Annex 46
Heat Pump Water Heaters

Heat Pump Water Heaters, a challenging future
Workshop at ICR2019
27th August 2019 Montréal

Onno Kleefkens
Phetradico
Introduction to IEA Heat Pumping Technology TCP

• ‘HPT (Heat Pumping Technologies)’ is one of the TCPs (Technology Collaboration Programmes) in CERT and organized in 1978.

• Participation country is now at 17 countries:
  • Austria, Belgium, Canada, China, Denmark, France, Germany, Italy, Japan, Korea, Netherlands, Norway, Sweden, Finland, Switzerland, UK, and USA

• Heat Pump Center (HPC) at Sweden, Borås.

Mission

• Public relations on energy saving and environmental benefits by heat pumps
• Development of information for market increase
• International cooperation on RD&D information
• Effective informative supply between stakeholders
Information sharing by HPC
• Project reports / Electronic newsletters
• Heat Pumping Technologies Magazine (formerly HPC Newsletter)
• https://heatpumpingtechnologies.org/

Objectives for 2023
• Energy Security
  • Frequent demonstration and deployment of HPT
  • HPT as a key element heating and cooling
• Economic Development
  • Increased innovation rate for HPT
  • Improved capacity building
  • Cost-effective solutions accepted by end users

• Environmental Awareness
  • Awareness of more policy makers on the environmental potential of HPT

• Engagement Worldwide
  • More member countries to HPT TCP
  • HPT TCP as an active player in, or partner to, other international initiatives and organisations
Communications and Activities in 2018 ~ 2019

HPT Workshops

• Sustainable Heating and Cooling Workshop as a part of Nordic Clean Energy Week, Malmö, Sweden in May 22, 2018
• Heat Pump Association Symposium (WPP Symposium), Ghent, Belgium in Oct 10, 2018
• National Workshop "Heat Pumps in Finland", Espoo, Finland in May 21, 2019.

• Annex Workshops (some examples):
  • Annex 46 – 16th May Workshop in Seoul for Korean Market
  • Annex 46 - Heat Pump Water Heaters, a challenging future at ICR 2019
  • Annex 46 – Modelling Workshop at 13th IEA Heat Pump Conference (Jeju)
  • Annex 55 – Workshop at European Heat Pump Summit 22/23 October in Nuremberg (Germany)

• 13th IEA Heat Pump Conference may 2020 in JEJU (http://hpc2020.org/)
  • A great number of presentations will be held on Heat Pump Water Heaters as a result of the Annex work
International Collaboration Projects called: “Annexes”

• At the NE (National Experts) meeting (once/yr), common interests among the participants are drawn and are developed as a new annexes.
• 2~3 Annexes are selected annually by voting.
• Annex structure (3 years)
  • OA (operating countries)
  • Participating countries (Mission of task share and annual fees)
  • Final report as a deliverable
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Introduction to HPT Annex 46

Domestic Hot Water Heat Pumps are traditionally seen as a stand alone product, but the truth is more complex.

The focus of the Annex has broadened as water heaters are one of the most complex product categories due to a large variety of product types, technologies, and fuels used for heating water. Not only ranging from individual to collective systems, but also introducing combined systems, hybrid systems and fresh water systems, with different terminology in different regions of the world.

As new buildings become more energy efficient, CO2 emissions from hot water start to exceed those from space heating. As we move towards more energy efficient houses, a similar level of detail should be applied to hot water system design as to the building envelope and ventilation systems.

The way in which most current building processes with the energy models consider hot water systems is too simplistic for newly build and deep renovation dwellings.
Introduction to HPT Annex 46

The Annex is a collaboration project with eight participating countries, being:

• Netherlands (OA) - Canada, France, Japan, Korea, Switzerland, UK, USA

The structure of the Annex is:

• Task 1 – State of art in the market and an overview of available technologies
• Task 2 – Calculation models for building systems
• Task 3 – Modelling of heat pump technology, heat exchangers and storage
• Task 4 – Research and Development
• Task 5 – Example projects
• Task 6 - Communication
Task 1 – gives a General Report on State of the art

- Market developments in participating countries
- Policy developments in participating countries
- Technologies
  - Storage
    - Wrap around condensor
    - Internal condensor
    - External condensor
  - Fresh water System
  - Combination with solar
  - High temperature HP
  - Hybrid
  - District Heating – Booster HP
  - Smart storage systems
- Refrigerants
- Legionella
- Test procedures and labelling
- Multifamily buildings
- Outlook and scenario’s for future developments
Future market developments

Great diversity in markets, due to existing markets and cultural difference in hot water usage.

• In Europe the pace is slacking down for the single DHW HP > Double function market is growing, especially in countries with a need for space heating

• Japan with 10% of market is the other biggest market (in numbers), mainly ECO Cute

• US has a large potential in replacing Electric and Gas DHW storage tanks (typically still a market of split systems)

• Largest market is China (also for thermal solar) – 20% of DHW market (?)

• Collective systems the biggest challenge (and District Heating in a number of European countries and Korea)

Policy

Drivers are: CO2, Energy Zero, Renewables, Polution, Water management, New Energy infrastructures, etc
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Quality labels
As homes become better insulated, energy consumption for spatial heating is decreasing. It is therefore more important to have a clear picture of energy consumption: hot water heating. A basis for a good choice is an objective calculation model in which different concepts of systems can be juxtaposed. In the energy market many calculation models, often on commercial basis are available.

Calculation models can be defined in (at least) two categories:

- calculation for the energy performance of a building in relation to legislative procedures, like the SAP and RdSAP models in the UK with which the EPC for the building is calculated
- calculation for designing the optimal system, used by consultants, building constructors, architects, installers, etc

These models have a number of characteristics:

- Impossible to compare different system concepts
- Innovative concepts are often not in the model
- Domestic hot water is often a secondary part of the energy system, based upon flat rate values
- Economical

More specifically for the Annex, this also means that a model must be set up that can be used for the different countries participating in the Annex.
Task 3 – Heat Pump Modelling

It must be admitted that much research is undertaken by manufacturers thus there is not much public knowledge at this moment which type of heat exchanger has a better performance for domestic hot water heat pumps. The questions to be answered which storage tank / condenser configuration has a better performance:

- better stratification and thus a better energy efficiency
- less heat losses
- cost effectiveness

In the next phase of the Annex this will be analyzed further in relation to the refrigerant choice and the storage sizes.

WORKSHOP ‘Modelling heat pump (and solar) water heaters’ at 13th Heat Pump Conference 2020
Task 4 – R&D

A general feeling of the participants was that:

- Manufacturers are very well aware of the refrigeration challenges and are ‘working on it’ as a consequence of worldwide regulation after the Kigali agreement.
- Regional and cultural differences are demanding for different solutions.
- End-users are not aware of the advantages on the long term and will traditionally go for the cheapest solution. Without clear governmental legislation the market will not develop in itself towards a wider application of DHW Heat Pumps.
- The traditional installer is not really capable (on a large scale needed for a market transition) to give consumer advice and install the best option. Often oversizing is the case to avoid complaints.
- Grid operators are interested in the storage capacity of DHW Heat Pumps, although the capacity is smaller than with direct resistance heating and alternative storage technologies are coming on the market and are being researched.

Based upon these findings a Roadmap is being developed.
Task 5 – Example projects (Visit the [website](#))

- Austria – Hot Ice – [Weiz](#)
- Switzerland – [DHW Supply in MF Dwellings](#)
- France – [Roquebrune Cap Martin](#) in Nice
- France – Renovation of 21 dwellings in [Rennes](#)
- France – Renovation of domestic hot water production in 12 social dwellings in [Soissons](#)
- France – New built private collective housing in [Marseille](#) with Solar HP
- Northern Ireland – [St Thomas Hall](#) apartments, Belfast – newly built MFB for facility catering.
- Netherlands – [Soendalaan](#) – Leiden – Plug & Play renovation of block of flats with individual hp’s
- Netherlands – [DUWO Studenthouse](#) – Leiden – Renovation of Water Heating system
- Netherlands – Collective HT HP – [Urlupsplantsoen](#) – Leiden – Renovation MFB
- Netherlands – [Leyhoeve – Tilburg](#) – New MFB for elderly people
- Netherlands – [Booster project – Sophia Staete](#) – Hendrik Ido Ambacht – New MFB
Task 5 – Example projects with CO2 as refrigerant

- **Koraku Onyado Fujiginkei** – This hotel it built in Lake Kawaguchi Area at the foot of Mt. Fuji, now a registered world heritage site. When the refurbishment was done, they installed a low-cost, environmentally friendly commercial Eco Cute, out of consideration for the environment and the continued development of the area. Thanks to the system’s cutting-edge technology, energy-saving performance and ability to reduce costs, they receive an energy-saving subsidy from the government in 2012, covering one third of the total cost.

- **Tateyama Country Club** – The new clubhouse was rebuilt in 2012. It is a fully electric building that combines safety and ease of maintenance, as well as protecting the environment and saving energy. For the hot water supply, load leveling was achieved by effective use of heat pump water heater combined with thermal storage tank which utilizes the less expensive overnight power. For air conditioning, high-efficiency heat pump system were installed for each room. The kitchens meanwhile are fitted with fully electric systems that maintain hygiene whilst also creating an excellent working environment.

- **Sakakibara Heart Institute of Okayama** – The concept of rebuilding this hospital was to save energy and improve the safety, comfort and cost of facilities, with the aim of improving management efficiency and reinforcing business continuity in the event of a disaster. In order to improve system efficiency air conditioning facilities combine high-efficiency heat pumps with Eco Ice and Eco Cute for hot water supply were installed.

- **France – Eco-Cute** – New built private collective housing with Sanden CO2 in **Toulouse**

- **Netherlands – The Albus Hotel** – Amsterdam – This renovation of the Albus hotel in Amsterdam became the first completely CO2-neutral hotel in Europe. The specially purchased state-of-the-art Mitsubishi Electric Multi R2 VRF system cools and heats all the rooms. In addition, it is also possible to heat the hotel’s hot water up to a maximum of 90°C with a Mitsubishi Eco Cute QAHV. Thus the hotel’s water is heated to more than 70°C in a sustainable manner.
Task 6 – Communication

The Annex communicates at different levels through publications in Scientific Journals and at a number of Conferences, presentations at Workshops and presentations at Working Meetings. The Operating Agent also focuses on inviting experts from non-participating countries.

- Papers by Annex participants have been published at the 12th IEA Heat Pump Conference, while other papers were presented at Purdue or published in the IIR Journal and other Journals.
- In April 2018 a Workshop was held at the Waseda University on Tokyo Japan. Presentations were held on R&D on Heat Pumps for Water Heating.
- At the regular Working Meetings participants exchange information in a number of presentations.
  - These are all available and published at the website.
- Regular Workshops
  - Annex 46 – 16th May Workshop in Seoul for Korean Market
  - Annex 46 - Heat Pump Water Heaters, a challenging future at ICR 2019
  - Annex 46 – Modelling Workshop at 13th IEA Heat Pump Conference (Jeju)

Contact us:

onno@phetradico.com
www.phetradico.com
+31 (0) 3606 1748
Modelling heat pump and solar water heaters is undertaken by a large number of Universities and Institutes in order to optimize the system. Next to that manufacturers are designing and developing new concepts based upon these methodologies.

A number of experimental, analytical and numerical studies is focused on the performance evaluation of HPWHs, efficient gas coolers, and thermal stratification of the water storage tank in relation to the behaviour of refrigerants and the draw-off profiles. In these studies publically available calculation models are often used.

There is a strong relation between heat pumping technologies and solar technologies as has been shown in a number of SHC and HPT Annexes. Especially the link with Photovoltaics and the relation with smart energy systems brings a new perspective.

The workshop is aiming to bring together experts in order to exchange ideas, experience, make contacts and discuss the way forward.
13th IEA Heat Pump Conference 2020

HEAT PUMPS – MISSION FOR THE GREEN WORLD
May 11 – 14, 2020, Jeju, Korea
HEAT PUMP WATER HEATERS, A CHALLENGING FUTURE

08.30 – 10.45  First part of the session
• 08.30 – 08.55 - Onno Kleefkens MSc., Phetradico: Introduction to the IEA TCP Heat Pumping Technologies and the Annex 46
• 08.55 – 09.20 - Prof. Kiyoshi Saito, Waseda University: History and latest trends of domestic hot water heat pump technologies
• 09.20 – 09.45 - Prof Emilio Navarro Peris, Universitat Politècnica de València: Evaluation of different heat pump systems for sanitary hot water production using natural refrigerants.
• 09.45 – 10.10 - Dr. Pavel Makhnatch, KTH Royal Institute of Technology: Easy LCCP analysis for Domestic Hot Water Heat Pumps.

10.15 – 10.45  Coffee Break

10.45 – 12.30  Second part of the session
• 10.45 – 11.10 - Dr. Kashif Nawaz, Oak Ridge National Laboratory: The roadmap of refrigerants for heat pump water heating- Challenges and Opportunities.
• 11.10 - 11.35 - Prof. Pedro G. Vicente Quiles, Universidad Miguel Hernández: Photovoltaics for Sanitary Hot Water Production
• 11.35 -12.00 - Prof. Neil Hewitt, Ulster University: Advanced vapour compression and/or sorption heat pumps with minimum compact thermal storage for DHW.
• 12.00 - 12.30  Pannel discussion