STF11 A92005

IEA Implementing Agreement on Advanced Heat Pumps

ÅRSRAPPORT 1991

SINTEF RAPPORT

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Rapportnummer STF11 A92005	D
Gradering åpen	

Rapportens tittel IEA Implementing Agreement on Advanced Heat Pumps ÅRSRAPPORT 1991	Dato 1991-01-27 Antall sider og bilag 5 + 9
Saksbearbeider/forfatter Rune Aarlien, Geir Eggen	Ansv. sign. Per-Erling Frivik Per-Erling Frivik
Avdeling Kuldeteknikk	Prosjektnummer 113213
ISBN nr. 82-595-7236-2	Prisgruppe

Oppdragsgiver NTNF	Oppdr.givers ref. Ulf Rivenæs

Ekstrakt

IEA-aktiviteter innenfor varmepumpeområdet er i 1991 hovedsaklig satt inn på to områder:

- Formannsvervet i Executive-komiteen for Implementing Agreement on Advanced Heat Pumps ved Per-Erling Frivik. Foruten ledelse av all varmepumpeaktivitet i IEA, er det i 1991 arbeidet spesielt med strategiplanen for 90-årene.

- Etablering av et sterkt National Team, som fra 1991 er identisk med programstyret og programledelse for "Program for anvendelse av varmepumper".

I tillegg er det startet opp et par nye annexer som går på anvendelse og sikkerhet med nye medier, hvor Norge skal delta.

	Stikkord på norsk	Indexing Terms: English
Gruppe 1	Kuldeteknikk	Refrigeration Engineering
Gruppe 2	Energi	Energy
Egenvalgte stikkord	Varmepumper	Heat Pumps
	Forskning	Research
	Utvikling	Development

SLF-126-86

IEA Implementing Agreement for a Programme of Research and Development on Advanced Heat Pump Systems:

ÅRSRAPPORT 1991

Generelt:

Ved inngangen til 1991 var Norges deltagelse innen IEA Implementing Agreement (IA) begrenset til Annex XVI; Heat Pump Centre (HPC). Det har imidlertid vært stor interesse for og arbeidet mye med å komme med i nye annexer, hvorav følgende er startet opp i 1991:

Annex XVII:	Experiences with New Refrigerants in Evaporators (med Sverige som Operating Agent).
Annex XX:	Working Fluid Safety (der Belgia er Operating Agent).
Annex XXI:	Global Environmental Benefits of Industrial Heat Pumps (Operating Agent er USA).

Formelt er vi med i Annex XVII, mens det ennå arbeides med å skaffe industripartnere og finansiering til Annex XX og Annex XXI. Annx XXI er formelt startet på den betingelse at nødvendig finansiering tilveiebringes.

I løpet av året er det utarbeidet et utkast til strategisk plan for varmepumpeaktiviteten innen IEA. Planen omfatter det som gjenstår av dette tiåret, da vedkommende IA avsluttes ved utgangen av 1999. Den norske aktiviteten innenfor IEA-arbeidet har vært betydelig, og innsatsen har i år som i fjor vært rettet mot følgende to hovedområder:

1 formannsverv i Eksekutivkommiteen (EXC) i IA on Advanced Heat Pumps, ved professor Per-Erling Frivik og

2 norsk National Team for varmepumper

Aktiviteter:

<u>1</u> <u>Formannsverv i Eksekutivkommiteen</u>

Professor Per-Erling Frivik er formann i EXC for IEA IA on Advanced Heat Pump Systems fra 1989 til 1992. Dette vervet medfører ledelse av all varmepumpeaktivitet i IEA, forberedelse og gjennomføring av møter, referater, oppfølging av annexer, m.m. Det er i 1991 spesielt lagt vekt på arbeidet med strategiplanen for det som gjenstår av 90-årene. Planens overordnede mål er å utvikle samarbeid og koordinering med andre virksomheter, både i og utenfor IEA.

Arbeidsinnsatsen for året kan kort oppsummeres til:

* Forberedelse og gjennomføring av møter i EXC:
  - Sittard, Nederland: 1991-04-4/5
  - Stockholm, Sverige: 1991-11-7/8

* Møter med potensielle medlemsland til Annex XVI, HPC:
  - Roma, Italia: 1991-03-20
  - Madrid, Spania: 1991-11-21
  - Lisboa, Portugal: 1991-11-22

* Utarbeidet utkast til strategisk plan (vedlegg 1).

* Deltagelse med to foredrag i Workshop om industrivarmepumper i Budapest 1991-10-24/25 (vedlegg 2).

* Deltagelse i møte om Clearinghouse Network i Paris 1991-09-9/10. Dette er en etablering av et informasjons-/kompetansesenter for energi og drivhusproblematikken.

* Forberedelse av nye annexer, bl.a. "Industrivarmepumper" og "Sikkerhet med nye arbeidsmedier".

2 Norsk National Team for varmepumper

Arbeidet med etableringen av et norsk National Team (NT) startet i januar 1990. Målsettingen er å dra nytte av og bidra til den aktiviteten som skjer internasjonalt på varmepumpeområdet. NTH-SINTEF Kuldeteknikk er sekretariat for aktiviteten. Geir Eggen har vært leder frem til høsten 1991 da Rune Aarlien overtok ansvaret. Aktivteten for NT har i 1991 bestått av:

* Nasjonale NT-møter:
  - strategimøte på Leangkollen 1991-02-18/19 der handlingsplan og budsjett for 1991 ble fastlagt (13 deltagere).
  - møte på Soria Moria konferansesenter 1991-10-09 (14 deltagere). Møtet var et ledd i forberedelsene til det internasjonale NT-møtet. Referater er gitt i vedlegg 3.

* Internasjonalt NT-arbeidsmøte:
  - Rune Aarlien og Geir Eggen deltok på det 3. National Team Working Meeting i Stein/Urmond, Nederland, 1991-10-14/15. Møtereferat er gitt i vedlegg 4.

* Forberedelser av nye annexer som kan ha interesse for Norge:
  - Geir Skaugen deltok i oppstartmøte om nye kuldemedier i fordampere (Annex XVII) i Zurich, Sveits, 1991-04-08

- Geir Eggen deltok i planlegging av nytt annex om industrivarmepumper i Sittard, Nederland, 1991-06-18. Møtereferater er gitt i vedlegg 5.

* Deltagelse i IEA workshops:
  - Einar Grønnevik (Normann Energiteknikk) og Geir Eggen deltok i workshop om "Ground-Source Heat Pumps - Advancements Towards Cost Reduciton" i Montreal, Canada, 1991-08-12/13. Referat gjengitt i vedlegg 6.
  - Per-Erling Frivik var som formann i EXC engasjert i Workshop om "Industrial Heat Pumps" i Budapest, Ungarn, 1991-10-24/25.

* Deltagelse på EXC-møte:
  - Rune Aarlien deltok på møtet i Stocholm 91-11-7/8. Referat er gjengitt i vedlegg 7

* Produsert to artikler til HPC Newsletter (begge aksepert):
  - *Geir Eggen og Odd M. Nesje:* Experiences from Air-Based Heat Pums in Cold Districts, Vol.9, No.2, Juni 1991 (Vedlegg 8).
  - *Per Johansen:* Heat Pumps in Salmon Smolt Hatcheries, Vol.9, No.3, 1991 (Vedlegg 8).

* Innlevert to anbud til analyser for HPC:
  - Impacts of Heat Pumps on the Greenhouse Effect
  - Domestic Hot Water Heat Pumps in Residential and Commercial Buildings

  Det lyktes ikke å få noe oppdrag i året som gikk.

* Planlegging og gjennomføring av fire delegasjonsbesøk fra Japan:
  - Thermostock 91 & New Urban Energy Systems Survey Mission, 1991-05-15/18
  - Osaka Science and Technology Center, 1991-10-01
  - Japanese Association of Refrigeration, 1991-10-09/12
  - Heat Pump Technology Center of Japan, Sources for HP Technology Exchange Mission, 1991-11-02/06
    Diverse informasjon er gitt i vedlegg 9.

I løpet av året har det skjedd en del utskiftninger av NTs medlemmer. Under "Program for anvendelse av varmepumper" (PVP) ble det vedtatt at NT skulle bestå av PVPs programstyre og sekretariat. Dette betyr at NT nå har følgende medlemmer:

Ulf Rivenæs, Energy Communication Systems
Helge Lunde, Refconsult
Per R. Samuelsen, AS Finsam
Per Finden, IFE
Ole Andreas Flagstad, IFE
Magne Amundsen, NVE
Mats Rosenberg, NEVF
Tom Svenningsen, Normann Energiteknikk
Per-Erling Frivik, SINTEF Kuldeteknikk
Geir Eggen, SINTEF Kuldetekinkk
Rune Aarlien, SINTEF Kuldeteknikk

Regnskap

Post	EXC	NT	TOT
Timekostnader	239.228	257.167	496.395
Leiestedskostnader	0	2.400	2.400
Materialer og komponenter	0	325	325
Ekstern utstyrsleie	0	550	550
Kontor- og trykkeutgifter	15.138	290.300	305.438
Reise- og møteutgifter	96.483	103.681	200.164
Påløpt i 1991	350.849	654.423	1.005.272
Balanse pr 1991-01-01			1.048
Balanse før bevilgning			1.004.224
Bevilgning 1991			880.000
Balanse pr 1992-01-01			(124.224)

Noter:

1 Medlemskontingent på kr 281.484 er inkludert i National Teams post for kontor- og trykkeutgifter.

2 Den negative balansen vil bli avskrevet for Kuldeteknikks egen regning.

Liste over vedlegg

1 IEA Executive Committee for Implementing Agreement on Advanced Heat Pump Systems: *Draft Strategy Plan for the Period of 1992 - 1999.*

2 Per-Erling Frivik: *Industrial Heat Pumps in Norway (presentation notes).*

3 Program for anvendelse av varmepumper: *Delprosjekt VP-IEA, Handlingsplan 1991.*
Rune Aarlien: *Møtereferat fra National Team møte på Soria Moria, 91-09-09.*

4 Rune Aarlien: *Møtereferat fra internasjonalt National Team arbeidsmøte i Stein/Urmond, Nederland, 91-10-14/15.*

5 Geir Skaugen: *Møtereferat fra First Working Meeting i Annex XVII i Zurich, Svetis, 91-04-8/9.*
Geir Eggen: *Møtereferat fra ekspertmøte i Sitterd, Nederland, 91-06-18 (Industrial Heat Pumping).*

6 Geir Eggen: *Møtereferat fra IEA Workshop i Montreal, Canada, 91-08-12/13 (Ground-Source Heat Pumps).*

7 Rune Aarlien: *Møtereferat fra møte i IEA's eksekutivkommite for Implementing Agreement on Heat Pump Systems, Stockholm, 91-11-6/8.*

8 Geir Eggen og Odd M.Nesje: *Experiences freom Air-Based Heat Pumps in Cold Districts (paper).*
Per Johansen: *Heat Pumps in Salmon Smolt Hatcheries (paper).*

9 Geir Eggen: *Diverse informasjon on japanske delegasjoner.*

Vedlegg 1

Draft Strategy Plan for the Implementing Agreement for a programme of Research, Development and Demonstration
on
Heat Pumping Technologies
in

Heat Pumps, Air Conditioning and Refrigeration Systems

for

The Period of 1992 - 1999

Version 2.0

HEAT PUMPING - AN IMPORTANT PART OF A SUSTAINABLE ENERGY SYSTEM

"If every human being in this world should have a livable existence in the coming decennium without changing our habits of producing and consuming, energy usage will increase eight-fold. This is impossible, intolerable and a perilous attack on our environment.
The industrialized countries have the greatest responsibility for a justified use of primary energy, an efficient use of natural resources and the abatement of waste and pollution."

According to UN reports it has been accepted that it should be possible to reduce energy consumption per capita with 50% in the industrialized countries.

SUMMARY (to be drafted)

INTRODUCTION

In 1989 a review of the Implementing Agreement on Advanced Heat Pumps (IA) has been concluded. The review team stated as a conclusion that, in general, the IA has been conducted in accordance with its original objectives. The benefits of the IA extend beyond the modest technological developments made, several Annexes demonstrating the strong value of international collaboration.

After a reassessment of the IEA Heat Pump Centre (HPC) in the period 1988-1989, given the present energy price and environmental situation, the chairman of the Executive Committee (EXC) of the IA launched the idea of starting a discussion on future strategy of the IA. It was felt that reviewing the aims of the IA would be reasonable and international cooperation in the field of heat pumps under the auspices of the IEA should be reassessed and ultimately reorganised, especially with regard to global environmental challenges.
This will create new building blocks and add to the critical mass and profile of the IA, bearing in mind that the heat pump offers an adequate answer to energy and environmental problems.

PRESENT SITUATION (1985-1990)

General

The IA started in July 1978. The original objectives of the programme are:
"To assess the current state-of-the-art of heat pumps, their market potential, and to develop new heat pumps jointly."

Contracting Parties are Austria, Belgium, Canada, Denmark, Finland, FR.Germany, Ireland, Italy, Japan, Netherlands, Norway, Spain, Sweden, Switzerland, UK and the USA.
The IA basically consists of collaborative projects between countries, socalled Annexes, both technical and market related. Annexes fall into two categories, i.e. cost sharing and task sharing. Combinations of both also exist. Ultimo 1990 approximately 10 Annexes have been concluded and reported, see Attachment 1.
With a few exceptions, the Annexes are limited, in general, to reviews, case studies and software studies rather than experimental R.D&D activities. One constraint concerns financing, whereas active collaboration is hampered also by geographical location of participants. There is some inconsistency in countries participation in Annexes and taking the role of Operating Agent (OA).

Industrial involvement in Annexes and other gremia within the IA is essential if energy technology is to move rapidly from the research stage to market deployment. Moreover, it will strengthen the position and awareness of the IA. However, industry's perception of Annexes and the use of generated data by industry is presently at a rather low level. This can partly be explained by the low priority image of the heat pump in the mind of industry at present, and by the low profile of the IA on advanced heat pumps.

Information dissemination from IA work and knowledge transfer with regard to Annexes and the outcome is hampered by the present restricted character. Information comes available for non-participants, however, only in level II reports. The contents of these reports usually are insufficient to be of value to non-participants, thereby having only limited effect. The reports are insufficient in detail to enable any reasonable technical or financial analysis.

The role of the IEA Secretariat is often unclear. Bureaucracy results in delays in the start of a new Annex. Responses do not come quickly, in general.

Coordination between IAs is underdeveloped. EXCs could benefit more from better coordination between related IAs, also on an Annex level.

In recent years, especially since the 1986 oil price fall, the trend in energy conservation and heat pump R.D&D has been interrupted. Interest and budgets declined and energy-efficiency was not a top-priority.

Overall, the IA has lead to improvements in heat pump technolgy, although on a modest scale. In addition, the strong value of international collaboration comes to value by using financial resources and efforts in an efficient way.

Annex XVI - Heat Pump Centre

The HPC is an Annex that has been extended a number of times since its establishment in 1982, although participants in this Annex have varied. The HPC is a typical cost sharing Annex. The participants contribute to a common fund for operation of the information processing Centre.
Functioning of the Centre has been reassessed in 1988-1989 by a sub-committee, chaired by prof. P.E. Frivik, present chairman of the EXC. The conclusion and recommendation were that the HPC should continue its work and an adequate structure be developed to take the HPC in the future.

In the meantime the OA of the HPC changed from FIZ, F.R. Germany, to Novem, the Netherlands and a new Annex (XVI) was created to that end. New elements in the HPC are the wider scope of work, to include related technologies like air conditioning and refrigeration (1); adopting promotion as one of the means to achieve the objectives (2); and increased involvement of the private sector in the HPC and the IA (3). A possible instrument to achieve the latter is the so-called Special Task.
Another modification has been the replacement of the Steering Committee by an Advisory Board (AB) to the HPC. The AB's primary task is to advice the HPC and survey the work. The objective is to further improve the HPC's links to the market and the research community. The AB will be composed of highly qualified experts from research, utilities, industry and marketing.

In many participating countries the National Teams (NT) have been reorganised and strengthened so as to bring in a representative of the target groups (government, private industry, gas/electricity utilities, consultants, researchers).

A time period of 3 years exists for the HPC (present period January 1990-1993). Each year the EXC decides upon extension, creating a 3-year horizon for the OA.

Conclusions

- Interest in heat pump R.D&D has declined since the oil price fall in 1986.
- The energy saving potential on the basis of energy prices alone, has moved from short term to medium or long term. However, with increasing environmental pressure likely to influence the use of energy-efficient technologies, the IA will become extra relevant.

- The IEA is getting "value for money" from the IA.

- The profile of the IA should be higher in order to increase industrial interest and involvement, especially as far as documentation of industrial benefit is concerned.

A short-form overview of the IA can be found in Appendix 3 - section 6.

STRATEGY OF THE IA 1992 - 1999

Goals

The main goals of the IA will be to:

G1 - act forcefully and focused based on careful planning and performance within the period from 1992 to 1999 and then to conclude and terminate all its activity at the end of 1999

G2 - establish heat pumps as a realistic, reliable and well known device to save primary energy and to reduce local and global emissions - especially CO_2

G3 - increase the installed base of heat pumps by a factor of 5 (20% annual growth) with respect to heat production

G4 - take advantage of and contribute to joint development and use of common components, working media and systems in heat pumps air conditioning and refrigeration systems

This will give the heat pump the proper position in future energy systems and at the same time avoid duplication of work in related areas

The means to achieve the goals are:

- conducting collaborative research, development and demonstration

- providing insight in existing and newly available markets

- promotion, especially to decision-makers/end-users outside the heat pump expert community

- information exchange and knowledge transfer on heat pumps and related technologies

It is a growing understanding that challenges related to energy conservation and environmental issues can best, perhaps only, be solved by international cooperation. However, for the efficiency of such a cooperation, specific national goals should be identified and pursued.

Strategies

The basis for the strategy plan is long-term planning rather than an ad-hoc policy. End-use energy efficiency and environmental issues will be in the centre of the work. A long-term horizon also implies that results of e.g. R&D will become available for implementation after 3 to 5 years or so. This enables definition of new and extended R&D and planning the strategy to achieve the goals.

Although important, energy price fluctuations and economic considerations should not dominate and determine national and international collaborative heat pump work. A more systematic approach to environmental and energy challenges will be adopted.

Main strategies and actions to achieve the goals are:

> S1 - strategy
>
> Establish a long term stable commitment for the period from 1992 to 1999 among the signatory parties to the IA and improve the efficiency of planning, organization and operations within the IA.

S1.A1 - Action

Seek support for the strategy plan (SP) from the contracting parties, amend the legal texts of the IA and Annex XVI and get them approved by IEA office of Legal Council (OLC), decide on the SP in the ExCo, and set it into action as soon as possible (spring 1992).

S1.A2 - Action

Introduce strategic planning and management by objectives (MbO) in the ExCo:

Define objectives and follow up on results and deviations

S1.A3 - Action

Limit the term of office for chairman/Vice-chairman of the ExCo to maximum 3 years.

(Needs amendment in Article 3 (d)(1) of the Legal text of the IA)

S1.A4 - Action

Produce plans for the 4 remaining working periods of the IA and Annex XVI:

1990-1992: Detailed plans for 1992. Start-up of Strategic Plan

1993-1995: Strategic and detailed plans (revised every year) for work period

1996-1998: Strategic plans for work period

1999: Strategic plans to conclude and terminate all activities within the IA

Produce plans for the 3 remaining IEA HP Conferences to be held:

1993: Europe

1996: North America/Southern/Eastern Europe - results from the working period 1993 - 1995.

1999: Final conference in Paris, France. Results from the working period from 1996 - 1998 (avoid date conflict with IIR Conference same year)

S1.A5 - Action

Make Annex XVI Heat Pump Centre the focal point of the IA for the period from 1992 to 1999 by letting it perform the following services:

- secretarial services to the ExCo and its chairman
  - planning and preparing ExCo meetings
  - preparing minutes from ExCo meetings
- follow-up on on-going services
  - level II reports
  - final reports in writing/oral to the ExCo
  - disseminating annex results
  - attending work meetings
- assistance in preparing and setting up new annexes
  - preparing consistant legal text
  - getting it through IEA Office of Legal Council
  - seeking participants through contact with National Teams
- preparing the annual progress report for the IA to the IEA Secretariate
- circulate relevant information from IEA (Newsletter) and other sources to ExCo and NT
- Keep files and reports for the IA

S1.A6 - Action

Create National Teams in all countries active in the IA, and make NT serve the IA, not only the HPC.

S1.A7 - Action

Introduce a basic membership in Annex XVI HPC for all participants active in the IA with an annual contribution of D.fl. 10.000,- to cover the S1.A5 - Action. The contribution of full members in Annex XVI should be raised accordingly.

(See Appendix 8 - section 11)

S1.A8 - Action

Amend article 3(b)(10) and 5(a) of the legal text of Annex XVI in order to incorporate Actions S1.A5 and S1.A6.

S1.A9 - Action

Start a new annex or HPC Task on Policy Analysis concerning

Energy, Environment and Economy

to guide the ExCo in their actions and information activities towards politicians and the public

S2 - Strategy Increase the participation in the IA and HPC from new countries and international organisations

S2.A1 - Action

Invite countries active in the IA to full membership in Annex XVI HPC with reference to the strategy plan:

- Belgium, Denmark, Finland, Germany, Switzerland, UK

(if more participants: increase activity - not decrease contribution)

S2.A2 - Action

Invite new countries within OECD to the IA with reference to the strategy plan, either to basic or full membership in Annex XVI HPC:

- France, Greece, Portugal, Spain

They can be members by signing the IA and with ExCo's approval and agreement from the IEA Governing Board, see Appendix 6 - section 8.

S2.A3 - Action

Invite countries outside OECD first as observers to ExCo's meeting, and then as associate's participants in Annex XVI with basic or full membership:

First step: Some East-European Countries

They can be associate's participants according to Appendix 6 - Section 8, Articles IV (e), VI (d), VII and IX, with agreement from the ExCo and the IEA Governing Board

S2.A4 - Action

Invite CEC DG 12 according to procedures in S2.A2.

S2.A5 - Action

Invite International Institute of Refrigeration by its Director to basic membership in Annex XVI HPC according to procedures in S2.A3 or as observer (IIR Director should participate in ExCo's meeting to secure maximum coordination of activity).

S3 - Strategy Build and strengthen new/existing internal and external networks

S3.A1 - Action

Invite other IEA IA and Information Centres to workshop on:

"What do they need on HPs and related technologies -
What can we do for them -
How can we coordinate and focus our activity":

IAs:
- SHC - Solar Heating and Cooling
- BCS - Energy Conservation in Building and Community Systems
- DH - District Heating
- ES - Energy Storage
- HTHE - Heat Transfer and Heat Exchangers
- PP - Pulp and Paper
- ETSAP - Energy Technology Systems' Analysis

Info Centres:

AIVC - Air Infiltration and Ventilation Centre (Annex of BCS)
CADDET- Center for Analysis and Dissemination of Demonstrated End Use Technologies
EDTE - Energy Technology Data Exchange

Workshop should be held end of -92/early -93

S3.A2 - Action

Arrange topical workshops in new countries -

i.e. - Heating and cooling in Greece, Portugal, Spain
- Heat Pumps and local/global emissions in East European Countries

S3.A3 - Action

Invite IIR, UNEP and other organisations to topical workshops (CFC, CO_2-mitigating technologies) and to our HP Conferences

S3.A4 - Action

Declare our willingness to support/participate in the IEA Energy Technology Clearinghouse within agreed-upon frames and conditions.

S4 - Strategy

Involve private industry and utilities (gas and electric) in the activity in the IA with reference to strategy plan (SP) and HPC Special Task

S4.A1 - Action

Approach private companies and gas/electric utilities via NT with info material on the IA and the SP

S4.A3 - Action

Contact big companies supplying HP/Air Conditioning/Refrigeration equipment, as well as industrial end-users to annexes, work shops, special task via HPC

S4.A3 - Action

Start new annexes that interests industry:

- standards
- newly available markets

Invite industry to start Annexes/Special Tasks

> S5 - Strategy
>
> Establish a systematic and strong promotion, information and educational activity directed towards individuals and society outside the heat pump expert community on the qualities, capabilities and consequences on the use of energy in general and of heat pumps in particular

S5.A1 - Action

Print a leaflet on the IA and our strategy.

S5.A2 - Action

Take info from annexes and tasks, and from open sources, and disseminate precise and reliable information in one or more brochures on quality of energy and its influence on the environment, and what existing heat pump systems already does and can do with respect to:

- higher end use energy efficiency
- reduced local and global emissions

and that it can lead to:

- reduced oil/gas import
- improved balance of trade

and how improved systems and widespread use can lead to a decisive influence of HPs in the future energy system.

The IA/HPC should provide basic, reliable material ("Approved and stamped by IEA").

This should be done in a HPC Task.

S5.A2 - Action

Seek alliances with other organizations (IIR, UNEP), National Teams, Energy Conservation Programs, Energy Utilities, other IEA IA, especially CADDET and the new clearinghouse, in order to systematically disseminate information.

S6 - Strategy

Improve efficiency, investment cost, and reliability figures of HP systems by 50% in the strategic period by addressing HP component and peripheral equipment as well as the systems that HPs are integrated into.

S6.A1 - Action

Establish an R,D&D annex for the period of 1993 - 1995 on efficiency improvement of heat pump units and systems.

Targets for 1995: SPF 4-6, PER 1,5
exergetic efficiency 40%, emissions of gas fired systems comparable with gas furnaces.

Content of annex:

- how good are present-day systems?
- where/how can they be improved?
- let's do it

(See suggestions from the Vettre meeting)

S6.A2 - Action

Establish an R&D&D annex for the period of 1993-1995 on cost and reliability improvement of HP units and systems.

Targets for 1995:	investment cost reduction	35%
	reliability figures (maintenance)	40%

Content of annex → same procedure as S6.A1.

Both annexes should focus heavily on the systems that HP units are integrated into, as well as peripheral equipment, such as gas/el supply and control (PLS), heat distribution systems (temperature level) etc.

S7 - Strategy

Remove the CFC - image from HP systems

S7.A1 - Action

Establish a new annex/HPC Special Task for the period of 1993 - 1995 on technical and economical consequences of, and specific experience with, CFC replacement working fluids in HP and AC units and systems.

S8 - Strategy

Investigate, develop and demonstrate the combined advantages between HP, AC and R components and systems with respect to end use, supply and R,D&D.

S8.A1 - Action

Establish a new annex/HPC Special Task for the period of 1993 - 1995 to explore the combined advantages in:

- end-use (simultaneous heating/cooling, dual-mode units/systems)
- manufacturing and supply of component and systems
- common R&D&D

S9 - Strategy

Facilitate international trade and common and safe design, installation and operation of HP systems

S9.A1 - Action

Establish an annex/HPC Special Task/Ad Hoc Group for the period of 1992-1994 on standards for design, testing, installation and operation of HP units and systems.

In the strategy elements described, international cooperation and coordination play a major role and only joint work with widespread dissemination of results will allow for an efficient use of effort and funding. This will speed up the process of achieving the goals and lead to quicker understanding.

In contrast with the past decade, conservation of fossil fuel will not be valued by cost effectiveness alone, but instead conservation is expected to be valued much more by environmental effectiveness.

Vedlegg 2

Industrial Heat Pumps in Norway

Heat pumps in industrial processes are characterized by small pressure ratios and long operation times and are therefore often very profitable.

Table 1 shows the application of heat pumps in industry in Norway - status 1990. Around 600 heat pumps are installed, with a heat capacity of approximately 100 MW. Fig. 1 shows a grafic representation of the heat pumps in different industrial sectors, both with respect to the numbers and heating capacities.

The last column in Table 1 shows the total energy potential to be covered by heat pumps in different industrial sectors. Fig. 2 shows this potential for heat pumps compared with the industrial primary energy consumption in 1986.

Identification of industrial sectors and processes.

Process water heating

The most successful areas in heat pump development during the last years in Norway has been in fish farming plants. Fish farming is the fastest growing industry in Norway, and since 1980 installed approximately 250 heat pumps for heating process water for smolt production plants have been installed.

Drying

Heat pumps are very suitable in drying processes, and in Norway more than 50 heat pumps for fish drying has been produced. Furthermore more than 200 small/medium sized heat pumps for wood drying have been installed, and about 40 plants for drying of skins.

Evaporation

In the food processing industry and paper industry several large heat pump systems for evaporation have been installed, most of them are thermo compressors.

- In the late 1970'ies 5 large thermo compressors were installed in the pulp and paper industry for evaporation.
- In the first half of the 1980'ies 3 "thermo compressors" were installed in the herring oil and meal industry.
- Around 1980 5 heat pumps operating with R12 as working fluid were installed in the dairy, most of them for evaporating. From 1987 until now 10 new developed open cycle heat pumps have been installed for evaporation.

High Temperature Heat Pumps for Steam Production

Around 1980 3 large heat pumps (thermo compressors) for steam production in the pulp and paper industry were installed.

Heat Pumps for Heat Recovery from Refr. Plants

More than 50 large heat pumps (200 - 2000 kW) using the condenser heat production from industrial refrigeration plants as heat source (food products, bakeries etc.) have been installed.

Vedlegg 3

PROGRAM FOR ANVENDELSE AV VARMEPUMPER

DELPROSJEKT VP-IEA, HANDLINGSPLAN 1991

Handlingsplanen er utarbeidet på grunnlag av diskusjoner og innspill i forbindelse med omleggingen av offentlig finansiert varmepumpevirksomhet i Norge. Handlingsplanen omfatter prosjektets to hovedaktiviteter:

* formannsvervet i eksekutivkomiteen for "Implementing Agreement on Advanced Heat Pumps", inkludert arbeidet med å lage ny strategiplan for varmepumpeaktiviteten i IEA.

* NATIONAL TEAM som bindeledd til det reorganiserte og vitaliserte IEA Heat Pump Centre. Programstyret i PVP er norsk National Team.

FORMANNSVERV I EKSEKUTIVKOMITEEN

Formannsvervet vil medføre følgende aktiviteter i 1991:

1 Forberedelse og gjennomføring av 2 hovedmøter i eksekutivkomiteen:
- Første møte: Nederland april 3 - 5
- Andre møte: ikke fastsatt enda

2 Oppfølging av Heat Pump Centre
Møter med:
- HPC administrasjon - direktør/sekretariat
- Advisory Board for HPC

3 Deltakelse i National Team møter nasjonalt og internasjonalt

4 Kontakt mot IEAs hovedkvarter/sekretariat i Paris og deltakelse i 1 - 2 møter
- End Users Working Party Committee
- Committee on Research and Development

5 Direkte møter med myndigheter/organisasjoner i IEA medlemsland

6 Sluttføre Strategisk Plan for varmepumpeområdet i IEA i 1991

HPC NATIONAL TEAM NORGE

National Team har som mål å dra nytte av og bidra til den aktiviteten som skjer internasjonalt på varmepumpeområdet. Det er derfor viktig å skape et nettverk av VP-personer som kan samles med jevne mellomrom for utveksling av erfaringer og for å koordinere VP-aktivitetene i Norge og i forhold til Heat Pump Centre (HPC).

I 1991 skal det legges vekt på følgende aktiviteter:

1 Avklaring av sammensetning og intern organisering av National Team

2 Informasjonsspredning. I tillegg til Newsletter og eventuell spredning av rapporter fra Workshops og analysearbeider, skal nyheter som kommer frem fra IEA's arbeid kort omtales i tidsskriftet KULDE.

3 Trekke analysearbeider til Norge. SINTEF Kuldeteknikk leverte inn anbud på et analyseprosjekt "Impact of heat pumps on the Greenhouse effect" 1. februar, men dette oppdraget gikk til Østerrike.

4 Deltakelse i følgende IEA-møter/workshops:
- Workshop i Montreal, Canada i august. 3 representanter fra Norge bør delta.
- National Team-samling i Holland 14. og 15. oktober. 2 representanter fra Norges National Team skal delta.
- Eventuelle andre workshops/IEA-møter

5 Arrangere en åpen VP-konferanse for erfaringsutveksling og informasjon om IEA's arbeid på varmepumper og om den FoU-virksomheten som skjer på varmepumpeområdet i Norge. Dette må koordineres med Norsk Kjøleteknisk Forening, som også har planer om et åpent VP-møte i 1991.

6 Innspill og deltakelse i IEA's info-virksomhet med blant annet artikler og notiser til Newsletter.

7 Hver enkelt National Team deltaker har ansvar for å fremme bruk av varmepumper innen sin sektor gjennom definerte mål, strategier og planer. Dette skal være en løpende aktivitet, og på National Teams møter skal deltakerne rapportere om utvikling og nye planer.

BUDSJETT 1991

Det er gitt samme bevilgning til IEA-arbeidet for 1991 som det var i 1990. Regnskap for 1990 er vedlagt årsrapport 1990 - IEA Implementing Agreement on Advanced Heat Pumps.

	Budsjett 1991	Herav til Heat Pump Centre	Til disposisjon
Formannsverv eksekutivkomite	450.000	100.000 *	350.000
HPC National Team	550.000	275.000 **	275.000
Sum	1.000.000	375.000	625.000

* Ekstern assistanse til HPC for sekretariatsfunksjon for formann i eksekutiv-komiteen

** Kontingent til IEA Heat Pump Centre

MØTE I NORSK NATIONAL TEAM

Dato: *9. sept., 1991*
Tid: *16:00 - 20:00,*
Sted: *Soria Moria Konferansesenter, Holmenkollen*

1 Geir Eggen ønsket velkommen.

2 Ulf Rivenes ga så status om varmepumpeaktiviteten generelt i Norge. All aktivitet skal nå kanaliseres gjennom PVP. Videre pratet han litt om bransjens sterkt fragmenterte struktur. For tiden er man også i programmstyret opptatt av at kommende støtteordninger til VP-installasjoner ikke må få "ødelegge" markedet og gi en effekt som man tidligere har hatt i Sverige. Noe må gjøres for å hindre dette.

Det ble stilt spørsmål om størrelsen på IEA-potten, og antydet at National Team aktiviteten kanskje burde beskjæres noe, spesielt mhp. formannsvervet i IEA. Eggen fremholdt at dette vervet er av stor betydning og skaffer Norge god PR ute. Moen (NTNF), Finden (IFE) og Rivenes mente likevel at det kanskje ikke er riktig at PVP finansierer dette vervet. Det ble bestemt at dette skulle tas opp direkte med Frivik. Moen antydet at IEA-posten burde kunne reduseres fra ca. 1,1 mill. NOK til omtrent 600.000 NOK.

3 Undertegnede orienterte så om IEAs aktiviteter og delte ut et hefte med noe bakgrunnsinformasjon.

4 Det ble så gått en runde rundt bordet der alle kort presenterte sin aktivitet på VP-området. Dette gjaldt Ulf Rivenes, Per Samuelsen, Pål Skjæggestad, Terje Moen, Magne Amundsen, Elisabeth Lycke (NVE), Lars Haua, Tom Svenningsen, Per Finden, Ole Flagstad (IFE), Atle Nørstebø, Geir Eggen og undertegnede.

5 Eggen orienterte så om en kommende kuldekonferanse på Kuldeteknikk i regi av Norsk Kjøleteknisk Forening. Den forholdsvis store pågangen av japanske delegasjoner på norgesturne ble også kommentert.

6 National Team aktiviteter for '92 ble så diskutert. Det ble foreslått å arrangere 2 NT-møter, ett VP-seminar, delta i ett HPC-NT møte (*2 pers.), delta i ett Ex.Comm. møte (*2 pers.), delta i 2 workshops (*3 pers.), produsere en side om NT til hvert nr. av bladet KULDE, samt å få inn 4 artikler i HPC Newsletter. Det var også interesse for en NT ekskursjon til f.eks. Japan, men finansiering kan bli vanskelig å finne.

Til slutt ble det påpekt at de som deltar på noe bør bli flinkere til å informere resten av NT om det de har vært med på.

Rune Aarlien
1991-10-17

Vedlegg 4

HEAT PUMP CENTRE - NATIONAL TEAM, MØTE I HOLLAND

Geir Eggen og undertegnede har representert Norge på National Team-møtet (IEA Heat pump Centre) i Urmond, Nederland, 14. og 15. oktober. Det følgende er et sammendrag av de viktigste sakene.

Møtereferat, 91-10-14

Jos Bouma ønsket velkommen og understreket at han så frem til det sammenslåtte møtet mellom representanter for de forskjellige National Teams (NT) og HPC Advisory Board (AB). Dette var det første møtet av en sådan karakter.

Italias NT

Det Italienske NT (INT) ble presentert av Dr. Laura Manduzio. Hun representerte ENEA som er Italiensk "Contractor" til Annex XVI. INT har 12 medlemmer og statlige organer, energiverk, produsenter, leverandører, m.fl. er representert. ENEA sponser virksomheten med 5 mrd. lire årlig. Teamet hadde i 1991 to ordinære og ett preliminært møte, og har så langt drevet aktiv kommunikasjon overfor sine medlemmer og holdt en presentasjon for VP-produsenter. Medlemmene bidrar med medlemskontingenter.

Lokale NT aktiviteter og VP status

Neste programpost var en kort gjennomgang av de forskjellige NTs aktiviteter så langt i år samt status for VP i de forskjellige land. Nederland hadde bl.a. laget en utredning med anbefalinger om fremtidig bruk av VP i Nederland (sammendrag i vedlegg 1). Det ble videre uttrykt ønske om å kartlegge "gode" varmekilder rundt om i landet. Viktigheten av å bruke lavtemperatur systemer (kontra høyt.sys.) samt utarbeidelse av manualer for installasjon og vedlikehold ble også understreket.

Østerrike hadde dannet en organisasjon av VP leverandører. De sliter også med at gode og suksessrike anlegg ikke får nok PR. Promotion er et generelt problem.

Norge v/Geir fortalte om PVP-virksomheten (antas kjent for de fleste).

Sverige har spesielt vært opptatt av KFK-problematikken, og understreket sterkt behovet for informasjon på dette området om hva som er mulig på forskjellige anlegg med forskjellige temperaturnivå. Man har for tiden "problemet" med en ny regjering og nye mennesker å forholde seg til. Dette har til en viss grad sinket kommunikasjonen med det offentlige.

Mr. Broders fra USA hadde foretatt en analyse av abonnementslisten for Nyhetsbrevet (NB) for å danne seg et oppdatert bilde av hvem som mottar NB. I teamets første driftsår (i ny form) hadde mye vekt vært lagt til KFK- og drivhusproblematikken. Ett av møtene ble lagt rett før HPC-NT møtet så HPC kunne få skriftlige innspill fra det lokale USA-NT møtet.

Canada hadde også avholdt to møter. Teamet er nå relativt produsent-tungt og færre akademikere er med. Det har vært lagt vekt på å forsøke å involvere så mange markedssegmenter som mulig. Teamet vil foreta en analyse av abonnementslisten for NB - tilsvarende den som USA hadde gjennomført. Forslaget ble støttet av Bouma som oppfordret andre land til å gjøre det samme.

Nyhetsbrev
Det er en generell oppfatning at NB nå inneholder for mange artikler av vitenskapelig karakter. I stedet bør nyheter om suksessfulle VP-anlegg, lover og regler, rammebetingelser og markedspotensialer trekkes frem i større grad. Det må også legge mer vekt på å følge reglene for artikkelskriving (se vedlegg 2: Author's Guidelines). Slik det er nå bruker HPC alt for mye tid på redigering av innkommet materiell. De forskjellige NTs ble samtidig oppfordret til å skrive flere artikler.

Annex XVI: Progress Report, 1991
Progresjonsrapporten for inneværende år ble så gjennomgått (allerede delt ut på det norske NT møtet). Stort sett ble det som står gjennomgått. I tillegg ble det pekt på at Frivik for tiden jobber med en strategiplan for IEA som vil knytte annexene mere samme. Det ventes spent på denne planen. Det er også laget såkalte "Product Sheets" som beskriver HPC rapporter på ett A4 ark (vedlegg 3).

Framework, 1991
Innledningsvis ble flere spørsmål reist: går HPC i "riktig" retning?, trengs en internasjonal talsmann?, bør det åpnes for ikke-medlemsland? Det ble fra USAs side pekt på at de spesielt vil ønske Øst-Europeiske land velkomne (policy diskuteres nå i IEA). Diskusjonen ble forlatt relativt åpen, men HPC vil ha feedback.

Handlingsplan 1992
Topics for NB i 1992 skulle så bestemmes. Etter stryking og tilleggelser skulle det stemmes over listen i vedlegg 4. Resultatet er vist i tabell 1. USA hadde vanskeligheter med å godta at forslag #2 ikke kom med, noe som utløste en lengre diskusjon. Resultatet ble imidlertid at man aksepterte å oversende prioriteringslisten (slik den opprinnelig ble) til AB møtet neste dag.

Til sist skulle Workshop og Analysis Topics bestemmes. Alternativene er gjengitt i hhv. vedlegg 5 og 6, mens resultatene fremkommer i tabellene 2 og 3. Disse avstemningene gikk adskillig glattere.

Analysis 1990
Mr. Halozan fra Østerrike redegjorde så kort for status i arbeidet med analysen: "Impacts of Heat Pumps on the Greenhouse Effect". Arbeidet går etter planen.

Møtereferat, 91-10-15
Formiddagen var avsatt til AB møte for å vurdere gårsdagen og gi videre innspill til NTs.

NT møtet
Innledningsvis gav Mr. Cane (Canada) en kort orientering om "International Power Utility Heat Pump Committee (IPUHPC), som er en uformell forening med mål å utveksle informasjon på internasjonalt nivå. På siste møtet i Stockholm deltok 9 land - deriblant Norge. Ikke alle land deltar i Annex XVI og man ønsker flere medlemmer. Av foreningens spesielle interesser nevnes: man vil ha oversiktsrapporter fra HPC, vil vite om trender og forventninger i markedet, info om hvordan barrierer i markedet kan

overkommes og de ser helst at EFs HP-gruppe koordineres med HPC.

ABs tilbakemelding
Mr. Groff (USA) orienterte så om formiddagens AB møte. AB var meget fornøyd med NTs arbeid sist år, og oppfordret samtidig til et mer proaktivt engasjement neste år. Det ble uttrykt tilfredshet med forhåndsmateriellet og utvelgingen av neste års topics for NB, Analysis og Workshop. De tre listene (tabellene 1, 2 og 3) ble så gjennomgått.

Avslutningsvis sa Groff at AB er meget fornøyd med NOVEMs arbeide, og at programmet for '92 nå vil bli oversendt Executive Committee.

Før Mr. Bouma rundet av og takket for et, etter alles mening, godt og hyggelig møte, fikk T. Berntson slippe til med litt reklame for Workshoppen om Prosess Integrering.

Rune Aarlien
1991-10-17

Vedlegg 5

IEA EXECUTIVE COMMITTEE ON ADVANCED HEAT PUMPS

Minutes of the Annex XVII

First Working Meeting

April 8-9, 1991, Zurich Switzerland

Chairman:
Lennart Vamling
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IEA - ADVANCED HEAT PUMPS, ANNEX XVII

EXPERIENCES WITH REFRIGERANTS IN EVAPORATORS

First Working meeting April 8-9, 1991 - Minutes

The meeting was held according to the agenda. A copy of the Agenda is found in Attachment 1.

The participants from each country was: Canada - Keith Snelson, The Netherlands - René van Gerwen, Norway - Geir Skaugen, Sweden - Katarina Hambraeus, Peter Melin, Lennart Vamling and Switzerland - Manuel Conde, Daniel Favrat, Kattan Nakhlé. A list of the participants in Annex XVII is given in Attachment 2.

1. Opening of the meeting

The chairman opened the meeting and gave a brief report of the number of participating countries. At the moment there are five counties participating in Annex XVII, Canada, The Netherlands, Norway, Sweden and Switzerland. Denmark may join later but for the moment they can not get the necessary funding.

2. Confirmation of decisions taken at the pre-meeting in Stockholm August 31, 1990.

The decision taken at the Stockholm meeting regarding the rules for publishing material within the Annex XVII was confirmed, i.e. that each group contributing to the Annex has the right to publish its own material elsewhere. The results of other groups contributing to the Annex may not be used in a report with or without references. Only after approval from the contributing group may material be used.

4. Possible contributions from National Teams.

Canada:
Has three possible contributions to the annex. The first is a horizontal evaporator operating with brine heating from the inside and the refrigerant on the outside. The tube is double-fluted with a diameter of 30.2 mm and the length is 1.2 m. It is possible to change the configuration of the tube and to let the refrigerant flow on the inside. The second suggestion is a horizontal evaporator divided into 4 sections. This evaporator operates with the refrigerant on the inside of the tube. The evaporator is a part of a heat pump system and the tube in the evaporator is double fluted. The third and last of the suggestions is a relatively large heat pump system. The evaporator is flooded and the heat transfer is under pool boiling conditions.

Netherlands:
Has a 15 kW heat pump system. The evaporator and condenser are of the coaxial type. The evaporator has an inner diameter of about 10-12 mm and consists of 5-6 tubes. The heat pump is designed for NARMs. Only the total heat transfer over the entire evaporator can be measured.

Norway:
Has an horizontal evaporator of 5 meters. Inner diameter is 16 mm and the tube is indirectly electrically heated. They have recently installed a pump in the system making it more flexible. Local values of heat transfer can be measured. They have performed measurements on R134a.

Sweden:
From KTH two suggestions: The first one is an electrically heated horizontal evaporator, inner diameter 12 mm and length 10 m. Temperature is measured along the tube which gives local values of heat transfer. Pressure drop is also measured. Measurements on R134a and R152a pure and with oil mixtures have been performed. The second suggestion is a 16 meter long brine heated evaporator. The inner diameter is 8 mm. Wall temperature is measured along the way but heat flux and saturation temperature are partly calculated. Local values can be obtained. The apparatus has been used with mixtures.
From CTH two suggestions: A horizontal evaporator heated by brine. Heat flux, wall temperature, saturation temperature and pressure are measured every 0.5 m. The length is 5 m and inner diameter 19 and 10 mm. The evaporator is built for mixtures. The measurements could be run with or without inserts. Also a falling film evaporator could be included in the project. The evaporator is about 4 m long and with an inner diameter of 25 mm. Measurements of R22 has been performed and measurements of R134a are in progress.

Switzerland:
From Zurich: They have an air-to-water heat pump. The evaporator consists of 6 layers of horizontal tubes. The inner diameter of the tubes is 8 mm. Every tube has several bends on the way where the temperature is measured. Pressure drop is measured over the entire evaporator. At the moment R22 is being used as working fluid.
From Lausanne: They have a 3 meter long horizontal tube-in-tube evaporator. The evaporator has the possibility to be leaned in both ways about 45 degrees. At the moment the brine is flowing on the inside of the inner tube and the refrigerant is flowing between the tubes, but it is possible to let the refrigerant flow on the inside of the inner tube if that is preferred.

5. Coordination of the NT projects

The possible contributions from the National Teams were summarized as follows.

Evaporator type	Configuration	Country	Local values
Intube	Straight	Norway	Yes
		Sweden	Yes
		(Switzerland)	Yes
	Double-fluted	Canada	Yes
	With bends	Switzerland	No
	Coiled	The Netherland	No
	Leaning	Switzerland	Yes
	With inserts	(Sweden)	Yes
Outside	Straight	Switzerland	Yes
	Double-fluted	Canada	Yes
Shell and tube		Canada	No
Falling film		Sweden	Yes

The countries written with parenthesis are unsure that they could perform the experiments.

Since one of the aims of the Annex is to use the experimental results to test the applicability of existing heat transfer correlations, it was decided that the main

emphasis should be spent on experiments with refrigerant flowing on the inside of straight, horizontal tubes.
The suggestions from the NTs were accepted, but for the reasons given above, the meeting strongly recommended Canada to exclude the flooded evaporator and to change their first proposal to be run with the refrigerant flowing on the inside of the inner tube.
It was also recommended that the suggestion from Lausanne, Switzerland should perform their experiments with the refrigerant on the inside of the tube as much as possible.
The Swedish suggestion of running the measurements using inserts will also be excluded due to the time limit of this project.

Fluids:
It was recommended that R22 and R134a should act as references and that all experimental facilities should use one or both of these substances to enable a check between the different apparatuses. The participants should also preferably perform measurements with pure substances, in order to facilitate the comparison with existing correlations.
Below is a summary of the fluids each country will use:

Canada	R134a, R152a
The Netherlands	R134a, DME, R22
Norway	R22, R134a
Sweden CTH	R134a
Sweden KTH	R134a, R152a, (DME), The DuPont mixt.
Switzerland Zurich	R143a, R22
Switzerland Lausanne	R134a, R22, R11

Other substances like R32, R123 and R124 etc. will be used if they become available and/or if the properties have been properly measured.

The chairman suggested that the flow pattern for each test should be determined if possible.

6. Formats for the experimental data

In attachment 3 there is a brief description of the data format, recommended by the OA, for the transfer of experimental data. All participants declared that they would use floppy discs.
The chairman explained that measured data with an estimation of the error should be sent. With each measurements the calibration standard should be named.
Text and formulas should be sent in Word Perfect version 5.1 format, plain text could be sent in ASCII.

7. Contents of the final report

The chairman went through the suggested chapters of the final report (Attachment 4).
In order to make the report easier to read it was suggested that an extra appendix containing tables of collected data etc. should be included, thus enabling this information to be excluded from chapter 5.

8. Time schedules and deadlines

It was decided that each NT should put forward their time schedule for the measurements before next meeting.

9. Next meeting

Due to the delay of this first meeting it was decided that the next meeting should be a short informal one, to be held in conjunction with the IIR conference in Montreal 1991. The two remaining meetings will be held about January 1992 and September 1992. The location of the meetings are to be decided.

10. Other matters

No other matters.

11. End of meeting

The meeting was ended by the Chairman.

Referat fra ekspertmøte i Sittard 18.06.91. Annex Proposal:
Industrial heat pumping - its worldwide impact in mitigating "greenhouse gases"

Deltakere:	Jos Bouma,	Holland
	Cees Hoedemakers,	"
	P.A.Oostendorf	" (TNO)
	J. Berghmans,	Belgia
	Reinhardt Holzer Schmidt,	Tyskland (GEA)
	Paul E. Scheihing,	USA (DOE)
	K.R.(Ammi) Amarnath	" (EPRI)
	Jean - Louis Pourier	" (RCG/Hagler)
	Thore Berntsson	Sverige
	Torbjørn Boström	"
	Truls Gundersen	Norge (Norsk Hydro)
	Geir Eggen	"

1. Jos Bouma åpnet møtet. Som Operating Agent for det foreslåtte annexet var foreslått RCG/Hagler fra USA. Operating Agent skulle samarbeide med Universiteit Leuven i Belgia og Chalmers Tekniske Høgskole i Sverige.

2. Introduksjon av Annex Proposal av P. Scheihing, DOE.
US DOE Industrial Heat Pump Program har et budsjett på 2 mill US$/år. Innsatsen settes inn på følgende områder:
- Prototype Process Integration Heat Pumps
- Brayton Solvent Recovery Heat Pumps
- Chemical Heat Pumps
- Magnetic Heat Pumps

Til det foreslåtte annexet var 15 land invitert.
Estimerte kostnader:
- USA, Tyskland og Japan?: 20000$/år
- Totalt 10 - 20000$direkte utlegg for mindre land pluss fire månedsverk per land

P.Scheiding orienterte om målet med annexet, om hva som skulle gjøres og hvem som skulle gjøre det, se vedlegg 1 (kopi av overheads).

3. Introduksjon av J. Berghmans.
Operating Agent skulle starte så raskt som mulig. Avslutning om ett eller halvannet år
Problemstillinger:
- Kan vi overføre data fra ett land til ett annet?
- Markedspotensiale: Antall / forskjellige typer.
- Dataregistrering: Kostnader for VP / kostnader for alternativer.

4. Introduksjon av Thore Berntsson:

Operating Agents arbeid:
- Varmepumpeteknologi
  * State of the art for forskjellige typer VP
    Kostnader og effektivitet
  * VPs økonomi sammenlignet med varmevekslere, kjeler og CHP (Combined Heat and Power Plants).
- Prosess Integrasjon
  * Grunnlaget for Process Integration (Basics)
  * Karakteristikk av forskjellige industriprosesser
  * Muligheter for introduksjon av forskjellige typer varmepumper i forskjellige typer industrier
- Drivhuseffekt/ miljømessige konsekvenser
  * Evaluering av NTs oppgaver over potensialet av forskjellige typer varmepumper
  * Beregning av mulige reduksjoner av CO_2 - utslipp

National Teams oppgaver:
- Presenter informasjon om :
  * Energisituasjonen i industrien i respektive land
  * Typer av industrier, relative størrelser osv.
  * Karakteristiske trekk ved forskjellige typer av industrier
- Tekniske opplysninger, status varmepumper osv.

5. Presentasjoner fra alle representerte land:
   - Hvordan er situasjonen i forskjellige land
   - Hvilken informasjon er tilgjengelig
   - Markedsundersøkelser

   Underlag fra USA finnes hos Geir Eggen

6. Diskusjon

Den potensielle Operating Agent skal utarbeide "legal document" som skal godkjennes av Executive komiteen før det forelegges IEA - sekretariatet. Første møte i Executive-komiteen er ikke før i november, og for å spare tid er det ønskelig å sende ut dokumentet til medlemmene i Executive komiteen tidligere slik at disse telefonisk kan godkjenne oversendelse til sekretariatet. Endelig godkjenning skjer i Executivekomiteen i november-møtet.

Det er ønske om å forkorte annex-teksten. USA fremmer forslag.

Ozon-nedbrytning skal inkluderes og diskuteres i rapporten, men skal ikke nevnes i tittelen.

20 år er et rimelig tidsaspekt, 30 år for lenge.

Veksthus skal defineres som industri.

7. Økonomi

Prof. Berghmans og Prof. Berntsson mente at kostnadene som var foreslått av USA var for små i forhold til det omfanget som annexet ville få. De foreslo at kostnadene ble økt til 60.000 US$ for store land og til 30.000 US$ for små land, i henhold til nedenstående tabell. Dette gir totalt budsjett på US$ 390.000,- som skal deles likt på de tre utførende nasjoner

Sverige	30.000	USA	60.000
Norge	30.000	Tyskland	60.000
Østerrike	30.000	Japan	60.000
Holland	30.000	Canada	60.000
Belgia	30.000		
Sum-små land:	US$150.000	Sum-store land:	US$240.000

Trondheim, 24.06.91

Geir Eggen

Vedlegg 6

REFERAT FRA IEA HEAT PUMP CENTER WORKSHOP:

"Ground-Source Heat Pumps - Advancements Towards Cost Reduction".

Sted: Montreal, Canada

Tid: 12. - 13. august 1991

Generelt

Workshop'en ble lagt til Montreal i forbindelse med at XVIIth International Congress of Refrigeration ble arrangert der i tidsrommet 10.-17. august.

Programmet var lagt opp av Caneta Research Inc. Canada, som hadde valgt ut foredrag fra Canada, USA, Sverige, Sveits og Tyskland.

Det deltok 44 representanter fra 8 forskjellige land. Norske deltakere var Einar Grønnevik, Normann Energiteknikk og Geir Eggen, SINTEF Kuldeteknikk, (referent).

Trykte foredrag foreligger i proceedings, og kan bestilles fra IEA Heat Pump Center gjennom SINTEF Kuldeteknikk, 7034 Trondheim, tlf 07-593900 (Rune Aarlien).

I vedlegg er vist program og deltakerliste.

Referat fra workshop

Jos Bouma, Heat Pump Center, ønsket velkommen. Denne workshop var oppfølging av en tidligere workshop om jordvarmepumper som IEA Heat Pump Center arrangerte i Morton Albany, N.Y. i 1985. Den begrensende faktor på utbredelse av jord/bergvarmepumper er ikke teknologi, men kostnader, derfor er temaet for workshop'en kostnadsreduksjoner.

Keith Snelson, National Research Council, Canada var leder for Workshop'en, og introduserte med status for jordvarmepumper i Canada. I 1985 var 800 anlegg installert, mens tallet er økt til 4000 i 1991.

Workshop'en var inndelt i 6 faglige temaer, og den ble avsluttet med gruppearbeid og diskusjon.

1. Nye kuldebærere.

James E. Bose, Oklahoma State University, USA, presenterte laboratorie- og feltmålinger med kalium acetate for å undersøke korrosjons-effekt.

Peter Top, ORTECH International, Canada foretok en vurdering av forskjellige kuldebærere med hensyn på varmeoverføringsegenskaper, giftighet og kostnader.

I diskusjonen etter foredragene presenterte Eric Granryd resultater fra arbeider utført ved Kungliga Tekniska Högskolan, hvor man har sammenlignet termodynamiske egenskaper for forskjellige løsninger. Det ble slått fast at på kort sikt (5 år) regnes glykolvann fortsatt som det mest aktuelle mediet.

2. Direkte ekspansasjonssystemer.

Frank Lenarduzzi, Ontario Hydro, Canada, la fram eksempler på nye systemløsninger for direkte ekspansjon av kuldemedium i rørsystemer (Cu-rør). Systemene skal dekke både kjøling og oppvarming, og er karakterisert av relativ små jordvarmesystemer. Eksempel: 10 kW VP og 3 x 30m ø½"Cu-rør (tur/retur) inneholder 7 kg KFK-fylling.

Robert Cochran, ECR Technologies Inc, U.S.A., tok for seg forskjellige tiltak til kostnadsreduksjoner:

- øke varmepumpens effektfaktor
- øke varmeovergangseffektiviteten for å tillate kortere rørkrets
- redusert montasjetid med nye jordsløyfesystemer

Eksempel - kuldemediefylling i en 3 ton unit er omkring 14 pounds.

Vince Mei, ORNL, U.S.A, la fram resultater fra laboratorieforsøk med små direkte-ekspansjonssystemer. Direkte ekspansjonssystemer er klart mer effektive enn indirekte varmeopptak, men de medfører også problemer som kompressor- og oljereturproblemer, fare for forurensning og større kuldemediefylling.

3. Dimensjonering og installering av jord/bergvarme- rørsystemer.

Johan Claesson, presenterte designverktøyet som er
utviklet i Lund, Sverige, og dette verktøyet brukes i mange andre land. (Cleasson opplyste at de selger PC-programmet til Skr 2500,-).

Buchard Sanner, Tyskland presenterte boremetoder i fjell. Optimal boredybde er ca. 100 m, og kostnader for ferdige borehull med fyllmasse osv. er 45-70 US$ per meter.

Harry Braud fra Louisiana State University vurderte effekten av forskjellige fyllmaterialer for gjenfylling av borehull. Borehullene gjenfylles både for å øke varmeledningen fra berget til røret, og for å beskytte mot lekkasjer av kuldemedium/kulde bærer til grunnvannet.

4. Forbedring av varmepumpeteknikken

Dan Ellis, Water Furnace Int. Inc, USA, pekte på forbedringer gjennom en rekke forskjellige tiltak:

- forbedret kompressorer (Scroll, rotasjonskompressor)
- variabel hastighet - viftemotorer
- elektronisk kontroll
- forbedret varmevekslere (koax- og messingplatevarmevekslere)
- forbedret design (optimalisering)

I fremtiden mente Dan Ellis at utviklingen for VP går mot integrert rom- og varmtvanns-VP med kapasitetsregulering (modulering).

5. Avanserte varmevekslere.

Robert Hopkins, Polydynamics Ltd., Zurich, Sveits. I sveits installeres nå omkring 500 VP med vertikale borehull pr. år. Hopkins presenterte målinger fra borehullsystem gjennom året, og slår fast at vertikale jordvarmesystemer er en sikker varmekilde for varmepumper.

Otto Svec, NRC-Canada, presenterte spiralvarmeveksler (32 mm plastrør eller 22 mm kobber-rør) tvinnet som spiral som legges i en ca. 20 m lang grøft for varmeopptak til en ca. 3,5 kW varmepumpe. En vann/metanol-blanding er varmebærer til VP.

6. Fou-støttet av Canadian Ground Source Heat Pump-Installation Standard.

Douglas Cane fra Caneta Reasarch Inc, Canada redegjorde for følgende prosjekter:

- islinse eksperiment
- tilbakefylling av og fyllemasser for borehull
- borehullgeometrier
- kuldebærere
- fyllmasser i borehullene
- spiralvarmeveksler

Tilslutt foretok Eric Granryd en sammenligning mellom vannholdige løsninger og ikke vannholdige løsninger som kuldebærer. Vannholdige løsninger krever bare ⅓ av volumstrømmen sammenlignet med ikke vannholdige. NH_3 vil være en svært bra løsning der den er sikker å håndtere.

Gruppearbeid - Diskusjon.

Bortsett fra Sverige og Norge fokuseres det nesten utelukkende på direkte ekspansjonssystemer blant de andre deltakerlandene. Fra svensk og norsk side ble det hevdet at dette er et trinn i feil retning med tanke på miljødebatten (reduksjon/kontroll med fyllingsmengden). Dessuten er erfaringene fra direkte expansjonssystemer hos Sveriges største produsent av slike systemer dårlig (Eric Granryd og Einar Grønnevik har begge hatt tilknytning til Thermia).

Gruppearbeidene konkluderte med følgende forslag til nye FoU-prosjekter innen jord/bergvarmepumper.

- elektronisk/computerstyrt væskeregulering
- nye arbeidsmedier, f.eks. propan
- reduksjon av kuldemediefyllingen
- internasjonale demonstrasjonsprosjekter

Vedlegg 7

Møtereferat:

IEA Executive Committee on Implementing Agreement for Advanced Heat Pumps

Stockholm, 6-8. november, 1991

Til stede:	Per-Erling Frivik	Formann, Del., Norge
	Onno Keefkens	Del., Nederland
	Bengt Lundquist	Del., Sverige
	Hans J. Laue	Alt. Del. Tyskland
	Rune Aarlien	Observatør, Norge
	Jos Bauma	Operating Agent HPC
	Hermann Halozan	Alt. Del., Østerrike
	Kaoru Honjo	Del., Japan
	John D. Ryan	Del., USA
	Hans U. Scharer	Del., Sveits
	N. Schacht	Del., Tyskland
	K. Snelson	Del., Canada
	G.C. Groff	Formann Advisory Board HPC
	Norman J. Maloney	Observatør, Storbr.
	Hiedo Kuroda	Observatør, Japan
	J. Lagerstrøm	Observatør, Sverige
	Thore Berntsson	Observatør, Sverige
	Paul Farrant	Del. Storbr.
	B. Snellberg	Observatør, Sverige
	Paolo Coda	Del., Italia

Norge har vært representert ved Per-Erling Frivik (formann og norsk delegat) og undertegnede (observatør). Møtet ble avholdt på GLG Center, Scandic Crown Hotel (midt mellom Stockholm og Arlanda).

Første dag ble i sin helhet viet studietur til fire nærliggende varmepumpeinnstallasjoner samt hotellets energianlegg. Omlag 2/3 av møtedeltakerne deltok.

Strategisk Plan

Møtet ble innledet med en presentasjon av det svenske Byggforskningsrådet som var verter. Deretter la formannen frem utkast til "Strategisk Plan" for Implmenting Agreement on Advanced Heat Pumps (IA). Etter en detaljert presentasjon ble planen kommentert og diskutert. Generelt ble den meget godt mottatt og det ble vedtatt at formen skal beholdes. Innhold vurderes videre og de forskjellige National Teams oppfordres nå til å komme med kommentarer. I denne sammenheng understrekes at det er innholdet som skal vurderes og kommenteres. (Strategisk Plan er lagt ved som vedlegg 1). Deretter ble møtereferatet fra siste EXCO-møte godkjent uten nevneverdige kommentarer. Ingen fra IEA-sekretariatet var tilstede, slik at kommentarer ikke var tilgjengelige. Sekretariatet er imidlertid positive til planene om et såkalt Clearinghouse Network for koordinert informasjonsspredning for samtlige IAs.

Annexer

Status for de forskjellige pågående annexene ble så gjennomgått og stort sett var alle "i rute". Spesielt nevnes her at det sannsynligvis ikke blir noe av det foreslåtte Annex XIX, Advanced Second Law Analysis for Heat Pump Systems. Utforming av tekst og andre formaliteter er unnagjort, men det var ikke mulig å oppnå tilstrekkelig finansiering til tross for at kun $70.000 var nødvendig. Det var en generell oppfatning at dette var synd og skam. Flere land kunne tenke seg å delta hvis annexet ble "task-shared" i stedet for "cost-shared". Tilgjengelige statusrapporter for de forskjellige annexene er lagt ved i vedlegg 2.

Annex XVI, Heat Pump Center

Progresjonsrapport for 1991 ble gjennomgått, etterfulgt av neste års arbeidsprogram og budsjett (vedlegg 3). I det store og hele ble programmet godkjent. Sveits vil forsøke å få arrangert workshoppen om drivhusproblemet (uke 42, 1992). Dette vil bli en åpen workshop. Den andre workshoppen ble foreslått utsatt til 1993. Videre ble det foreslått å lage en brosjyre og muligens en videotape for PR. Det ble inntatt en positiv holdning til samarbeid med IIR. HPC Advisory Board v/Mr. Groff presenterte så sine anbefalinger for HPC (NOVEM) med hovedkonklusjon at man er meget godt fornøyd med driften gjennom siste år. Mr Halozan (Østerrike) presenterte så "Analysis 1990" som ser ut til å gå etter planen. En gledelig overraskelse var at Sveits bestemte seg for å bli med i HPC. Økonomisk vil de bidra på linje med Norge og Østerrike. Storbritannia vurderer også medlemskap.

Nye Annexer

Som tidligere nevnt blir det etter all sannsynlighet ikke noe av Annex XIX, men det kan i stedet være aktuelt å gjøre det om til analyse. Annex XXI, Global Environmental Benefits of Industrial Heat Pumps (vedlegg 4), kan komme i gang relativt snart. Her vil USA bli Operating Agent, og samarbeide nært med Sverige. Land som ønsker å delta ble bedt om å få avklart eventuell finansiering innen årets utløp. En smule interessant er at Malaysia har ytret ønske om å få delta. Det ble avtalt å holde et initieringsmøte uten forpliktelser i januar '92 i Gøteborg. Det foreslåtte annexet "International Heat Pump Status and Policy Review vil bli omgjort til en Analyse, og IEA/OECD-rapporten "Heat Pump Systems - a Technology Review" (1982) vil bli brukt som modell.

4de IEA HP Konferanse

I utgangspunktet er det ønskelig å få avholdet denne konferansen i et større, mellomeuropeisk land. Tyskland var ønskestedet men vil trolig ikke stille opp av forskjellige grunner. Nederland vil undersøke sine muligheter, og begge land avgir svar innen en måned. Norge vil påta seg ansvaret hvis ingen av de to nevnte kan/vil. Konferansen avholdes våren eller høsten '93.

Ikke-Medlemsland

Land som ikke er medlemmer av IA gjennom deltagelse i annexer har til nå ikke hatt mulighet til å skaffe seg produkter som organisasjonen har produsert. Formannen mente at tiden nå muligens er inn til å lempe litt på disse reglene. Dette kan tenkes gjort ved at sluttrapporter fra annexer tilgjengeliggjøres etter 2 til 3 år. Filosofien bak er både at informasjon i dag har begrenset levetid og at salgsinntektene kunne bli et kjærkomment tilskudd til HPC. Saken vil bli forfulgt videre.

Diverse

* Skifte av "Contracting Parties" for Italia (ENEA) og Storbritannia (National Engineering Laboratories) ble godkjent.

* K. Snelson (Canada) ble valgt til co-chairman.

* En avgift på DFL 10.000 for alle land under IA ble vedtatt. Avgiften skal dekke sekretariatskostnader og må betales for at man i hele tatt skal kunne delta i annexer.

* EXCO-møter i '92 blir: 6-8 mai (USA) og 14/15 oktober (Sveits).

Forøvrig bemerkes at møtet ble avholdt i ryddige former og en god atmosfære, og generelt sett var fruktbart.

1991-11-10
Rune Aarlien

Vedlegg 8

objectives, increasing the thermal conductivity of the sorption material and designing a heat exchanger to minimize the sorption material-heat transfer fluid temperature drop while still being inexpensive and durable over the long time periods and large number of temperature (and pressure) cycles typical of heat pump service. The chemi-sorption work is currently in the laboratory stage of obtaining the P-T-X (Pressure-Temperature-Quality) data on the leading salt refrigerant combinations and beginning work in reactor-heat exchanger configuration concepts. Single-effect, double-effect, and cycles with new configurations are being evaluated for use with various salt-refrigerant combinations in chemi-sorption systems.

In a similar manner, the improvements in the single-effect ammonia absorption system all involve improved heat exchanger design. Efforts are under way to improve the burner-vapor generator heat transfer interaction in order to apply the heat exactly where in the generator it is most effective, to minimize flue losses, and to improve the internal heat transfer between streams at different temperatures within the cycle.

Conclusion

In summary, one can say that the key to all the sorption systems is being able to accomplish the required heat transfer interactions at competitive cost.

References

[1] *Freedman, S.I., French, C.E., and Myers, G.H., "Combustion Engine-Driven Heat Pumps", IEA Heat Pump Centre Newsletter, Vol. 8, No. 3, September 1990.*

[2] *Freedman, S.I., and Maret, A.R., "Heat Pump Research at the Gas Research Institute", IEA Heat Pump Centre Newsletter, Vol. 4, No. 3, October 1986.*

**Authors:*

S.I. Freedman, W.A. Ryan, C.E. French, G.H. Myers, Gas Research Institute, USA.

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Experiences from Air-Based Heat Pumps in Cold Districts

G. Eggen and O. Nesje

Summary

Most of the small and medium-sized air-based heat pumps in Norway are equipped with air coolers with narrow fin spacing (1-3 mm) which require frequent defrosting. In the southern and western parts of the country where there is a mild coastal climate, these heat pumps perform well. There are some air-based heat pumps in colder parts of the country, on the other hand, that have not functioned satisfactorily. Experience shows that heat pump evaporators, which mainly operate at outdoor temperatures within the ranges of 0 to -10°C and in high relative humidity, require increased fin spacing compared to the standard units developed for the air-conditioning market.

Experiences Gained from Prototype and Demonstration Plants

SINTEF Refrigeration Engineering has been involved with prototype- and demonstration plants which have received grants during the last decade from the Norwegian government. Sixteen air-based heat pumps have been investigated, and half of these are standard units developed for the air-conditioning market. The characteristic feature of these heat pumps are finned tube air coolers with narrow fin spacing (1-2 mm), which require frequent defrosting.

Most of the standard units were installed during the period from 1983 to 1986 in greenhouses in the south-western part of Norway. The heat pumps, with condenser capacities from 20 to 60 kW, are in operation during the tomato growth season between February and October. During this period outdoor air temperatures are rarely below 0°C in this part of the country. This means favorable operating conditions, and the experience gained from these air-to-air heat pumps is very good.

However, one air-based heat pump which uses an air cooler with narrow fin spacing, has not performed satisfactorily. This air-to-water heat pump was installed in 1981 in Trondheim, mid-Norway. The heat pump operates with R22 as the working fluid. The heat pump was operating satisfactorily for about five years. However, during the last few years, there have been problems with refrigerant leaks every year. The first leaks were discovered on the high pressure side of the

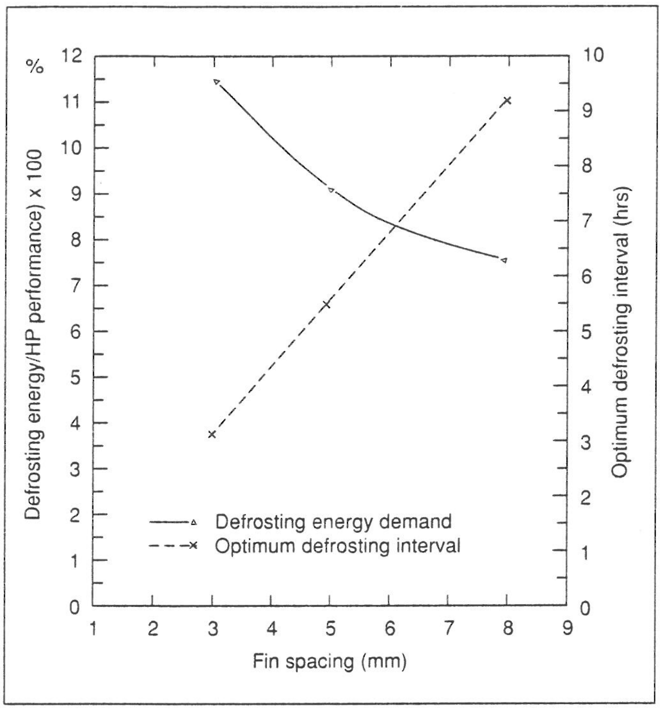


Figure 1: Defrosting Interval and Defrosting Energy Demand Versus Fin Spacing.

heat pump (pressure gauge, expansion valve for defrosting and hand stop valve). In 1989 a leak occurred due to a broken capillary tube, and finally, in 1990 a crack was discovered in a copper tube of the evaporator. It is not unlikely that this crack was caused by the rather severe operating conditions and the rapid defrosting which involve temperature changes in the material.

Experiences from larger heat pump installations (50-300 kW) show that evaporators mainly operating at outdoor temperatures in the range between 0 to -10°C, and high relative humidity (80-100%), should have increased fin spacing compared to the standard units developed for the air-conditioning market.

Evaporator Fin Spacing Influence on Defrosting Cycles

Compared to evaporators with small fin distance, concepts with increased fin spacing can be more effective as heat exchangers. The costs and space demand connected to larger fin distance must, however, be balanced by the corresponding lower running costs due to reduced energy demand for defrosting and more effective evaporators.

Practical experiments combined with system simulations have been carried out at SINTEF Refrigeration Engineering [1]. This analysis shows that the optimal defrost interval will increase approximately at the same rate as the fin spacing, see Figure 1.
The additional energy demand for defrosting significantly increases as the fin spacing is reduced. Figure 1 shows results from the analysis which is valid for an outdoor temperature of 0°C and a relative humidity of 85%. If the fin spacing is increased from 3 to 8 mm the additional energy demand for defrosting is reduced from 12 to 7% of the total heat pump design performance.

The drop in heat pump performance due to the frost formation on the evaporators has to be taken into account when the nominal heat output for the installation is determined.

Depending on the fin spacing, the design capacity of the heat pump should be increased in accordance with the range indicated in Figure 1.

Economic evaluations must decide which fin distance should be chosen. From an "energy point of view" increased fin spacing is favorable, however, the investment combined with the running costs will have to determine the final choice.

Larger fin distances with correspondingly longer defrosting intervals may also reduce the risk of generating excessive material stress caused by frequent temperature changes in the evaporators.

Air-based Heat Pumps Designed for Cold Climate

In order to evaluate two different evaporator systems for air-based heat pumps, the Norwegian heat pump company, Aquaterm AS, has built two prototype heat pumps, both with fin spacings of 8 mm [2].

At Gruben near the city of Mo i Rana, an air-to-water heat pump was installed in 1986. The heat pump has been in operation since spring 1987 and uses R22 as the working fluid. The heating capacity of the heat pump is 55 kW at -5°C outdoor air temperature and 45°C forward water temperature from the condenser.

The heat pump is equipped with a finned tube air cooler (evaporator). The tubes are connected to a liquid separator, and refrigerant circulation is by gravity (Figure 2). The evaporator is placed on the roof above the heat pump. For defrosting, the compressor is switched off, and liquid refrigerant is drained from the evaporator down to the condenser, where the cold refrigerant will evaporate, due to heat exchange with the heat distribution water.
The refrigerant vapour will bypass the compressor and stream up to the evaporator, where it condenses and thereby melts the ice. The defrosting period is started by a timer, and is terminated by a temperature sensor placed at a fin at the bottom of the evaporator.

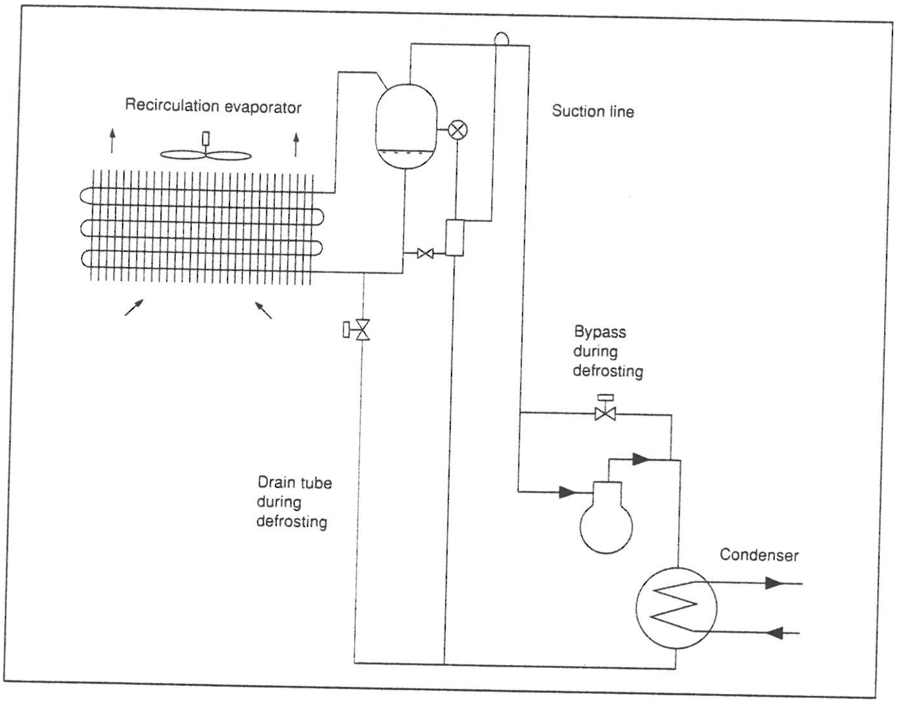


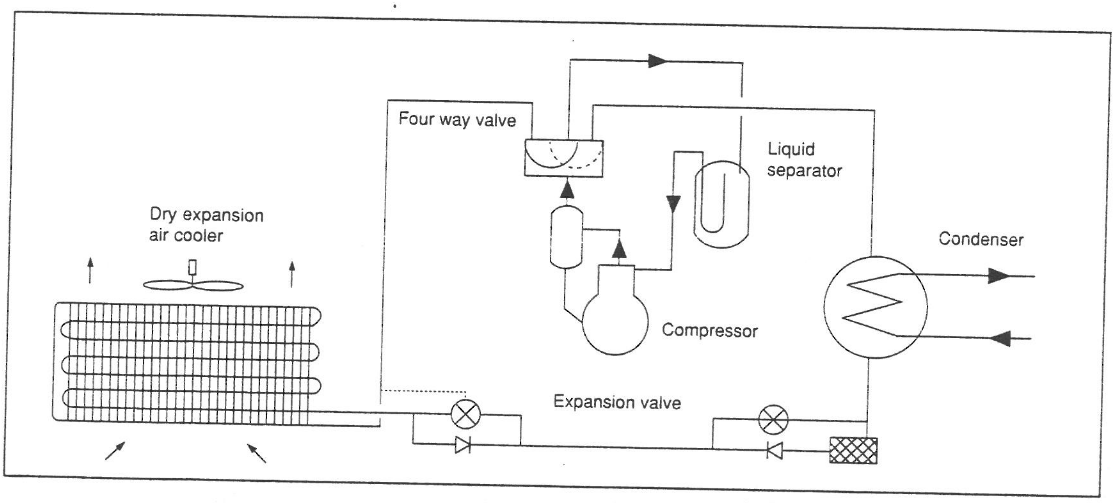
Figure 2: Air-to-water Heat Pump with Recirculation Evaporator.

The air-to-water heat pump has been in operation for about three years, and experiences gained are good, with the exception of some minor problems which were solved during the first year of operation.

The defrosting system is functioning satisfactorily, although defrosting normally takes about 15 minutes when defrosting occurs at six hourly intervals under the worst frost formation conditions. The self circulation defrosting system performs very efficiently producing up to 70 kW defrosting heat during the first couple of minutes or as long as there is ice on the tubes. As the defrosting heat has to be transported to the fins, the recirculation and production of defrosting heat decreases gradually until the defrosting cycle is terminated after about ten minutes. Finally, it takes about five minutes to transport the liquid refrigerant back to the evaporator before the compressor starts again.

Since the recirculation evaporator system is quite expensive, and the defrosting system requires the evaporator to be placed above the condenser, the heat pump manufacturer, Aquaterm A/S in Molde, also offers a more conventional reversible air-based heat pump with dry expansion cooler, Figure 3. This heat pump system is equipped with a cheaper evaporator, but due to the suction line liquid separator and the four-way valve, the pressure losses in the suction line are considerably higher compared to those in the recirculation type system.

Figure 3: Air-to-water Heat Pump with Dry Expansion Cooler.



Conclusion

The reversible heat pump principle is well known as shown in millions of air-to-air heat pump installations in Japan and the USA. The main difference is that the Aquaterm air-to-water heat pump is specifically designed for cold climates, by equipping the evaporator with a much wider fin spacing.

References

[1] *O.M. Nesje, B. Byggstøyl: "The influence of the Evaporator Fin Spacing on Defrosting Cycles and Front Velocities in Electrically Driven Air-Based Heat Pumps". XVIIth International Congress of Refrigeration, Vienna, 1987.*

[2] *G. Eggen, P.E. Frivik: "Medium-sized heat pumps for cold districts". 3rd IEA Heat Pump Conference, Tokyo, 1990.*

**Authors:*

G. Eggen and O. Nesje, SINTEF Refrigeration Engineering, N-7034 Trondheim, Norway.

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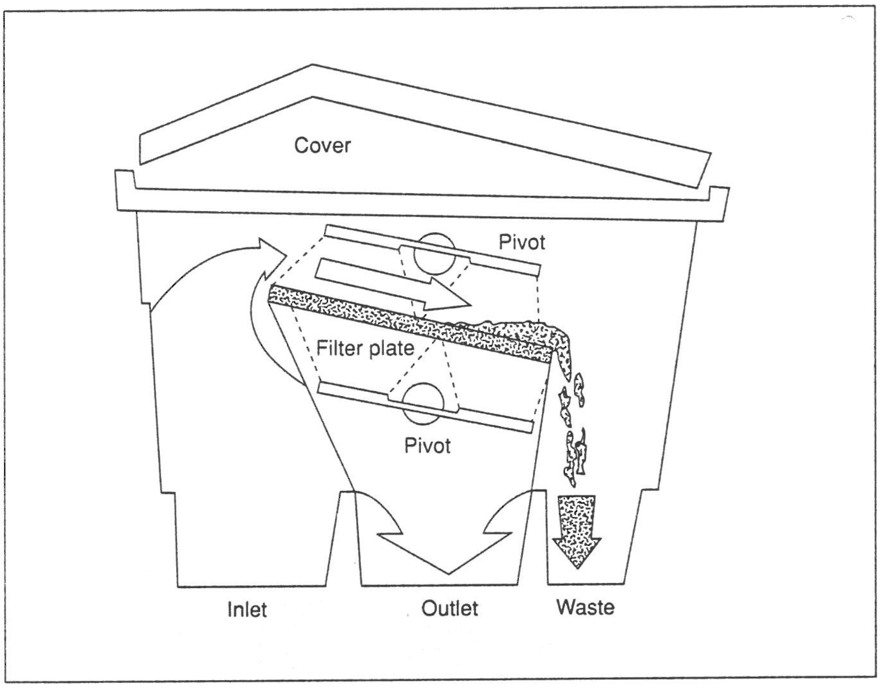

Figure 4: Triangle Filter.

necessary. For a heat pump of the size explained, a 30 kW heater would be sufficient to secure operation down to 0°C. This means that the power consumption is doubled and the COP of the system is reduced below 10.

SEA WATER HEAT EXCHANGERS

Hatcheries having access to deep sea water can warm up large flows of fresh water at low cost by using sea water heat exchangers. Shores which are influenced by the Gulf Stream have 7 - 8°C salt water available at a depth of 20-30 m, during the coldest winter period. A sea water heat exchanger is of the plate-heat exchanger type. The plates used are of a Titanium material which resists sea water corrosion. The heat exchanger connected to the heat pump uses stainless steel plates. A plate-heat exchanger is highly efficient and flexible and can be opened for cleaning. Plate-heat exchangers can be delivered in many sizes, from small harmonicas to 30 tonne units.

The normal running period (Norwegian locations) of these exchangers is from November to May. Sea water heat exchangers are also used to cool fresh water in case of high summer temperatures and/or high fish stocking densities.

Furthermore, sea water heat exchangers are used to compensate day/night fluctuations during the spring and autumn. The following example is given to illustrate investment and running costs of a sea water heat exchanger:

Fresh water temp.:	0.5°C
Sea water temp.:	7°C
Warmed fresh water:	5.3°C
Fresh water flow:	180 m^3/h
Sea water flow:	180 m^3/h
Transferred heat:	1000 kW
Pumping power:	20 kW

Total investment: NOK 350,000 (approx. US$ 50,000).

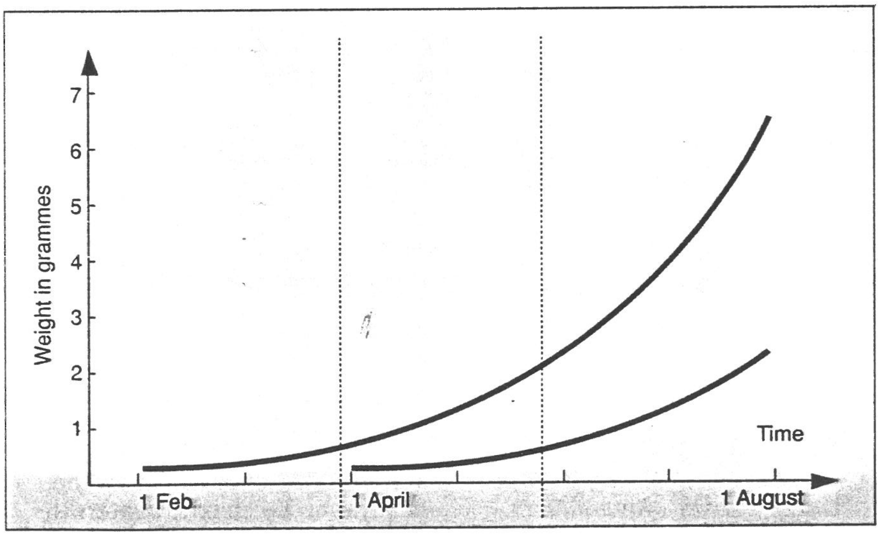

Figure 5: "Start-feeding".

Heat Pumps in Salmon Smolt Hatcheries

* P. Johansen

ABSTRACT

The first heat pump system in a salmon smolt (young salmon) hatchery was built in 1979 in Norway. The purpose was to warm the water up to 12°C from February onwards in order to begin "start-feeding" early, and to keep the fish in warmed water until the natural water temperature exceeded 10°C in the spring. This was quite successful. "Start-feeding" loss was reduced and the amount of smolts ready for further rearing after one year of being in the hatchery (one year smolts) was increased.

During the first few years, this new process met with scepticism from farmers and scientists, claiming that this unnatural process would result in reduced resistance when smolts were put into salt water, and problems with prematurity would arise.

However, after a number of years, experience had shown that there were no reasons for this scepticism, and the one year old smolts provided good results. In 1984 there were approximately 50 heat pumps installed in salmon hatcheries worldwide, the majority in Norway. From that time onwards things developed quite rapidly, and presently, the total number in Norway and other countries is estimated to be approximately 230 units.

SALMON HATCHERY HEATING UNIT

The heat pump is connected to a heat exchanger at the water intake of the hatchery. Typical temperatures of the process are shown in Figure 1.

The 2°C inlet water passes the heat exchanger and is warmed up to 13°C. Passing through the fish tank, results in a heat loss of approx. 0.3°C, and the effluent water temp. drops to 12.7°C.
A pump takes the effluent water through the condenser, where it is warmed up to 15.5°C. The water is now warm enough to exchange heat with the inlet water. Passing the heat exchanger the effluent water is cooled down by 11°C to 4.5°C. Having equal flows on both sides of the heat exchanger, allows the inlet water to gain 11°C, the same as the temperature decrease on the effluent side. From the heat exchanger, the effluent water of 4.5°C passes the evaporator and is rejected at a temperature of 2.3°C.

The heat exchange and power consumption figures of the process are:

Evaporator:	Q_0	= 110 kW
Compressor:	W	= 25 kW
Condenser:	Q_c	= 135 kW
Heat exchanger:	Q_{HE}	= 535 kW
Pump:	Q_p	= 5 kW

The coefficient of performance of the total system is:

$$COPs = Q_{HE} / (W + Q_p) = 535/(25 + 5) = 17.8$$

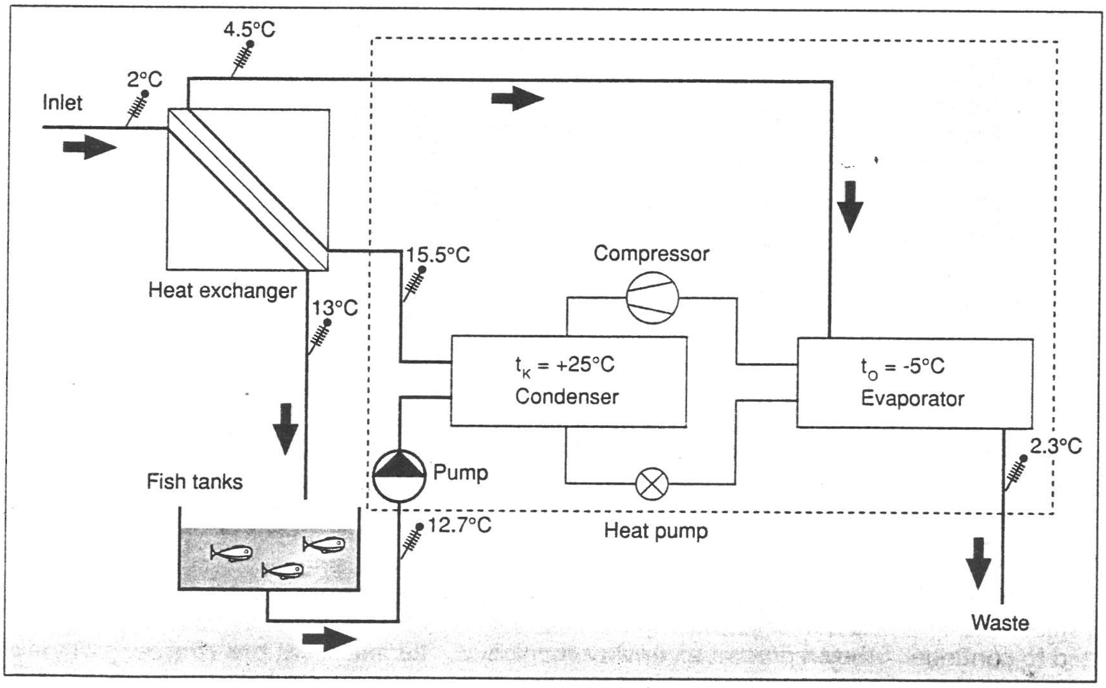

Figure 1: Diagram of a Hatchery Process Using a Heat Pump.

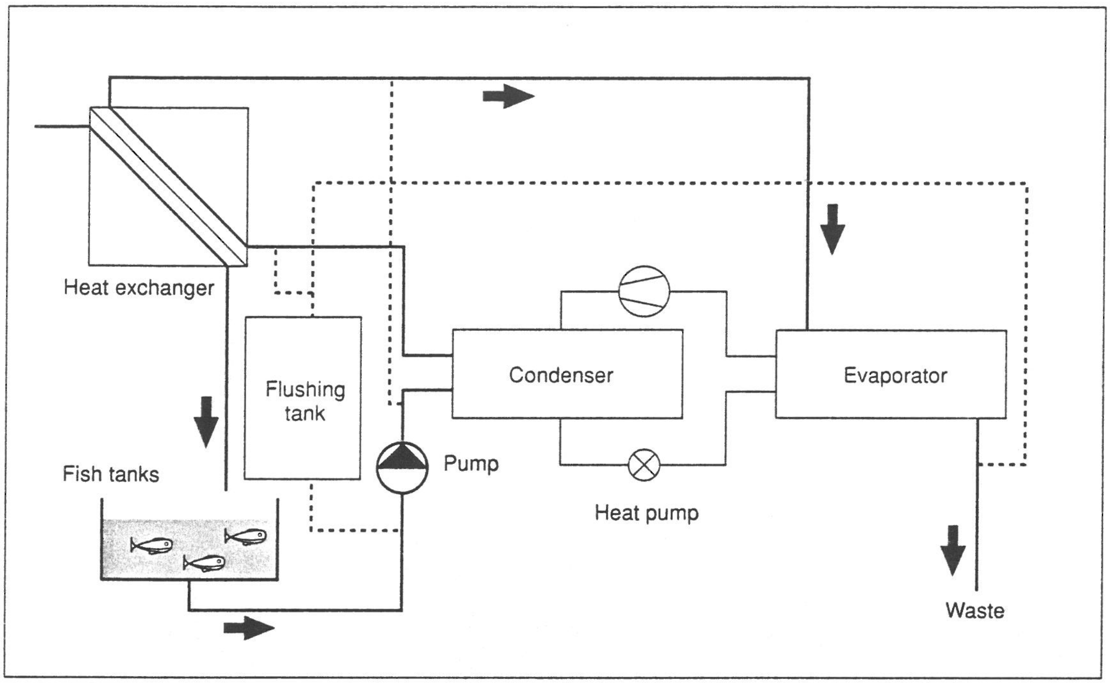

Figure 2: Backwashing System.

OPERATIONAL PROBLEMS

The waste water contains feed and excrements, which coat the heating surfaces. A "standard type" heat pump would clogg up within a short period. It is therefore very important to use condensers and evaporators that are specifically designed for operation with contaminated waste water. The design of the plate-heat exchanger must minimise fouling. However, even if a special design is used, periodic cleaning is still necessary.

An effective backwashing system is therefore integrated in the plant (see Figure 2). Heated water with fat solvents is circulated from a flushing tank in a closed cycle. The heat exchanger, condenser and evaporator are backwashed separately one after the other. The backwashing operation takes 10 minutes, and must be performed every 4-5 days.

The recent introduction of filters between the fish tank and the pump has prolonged the running period between backwashings to 15-20 days. The Unic Rotary Filter in Figure 3 and the Triangle Filter in Figure 4, both operate satisfactorily. It is now always recommended to install filters to screen the waste water coming from the fish tanks.

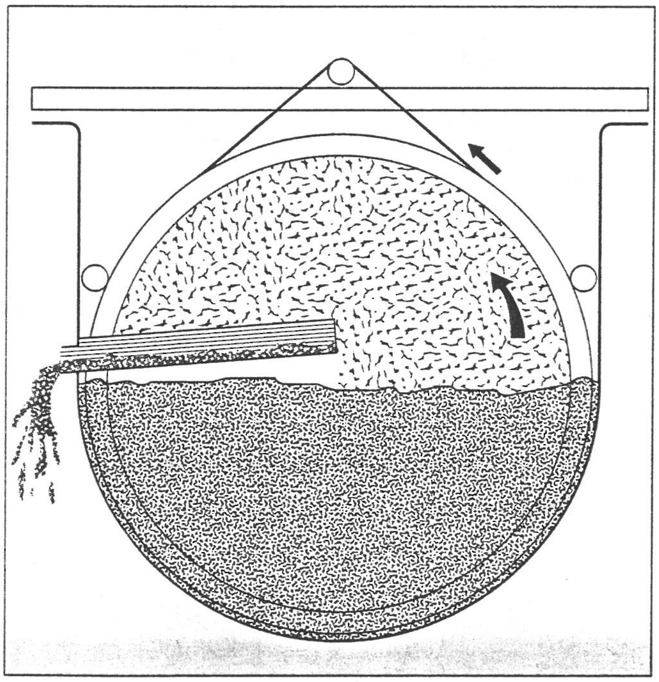

Figure 3: Unic Rotary Filter.

As the water is heated when passing the heat exchanger, supersaturation conditions will occur. The water must therefore pass a de-gassing unit before it goes to the fish tanks. Many home-made de-gassing units have been used with unsatisfactory results. Too high levels of nitrogen saturation do not allow the fish to prosper and result in a high mortality rate. It is advised to keep a record of the saturation values, and a saturometer should be available at the site at all times.

Sites having low temperature water supply in the winter, can expect freezing in the heat pump evaporator if the water temperature drops below 1.5°C. This temperature includes a safety margin of 1°C, because unstable conditions occur when tanks are drained for cleaning, or after backwashing. The best way to handle low temperatures is to heat the supply water with sea water. If sea water is not available, frost protection of the heat pump by electric heaters is

The investment cost is highly dependent upon the length of the sea water intake pipe and tide differences at the location. But this is the cheapest energy there is - only 20 kW pumping power is needed to obtain 1000 kW of heat.

THE ONE YEAR SMOLT PROCESS

It is important to have a large share of one year smolts to achieve profits in smolt rearing, because:

- production capacity can be doubled at the same tank volume;
- feeding costs are lower;
- labour is less;
- the payback period is shorter.

To make "start-feeding" possible with minimum losses, the water temperature should be about 12°C. The fish must thereafter be kept at 12°C water until the natural water temperature rises in the spring.

The curves in Figure 5 show how important early "start-feeding" is. When "start-feeding" begins from February 1, an average fish weighs approximately 7 grammes by August 1, compared to only 2.5 grammes when "start-feeding" begins on April 1.

A second heating period begins in the autumn when the natural water temperature falls below 8-9°C. Since the larger biomass (fish) requires a much higher water flow, heating is only applied to the smallest fishes. This helps them to grow and become smolts the following spring. Heating during the autumn also yields a larger weight smolt, which, in turn, results in a better profit. This process also utilises the heating equipment. A heat pump is a big investment, but the running cost is low. A longer running period gives a better investment payback, as long as heating improves growth and production.

TYPICAL ANNUAL COST

This is a difficult subject to tackle, especially in fish farming where different running conditions have a strong influence on the productivity. The figures in Table 1 are taken from a middle-sized Norwegian smolt unit.

CONCLUSION

Experience with a great number of installations gained in Norway over more than a decade, has shown that the application of heat pumps in salmon smolt hatcheries does not pose technical problems, yields a higher fish production rate, and is economically attractive.

Table 1: Economic comparison of a heat pump versus an oil boiler for an annual production of 600,000 smolts (average size 70 grammes).

Heat Pump	
Total investment whole smolt unit:	NOK 6,100,100
Heat pump investment:	NOK 818,000
Annual running hours:	4,300 h
Power consumption:	65 kW
Heating power:	1,080 kW
Utilisation factor HP:	0.7
Electricity price:	NOK 0.35/kWh
Interest rate:	12%
Amortisation factor 10 years:	0.17
Running costs:	NOK 68,470
Capital cost HP	NOK 139,060
Total annual costs:	NOK 207,530
Cost per smolt:	NOK 0.35
Oil boiler	
Total investment:	NOK 5,720,000
Boiler plant:	NOK 470,000
Running hours:	4,300 h
Oil consumption:	36 l/h
Electric power consumption:	10 kW
Oil Price:	NOK 2.3/l
Running costs for oil:	NOK 250,000
Running costs for electricity:	NOK 10,500
Capital costs for boiler:	NOK 79,900
Total annual costs:	NOK 340,400
Cost per smolt:	NOK 0.57

(Note: 1 NOK (Norwegian Krone) = approximately 0.142 US$)

* *Author:* *Per Johansen, Aquaterm, Norway.*

□

Vedlegg 9

JAPANESE MISSION TO NORWAY 1991-05-15--18

PROGRAM

May 15th Wed.	09:45am	Arrival Fornebu airport. The mission will be met at the meetihg point by Ms. Sandbakk and Mr. Årøen
	10:00am	Transport by bus to Royal Norwegian Council for Scientific and Industrial Research. Address: Sognsveien 72, Oslo
	10:30am	Brief overview of Norwegian Heat Pump Activities given by <u>Welcome address</u> Erik Skaug, Royal Norwegian Council for Scientific and Industrial Research (NTNF) <u>Presentation of the Norwegian Policy for Increased use of Heat Pumps</u> M. Amundsen, Norwegian Water Resources and Energy Administration (NVE) <u>Use of Heat Pumps in Norway, Technical Aspects</u> Audun Årøen, The Foundation for Scientific and Technical Research at the Norwegian Institute of Technology (SINTEF) <u>Briefing on Excursion Site Visits and Travels</u> Marit Sandbakk, The Foundation for Scientific and Technical Research at the Norwegian Institute of Technology (SINTEF)
	12:15pm	Transport by bus to Bærum Energiverk, Brynsveien 88A, 1300 RUD
	12:45pm	Lunch
	13:30pm	Technical briefing and visit to Bærum Energiverks Heat Pump District Heating/ Cooling Plant incl. snow melting system. (heat source is sewer)
	16:00pm	Transport by bus to hotel
	19:00pm	Dinner given by Royal Norwegian Council for Scientific and Industrial Research. Dinner speaker: William Christensen, The Royal Ministry of Petroleum and Energy Restaurant not yet decided.

May 16th Thu.	09:30am	Transport by bus to Fornebu airport
	10:30am	Flight nr BU066 from Oslo to Ålesund airport
	11:45am	Transport by bus to Ålesund (through road tunnels crossing under the fjords)
	12:30pm	Lunch at Fjellstua
	13:15pm	Technical Briefing and visit to Ålesund og Sula Energiverks Heat Pump District Heating Plant, Norways largest heat pump system using sea water as heat source)
	16:20pm	Transport by bus to Ålesund airport
	17:20pm	Flight nr BU075 from Ålesund to Oslo
	18:30pm	Transport by bus to hotel Afternoon free
May 17th Fri		Day free / National holiday
May 18th	11:05am	Departure

Guides will be Ms. Marit Sandbakk, SINTEF and Mr. Audun Årøen, SINTEF

All bus transport required on May 15th and 16th will be arranged by SINTEF

MAY 1ST, 1991

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Osaka Science and Technology Center, Japan

Program for visit to Trondheim, 1. October 1991.

1. 0900 - 1300 Meeting at SINTEF Refrigeration Engineering, 6th floor.

0900 - 0920		Introduction of NTH-SINTEF	Geir Eggen
0920 - 0940		Introduction of OSTEC/ISCO	
0940 - 1020		Heat Pump R&D-projects at SINTEF Refrigeration Engineering	
	-	Fluidized bed heat evaporators	Tor Lystad
	-	Heat pumps in industrial drying systems	Ingvald Strømmen
1020 - 1100		R&D-projects at SINTEF Applied Thermodynamics	
	-	Energy from waste production	Helge Rosvold
	-	Fluidized bed combustion	Erling Østerbø
1100 - 1120		Conversion of Natural Gas into methanol	Marit Semmen Andersen
1120 - 1140		Discussion	
1140 - 1220		Visit to the laboratory at SINTEF Refrigeration Engineering	O.N, K.A, H.M, G.
1220 - 1300		Lunch (SINTEF Refrigeration Engineering, 6th floor)	

2. 1300 - 1500 Visit to the District Heating System Central of Trondheim.

(Osaka Science & Technology Center Building)

OSAKA SCIENCE & TECHNOLOGY CENTER
INTERNATIONAL SCIENCE CLUB OF OSAKA
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Telephone: 06–443–5321
Facsimile: 06–443–5310

Printed in Japan, 1991

OSTEC MISSION

The New Alternative Energy Study Group

(September 27 ~ October 12, 1991)

Osaka Science and Technology Center
(OSTEC)
International Science Club of Osaka
(ISCO)

The Mission's Purpose

The Osaka Science and Technology Center was established in 1961 in cooperation with the Science and Technology Agency and the Ministry of International Trade and Industry. Since then it has been involved in the promotion of the development and application of new energy sources such as solar energy, geothermal energy, wind energy and biomass energy, and reclamation energy sources including waste industrial heat and waste hot water heat.

Since 1990 we have been working on research into a combined heating and power system using heat generated by the incineration of garbage, and into possibilities of methanol.

This study group has the power to propel the development of petroleum energy alternatives and energy conservation through its involvement with research institutions and private enterprises. We look forward to receiving your support.

research subjects
(1) Regional heating supply systems
Regional heating supply networks
Heat pump systems and use of waste heat (industrial, waste water)
Combined heat and power plants
(2) Ice bank stored cooling systems
(3) Large-scale water electrolysis plants
(4) Large-scale solar energy systems
Photovoltaic systems
Solar thermal power plants
(5) Wind energy systems (wind farms)

MISSION LEADER
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Capital: US$3,590,970,093
Employees: 24,825
Type of Business: Electric Utility

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FAX. 06–202–2680

Capital: US$977,784,030
Employees: 10,931
Type of Business: Gas Utility

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Capital: US$1,830,000,000
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Type of Business: Manufacturing of Electric Machinery

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Employees: 21,300
Type of Business: Iron & Steel Making/Engineering & Machinery.

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Employees: 8,650
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Capital: US$74,000,000
Employees: 3,000
Type of Business: Electric & Electronics Products Manufacturer

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Employees: 48,616
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The JAR Tour of Norway

(October 9 through 12, 1991)

Wed. Oct. 9:	12:55	Arrival at Trondheim Airport (SK1348). Bus directly to Royal Garden Hotel.
	15:00	Meeting at NTH-SINTEF Refrigeration Engineering (bus from hotel 10 minutes before). - Refreshments - Presentation of NTH-SINTEF Ref.Eng. activities
	20:00	Dinner given by NTH-SINTEF Ref.Eng. at Restaurant Havfruen (bus from hotel 5 minutes before). *Host:* Mr. Arne M. Bredesen, Professor
Thu. Oct.10:	06:45	Leave Trondheim.
	08:00	Departure from Trondheim Airport (BU332).
	08:35	Arrival at Ålesund Airport. Bus directly to ÅSEV. Meeting at ÅSEV. - Refreshments - Presentation of ÅSEV activities - Tour of heat pump plant (district heating system) *Contact person:* Mr. Audun Årøen
	14:00	Lunch given by ÅSEV at Fjellstua.
	14:30	Sightseeing/shopping
	17:20	Departure from Ålesund Airport (BU075).
	18:20	Arrival at Oslo Airport. Bus directly to Bristol Hotel.
Fri. Oct.11:	09:00	Meeting at Oslo Energi. - Refreshments - Presentation of Oslo Energi activities
	10:30	Tour of Skøyen Vest heat pump plant (district heating system). *Contact person:* Mr. Knut Erik Madsen
	12:00	Lunch at Bærum Energiverk.
	13:30	Tour of Bærum Energiverk heat pump plant (district heating and district cooling system). *Contact person:* Mr. Atle Nørstebø
	20:00	Dinner given by the Norwegian Association of Refrigeration (at Holmenkollen Park Hotel or Frognersetra). *Host:* Mr. Torbjørn Olsen, Chairman
Sat. Oct.12:	12:30	Departure from Oslo (SK463).

We are pleased to inform you that a reprecentative from SINTEF Refrigeration Engineering will meet the delegation at Trondheim Airport on Oct.9 and stay with the group until it departes from Oslo Airport on the 12th.

欧州エネルギー有効活用調査団

List of Members

NAME	POSITION	COMPANY
Minoru Araki	President	Kansai Netsuken Eng. Co., Ltd
Toshiyuki Hirota	President	Hirota Reiki Co., Ltd
Hirotake Yoshida	Manager Airconditioning Division	Itami Daikin Airconditioning Co., Ltd
Hidenari Fujino	President	Soei Consultants
Masao Arisawa	President	Usio Equipment Consultant Co., Ltd
Toshihiro Fujino	Manager, R & D	Osaka Gas Co., Ltd
Isao Nomura	Engineer, Airconditioning and Refrigeration	Daikin Industries, Ltd
Yukio Yamaguchi	Project Manager, R & D	Daikin Industries, Ltd
Kazuo Tanaka	Senior Engineer Internationl Trading Division	Daikin Industries, Ltd
Tadaaki Nakano	Manager Domestic Airconditioning Division	Mitsubishi Electric Co., Ltd
Yoshimitsu Ichiryu	Market Development Division	The Kansai Electric Power Co., Inc
Shuji Kakutani	Manager Airconditioning Engineering	Mitsubishi Heavy Industries, Ltd
Toshiyuki Toyonaka	President	Environmental System-Engineering Co., Ltd
Shiro Kawakami	Research Laboratory	Konoike Construction Co., Ltd
Tomohiro Nomura	Doctor Professor, Faculty of Engineering	Osaka City University
Yoshinobu Yamamoto	Senior Manager Energy Engineering Division	Shin Nippon Airconditioning Engineering Co., Ltd

HPTC Energy Sources for HP Technology Exchange Mission

Program for visit to Norway November 2nd - 6th

Nov. 2nd	**2200**	**pm**	Arrival Oslo, Transfer to Hotel. Accomodations at Hotel in Oslo.
Nov. 3rd	**1430**	**pm**	Departure Oslo Airport.
	1525	**pm**	Arrival Trondheim, Transfer to Hotel.
	1800	**pm**	Bus departure.
	1900	**pm**	Visit to Ringve Music Historic Museum.
	2000	**pm**	Dinner at Ringve Museum.
Nov. 4rd			HP-Technical Exchange Meeting at NTH-SINTEF Refrigeration Engineering (6th floor).
	0900	**am**	Welcome Address
	0910	**am**	Introduction of the Mission. Speaker from Japan.
	0920	**am**	The Norwegian Institute of Technology and the SINTEF Group. Per-Erling Frivik, Professor
	0940	**am**	Presentations from Japan.
			Performance of Chemical Heat Pump. Using $CaCl_2/CH_5NH_2$. Mr. T. Fujita, Senior Research Engineer, Kansai Electric Power Co., Inc.
			Heat Pumps Utilizing Low Temperature Water as Heat Source and its application. Mr. S. Takeuchi, Assistant Manager, Hokkaido Electric Power co., Inc.
			Development of Heat Pump Applied Hot Water Supply System Recovering Heat from Dairy Waste Water. Mr. K. Takahashi, Researcher, Kumagal Gumi Co., Ltd.
			District Heating and Cooling System Using Heat from Rivers in Japan-Hakozaki Installation.
	1200		Lunch

	1300	**pm**	Presentation of NTH-SINTEF Refrigeration Engineering. Per-Erling Frivik, Professor. The Heat Pump in the Energy System. Experiences from Sea Water based Heat Pumps in Norway. Mr. Geir Eggen, Senior Research Engineer. Heat Pumps in Industrial Drying Systems. Dr. I. Strømmen, Ass. Professor. Compressor Testing and Simulation. Mr. K. Haugland, Researcher.
	1520	**pm**	Coffee-break
	1540	**pm**	Visit to the Laboratory.
	1630	**pm**	Discussions (6th floor).
	1700	**pm**	Transfer to hotel.
	1900	**pm**	Dinner given by NTH-SINTEF Refrigeration Engineering
Nov. 5th	**0800**	**am**	Departure Trondheim Airport.
	0835	**am**	Arrival at Ålesund. Bus directly to ÅSEV for tour of heat pump plant/district heating system. Contact person: Mr. Audun Årøen.
	1200		Lunch given by ÅSEV
	1435	**pm**	Departure Ålesund Airport.
	1500	**pm**	Arrival Oslo, Transfer to Royal Christiania Sara Hotel.
	2000	**pm**	Dinner given by the Royal Norwegian Council for Scientific Research and Development.
Nov. 6th	**1230**	**pm**	Lunch at Bærum Energiverk
	1330	**pm**	Visit Sandvika Heat Pump (district heating and district cooling system). Contact person: Dr. Atle Nørstebø.
	1705	**pm**	Departure Oslo Airport for Stockholm.

MEMBER LIST

Nar[illegible]	Affiliation
K. Ho[illegible]jo (Leade[illegible])	Director for Development Program Agency of Industrial Science and Technology Ministry of International Trade and Industry
N. Ka[illegible]ta (leade[illegible])	Manager Advanced Technology Programs Department Nuclear and Advanced Technology Project Division JGC Corporation
Y. Ni[illegible]ino	Senior Manager Engineering Department of Cogeneration & District Heating/Cooling Osaka Gas Co., Ltd.
T. F[illegible]ta	Senior Research Engineer Technical Research Center Kansai Electric Power Co., Inc.
M. Na[illegible]no	Section Manager Technical Division Kiyota Kogyo Co. Ltd.
K. T[illegible]hashi	Researcher Building Environment & Energy Department Tsukuba Institute of Construction Technology Kumagai Gumi Co., Ltd.
Y. O[illegible]	Deputy General Manager Underground & Geotechnical Engineering Department Shimizu Corporation
S. Ma[illegible]yama	Section Manager Urban Facility Division Shinryo Corporation
Y. A[illegible]oto	Chief Engineer Engineering Department Osaka Office Taikisha Ltd.

Name	Affiliation
S. Ku[illegible]ta	Manager Mechanical & Electrical Engineering Section Building Design Department Tokyo Main Office Takenaka Corporation
T. T[illegible]i	Manager Sales Planning &Marketing Section Sales Administration Department Air Conditioning Sales Division Daikin Industries Ltd.
K. Fu[illegible]kura	Senior Researcher Heat Pump Systems Energy Technology Research Institute Tokyo Gas Co., Ltd.
T. I[illegible]e	Assistant Manager Building System Engineering Project Team Market Development Department Tokyo Electric Power Co., Inc.
T. Na[illegible]maru	Deputy Manager Urban System Group Local Government System Division Toshiba Corporation
K. K[illegible]	Deputy Section Chief Urban Building Facility Design Department Architectual & Structual Engineering Operation Center Tokyo Electric Power Services Co., Ltd.
T. T[illegible]da	Chief Heating & Cooling Supply Section Tokyo Electric Porer Real Estate Maintenance Co.
K. K[illegible]	Senior Mechanical Engineer Nikken Sekkei Ltd.
S. T[illegible]uchi	Assistant Manager Electricity Utilization Research Section Department of Research and Development Hokkaido Electric Power Co., Inc.

Name	Affiliation
T. Yo[illegible]hii	Project Manager Plant Sales & Engineering Air-conditioning & Refrigerating Machinary Headquarters Mitsubishi Heavy Industries, Ltd.
H. Ku[illegible]bara	Assistant Group Manager STL Department Mitsubishi Petrochemical Engineering Co., Ltd.
Y. Ta[illegible]no (Secretariat)	General Director Heat Pump Technology Center of Japan
H. Ku[illegible]da (Secretariat)	Manager Heat Pump Technology Center of Japan
P. Sa[illegible] (Tour Escort)	Chief Manager Overseas Tour Promotion Inc.
H. Mi[illegible]guchi (Tour Escort)	Assistant Manager Sales Department Overseas Tour Promotion Inc.

Norwegian participants at the "Technology Exchange Meeting", Trondheim, November 4, 1991:

Name:	Affiliation:
Mr. Geir Eggen	Senior Research Engineer Section Manager (HP Section) SINTEF Refrigeration Engineering
Mr. Ingvald Strømmen	Assistant Professor SINTEF Refrigeration Engineering
Mr. Kjell Haugland	Research Engineer Norwegian Institute of Tech.
Mr. Tor Lystad	Senior Research Engineer SINTEF Refrigeration Engineering
Mr. Rune Aarlien	Research Engineer SINTEF Refrigeration Engineering
Mr. Per Arne Schiefloe	Research Engineer SINTEF Refrigeation Engineering
Mr. Olav Slettahjell	Consultant Engineer Siv.ing. Gaute Flatheim
Mr. Per Røsæg	Chief Engineer Sør-Trøndelag County Administration
Mr. Knut Wanvik	Consultant Engineer Siv.ing. Kr. Gjettum A/S
Mr. Eirik Skare	Sales Manager Nobø Fabrikker A/S
Mr. Ole Flagstad	Research Engineer Institute for Energy Technology

Tour of Laboratories

Anticipated start: 15:40

Participants will form 4 groups, which will be guided through the laboratory by SINTEF personnell. The tour will consentrate on 4 different exhibits:

	Exhibit:	Presented by:
1	Compressor Test Rig	Kjell Haugland
2	Heat Pump Drying	Ingvald Strømmen
3	Multy Purpose Heat Pump	Odd Nesje
4	Compact HP with R-152a as Working Fluid	Tor Lystad

Guide of group:	T-10	10-20	20-30	30-40
Per Arne Schiefloe	1	2	3	4
Jørn Stene	2	3	4	1
Trude Tokle	3	4	1	2
Rune Aarlien	4	1	2	3