant, used a safety refrigerant (R 407C or R 410A).

Firstly, the key data of the selected heat pumps were summarised in a table. Then the heating load, the specific heating load and the seasonal performance factor (SPF), together with the electric power input and the heating output, were displayed in a diagram (see Figure 3.9).

Another diagram shows the heating costs/a and the specific heating costs/m²a. For this purpose, the current fuel costs/kWh of [5] have been used (see Figure 3.10).

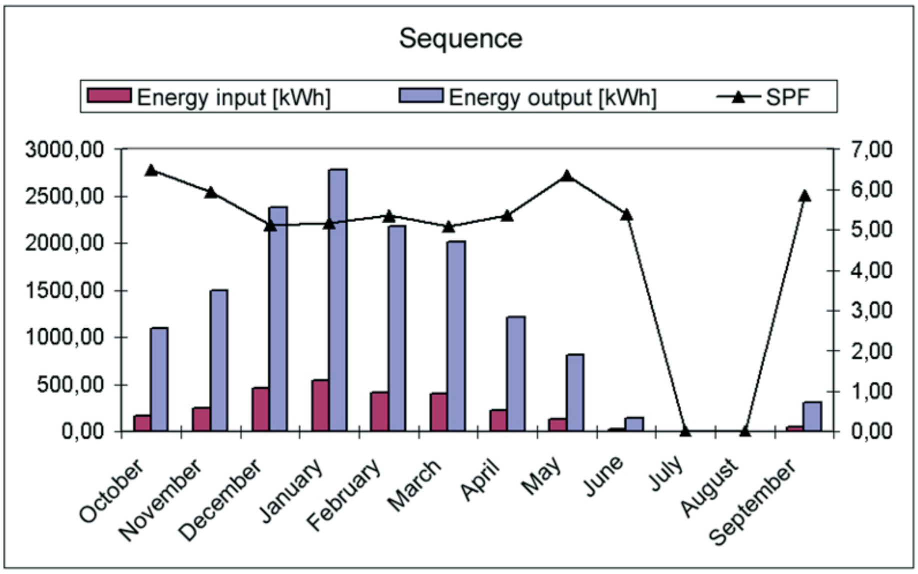

Fig 3.6: Characteristics of the monthly seasonal performance factor, as well as the energy input and output

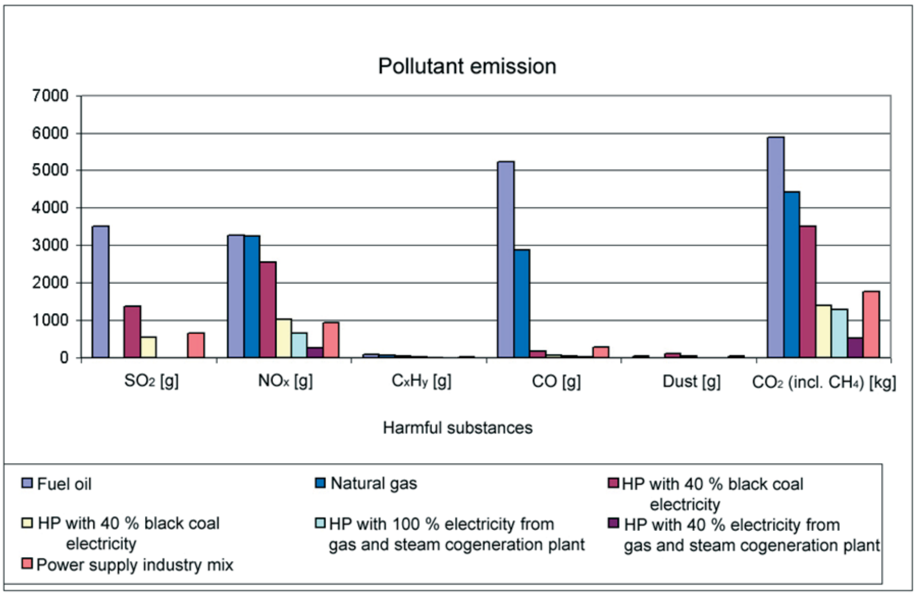

Fig. 3.7: Comparison of pollutant emissions during the testing period

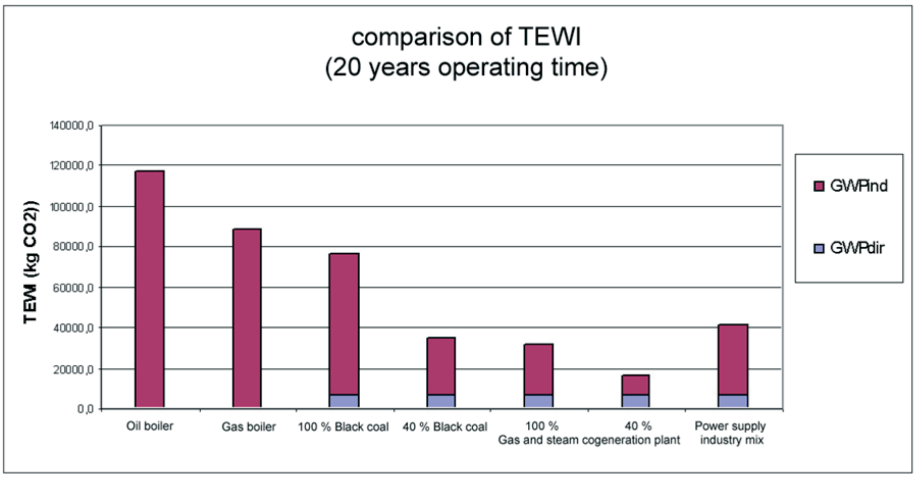

Fig. 3.8: Comparison of the TEWI of the analysed heat pumps

In a final step, the TEWI factors of the examined heat pumps are compared. Here, the TEWI refers to the kWh heating energy. This is necessary since the calculation of the TEWI according to [3] refers to only one heat pump, and therefore an evaluation of heat pumps of different sizes is not possible (see Figure 3.11).

Evaluation and analysis of the measuring data

After defining the necessary measuring data and the required measuring instruments, nine different heat pumps were measured until the end of the heating season 2004. This measured data has been evaluated with the data base, and the results have been interpreted.

For this project, only direct expansion heat pumps without domestic hot water production were chosen, in order to establish a practical comparison. By continuing the monitoring in the future, other versions of heat pump units can be measured and analysed, which will permit comparison of different units.

The analysis of the investigated heat pump units shows that the mean seasonal performance factor (SPF) is 4.7. The best unit reached a SPF of 5.4. The average heating costs amount to EUR 589/a, with the lowest heating costs amounting to EUR 341/a. The specific heating costs of the investigated heat pumps are between EUR 1.48 and EUR 4.48 EUR/m².

The comparison of the specific TEWI shows that, on average, the nine heat pumps emit about 98 % less carbon dioxide than a gas boiler, and 163 % less than an oil boiler. Over 20 years, this represents a reduction in emissions of 861 000 t CO_2 in comparison to heat supply from oil, and a reduction of 519 000 t CO_2 in comparison with natural gas.

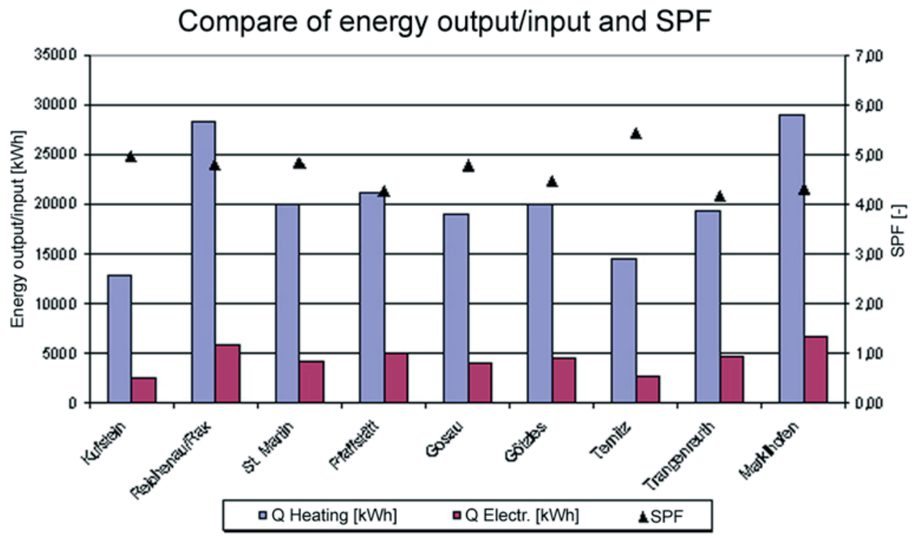

Figure 3.9: Diagram of the SPF and energy input and output of the compared heat pumps

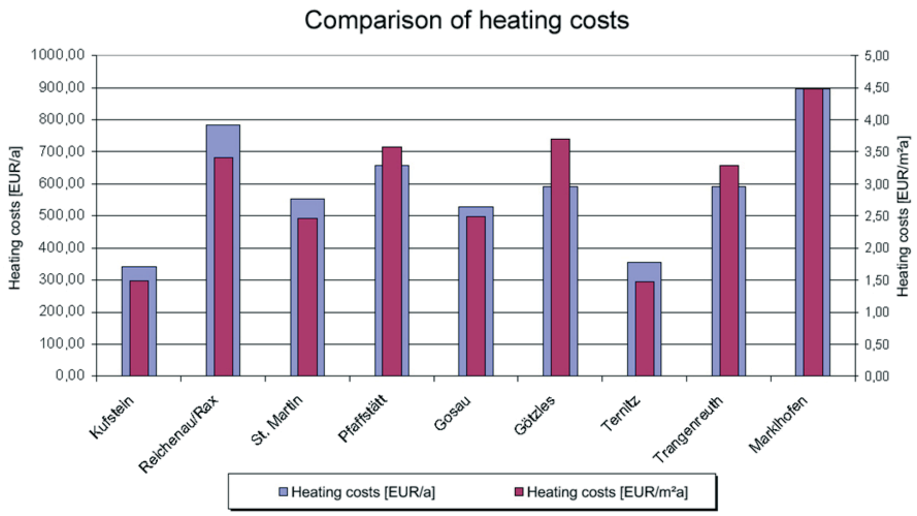

Figure 3.10: Comparison of the absolute and specific heating cost of the selected heat pumps

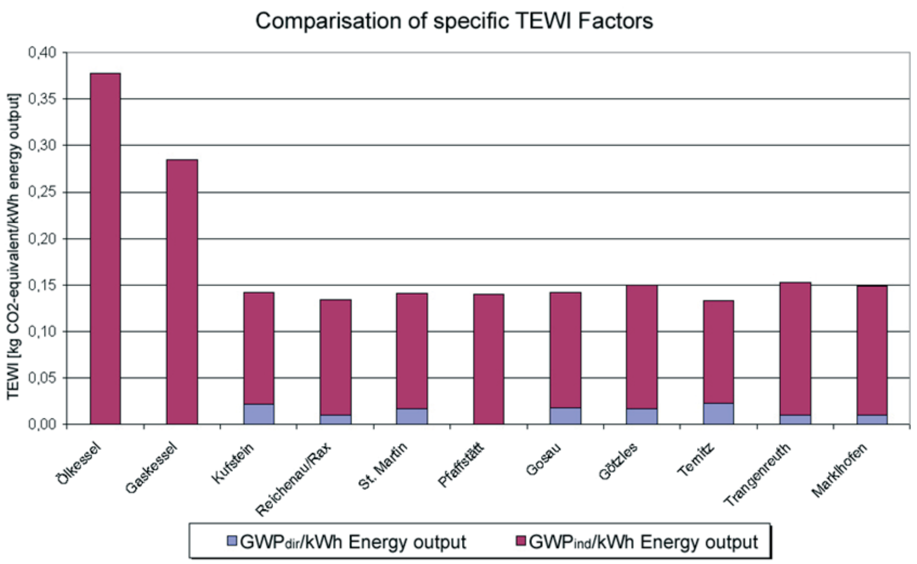

Figure 3.11: Diagram of the specific TEWI factors

The evaluation of emissions confirms that the heat pump units are far more eco-friendly than gas or oil boilers as far as SO_2, NOX, CXHY, CO and CO_2 are concerned. Only in the case of 100 % power generation from coal will dust emissions exceed the emissions of a gas or oil boiler by 186 %, or the Austrian electricity mix (EVU-Mix) by 97 %.

Summary

Monitoring of the first nine heat pumps shows that heat pump technology has the potential to significantly contribute to the aims of the Kyoto protocol.

It is now necessary further to develop this monitoring standard and apply it to other heat pump units. Heat pump units which are used for both space heating and domestic hot water production will provide a particular challenge. This is due to the variation in the domestic hot water production and storage possibilities, which imply a modification in the energy balance. In addition, many more heat pumps will have to be evaluated in order to present a statistically and scientifically valid description of the current state of the art of the heat pump technology.

References

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[3] EN 378-1, Kälteanlagen und Wärmepumpen, Sicherheitstechnische und umweltrelevante Anforderungen, Teil 1: Grundlegende Anforderungen, Definitionen, Klassifikationen und Auswahlkriterien, 11.2003

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Ammonia refrigeration technology for today and tomorrow

The proceedings of this IIR conference held in Ohrid, Macedonia, on April 19-21, 2007, comprise 37 papers covering a broad range of state-of-the-art development and applications regarding ammonia refrigeration.

Main topics:
- Design of modern ammonia systems and technological innovation
- Energy efficiency of ammonia refrigeration
- Applications of ammonia refrigeration
- Ammonia systems in developing countries
- Technical and safety standards
- Guidelines, instructions and training materials
- Public awareness of the image and benefits of natural refrigerants.

Location: Ohrid, Macedonia
37 papers. English version only.
Price: EUR 30
Source: www.iifiir.org

Refrigerant cycle data: Thermophysical properties of refrigerants for applications in vapour-compression systems

The aim of this booklet is to provide, in an easily accessible form, the most important thermophysical property data for a number of different refrigerants with applications in vapour-compression systems. Tables are given for basic cycles at different evaporating and condensing temperatures. The tables also provide information on the pressure ratio, volumetric capacity and isentropic compression work. The coefficients of performance (COPs) of cycles with isentropic compression are given, as is the thermodynamic efficiency of each cycle (with the Carnot cycle used as reference).

In addition, the effect of modifying the basic cycle by subcooling of liquid before throttling, and superheating the vapour before compression (internal as well as external), is illustrated.

Data are provided for the following refrigerants: R-32, R-125, R-134a, R-152a, R-290 (propane), R-404A, R-407C, R-410A, R-507, R-508A, R-600a (isobutane), R-717 (ammonia), R-744 (carbon dioxide, including transcritical cycles and R-1270 (propylene).

Price: EUR 30
Source: www.iifiir.org

Tracking industrial energy efficiency and CO_2 emissions

Industry accounts for about one-third of global energy demand. Most of that energy is used to produce raw materials: chemicals, iron and steel, non-metallic minerals, pulp and paper and non-ferrous metals. Just how efficiently is this energy used? This question was on the minds of the G8 leaders at their summit in Gleneagles in 2005, when they set a "Plan of Action for Climate Change, Clean Energy and Sustainable Development". They called upon the International Energy Agency to provide information and advice in a number of areas, including special attention to the industrial sector.

Tracking Industrial Energy Efficiency and CO_2 Emissions responds to the G8 request. This major new analysis shows how industrial energy efficiency has improved dramatically over the last 25 years. Yet important opportunities for additional improvements remain, which is evident when the efficiencies of different countries are compared. This analysis identifies the leaders and the laggards. It explains clearly a complex issue for non-experts.

With new statistics, groundbreaking methodologies, thorough analysis and advice, and substantial industry consultation, this publication equips decision-makers in the public and private sectors with the essential information that is needed to reshape energy use in manufacturing in a more sustainable manner.

Source: www.iea.org

Energy statistics of OECD countries - 2007 edition

This publication contains data on energy supply and consumption in original units for coal, oil, gas, electricity, heat, renewables and waste. Historical tables summarise data on production, trade and final consumption. The book also includes definitions of products and flows and explanatory notes on the individual country data.

Source: www.iea.org

World AC market review

In 2006, the value of the world market for air conditioning was estimated at 53.4 US$ billion (including airside products), a 7 % increase over the previous year. The airside section was included in the world study for the first time and incorporated air handling units and fan coils. In 2006, the airside market reached 4,407US$ million, and the USA alone contributed to 30 % of this value.

Further information:
The new study from BSRIA Worldwide Market Intelligence (WMI) is available now, published in March 2007. The World Air Conditioning Market Review 2007 covers 29 countries individually, and also includes regional totals. Product areas covered are windows, moveables, minisplits, rooftops, indoor packaged, ducted splits, chillers, fan coils and AHUs.

For further information and pricing please contact Simon Hurst at WMI.

Source: http://www.bsria.co.uk/

2007

22nd IIR International Congress of Refrigeration (ICR2007)
21 – 26 August
Beijing, China
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Tel: +86 10 6843 4683
Fax: +86 10 6843 4679
E-mail: icr2007 @ car.org.cn
http://www.icr2007.org
http://www.iifiir.org

10th International Building Performance Simulation Association Conference and Exhibition
3 – 6 September
E-mail: bs2007 @ tsinghua.edu.cn
http://www.bs2007.org.cn/

Sustainable building 2007
12 – 14 September
Lisbon, Portugal
http://www.portugalsb07.org/

Fan Noise 2007
17 – 19 September
E-mail: info @ fannoise2007.org.
http://www.fannoise2007.org/

Sixth International Conference on Enhanced, Compact and Ultra-Compact Heat Exchangers: Science, Engineering and Technology
16 – 21 September
Potsdam, Germany

International Heat Pump Symposium
18 – 19 September
German Society of Refrigeration and Air Conditioning (DKV)
Nuremberg, Germany

28th AVIC Conference
27 – 29 September

BUILDING LOW ENERGY COOLING AND ADVANCED VENTILATION TECHNOLOGIES IN THE 2IST CENTURY
Crete Island, Greece
http://palenc2007.conferences.gr/

RENEXPO
INTERNATIONAL TRADE FAIR AND CONFERENCE FOR RENEWABLE ENERGIES AND ENERGY EFFICIENT BUILDING AND RENOVATION
27 – 30 September
Augsburg, Germany
http://www.renexpo.de/content/view/39/88/lang,en/

HARDI Annual Fall Conference
6 - 9 October
Orlando, Florida, USA
http://www.hardinet.org/

3rd Annual European Energy Policy Conference
9 - 10 October
Brussels, Belgium
http://guest.cvent.com/EVENTS/Info/Summary.aspx?e=455c0ca8-3464-4a45-9181-2c24fb62ff74

ASHRAE's IAQ 2007 - Healthy & Sustainable Buildings
15 - 17 October
Baltimore, Maryland, USA
http://www.ashrae.org/publications/detail/15187

2nd International Conference SOLAR AIR-CONDITIONING
18 - 19 October
Tarragona, Costa Dorada, Spain
Organisation Commitee:
Das Ostbayerische Technologie-Transfer-Institut (OTTI e.V.)
Regensburg, Germany
Tel: +49 941 29688-29/-37
Fax +49 941 29688-17
E-mail: gabriele.struthoff-mueller @ otti.de
britta.haseneder @ otti.de

SMACNA Annual Convention
21 - 25 October
Las Vegas, Nervada, USA
http://www.smacna.org/

The 6th International Conference on Indoor Air Quality, Ventilation & Energy Conservation in Buildings - IAQVEC 2007
28 - 31 October
Sendai, Japan
iaqvec2007 @ sabine.pln.archi.tohoku.ac.jp
www.iaqvec2007.org

20th Anniversary, IGSHPA's Technical Conference and Expo
29 -30 October
IGSHPA - The International Ground Source Heat Pump Association
Oklahoma City, Oklahoma, the USA
www.igshpa.okstate.edu/conf/2007conf.htm

New Ventures in Freeze-drying
7 - 9 November
l.rey @ aerial-crt.com
Fax: +33 (0)3 8819 1520
http://www.aerial-crt.com

ARI Annual Meeting
10 - 13 November
www.ari.org

In the next Issue

Heat pump components development trends

Volume 25 - No. 3/2007

International Energy Agency

The International Energy Agency (IEA) was established in 1974 within the framework of the Organisation for Economic Co-operation and Development (OECD) to implement an International Energy Programme. A basic aim of the IEA is to foster co-operation among its participating countries, to increase energy security through energy conservation, development of alternative energy sources, new energy technology and research and development.

IEA Heat Pump Programme

International collaboration for energy efficient heating, refrigeration and air-conditioning

Vision

The Programme is the foremost world-wide source of independent information & expertise on heat pump, refrigeration and air–conditioning systems for buildings, commerce and industry. Its international collaborative activities to improve energy efficiency and minimise adverse environmental impact are highly valued by stakeholders.

Mission

The Programme serves the needs of policy makers, national and international energy & environmental agencies, utilities, manufacturers, designers & researchers. It also works through national agencies to influence installers and end-users.
The Programme develops and disseminates factual, balanced information to achieve environmental and energy efficiency benefit through deployment of appropriate high quality heat pump, refrigeration & air-conditioning technologies.

IEA Heat Pump Centre

A central role within the programme is played by the IEA Heat Pump Centre (HPC). The HPC contributes to the general aim of the IEA Heat Pump Programme, through information exchange and promotion. In the member countries (see right), activities are coordinated by National Teams. For further information on HPC products and activities, or for general enquiries on heat pumps and the IEA Heat Pump Programme, contact your National Team or the address below.

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IEA OECD heat pump centre

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