Info project proposal within CORNET-frame:

Energetic and environmental optimisation of drying processes by integration of heat pumps
HP4Drying

Applicant:
Ing. Bruno Vanslambrouck
Howest, University of Applied Sciences, Kortrijk-Belgium
Dept of Electromechanics, Research Group on Thermodynamics
Ghent University Association (integration from October 2013)

Framework

CORNET (**CO**llective **R**esearch **NET**work): European collaboration, first 2013 call, deadline 30/03/2013

Partners needed from other participating countries/regions

Both project types directed to practical implementation of new technologies.

Both strongly SME directed.

Financing (Flemish research part):

- 92,5% from Flemish Government (both TETRA and CORNET)
- 7,5% cofinancing by User Group memebers (target group of interested companies and organisations).

Initiative and coordination Flemish part: Bruno Vanslambrouck, Howest

Proposed execution time: 01/01/2014 - 31/12/2015

Portfolio

TETRA-IWT project (2007-2009):

Waste heat recovery via ORC on renewable energy applications

User group with 15 member, 5 case studies executed

TETRA-IWT project (2010-2012), within European ERA-SME frame:

Waste heat recovery via Organic Rankine Cycle

German partner: Hochschule für Technik, Stuttgart
36 members within the Flemish user group, 7 within the German one
9 case studies

CORNET-project (2012-2013):

From waste heat to process heat (W2PHeat)

Project structure: see next slide
29 members within the Flemish user group, 7 within the German one
7 case studies in Flanders, whereof 2 being drying applications

W2PHeat

From Waste Heat to Process Heat

Partners

PTS – THE PAPER TECHNOLOGY SPECIALISTS
Coordinator
Association
RTO
Collective Research Centre

PFI Germany
Association
RTO
Collective Research Centre

howest – De Hogeschool West-Vlaanderen
RTO

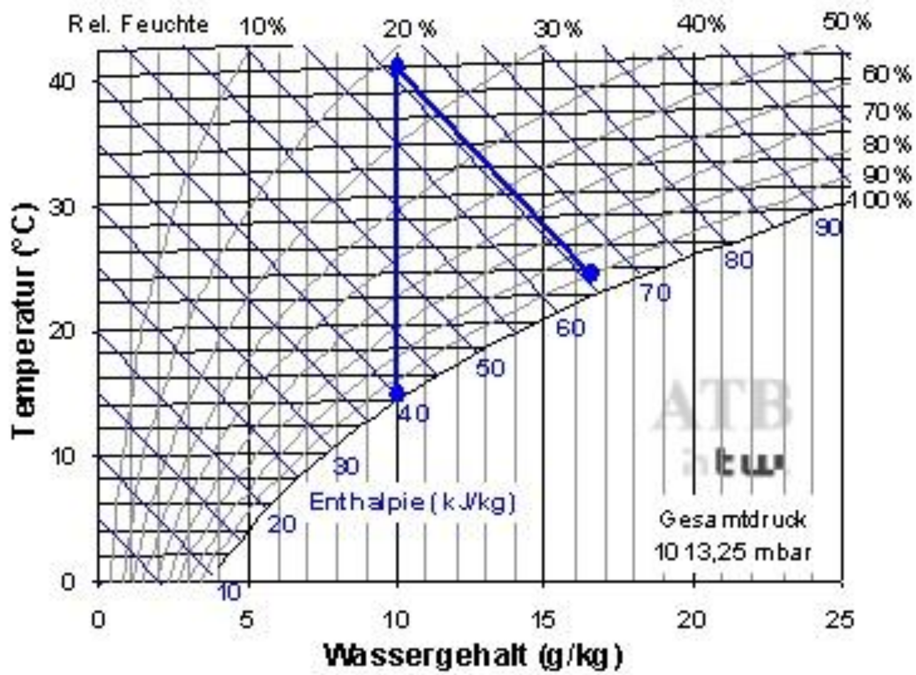
Flemish User Group
Association

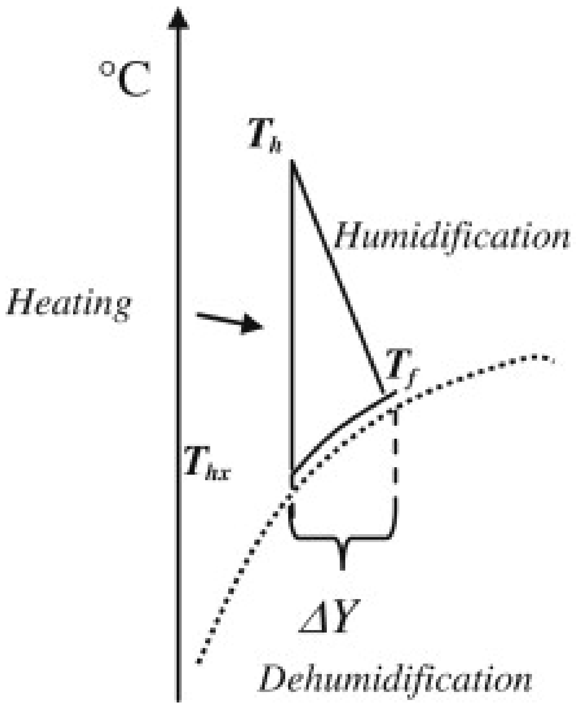
Universiteit Gent
RTO

CORNET
Collaboration agreement

What we learned from W2PHeat:

- Drying processes are attractive to integrate heat pumps into it.
- But: specific approach needed to determine t°-levels on which heat can be recovered, depending of relative humidity and dew point of dryer exhaust.





UNIVERSITEIT GENT

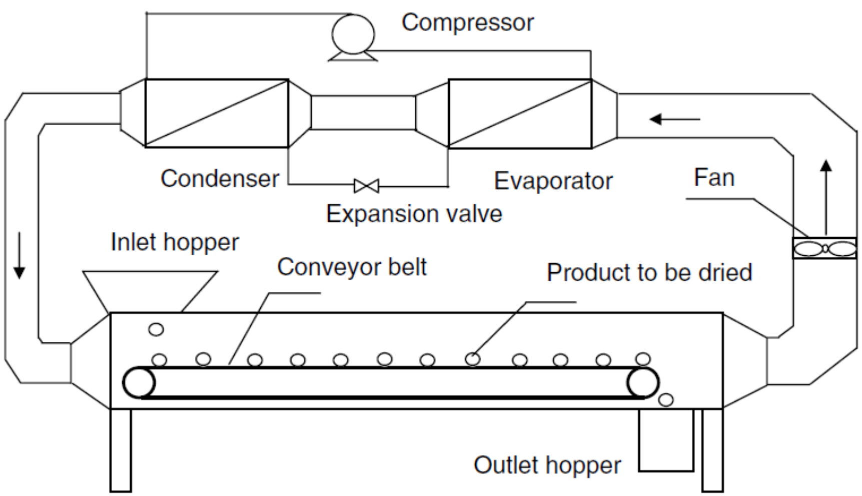
howest De Hogeschool West-Vlaanderen
Lid van de Associatie Universiteit Gent

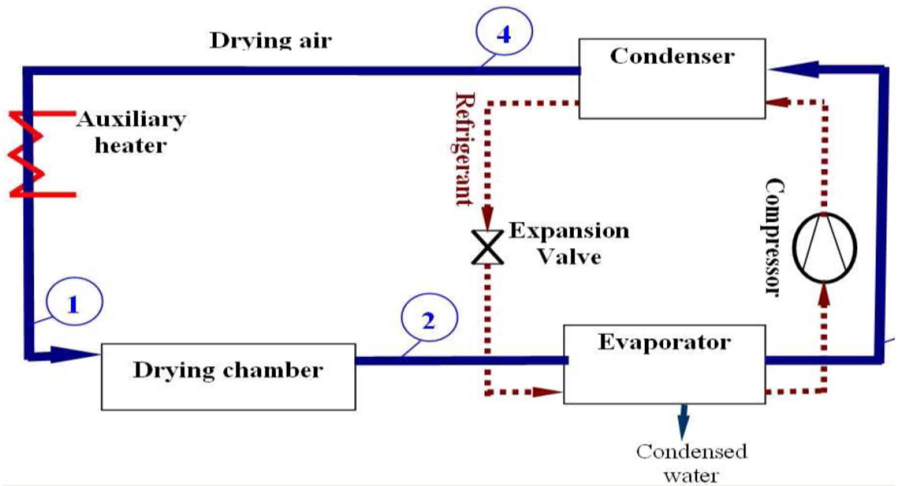
Proposed principle:

Dryer exhaust gas dehumified, condensation heat to recover and to upgrade by a heat pump.

Heat pump delivers heat for (partial) (re)heating of the fresh or recirculated drying gas (or another application)

A closed cycle dryer could be realized but is not a prerequisite.





Benifits:

- considerable energy savings
- closed cycle drying feasable to avoid odor (also feasible without a heat pump)
- applicable in various industrial fields

Additional attention needed for:

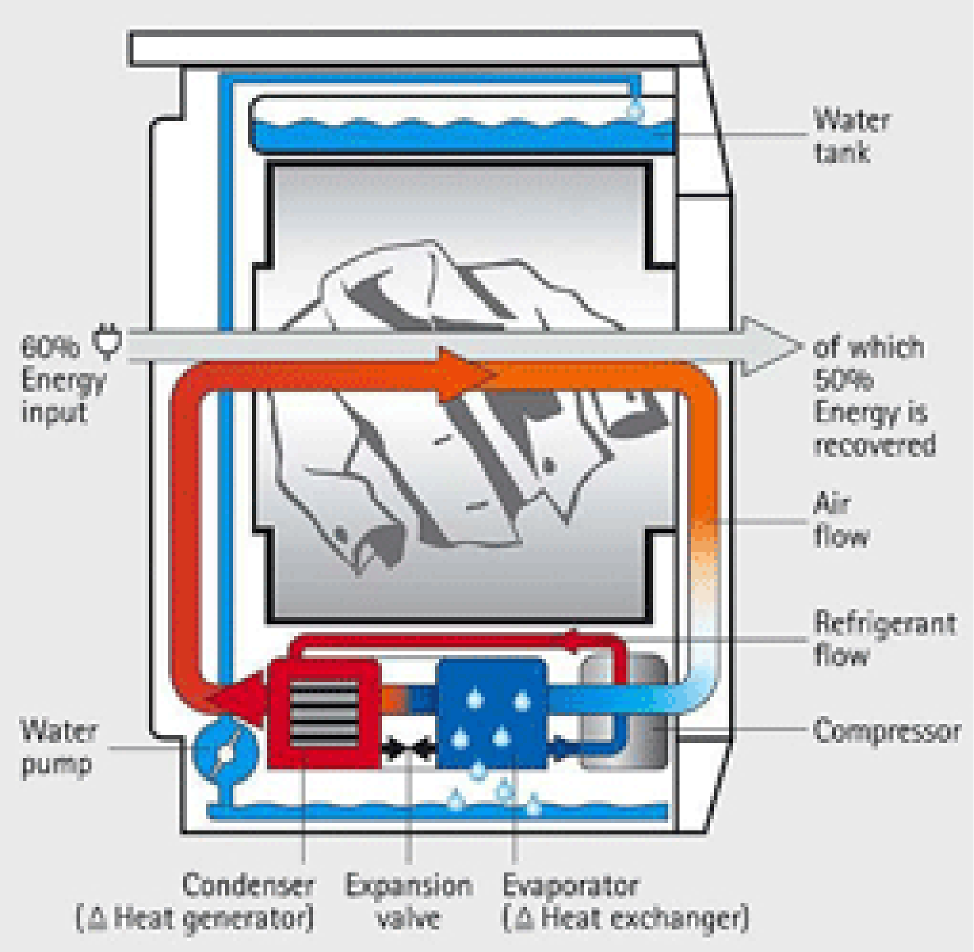
- Condensation water cleaning ? Otherwise disappears with the humid air at the dryer outlet.
- Air (gas) contamination within a closed cycle dryer: dust removal, refreshing…
- Economic feasibility

Need for multidisciplinary approach: expert knowledge heat-pumps combined with process knowledge drying processes, made possible by (international) collaboration of multiple research organisations.

Available on the market:

Heat Pump tumble dryers (Miele and others)

This dryer uses a refrigerant that is condensed by a compressor and led in a closed circuit through a heat exchange unit where heat exchange with the circulating drying air takes place.
Because this transfer of energy is rapid and very efficient on this dryer, energy consumption and running costs are about 46% lower.



Scientific literature: (some examples)

HEAT PUMP DEHUMIDIFIER DRYING TECHNOLOGY—STATUS, POTENTIAL AND PROSPECTS
Dr Paul Bannister, Managing Director, Exergy Australia
Dr Gerald Carrington, Professor, Department of Physics, University of Otago, New Zealand
Dr Guangnan Chen, Senior Research Consultant, Energy Group Limited, New Zealand

Designing – Manufacturing of Heat Pump Dryer and Testing with “Gia Huong” Banana
Nguyen Van Hung, Nguyen Dang Tuan Kiet
Faculty of Engineering, Nong Lam University, Vietnam,
ThuDuc District - Hochiminh city – Vietnam,

Design Of Hybrid Heat Pump Dryer - Dehumidifier For Drying Of Agricultural Products
Chung Lim. LAW, Wan Ramli Wan. DAUD,Luqman Chuah. ABDULLAH
School of Chemical and Environmental Engineering, University of Nottingham Malaysia
Department of Chemical and Process Engineering, National University of Malaysia
Department of Chemical and Environmental Engineering, University Putra Malaysia

Modeling Kinetics of Heat Pump Atmospheric Freeze Drying
Kirill Mukhatov, Odilio Alves-Filho
Department of Energy and Process Engineering, Norwegian University of Science and Technology
Trondheim, Norway

Clues

HEAT PUMPS FOR WOOD DRYING – NEW DEVELOPMENTS AND PRELIMINARY RESULTS
Vasile Minea
Institut de Recherche d'Hydro-Québec, Laboratoire des Technologies de l'Énergie, Canada

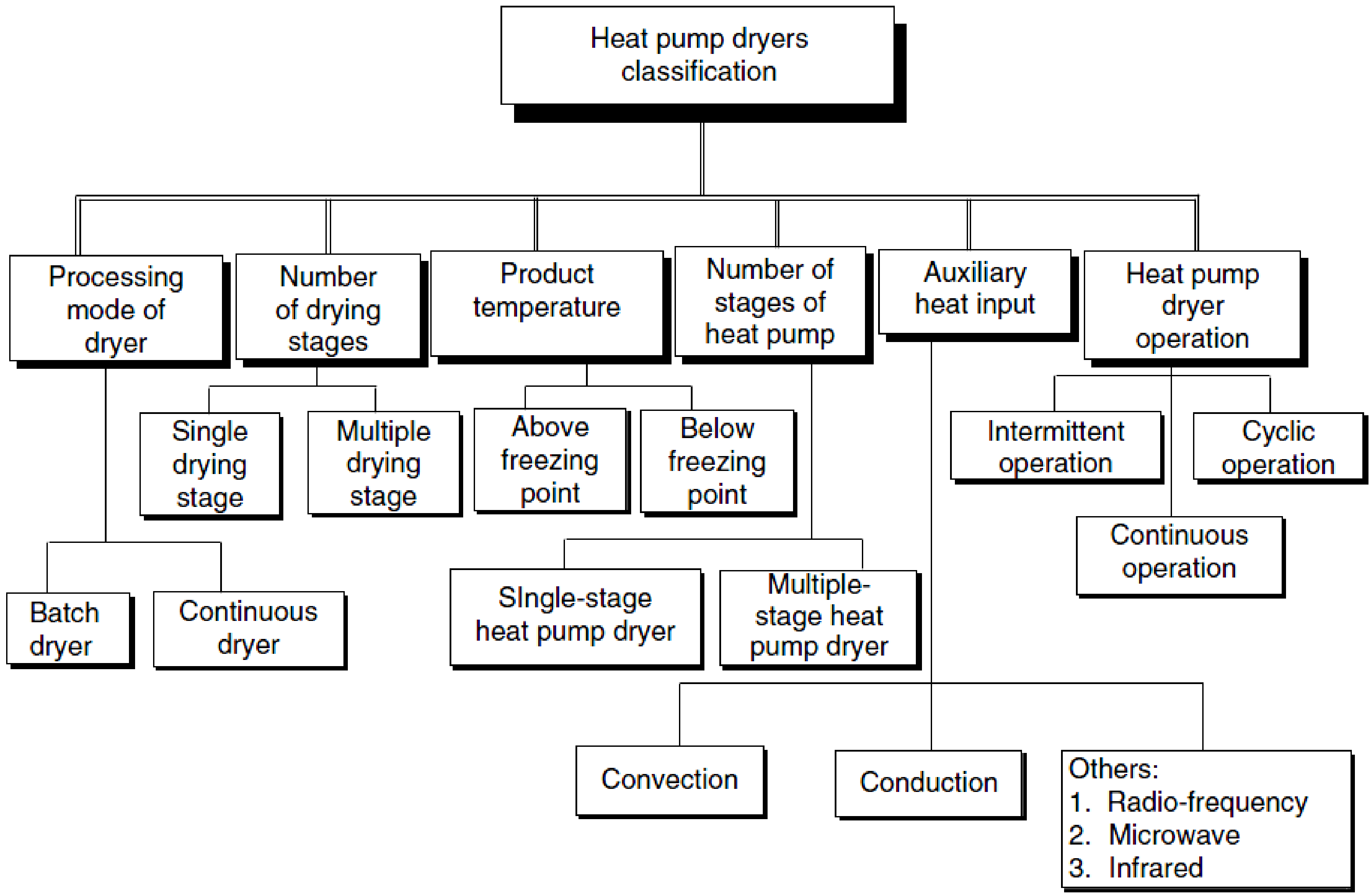
HEAT PUMP DRYING OF SULPHATE AND SULPHITE CELLULOSE
Ingvald Strømmen, Trygve Eikevik, Odilio Alves Filho and Kristin Syveru
Norwegian University of Science and Technology, Dep. of Energy and Process Engineering
SINTEF Energy Research, NO-7465 Trondheim, Norway
Paper and Fibre Research Institute, Trondheim, Norway

COMBINED INNOVATIVE HEAT PUMP DRYING TECHNOLOGIES AND NEW COLD EXTRUSION TECHNIQUES FOR PRODUCTION OF INSTANT FOODS
Odilio Alves-Filho
pages 1541-1557

Comparison of Heat Pump Dryer and Mechanical Steam Compression Dryer
Lionel Palandre, Denis Clodic
Ecole des Mines de Paris, Center for Energy Studies, Paris Cedex 06

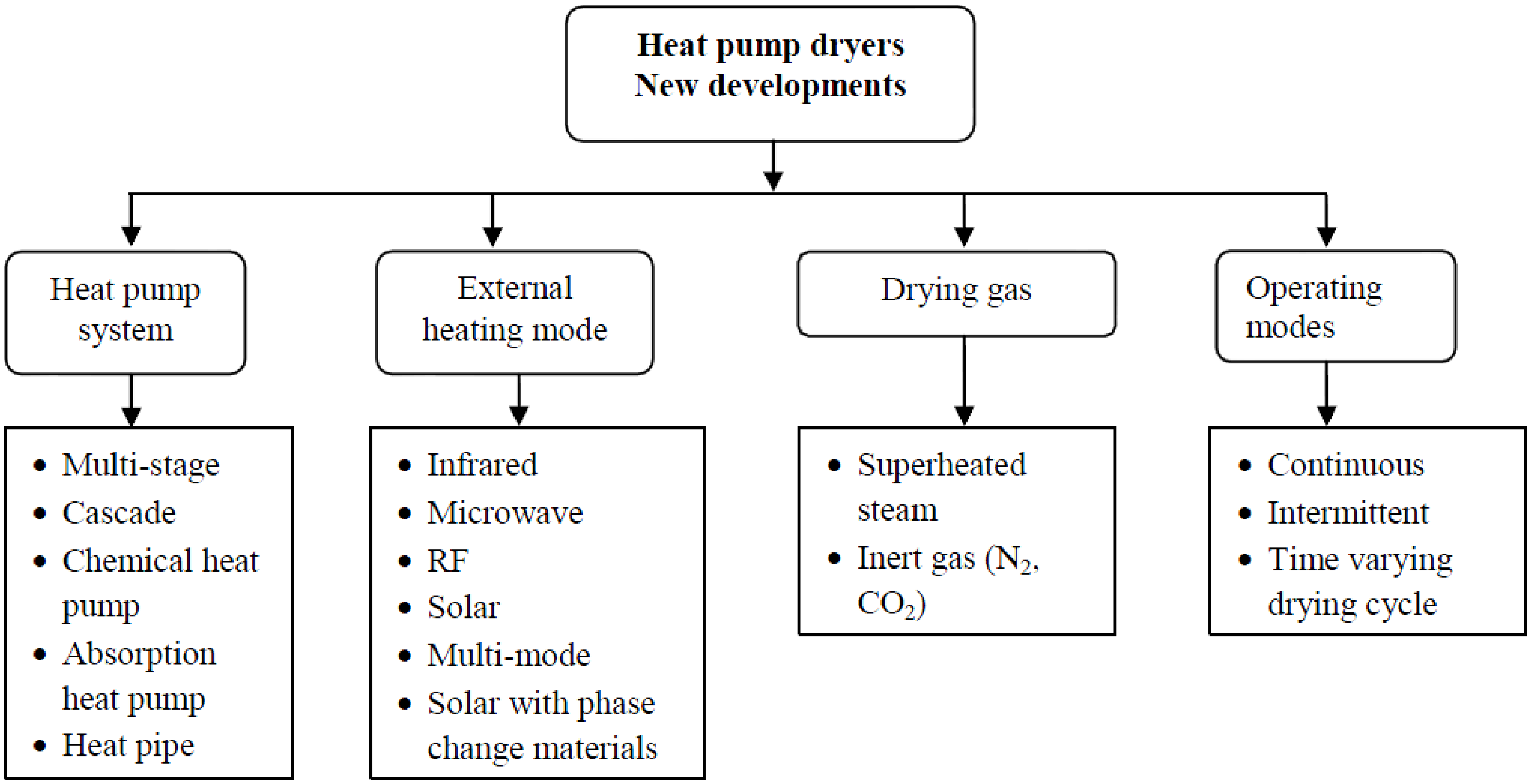
Wood chip drying with an absorption heat pump
Brice Le Lostec, Nicolas Galanis, Jean Baribeault, Jocelyn Millette
Génie Mécanique, Université de Sherbrooke, 2500 Boul. de l'Université, Canada
LTE, 600 Avenue de la Montagne, Shawinigan, QC, Canada

Current state of the art



Source: Mujumdar, A.S., Handbook of Industrial Drying, CRC/Taylor and Francis (2007)

Current state of the art



Source: Mujumdar & Jangam Some Innovative Drying Technologies for Dehydration of Foods

Current state of the art

Drying heat pump technology: R&D needs and future challenges (1)

- Provide **drying-schedules** in terms of set dry- and wet-bulb temperatures, temperature depression in relation with the air relative and absolute humidity, and flow rate.
- Provide **drying curves** of the dried products, specifying wether theirmoisture content was measured and how (oven, continuously or intermittently)
- Install pre-heating and supplementary (back-up) heating (if necessary)
- **Essential data:**
  - Input/output quantities and initial/final moisture contents or dried materials
  - Heat pump dehumidification capacity and/or compressor rated input power
  - Condenser heating and heat rejection capacity
  - Heat pump pressures and temperatures throughout the drying cycles

Source: Minea, V., Part II – Drying heat pumps – Agro-food, biological and wood products, International Journal of Refrigeration (2012)

Drying heat pump technology: R&D needs and future challenges (2)

- R&D focused on final structure, color and nutritional quality of dried products, while the experimental set-up and drying methods were sometimes questionable
- Any change made in one aspect of the drying heat pump system will inevitably influence many others
  - dehumidification capacity
  - different products (solids, liquids)
  - drying modes (batch, continuously, intermittent)
  - drying mediums (air, inert gases, CO2)
  - (negative/positive) temperatures
  - system control

Any convective-type dryer can be fitted with a suitable designed heat pump !

Source: Minea, V., Part II – Drying heat pumps – Agro-food, biological and wood products, International Journal of Refrigeration (2012)

Current state of the art

Application examples: few implementations up to the present day
Described most frequently in litterature:
- sludge drying
- wood drying
- drying of food products: herbs, fruit (apples, banana's, nuts…)

Some researchers point at the following bottlenecks:

- Uncertainty by potential users as to heat pump reliability
- Lack of good hardware in some types of potential applications
- Lack of experimental and demonstration installations in different types of industries
- Lack of required knowledge of chemical engineering and heat pump technology in target industries
- Relative cost of electricity and fossil fuels affecting the commercial viability of drying heat pumps

Minea, V., 2011, Industrial Drying Heat Pumps,
Refrigeration: Theory, Technology and Applications (Larsern, M.E.), Nova Science Publishers, Inc.

STC (Spain): Thermal sludge drying at low temperature

STC

e.g. reference:
LOUIS FARGUE (Bordeaux – France)

15,000 t/year of urban sludge
From 30% to 90% dry matter
1 line x 1,400 l/h
Heat pump technology + 30% biogas

Application: wood drying

High-Temperature Wood Drying Heat Pump

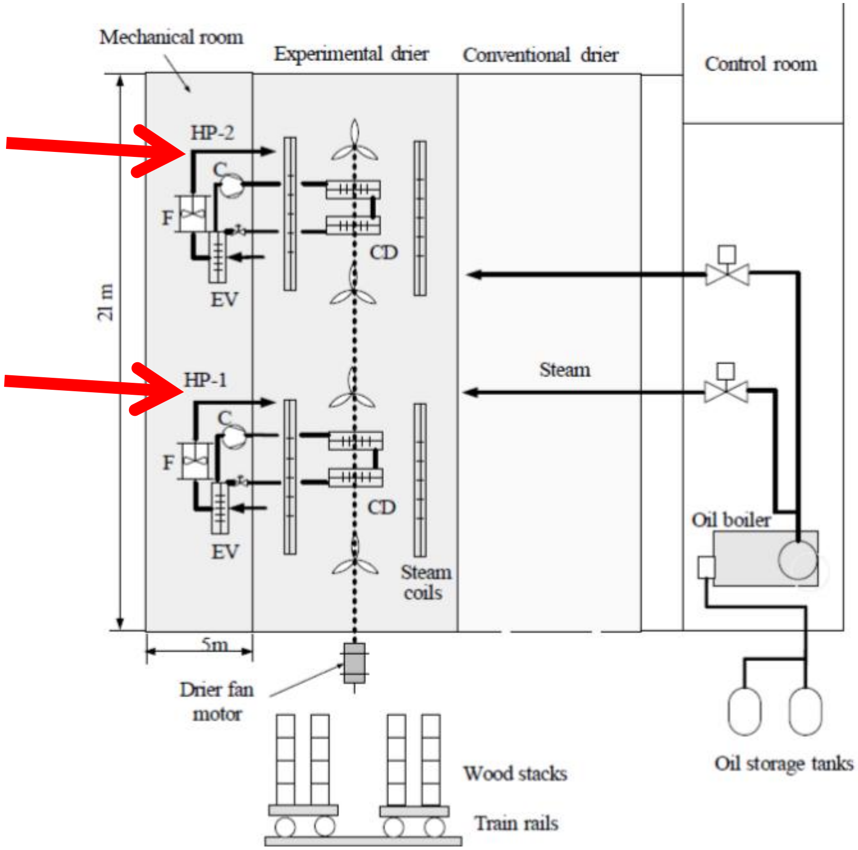
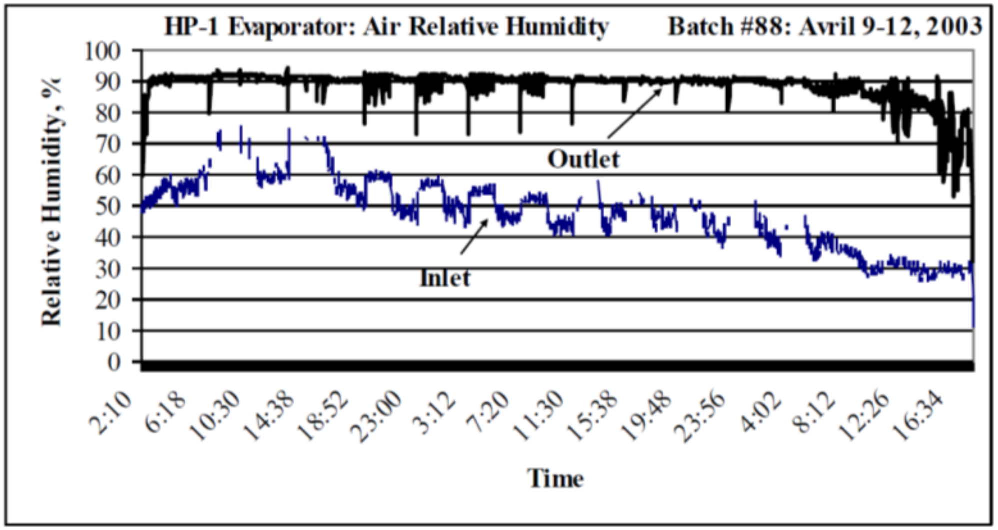


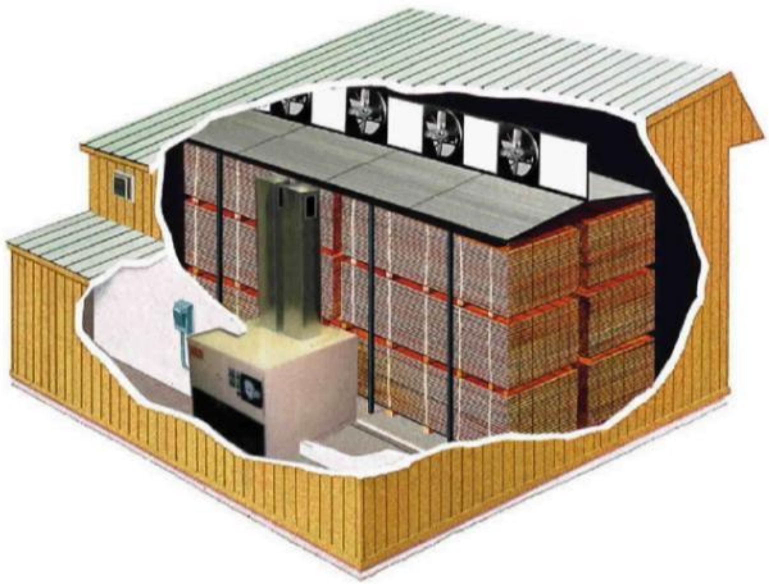
Figure 1 –View of the Experimental Wood Dryer (on left)



Source: Minea 2004 HEAT PUMPS FOR WOOD DRYING - NEW DEVELOPMENTS AND PRELIMINARY RESULTS

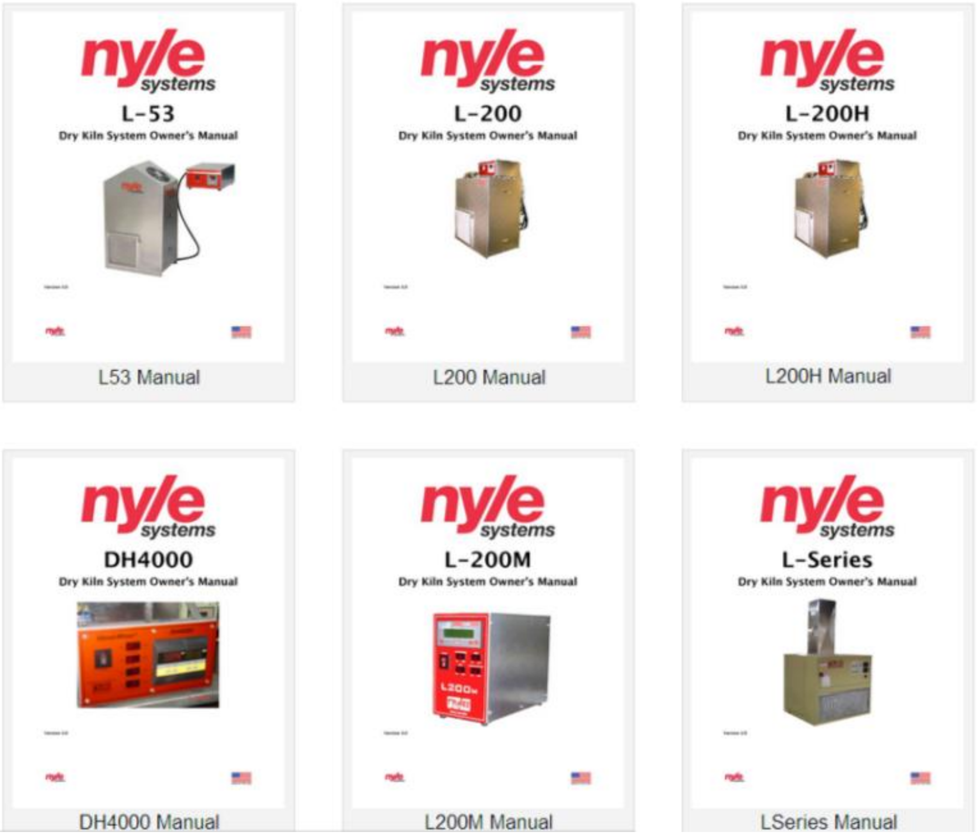
Figure 6.11. Air relative humidity entering and leaving the heat pump evaporator.

Application: wood drying



nyle systems

Lumber Drying Systems



Application: food

Nyle Systems dryers use heat pumps to dry any product that is ideally dried between 4°C and 93°C

Food applications where our dryers are used include:

- Confectionary (Candy)
- Croutons
- Fish & Sea Cucumber
- Fruits (Apple, Tomato, Blueberry, Pineapple, Papaya)
- Meat (Beef Jerky)
- Mushrooms
- Scrambled eggs (part of ready-to-eat meals)
- Seaweed

Other Products where our dryers are used include:

- Drum Sticks
- Fluorescent tubes and light bulbs
- Helicopter Blades
- Ink (on paper)
- Leather
- Lumber
- Paint
- Paper Core

Application: food

ATB Leibniz-Institut für Agrartechnik Potsdam-Bornim e.V.

ATB Drying Group

Drying moist crops such as medicinal and spice plants.
By combining heat pumps with conventional air heating for low-temperature drying processes, energy savings of already 30 %.

Heat pump drying of medicinal plants (semi-technical scale)

Example: Batch type drying plant with heat pumps Agrarprodukte Ludwigshof e.G. (Thuringia)

Application: food

Advantages found in litterature:

- Heat pump dryers are **cost-effective** for drying solid food products and other labile substances
- Relatively low drying temperatures (25-45°C)
- Systems ***operate independently of ambient conditions*** as totally enclosed systems
- Higher rehydration capacity
- Better color retention with less browning effect
- Higher retention of vitamin C
- Better preservation of volatile compounds

Source: Minea, V., Part II – Drying heat pumps – Agro-food, biological and wood products, International Journal of Refrigeration (2012)
Ong, S.P. & Law, C.L., 2009. Intermittent heat pump drying in food and vegetable processing (2009)

Approach

Submitting of a well documented and structured project proposal on which the activities are to subdivide as:

1) Technology exploration

To present the state of the art via literature search, contacts with research organizations and companies.

2) Technology translation

To check technical and economical feasibility within industrial processes with the help of case studies, detected within the user group member companies.

3) Technology distribution and valorization

Project results will be distributed via publications, presentations on seminars and conferences, lecturers… to reach the broad target group.

User Committee

Further development of the project request:
- This presentation aims at helping us to obtain insight in your industrial intrest for the project concept
- Adjustments are possible, additional proposals are welcome
- Call for proposals of case studies (confidentiality is possible to a certain degree, will be further discussed).
- Contacting potential scientific partners, inland or abroad (CORNET)
- Composing a User Committee through Letter of Intent for participation

Composition User Committee:
- Technology users (drying system operators, users)
- Technology providers (manufacturers, consultants…)
- Promoter institutions

User Committee

Engagement members User Committee:

- To (re)direct the project team (when discussed and agreed within the User Committee, IWT usually accepts "adjustments" during the process of the project)
- Involvement at User Committee meetings on a regular basis (typically 3x per year).
- Financial contribution to the 7.5% cofinancing

Cofinancing:

Project budget Flemish part CORNET max. € 480 000

Cofinancing (7,5% = max. € 36 000)

Equitable sharing among industrial partners User Committee (usually 10 - 15 or more companies, among which minimally 4 SME's)

Equitable = according to company size, importance of results for company, whether or not developing case study for company

User Committee

Advantages for User Committee:

- First hand knowledge of project results, prior to broader audience.
- Important knowlegde bonus for your company
- Possibility to evaluate scientific knowledge and technology to a specific application, e.g. via a case study
- Numerous networking opportunities during meetings User Committees and other activities

Via CORNET-framework:

CORNET partner countries/regions

Country/Region	Funding Agency
Austria	Austrian Research Promotion Agency
Belgium-Flanders	Agency for Innovation by Science and Technology
Belgium-Wallonie	Service Public de Wallonie
Cyprus	Research Promotion Foundation
Czech Republic	Czech Ministry of Industry and Trade
Germany - Programme Owner	Ministry of Economics and Technology
Germany - Programme Manager	German Federation of Industrial Research Associations
Poland	National Centre for Research and Development
The Netherlands	Agentschap NL

International dimension

Interested in collaboration with **Poland** because of:
- Wood drying as a high potential application
- Interest detected within several Polish universities
- Existence of a Polish heat pump platform

PORT PC

- Unique collaboration opportunities because of the presence of a Russian (and some Polish) speaking researcher within our team.

More info ? Please contact:

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www.orcycle.eu www.cornet-w2pheat.eu