STF11 A94009

Årsrapport 1993 for norsk deltakelse i internasjonale varmepumpeaktiviteter

1994-03-07

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RAPPORT

TITTEL

Årsrapport 1993 for norsk deltakelse i internasjonale varmepumpeaktiviteter

FORFATTER(E)

Rune Aarlien

OPPDRAGSGIVER(E)

Norges Vassdrag- og Energiverk, Norges Forskningsråd, Miljøverndepartementet, Nærings- og Energidepartementet, SINTEF

ARKIVKODE	GRADERING	OPPDRAGSGIVERS REF.	
	Åpen	Ulf Rivenæs	
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SAMMENDRAG

Redegjørelse for internasjonale varmepumpeaktiviteter som Norge har vært involvert i gjennom Det Internasjonale Energibyrået (IEA) og EU.

Norge har i flere år vært aktivt med i IEAs internasjonale Varmepumpeprogram, og de siste par årene også i EUs Concerted Action Heat Pump Group. Aktivitetene i 1993 har vært en naturlig videreføring av tidligere års aktiviteter.

I løpet av 1993 har Norge høstet nye og meget nyttige erfaringer fra det internasjonale varmepumpe-samarbeidet. Dette er erfaringer som både på kort og lang sikt kommer til nytte for våre forskningsmiljøer, industri og næringsliv. Arbeidet er en naturlig og nødvendig del av aktivitetene til en kunnskapsbedrift som NTH-SINTEF Kuldeteknikk, som både skal sørge for å utvikle kunnskaper selv og følge med i det som ellers skjer i sitt fagfelt.

Den største utfordringen for varmpumpeindustrien i dag er overgangen til miljøakseptable arbeidsmedier, og aktivitetene under det internasjonale varmepumpesamarbeidet reflekterer dette i høy grad. Rapporten tar for seg: Anneks-virksomheten, Norsk National Team, Norsk Varmepumpekonferanse 1993, HPCs Newsletter, IEAs 4de Internasjonale Varmepumpekonferanse, IEA "Analysis 1992", Eksekutivkomitemøter, EUs Varmepumpeprogram og regnskap for aktivitetene i 1993.

STIKKORD	NORSK	ENGELSK
GRUPPE 1	Kuldeteknikk	Refrigeration Engineering
GRUPPE 2	Forskningssamarbeid	Research Cooperation
EGENVALGTE	Varmepumper	Heat Pumps
	Energi	Energy
	Oppvarming	Heating

SINTEF

INNHOLDSFORTEGNELSE

IEA Implementing Agreement for a Programme of Research, Development, and Demonstration of Heat Pumping Technologies

Årsrapport 1993

Norge har i 1993 deltatt i IEAs Varmepumpeprogram (Implementing Agreement for a Programme of Research, Development, and Demonstration of Heat Pumping Technologies) med full styrke. Utøvende parter har vært NTH-SINTEF Kuldeteknikk og NVEs Varmepumpeprogram ved Programledelsen. Resultatene fra fjorårets aktiviteter er beskrevet under, og i vedlegg.

1 Anneks-virksomhet

Norge har i 1993 vært med i følgende annekser:

Anneks 16: Heat Pump Centre
Anneks 17: Experiences with New Refrigerants in Evaporators
Anneks 18: Thermophysical Properties of the Environmetally Acceptable Refrigerants
Anneks 20: Working Fluid Safety
Anneks 21: Global Environmental Benefits of Industrial Heat Pumps

Anneks 16, eller Heat Pump Centre (HPC) er et "clearinghouse" for informasjon innen dette programmet, og har ansvaret for koordineringen av de forskjellige anneksene. Viktige oppgaver for HPC i 1993 har vært:

- Arbeidet med "Analysis 1991" og "Analysis 1992"
- Tilrettelegging av workshop i Fukuoka, Japan (Heat Pumps and Thermal Storage) og i Breckenridge, USA (Domestic Hot Water Heaters)
- Utgivelse av Newsletter
- Svartjeneste
- Informasjonsspredning
- Arrangement av National Team Working Meeting
- Promotion
- Møteaktivitet

Aktivitetene er beskrevet i større detalj i **vedlegg 1** (Progress Report 1993). For en oversikt over aktiviteter i perioden 1988 til 1992 henvises det til **vedlegg 2** (Revised End-of-Term Report).

Under HPC ligger også Technical Support Services Unit (TSSU), som har til oppgave å bistå de forskjellige anneksene og Eksekutivkomiteen (EXCO) med administrative oppgaver. En detaljert beskrivelse av aktivitetene er gitt i **vedlegg 3** (Progress Report 1993, TSSU).

Vedlegg 4 gir en oversikt over HPCs publikasjoner.

Anneks 17, Experiences with New Refrigerants in Evaporators, ble formelt avsluttet på EXCO-møtet i Roma i oktober 1993. Resultatene foreligger i egen SINTEF-rapport (STF11 A94003). Det er stor sannsynlighet for at det vil bli foreslått en videreføring av dette arbeidet i et nytt anneks. Dette vil tidligst kunne startes opp i 1995.

Anneks 18, Thermophysical Properties of the Environmetally Acceptable Refrigerants, har hatt to møter i 1993, og Norge var representert på begge. Pga. kutt i bevilgningene i forhold til det vi på forhånd hadde blitt forespeilet, har vi måttet utsette oppstarten av vårt faglige bidrag til dette annekset. Det er vår intensjon å bidra med forbedrede beregningsmetoder for kuldemedieblandingers oppførsel under varierende trykk og temperatur. Egne rapporter for termofysiske egenskaper for kuldemediene HFC134a og HFC123 finnes hos NTH-SINTEF Kuldeteknikk. Vår deltakelse har, selv om vi ennå ikke har fått bidratt med så mye selv, skaffet oss nyttig informasjon som grunnlag for overgangen fra KFK-stoffene til mer miljøvennlige arbeidsmedier.

Anneks 20, Working Fluid Safety, ble avsluttet på EXCOs vårmøte i Maastricht. Der ble sluttrapporten presentert, og arbeidet, som er utført av Professor Jan Berghmans ved Det Katolske Universitet i Leuven, Belgia, høstet stor anerkjennelse. I rapporten er analysert potensielle farer ved bruk av de såkalte naturlige arbeidsmediene, og det viser seg at frykten som i dag eksisterer i enkelte miljøer i det store og hele er overdrevet. Med rapporten hører også et PC program for beregning av farer ved ulike typer utslipp av brennbare og eksplosive arbeidsmedier. Både rapport og PC program finnes hos NTH-SINTEF Kuldeteknikk. **Vedlegg 5**, som ble publisert i bladet KULDE, gir en omtale av anneksets resultater.

Anneks 21, Global Environmental Benefits of Industrial Heat Pumps, har som hovedmål å vurdere muligheter og fordeler ved økt bruk av industrielle varmepumper. **Vedlegg 6** gir en beskrivelse av annekset og referat fra siste ekspertmøte. De forskjellige deltakerlandene er nå i ferd med å gjøre ferdig sine bidrag, som senere vil bli satt sammen til en helhetlig rapport. Den norske rapporten vi være klar i løpet av mars 1994. Mot slutten av 1994 er det planlagt en workshop som en naturlig avslutning på dette annekset.

Nytt anneks. På EXCO-møtet i Roma i oktober la Norge frem et forslag til et nytt anneks med tittelen "Vapor Compression Systems with Ecologically Safe Working Media" (se **vedlegg 7**). Under dette annekset ønsker man utelukkende å se på naturlige arbeidsmedier, og ikke medier som er fremstilt av kunstige kjemikalier. Det er ønskelig å gjøre dette annekset så praktisk rettet som mulig, og på denne måten forsøke å få med industrien til aktiv innsats. Forslaget ble meget godt mottatt, og i ettertid har vi fått kommentarer som viser at interessen er stor for å få i gang aktiviteter på dette området. Hvis annekset blir realisert, vil Norge bli "operating agent". Dette vil vi vite i løpet av første halvdel av 1994.

2 Norsk National Team

Land som deltar i Anneks 16 (HPC) har sitt eget National Team, som er bindeleddet mellom sitt lands varmepumpemarked og HPC. Norsk National Team har i 1993 vært identisk med styret i NVEs Varmepumpeprogram, og har bestått av følgende medlemmer:

Ulf Rivenæs (formann)	NVEs Varmepumpeprogram
Magne Amundsen	NVE
Torodd Jensen	Norges Forskningsråd
Erik Strømsøe	Kverner Eureka AS
Chr. Nørgaard Madsen	Techno Consult AS
Roar Rose	Norsk Varmepumpeforening
Rune Aarlien	SINTEF Kuldeteknikk

National Teams møter har naturlig vært kombinert med Varmepumpeprogrammets styremøter. I tillegg var vi representert med to utsendinger på det årlige National Team Working Meeting i Maastricht, 27. og 28. september. Dette møtet har til hovedhensikt å legge neste års planer for HPC. Rapport fra møtet er gitt i **vedlegg 8**. Siden NVE har terminert sitt varmepumpeprogram med virkning fom. 94-01-01, har National Team stilt sine plasser til disposisjon.

3 Norsk Varmepumpekonferanse

Den årlige konferansen ble i år arrangert 8. desember på Fornebu med 106 deltakere. Konferanseprogram og deltakerliste er gitt i **vedlegg 9**. Vi hadde i år inviterte foredrag fra EU, Belgia, og Sverige. Det ble tatt en konferanseavgift på NOK 700 pr. person.

4 HPC Nyhetsbrev

Nytt av året er at hver utgave av Newsletteret har sitt tema. I tillegg til tamaartiklene skrives det også en sammendragsartikkel på tema som omfatter alle landene som er med i HPC.
Følgende numre av Newsletter ble utgitt i 1993:

- Vol 11, No 1: Industrial Heat Pumps
- Vol 11, No 2: 4th IEA Heat Pump Conference
- Vol 11, No 3: Heat Pumps and the Environment
- Vol 11, No 4: Developments and Trends

Forside og innholdsfortegnelse for samtlige numre er gitt i vedlegg 10. I Norge mottar ca. 500 bedrifter og privatpersoner hvert nummer av Newsletteret. Dette er det største antall newsletter pr. capita blant alle deltakerlandene - større i absolutte tall enn både USA og Japan.

5 IEAs 4de Internasjonale Varmepumpekonferanse

Årets største begivenhet i dette programmet var uten tvil IEAs 4de Internasjonale Varmepumpekonferanse som ble arrangert i Maastricht 26.-29. april. Konferansen, som hadde temaet "Heat Pumps and the Environment", samlet bortimot 300 deltakere fra hele verden, og ble et meget vellykket og givende arrangement. Fullstendig proceedings fra konferansen finnes som egen bok (ELSEVIER forlag). En oversikt over alle "papers" som ble presentert og "posters" som ble utstilt, samt et sammendrag av de forskjellige sesjonene (tatt fra Newsletter No. 2) er gitt i **vedlegg 11**. Norge bidro med én chairman (Professor Per-Erling Frivik) og sju "poster"-presentasjoner.

I forbindelse med denne konferansen ble det også arrangert en "før-konferanse" tur som det norske og det svenske National Team hadde ansvaret for. På turen, som blant annet inkluderte noen av OL-anleggene på Hamar, Gjøvik og Lillehammer, samt fjernvarme- og fjernkjøleanlegget i Sandvika, deltok 17 japanere og to kanadiere. Program og deltakerliste, samt omtale i Newsletter, er gitt i **vedlegg 12**. Turen startet i Gøteborg og endte opp i Oslo.

6 "Analysis 1992"

Som de fleste andre medlemsland, har Norge i løpet av 1993 utarbeidet sitt bidrag til "Analysis 1992": *International Heat Pump Status and Policy Review*. Dette er en analyse som skal vise hvor verden står mht. utvikling og implementering av varmepumper. Grovarbeidet ble utført av student ved Institutt for Kuldeteknikk, Kjetil Evenmo, mens Jørn Stene har videreforedlet rapporten (**vedlegg 13**), som også er utgitt som SINTEF-rapport (STF11 A94005). I forbindelse med dette prosjektet har også Jørn Stene vært ansatt en tid ved HPC i Nederland for å sy sammen alle delrapportene til en helhetlig rapport. Sluttrapporten vil foreligge i løpet av 1994.

7 EUs Varmepumpeprogram

Selv om denne aktiviteten pr. definisjon ligger utenfor IEAs virkeområde, er den tatt med her for helhetens skyld. Norge har i 1993 deltatt på to møter i den såkalte Concerted Action Heat Pump Group (CAG). Referater er gitt i **vedlegg 14**. IEA og EU inngikk i løpet av året et avtale om formell utveksling av informasjon, og Ulf Rivenæs fikk i oppgave å fungere som *Liasion Officer*. Dette betyr at Rivenæs vil rapportere fra EXCO-møtene til CAG-møtene, og vise versa.

8 EXCO-møter

Norge var i 1993 representert på begge møtene i Eksekutivkomiteen. Referater er gitt i **vedlegg 15**. I tillegg fungerte Rune Aarlien som offisiell observatør på EXCO-møtet i *Implementing Agreement on District Heating and Cooling* i Ålesund i mai (**vedlegg 16**). Det er et uttalt ønske fra flere av de såkalte Implementing Agreements, og fra IEA sentralt, at man i større grad utveksler informasjon og holder hverandre oppdatert om sine aktiviteter for å unngå dobbeltarbeid og på den måten dra nytte av hverandres aktiviteter.

9 Regnskap

Virksomheten har vært finansiert av: Norges Forskningsråd (NOK 1.000.000), NVEs Varmepumpeprogram (NOK 400.000), Miljøverndepartementet (NOK 250.000), Nærings- og Energidepartementet (NOK 150.000) og SINTEFs strategiske midler (250.000). I tillegg ble det betalt inn NOK 161.721 i deltakeravgift for en studietur arrangert av det norske National Team i forbindelse med IEAs 4de Internasjonale Varmepumpekonferanse. Totalbudsjettet ble dermed på NOK 2.211.721. Av dette rådde SINTEF Kuldeteknikk over NOK 1.536.721. Resten (NOK 675.000) stod til rådighet for NVEs Varmepumpeprogram. Tabellen under viser hvordan Kuldeteknikk har anvendt sin del av midlene.

Post:	**Annexer**	**National Team**	**Totalt**
Timekostnader	472.295	305.586	777.881
Leiestedskostn.	14.575	12.111	26.686
Direkte kostnader	308.640	319.006	627.646
TOTALT	795.510	636.703	1.432.213

Kuldeteknikks ramme for aktivitetene i 1993 var, som nevnt, NOK 1.536.721. Differansen mellom rammen og regnskap (1.536.721 - 1.432.213=) NOK 104.508 er anvendt til å dekke opp et planlagt underskudd på anneksaktiviteten i 1992 på NOK 51.000, mens resten (NOK 53.508) er overført til 1994 for aktiviteter vi ikke fikk gjort på slutten av 1993, grunnet sykdom.

Vedleggsliste:

Vedlegg 1: "Progress Report 1993", IEA Heat Pump Centre

Vedlegg 2: "Revised End-of-Term Report, 1988-1992", IEA Heat Pump Centre

Vedlegg 3: "Progress Report, 1993, Technical Support Services Unit

Vedlegg 4: Publikasjonsliste fra HPC

Vedlegg 5: Omtale av Anneks 20 i bladet Kulde

Vedlegg 6: Beskrivelse av Anneks 21 og referat fra siste ekspertmøte

Vedlegg 7: Anneksforslag: Vapor Compression Systems for Ecologically Safe Working Fluids

Vedlegg 8: Referat fra National Team Working Meeting

Vedlegg 9: Norsk VP-konferanse: Program og deltakerliste

Vedlegg 10: Newsletter: Forside og innholdsfortegnelse for utgaver i 1993

Vedlegg 11: Den 4de Internasjonale Varmepumpekonferanse: Oversikt over "papers", "posters" og sammendrag av sesjonene

Vedlegg 12: Pre-konferanse tur: Program, deltakerliste og omtale i Newsletter

Vedlegg 13: "Analysis 1992": Norges bidrag

Vedlegg 14: Referater fra to møter i EUs Varmepumpegruppe

Vedlegg 15: Referater fra årets to EXCO-møter

Vedlegg 16: Referat fra "District Heating and Cooling"s EXCO-møte i Ålesund

Progress report 1993

Annex 16 - IEA Heat Pump Centre

Date	:	October 13, 1993
Operating Agent	:	The Netherlands Netherlands Agency for Energy and the Environment Swentiboldstraat 21 6137 AE Sittard tel. 31 46 595236 fax. 31 46 510389
Participants	:	Austria Canada Italy Japan Netherlands Norway Sweden Switzerland USA
Organizational basis	:	Cost-sharing
Date begun	:	January 1, 1990
Completion date	:	-
Extension	:	January 1, 1996

IEA Heat Pump Centre

Objective

The HPC's objective is to accelerate the implementation of heat pumping technology and thereby optimize the use of energy resources for the benefit of the environment.

Previous progress

Reference is made to HPC annual report 1992.

Progress during this period

Period: January 1 - October 1, 1993

Analysis

1991 Analysis "Heat Pump Water Heaters". The draft final report was reviewed by all National Teams and the IIR. Comments and suggestions received were discussed with the contractor and implemented where appropriate.

1992 Analysis "International Heat Pump Status and Policy Review". A revised list of countries was submitted to the IIR. The list contains additional countries as discussed at the Maastricht AB meeting, leading to a considerable extension of the scope of work and cost. The Analysis project is a joint project between IEA HPC and IIR. In addition to the IIR, organizations in Germany, France, Spain, England, Belgium, Denmark, Greece, Australia and New Zealand have been invited to participate in the project. These countries were involved in the previous study, published earlier by the OECD. Positive reactions have been received from all countries. France will be covered by the IIR. Contracts have been made with Greece, Belgium, Germany and the IIR. In October/November, Denmark and England will be visited to collect the information through interviews.

Mr. Jorn Stene from SINTEF, Norway, joined the HPC staff in September to assist in the analysis work. It is envisioned that he will stay for 3 months, with a possible extension.

Workshop

The workshop on Heat Pumps and Thermal Storage in Fukuoka was held successfully with 13 participants from outside Japan (total number 38). Participating countries were Japan, Korea, Malaysia, Germany, France, Sweden, Belgium and the Netherlands.

The US National Team was supported in arranging the workshop on "Domestic Hot Water Heat Pumps" in Breckenridge, USA. The workshop was a follow-up of the Analysis 1991. Assistance was given in securing speakers and possible participation, particularly from Europe. The HPC invited speakers and participants. The facilitator of the workshop was contracted. The final draft of the proceedings was received for review and comment in September. Publication of the proceedings is scheduled for November.

Publications

Newsletter:

Vol.11, no.1 (Industrial heat pumps). Implementation of the new style began in this issue. A topical overview article was included, based on National Team contributions.

Vol.11, no.2 (4th IEA Heat Pump Conference) has been issued. This issue was produced by the HPC staff with news contributions from the National Teams. For this issue potential correspondents in non-member countries were approached with the purpose of providing contributions on a regular basis in future.

Vol.11, no.3 (Heat pumps and the environment) is about to be distributed; National Teams were provided with guidance on the National Topic Appraisal for this issue, along with suggestions on activating communication with journals in their country to promote the HPC and NT activities.

Proceedings:

The proceedings of the Merligen workshop (Impact of Heat Pumps on the Greenhouse Effect) and a product sheet were published and distributed to the National Teams and others within the network.

The HPC has published and distributed the proceedings in September. Also a product sheet has been made.

The meeting of the Publication Task Group on 16 February was successful. The new style newsletter was the main issue on the agenda. Suggestions were made for further improvements. The minutes of this meeting were distributed among the participants and the AB.

Analysis:

The final report was printed and distributed. A product sheet was produced and distributed as well.

Reports:

The 1992 annual and financial report were made, and approved by the EXC. Other reports produced include the spring 1993 and fall 1993 interim activities report on the HPC, NTWM and the minutes of the spring and fall AB meeting.

Inquiries

Various inquiries from member and non-member countries were answered. The 1993 overview will be included in the annual report.

A Japanese group representing the Petroleum Association of Japan visited the HPC and information on diesel engine driven heat pumps was exchanged.

Advisory Board

The AB held three meetings (see meetings). At the fall meeting the 1994 workprogramme was discussed with the NTs and the HPC.

NTWM

September 27 and 28; National Teams Working Meeting in Maastricht, Netherlands. Except Italy, all NTs were in attendance. The NTs of Sweden and the Netherlands are in a transitional stage. The meeting included a workshop on Promotion, where the HPC promotion programme was discussed. Further discussion at NT level is needed before implementation of the programme can commence.

Promotion

A draft workplan for a promotion campaign was developed and discussed at the Maastricht AB meeting. As a result, National Teams have been requested to provide their views and needs regarding promotion. A revised version of the promotion strategy plan was sent to National Teams and the AB for review and further discussion at the 1993 NTWM. No agreement on the proposed promotion strategy was achieved at the 1993 NTWM, mainly because promotion needs have still to be discussed on a National Team level. The consequence is a delay in implementing the promotion strategy. NTs were encouraged to speed up the discussion and were also reminded that promotion is one of the Programme's important means.

The so-called heat pump platform document, a promotional brochure, was produced and widely distributed.

The Swedish EXC delegate was provided with an information package on the Heat Pump Centre to support efforts to continue Sweden's participation in Annex 16.

Three heat pump posters were developed for the 4th IEA Heat Pump Conference. The posters have been designed for wider use. National Teams were provided with a copy of the posters. The HPC shared a booth with the IEA at the 4th IEA Heat Pump Conference. The booth was well visited and many requests for information were dealt with.

Meetings

January 7; meeting with Mr.L.Lucas (IIR) in Paris to discuss possible contract in relation to the Analysis "International Heat Pump Status and Policy Review".

January 24 to 27; attended 1993 ASHRAE winter meeting and gave a presentation on the Analysis "The Impact of Heat Pumps on the Greenhouse Effect".

February 16; Publication Task Group meeting in Sittard. The meeting was attended by a Dutch National Team representative, the editor of a Dutch bi-weekly engineering magazine, and the editor of the Norwegian magazine "Kulde". Corresponding members were Ms.Keyser (N.America) and Mr.Igarashi (Japan).

March 25; Mr. Stuij visited the ISH exhibition in Frankfurt, Germany.

April 25 to 29; 4th IEA Heat Pump Conference, Maastricht. Parallel meetings attended: Advisory Board on 27 April, IPUHPC on 28 April.

May 2 and 3; attended the EXC meeting in Maastricht.

May 5; attended the IEA Energy Technology Information Centre/Information Implementing Agreements coordination meeting in Paris.

May 18 to 22; Seoul, Korea. Visited Korea Institute of Science and Technology (dr.Byung Ha Kang/dr.Chun Sik Lee) where presentations were given on the IEA Heat Pump Programme, the Heat Pump Centre, and Heat Pump R&D in Europe. The Korean heat pump market and technology status were discussed in a seminar at KIST, attended by manufacturer, university and government representatives. A meeting was arranged with dr.Ki Ryun Choi, president of the R&D Management Center of Energy and Resources. He stated that heat pumps have become key technology in Korea and participation in the Heat Pump Programme is seriously considered. Visits were also made to Samsung Electronics (electric reversible heat pumps) and Kyungwon Century Co., manufacturer of reversible electric heat pumps and absorption chiller heaters.

May 24 and 25; Joint HPC/Japanese National Team Workshop in Fukuoka on Heat Pumps and Thermal Storage.

May 26; Annex preparatory meeting on Chemical Processes for Ecological Thermal Energy Systems (CPTES) in Fukuoka. The HPC, assisted by the Heat Pump

Technology Center of Japan, arranged and coordinated the meeting. Minutes were produced and distributed.

June 26; Advisory Board meeting Denver

June 27 to 30; attended 1993 annual ASHRAE meeting, the US National Team meeting, ASHRAE Technical Committee meetings on Heat Pumps, and the ASHRAE International Committee meeting in Denver.

July 1 and 2; US NT/HPC workshop on Domestic Hot Water Heat Pumps in Breckenridge. Draft proceedings received for review in September 1993.

August 16 and 17; attended Cold Climate Heat Pumps Conference in Moncton and briefly introduced IEA Heat Pump Programme Strategy Plan in the Opening Session.

August 19 and 20; attended ASHRAE/NIST Conference on Alternative Refrigerants in Gaithersburg.

August 27 to September 10; mission to New Zealand and Australia to promote the IEA Heat Pump Programme and the Heat Pump Centre. For detailed information reference is made to the mission report to the EXC.

September 21; gave presentation "Absorption Heat Pumps in Industry - An International Overview" for the International Industrial Heat Exchangers Users Group in the Netherlands.

September 28 (morning); Advisory Board meeting in Maastricht. Three members were in attendance.

Plans for coming period

- Analysis 1992; collecting information from non-member countries and analyzing completed National Position papers.
- Production of Newsletter Vol.12, no.4.
- Production of Breckenridge workshop proceedings and product sheet (Heat Pump Water Heaters).
- Preparing production of Annex 20 report for publication by the HPC.
- Arranging of 1994 Users Club meeting and producing minutes.
- Presentations on IEA Heat Pump Programme/HPC and Industrial Heat Pumps (short course Palermo)
- Preparing 1994 workshops in Sweden and Switzerland.

INTERNATIONAL ENERGY AGENCY

IMPLEMENTING AGREEMENT
FOR A PROGRAMME OF RESEARCH AND
DEVELOPMENT ON
ADVANCED HEAT PUMP SYSTEMS

REVISED
END-OF-TERM REPORT
For the Period 1988 - 1992

Submitted to the
WORKING PARTY ON ENERGY END-USE TECHNOLOGIES

SEPTEMBER 1993

INTRODUCTION

In the past four years, the Implementing Agreement (IA) has made tangible progress both in strengthening its internal structure, and in communicating its fundamental message to a wider community: that heat pumping technologies provide a viable means of helping to solve energy end-use and related environmental problems.

I. CHANGES IN THE PROGRAMME 1988-1992

In 1988/89, participants in the IA Programme declared that heat pumps had a promising future, due to continuing energy and increasing environmental concerns. At the same time, they identified several aspects of the Programme which needed strengthening, calling for more industry interaction, a closer link to actual market activities, less emphasis on academic research and development, more impact on governmental policy and widening the scope of the Programme to include related technologies. In other words, a new strategy was needed.

In order to effectively address these points and concerns raised in the 1988 End-of-Term Review, and accomplish the aims mentioned above, decisive steps were taken.

Development of the Strategy Plan

The Strategy Plan to the Year 2000 includes a long-term planning period, a clear statement of Objective, Goals, Strategies and an extensive Actions List. The Plan provides a management tool to assist in the development of work plans which support the overall IA aims. The key elements of the Plan are Technology, Markets and Application. The revised and more specifically defined main objective of the Programme is to perform "cooperative research, development, demonstration, promotion and exchanges of information aimed at supporting heat pumping technologies as realistic, reliable and well-known devices to save energy resources and reduce local and global emissions to protect the environment." To reflect this widened scope, a change of title of the IA has been made, to "A Programme of Research, Development, **Demonstration and Promotion** of **Heat Pumping Technologies.**"

A more pro-active stance is reflected in the upgrading and transfer of products and information, and more and better promotion of the expertise found within the IA. Linkage with other IAs based on mutual interests has been envisioned and programmatic suggestions have been made.

Another important component in the overall management of the IA has been the development of an Operation Principles and Guidelines document, which clearly describes the working methods used by the entire network. It is intended to foster greater and more effective participation in the activities of the IA by providing a clear outline of expectations. It includes a model Progress and Annual Annex report, so that pertinent information about Annex activity can be provided in a timely manner to both the Executive Committee (EXC) and the IEA Secretariat.

The Strategy Plan has allowed for the creation of the "Technical Support Services Unit" which provides support for IA activities, including the EXC and all Annexes. Reporting will be streamlined, and Annex information will be more widely disseminated.

The decision process affecting the Strategy Plan required the participants to hold two extraordinary meetings, in addition to the regular two EXC meetings per year.

This Strategy document meets with the IEA Guidelines for a Strategy Development and Regular Review...[IEA/CRD(91)67]. Its focused approach on specific targets, multi-year format, and regular review process (planned to coincide with the three year working periods of Annex 16, Heat Pump Centre) create a strong planned programme and at the same time, a built-in flexibility to meeting changing needs.

Increasing international cooperation

- Other Implementing Agreements

  Increased cooperation with other IAs has taken the form of inviting EXC chairmen to meetings, exchanging EXC meeting Minutes, attending EXC meetings where appropriate, and making presentations at workshops and conferences sponsored by other IAs as well as other international organizations. The IA Chairman participated in a coordinating meeting with other IA Chairmen in June 1992. In future, in addition to the above, joint efforts on topics of mutual interest will be organized.

  The IA has expressed interest in the development of the IEA GREENTIE Programme on greenhouse gases information dissemination; the Heat Pump Centre (HPC) has contributed to discussions prior to its establishment.

- International Institute of Refrigeration (IIR)

  A strong relationship has been forged between the IEA and the IIR in this IA, with a commitment to information sharing and cooperation, currently manifested in the following ways:

  - Through IIR attendance of IEA EXC meetings, IIR membership on the Advisory Board, and representation of the IEA on IIR Commission E2 on Heat Pumps and Heat Recovery (Head of the HPC is a Vice-president of the Commission).

  - Using the publication channels of both groups to disseminate information, whether through articles or by the inclusion of announcement sheets.

  - IIR scientific reviews of HPC technical publications (analysis reports), to enhance their value as authoritative and reliable sources of information.

  - Using the IIR network to secure potential speakers at HPC workshops

  - IIR co-sponsorship of the 4th IEA Heat Pump Conference

- Outreach to Eastern Europe

  During this period of fundamental change in Eastern Europe, information exchange is vital in establishing cooperative links between newly emerging nations and the rest of Europe and the world. Acting on a request from the IEA, the HPC organized a workshop in Budapest, Hungary in 1991. The efforts of the Austrian National Team and the HPC, along with the Hungarian Ministry of Industry and Trade and the Hungarian Electrotechnical Association made the "Industrial Heat Pumps Workshop" a great success, with over 85 participants, including approximately 60 from Eastern Europe. Proceedings were widely disseminated, together with general information about the IEA and its network.

- European Community Heat Pump Group

  The formation of the European Heat Pump Supporting Group is another indication of the perceived need for more emphasis and work to be done with heat pumps. The group serves to support activities relevant to heat pump technology, its promotion and wider application. This group has developed as a complementary rather than competitive activity. The IA continues to cultivate a cooperative relationship with this group.

- Users Club of Sorption Systems

  The Club was established in 1990 as an initiative of end-users in industry in IA countries. The need for an unbiased informal forum for the exchange of practical experience and information gave rise to this group. The HPC acts as Secretariat at its annual meetings. The initiative proves industry's interest in the IEA network.

Other important developments contributing to the accomplishment of the Programme's goals include:

Increasing membership and interest in IA Activities

The development of the IEA Associate membership mechanism has allowed the participation of non-OECD countries: Malaysia is expected to become a member of the IA through its participation in Annex 21, Global Environmental Benefits of Industrial Heat Pumps.

Regularly invited observers at EXC meetings have expressed interest in participating in the IA: these have included France, and more recently, Spain.

Regarding Annex 16 (Heat Pump Centre) membership, Italy confirmed its intention to continue its participation and Switzerland joined in 1992.

The pool of participants in Annex work has grown in this period. For example, two organizations representing the United Kingdom are active in two different Annexes.

Strengthening the Heat Pump Centre

In 1988/89 the HPC was evaluated and its continuation received full support. Reflecting the desire to strengthen it, the following measures were taken:

- *Creation of the Advisory Board*

  Acting upon the recommendations made in 1989, an Advisory Board replaces the Steering Committee (which was responsible only for Annex 4). Composed of four representatives of industry, utilities and the IIR, this group lends its expertise both in the market and in technology, and has proved a valuable addition to the IA network, particularly in assisting the HPC with sound advice on proposals, both financial and programmatic. The Board also reflects the Programme's increasing industry involvement. Since its formation, the Advisory Board has been solely concerned with Annex 16, but with the adoption of the Strategy Plan, its scope has been widened to include all Annex activity with the IA. The Advisory Board holds 3 meetings a year, one in conjunction with the annual National Teams Working Meeting of the HPC member countries. The Board is represented at EXC meetings. Their reports to the EXC have provided helpful feedback and suggestions in terms of establishing a clear set of market-oriented priorities.

- *Strengthening the National Teams Network*

  An extensive international network in the field of heat pumps has been established, in which National Teams (NTs) have a key role. The role of some NTs goes even further. Upon request by the Dutch government, the Netherlands National Team issued a policy advisory document containing specific recommendations on the future of heat pump activities in the Netherlands. The government has adopted the policies suggested in this document. Efforts and results of this kind illustrate the importance and strength of the IA network. The majority of NTs have been reorganized to increase representation of the most important target groups such as industry, utilities and governments - for example, the majority of US National Team members are equipment manufacturers. The NT scope has been widened to include all Annex activity.

- *Increasing Emphasis on Analysis*

  The Analysis report, "The Impact of Heat Pumps on the Greenhouse Effect," was published in October 1992. Forty-six studies from all over the world were identified, reviewed and evaluated in the course of the Analysis; the report provides a detailed overview of the current world-wide "state of knowledge" on this issue. In addition to the final report, the HPC has produced a comprehensive summary of the Analysis and a brochure highlighting its contents. As a follow-up activity, an international workshop was held in Switzerland during which the Analysis findings were discussed and gaps in the knowledge base identified.

  The second Analysis "Domestic Hot Water Heat Pumps in Residential & Commercial Buildings" comprises a review of the world-wide "state-of-the-art" of technology, applications, and markets. The final report was published in May 1993.

The third Analysis, based on the 1982 IEA/OECD publication "Heat Pumps, A Technology Overview," commenced in 1992. The results will serve as input to governmental policy makers. The HPC is conducting this Analysis ("International Heat Pump Status and Policy Review") itself rather than contract out the work. This study will be a joint effort with the IIR.

- *Creation of the Special Task mechanism*

  In this new kind of project, two or more organizations participate, under the auspices of the HPC and control of the EXC. Unlike an Annex, the participants are institutes, associations, companies etc. rather than the Contracting Parties themselves. Proprietary rights and information arising from the performance of the Special Task belong to the HPC.

- *Change in Operating Agent*

  In 1989, it was decided that Novem (the Netherlands) should assume the Operating Agent role for the HPC. The following remarks, excerpted from the 1991 Advisory Board report to the EXC, concern the performance of the HPC at its new location in the Netherlands, and the work of the IA:

  "The Advisory Board has been very pleased with the evolution of the Heat Pump Centre under the management of Novem...and strongly recommends continuation of the Heat Pump Centre under its current management.... The Advisory Board fully supports the premise that heat pumps are an important energy technology strategy which should be adopted by industrialized countries, and that the IEA Programme must be pro-active in providing leadership and information to assist in the growth of heat pump usage worldwide."

- *Change in Legal Text and scope of work*

  With the change in Operating Agent, the previous Annex 4 (IV) was terminated and new Annex legal text approved, so that the HPC began anew as Annex 16. Other changes in the legal text included a provision for the establishment of the Advisory Board, introduction of the Special Task mechanism, and broadened scope of work to include related technologies.

II. IMPACT ON THE WIDER COMMUNITY

1. Heat Pumps and the Energy Situation 1988 - 1992

In the 1980's heat pumps in OECD countries were expected to save most of the oil in the residential and commercial sectors. Their impact on oil saving is difficult to quantify because of great uncertainty about actual installed equipment. Heating-only and heat recovery heat pumps have seen an average annual market growth rate of 10% globally. Mainly, applications include residential and commercial buildings, district heating and industries. A continued growth of 10% annually is expected until the year 2000.

Unitary heat pumps, which provide both heating and cooling, comprise a significant part of air conditioning equipment used worldwide. Almost all are electrically driven vapour compression machines using HCFC 22 as a working fluid. In 1991 approximately 260 million kW heating capacity (260 TWh heat production annually) had been installed worldwide.

The estimated total installed heating capacity of heating-only heat pumps in buildings and district heating is 7,300 MW. Market and economic constraints still limit the application of this category of heat pumps in Middle and Northern Europe. In a workshop organized by the HPC in 1990 (in Graz) the space conditioning market potential and barriers were discussed, and in early 1992 a report concerning the South Europe market was published. In industry, heat pumps deliver 45 TWh of heat annually, saving considerable energy resources, although this is only a small fraction of the total technical potential.

The heat pump market has been adversely affected by the general worldwide drop in energy prices. However, during the same period there has been increasing environmental concern about the growth of greenhouse gas emissions, and a recognition that the heat pump is one of the technologies which can play a role in contributing to a reduction of CO_2 levels.

By implementing the new strategy for the IA, an important vehicle is available which improves the conditions for an accelerated introduction of heat pump technology.

2. IA Achievements

Since 1989, there has been activity in 14 Annexes (initiated and/or completed). The activities reviewed below indicate both the amount of work accomplished in the period 1988 - 1992 and the potential and need for more work to be performed in this area.

- Annex Overview - see **ATTACHMENT 1**

- Annex accomplishments

  Overall, the IA and its Annexes have contributed to improved heat pump technology and insight into markets and their constraints. Many heat pump researchers, with their expertise in thermodynamics/working fluids etc. have been in the forefront of investigations into identifying and researching suitable alternatives to CFCs during this period. This ongoing work has applications extending also into the refrigeration and air-conditioning industries. From the onset of this serious environmental concern, the IA has been very active in this area, making a strong contribution through the undertaking of several joint international projects, such as Annexes 13, 17, 18 and 20.

  Accomplishments of Annex 7 - 20 include:

  - Detailed state-of-the-art overviews, case studies providing technical and economic field data of heat pump systems and components in buildings, district heating and industry (7,9)

- Development, improvement and demonstration of (direct expansion) ground heat exchangers and installation techniques, with subsequent transfer of technology to industry (8,15)

- A strategic assessment and exchange of information on Stirling engine-driven heat pump technology which provided participating countries with a basis for decisions on the continuation or termination of major domestic hardware development programmes (11)

- Detailed market data of space conditioning heat pumps in Southern Europe (10)

- Comparison and validation of leading simulation methods for state-of-the-art variable speed heat pumps using laboratory test data (12)

- Increased awareness about heat pumps and their proper use through information dissemination and knowledge transfer through the IEA network (16).

- Increased knowledge base on heat pump working fluids, working fluid mixtures, fluid dynamics and properties of environmentally acceptable refrigerants resulting in among other things a Properties bulletin and a unique fluids database, contributing to solving one of the main challenges facing the HVAC industry today (13, 14, 17, 18, 20)

In regard to specific HPC (16) achievements, activities and products, Proceedings of all Workshops were published (see **ATTACHMENT 2**) as were various reports and promotional brochures (see **ATTACHMENT 3**). Detailed responses to Inquiries continued to be an important service both to member and non-member countries, confirming the HPC's position as a respected source of information internationally. The profile of the HPC has been heightened in recent years as a result of the new approach. Presentations have been frequently sought: for a listing of recent activity, see **ATTACHMENT 4**.

- Future Annex development

The initiation of Annexes, historically done on an ad-hoc basis, as noted in the 1988 IA Review, has also been addressed in the Strategy Plan, which encourages the 'top-down' approach of initiating new Annexes based on perceived gaps in knowledge or area of interest or concern, in addition to the 'bottom-up' approach. This new appoach will be useful in achieving the goals articulated in the Strategy Plan.

Greater dissemination of the information and knowledge gained through Annex activity throughout the IA network and beyond has also been emphasized in the Strategy Plan. The EXC has initiated the development of a policy whereby Annex reports may be adapted and published by the HPC for wider distribution after the conclusion of the Annex, dependent on the agreement of the Annex participants, and general interest in the topic. Various products developed in different Annexes (computer programmes, tools for evaluation) may become available as well.

- 3rd and 4th IEA Heat Pump Conference

  The 3rd IEA Heat Pump Conference was held in Tokyo, Japan in 1990. Attendance exceeded expectations, with 466 registered participants from 19 countries. For the first time, a poster session was organized, in response to the enormous response to the call for papers. In total, 45 papers were presented in 8 sessions, with an additional 50 in poster sessions. The conference ended with a resolution calling upon the governments represented to acknowledge the large potential of heat pumps with respect to energy conservation and the reduction of global warming, and support their use as part of a comprehensive energy conservation and environmental programme. Furthermore, they were urged to support R&D efforts to improve the performance and application of heat pumps.

  The 4th IEA Heat Pump Conference, scheduled for 26- 29 April 1993 in Maastricht, the Netherlands, with its theme "Heat Pumps for Energy Efficiency and Environmental Progress" addresses market, regulatory and technical issues, summarizing the technology progress, status and trends, and providing a perspective over a multi-year period. In addition to regular sessions and a poster session, the Conference featured an exhibition by various groups.

ANNEX OVERVIEW 1988 - 1992

ATTACHMENT 1

ANNEX # and NAME		STATUS
7	New Developments of the Evaporator Part of Heat Pump Systems	1990
8	Advanced In-Ground Heat Exchange Technology for Heat Pump Systems	1992
9	High Temperature Industrial Heat Pumps	1990
10	Technical and Market Analysis of Advanced Heat Pumps	1991
11	Stirling Engine Technology for Application in Buildings	1989
12	Modelling Techniques for Design of Compression Heat Pumps	1992
13	State and Transport Properties of High Temperature Working Fluids	1992
14	Working Fluids and Transport Phenomena in Advanced Absorption Heat Pumps	1991
15	Heat Pump Systems with Direct Expansion Ground Coils	1992
16	The IEA Heat Pump Centre	cr
17	Experiences with New Refrigerants in Evaporators	cr
18	Thermophysical Properties of the Environmentally Acceptable Refrigerants	cr
20	Working Fluid Safety	cr
21	Global Environmental Benefits of Industrial Heat Pumps	cr

Status: cr = current   Completion date given

A SHORT DESCRIPTION OF ANNEXES

Annex 7 New Developments of the Evaporator Part of Heat Pump Systems (1986- 1989)

In this state-of-the-art report, information was collected about different types of evaporators, heat transfer and pressure drop on the heat source side as well as on the refrigerant side, the optimization of heat pump evaporators, and research and development trends in participating countries. A listing of computer programs dealing with heat pump evaporators was included.

Annex 8 Advanced In-Ground Heat Exchange Technology for Heat Pump Systems (1985 - 1992)

A combination of mathematical modelling and computer program development, field experiments, and monitoring of "demonstration" and commercially installed ground source heat pumps (GSHP) constituted the main effort in this project. The development of new ground-source heat exchangers as well as contributions to basic design techniques, and the advancement of fundamental understanding of GSHP technology was achieved.

Annex 9 High Temperature Industrial Heat Pump Systems (1986 - 1990)

The state-of-the-art and an analysis of economics were described in the Final Report which looked at high temperature compression heat pumps (electrically driven) and absorption heat pumps in eight case studies.

Annex 10 Technical and Market Analysis of Advanced Heat Pumps (1985 - 1991)

The objectives were to provide technical and market analyses of heat pumps as the basis for developing new tasks, to produce documentation, and to develop the technical content of conferences, symposiums, and workshops sponsored by the participants. The work supported the 2nd and 3rd IEA Heat Pump Conferences (in Orlando, Florida, the US, and Tokyo, Japan). In addition, a market study of air conditioning equipment used in Southern Europe (Italy, France and Spain) was published by the Heat Pump Centre for a general audience.

Annex 11 Stirling Engine Technology for Application in Buildings (1986 - 1989)

Begun with the aim of cooperating to form a more complete strategic assessment of Stirling Engine heat pumps than could be obtained through individual country programmes, the achievements included the publication of a comprehensive survey of Stirling Engine projects in participating countries, and a comparative assessment of free piston and kinematic Stirling Engine technologies. In addition three separate workshops on technology status and development issues were held, supporting the achievement of the second objective of identifying specific topics for further cooperative research.

Annex 12 Modelling Techniques for Design of Compression Heat Pumps (1986 - 1992)

Performed in two stages, the work initially centered upon three different heat pump models simulating seasonal performance factors, based on single speed heat pumps. The second phase concentrated on variable speed heat pumps, and included laboratory testing, comparisons with model calculations and evaluation of applicability and deficiencies of available models.

Annex 13 State and Transport Properties of High Temperature Working Fluids (1987 - 1992)

The identification, assessment and measurement of data for eight pure fluids and three non-azeotropic mixtures was carried out. Special emphasis was placed on fluorohalocarbons.

Annex 14 Working Fluids and Transport Phenomena in Advanced Absorption Heat Pumps (1987 - 1991)

A two volume final report deals with air-source absorption and compact high-performance water source absorption heat pumps. Surveys on working fluids, transport phenomena and absorption cycles were conducted. Approximately 70 cycles were evaluated thermodynamically. A data base containing a review of over 500 publications covering thermophysical properties, advanced absorption cycles and transport phenomena was produced.

Annex 15 Heat Pump Systems with Direct Expansion Ground Coils (1989 -1993)

The aims included assessing problems of oil return from ground coil back to compressor, determining and solving the problem of refrigerant flow in vapour and liquid stages, and developing a new high performance Direct Expansion (DX) ground source heat pump.

Four different ground heat exchange (GHE) and DX systems were developed and tested. Products resulting from the work of this Annex included computer programs, general design guidelines and new technology (DX copper spiral GHEs) which has since been successfully demonstrated in various field installations.

Annex 16 The IEA Heat Pump Centre - The Netherlands (1990 onwards) **

The objective of the Centre, to promote the use of heat pumps and foster international cooperation on all aspects relating to research, development and demonstration of heat pumping and related technologies. Collection, analysis and dissemination of information constitute the bulk of its work. Products include reports, proceedings, brochures and quarterly Newsletters. Its message reaches an international audience through the sponsorship of workshops and meetings, and with the organization into "National Teams" of heat pump experts in participating countries.

Annex 17 Experiences with New Refrigerants in Evaporators **

The heat transfer and pressure drop behaviour in the evaporator of heat pump installations was studied in this effort to increase the knowledge of the performance of new refrigerants. This will enable the revision of existing correlations, and possibly suggest new correlations.

Annex 18 Thermophysical Properties of the Environmentally Acceptable Refrigerants **

A two-phase project, the first resulting in a Properties Bulletin in which compilation, evaluation and correlation of thermophysical data for environmentally acceptable refrigerants and their mixtures was made. A "New Fluids Database" has been under development. In the second phase, the focus will be on accelerating studies of several promising alternatives to HCFC22 (HFC's -32, -125, -143a and their mixtures). An annual report on HCFC22 alternatives is planned, and the work will culminate in the publication of a bulletin on the thermophysical properties of HCFC22 alternative. The results and products of this Annex are widely available.

Annex 20 Working Fluid Safety **

Investigating the safety of refrigerating machines and heat pumps involved looking at accident statistics, safety norms and regulations, and safety evaluations (hazard identification, effects evaluation techniques, and accident and risk evaluation). Results include development of calculation techniques which can be used to assess in a quantitative way the risks involved in the use of conventional and alternative working fluids.

Annex 21 Global Environmental Benefits of Industrial Heat Pumps **

Industrial heat pumps (IHPs) offer the potential to conserve energy, improve plant productivity and process capacity at the least cost, but can also reduce air and water pollution by decreasing the combustion of fuels. In this study of possible IHP applications and evaluation of market development and environmental impact, anticipated products include a detailed IHP manual, guidelines for IHP applications, an expert computer programme to assist in IHP implementation, and a comprehensive report on the global environmental benefits on IHPs. The Annex will conclude with an international workshop.

** ongoing Annexes

Summary of the Annexes

Annex	Operating Agent	Participants	Began[1]	Scheduled Completion	Completed[1]
1 Common study of advanced heat pumps	Germany	Austria, Belgium, Canada, Denmark, Germany, Italy Japan, The Netherlands, Spain, Sweden, Switzerland UK, USA	1978		1980
2 Vertical earth heat pump systems	Sweden	Austria, Canada, Denmark, Sweden, USA	1981		1983
3 Heat pump systems applied in industry	Belgium	Austria, Belgium, Canada, Denmark, Finland, Ireland Italy, Japan, The Netherlands, Sweden	1981		1984
4 IEA Heat Pump Centre	Germany	Austria, Belgium, Canada, Finland, Germany, Italy Japan, The Netherlands, Norway, Sweden, USA	1982		1990
5 Integration of large heat pumps into district heating and large housing blocks	Sweden	Denmark, Germany, Italy, Sweden	1983 - 84		1986
6 Study of working fluid mixtures and high tempera -ture working fluids for compressor driven systems	Sweden	Austria, Denmark, Finland, Germany, Japan, USA	1982		1986
7 New development of the evaporator part of heat pump systems	Sweden	Canada, Denmark, Finland, Norway, Sweden	1986		1989
8 Advanced in-ground heat exchange technology for heat pump systems	Canada	Canada, Germany, Switzerland, USA	Sept 1985	Aug 1987	May 1992
9 High temperature industrial heat pumps	Belgium	Belgium, Germany, Finland, Japan, The Netherlands Sweden, Switzerland, USA	1985		June 1990
10 Technical and market analysis of advanced heat pumps	USA	Sweden, USA	May 1985	June 1991	April 1991

[1]Based on ExCo Approval
[2]Phase one only
[3]Predicted completion date

Summary of the Annexes (cont.)

Annex	Operating Agent	Participants	Began[1]	Scheduled Completion	Completed[1]
11 Stirling engine technology for application in buildings	USA	Japan, Sweden, USA	1986		June 1989
12 Modelling techniques for stimulation and design of compression heat pumps	USA[2], Italy	Austria, Belgium, Germany, Italy, Japan[2], Switzerland, USA	1986 1989	Phase 1 Phase 2	1989 Sept 1992[3]
13 State and transport properties of high temperature working fluids and non-azeotropic mixtures	Sweden	Canada, Germany, Japan, Norway, Sweden, USA	1987	1989	May 1992
14 Working fluids and transport phenomena in advanced absorption heat pumps	Japan	Belgium, Denmark, Germany, Japan, Sweden, USA	Dec 1987	June 1990	1991
15 Heat pump systems with direct expansion ground coils	Canada	Austria, Canada, Japan, USA	1989	1990	Apr 1993
16 Heat Pump Centre	The Netherlands	Austria, Canada, Italy, Japan, The Netherlands, Norway Sweden, Switzerland, USA	Jan 1990		
17 Experiences with new refrigerants in evaporators	Sweden	Canada, The Netherlands, Norway, Sweden, Switzerland	Nov 1990	Oct 1992	
18 Thermophysical properties of environmentally acceptable refrigerants	USA	Austria, Canada, Germany, Japan, Norway, Sweden, UK USA	Dec 1989[2] Jan 1993	Dec 1992[2] Dec 1996	
20 Working fluid safety	Belgium	Belgium, Japan, The Netherlands, Norway, Switzerland	April 1991	Jan 1992	Dec 1992[3]
21 Global environmental benefits of industrial heat pumps	USA	Canada, Japan, The Netherlands, Norway, Sweden, UK USA	Jan 1992	April 1994	

[1]Based on ExCo Approval
[2]Phase one only
[3]Predicted completion date

ATTACHMENT 2

LIST OF WORKSHOPS 1988 - 1992

Date	*Location*	*Sponsored by*	*Subject*
January 1989	Mainz, Germany	HPC	IEA Heat Pump Centre Future Activities and Organization
November 1989	Hannover, Germany	HPC	High Temperature Heat Pumps
March 1990	Susono City, Japan	HPC/Japan	High Performance Heat Pumps, Wider Applications & Market
September 1990	Graz, Austria	HPC/Austria	Market Potential & Programmes to Overcome Impediments for Acceptance of Space Conditioning Heat Pumps
August 1991	Montreal, Canada	HPC/Canada	Ground-Source Heat Pumps - Advancement Towards Cost Reduction
October 1991	Budapest, Hungary	HPC/IEA	Industrial Heat Pumps
October 1992	Merligen, Switzerland	HPC/Switzerland	Impact of Heat Pumps on the Greenhouse Effect

1. HPC NEWSLETTER

Issue	Theme
Vol.6, No.1, March 1988	Air Source Heat Pumps
Vol.6, No.2, June 1988	Working Fluids
Vol.6, No.3, September 1988	10th Anniversary of the IEA Implementing Agreement on Advanced Heat Pumps
Vol.6, No.4, December 1988	Absorption Heat Pumps
Vol.7, No.1, March 1989	Prospects in Industrial Heat Pumps - Process Integration
Vol.7, No.2, June 1989	Heat Pumps and the Environment
Vol.7, No.3, September 1989	Heat Pumps - Heating and Cooling
Vol.7, No.4, December 1989	National RD&D programmes,incentives, codes and standards
Vol.8, No.1, April 1990	IEA-HPC, National Teams
Vol.8, No.2, June 1990	3rd IEA-HPC Conference
Vol.8, No.3, September 1990	Gas Engine-Driven Heat Pumps
Vol.8, No.4, December 1990	Sorption Heat Pumps
Vol.9, No.1, March 1991	Cold Climate Heat Pumps
Vol.9, No.2, June 1991	Member country programmes and activities to find replacements for CFCs, incl. NH3 refrigeration systems
Vol.9, No.3, September 1991	Effective usage of waste heat by heat pumps (residential, commercial and industrial applications)
Vol.9, No.4, December 1991	Technical Advancements in Heat Pumps, Aiming at Improved Performance and Reliability, and New Cycles.
Vol.10, No.1, March 1992	Heat Pumps and Heat/Cold Storage.
Vol.10, No.2, June 1992	Utilities and Heat Pumps Servicing and Maintenance
Vol. 10, No.3, August 1992	Space conditioning heat pump equipment and applications, including novel applications

2. HPC ANALYSIS REPORTS - Distribution restricted to member countries.

HPC-R6, Nov. 1989	Engine Driven Heat Pumps Analysis of Existing Systems
Analysis Summary Report Report No. HPC-ASR 1 June 1992	The Impact of Heat Pumps on the Greenhouse Effect
Analysis Report Report No. HPC-AR 1 September 1992	The Impact of Heat Pumps on the Greenhouse Effect.

3. HPC WORKSHOP REPORTS - Distribution restricted to member countries.

HPC-WR-4, 1989	Workshop Proceedings "The IEA Heat Pump Centre's Future Activities and Organization" **(available to all countries)**
HPC-WR-5, Nov. 1989	IEA Heat Pump Centre Workshop Proceedings on High Temperature Heat Pumps
HPC-WR-6, March 1990	Workshop Proceedings, High Performance Heat Pumps, Wider Applications & Market
HPC-WR-7, Sept. 1990	Workshop Proceedings Market Potential & Programmes to Overcome Impediments for 1990: Acceptance of Space Conditioning Heat Pumps
HPC-WR-8, Aug. 1991	Workshop Proceedings Ground-Source Heat Pumps - Advancements Towards Cost Reduction
HPC-WR-9, Oct. 1991	Workshop Proceedings Industrial Heat Pumps

4. HPC REPORTS - Distribution restricted to participants in the Implementing Agreement.

HPC-R7, Dec. 1991	The Air Conditioning Equipment Market in Southern Europe Summary Report of an Analysis Performed under Annex 10
HPC Handbook HPC-HB1, 1989	User's Handbook for Heat Pumps in Dairies

Product Sheets **on many of the above-named reports**

PRESENTATIONS by the HPC GENERAL MANAGER and/or EXC CHAIRMAN

ATTACHMENT 4

1990

Harwell, UK (ETSU)	Information about the HPC
Sophia, Antipolis France (ADME)	Information about the HPC (Experts Meeting)
Tokyo, Japan	Paper at the 3rd IEA Heat Pump Conference (Heat Pump R&D in Europe)
Moncton, Canada	Paper at Cold Climate Heat Pump Conference (Improving prospects of heat pumps through promotion)
Stockholm, Sweden	Information about the HPC (IIR Workshop)

1991

Paris, France (ADME)	Information about the IA/HPC
Madrid, Spain	Information about the IA/HPC
Lisbon, Portugal	Information about the IA/HPC
Syracuse, USA (Carrier)	Information about European Heat Pump R&D (Experts Meeting)
Montreal, Canada (IIR Congress)	Paper on Industrial Heat Transformers
Tokyo, Japan (Absorption HP Conference)	Paper on Users Club of Absorption Systems
Paris, France	Paper on Gas Engine Driven Heat Pumps Heat Pump Status in the USA and Japan (EC workshop)
Dallas, USA	Paper on Industrial Heat Pumps in Europe (EPRI Conference)
Giessen, Germany	Paper on Results of HPC Workshop on Ground Source Heat Pumps (German workshop)

1992

Dortmund, Germany	Paper on Heat Pumps and the Greenhouse Effect (IEA Conference)

Solihull, UK	Paper on Advanced Heat Pumps (IEA BCS workshop)
Baltimore, USA	Paper on HPC's Environmental Projects (ASHRAE meeting)
Oslo, Norway	Information about the HPC (Norwegian Conference)
Maastricht, the Netherlands	Paper on Heat Pump Market and Technology Development (Conference Energy Economy)

1993 PROGRESS REPORT

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Contributing Countries

Country	*As a result of participation in:*
Austria	*Annex 16, 18*
Canada	*Annex 16, 18, 21*
France	*Annex 21*
Germany	*Annex 18*
Italy	*Annex 16*
Japan	*Annex 16, 18, 21*
Netherlands	*Annex 16, 18, 21*
Norway	*Annex 16, 18, 21*
Sweden	*Annex 16, 18, 21*
Switzerland	*Annex 16*
United Kingdom	*Annex 18, 21*
United States	*Annex 16, 18, 21*

1. Abstract of purpose / goals and objectives / main topics

The Technical Support Services Unit (TSSU) has been established to provide the IEA Heat Pump Programme with a focus for administration and support for its activities. Main topics include realization of various Action items identified in the 1993 Action Plan which would implement the first stages of the Strategy Plan.

2. Activity/progress during 1993

EXECUTIVE COMMITTEE

- In regard to France's intention to sign the IA, delegates were invited to state their position with regard to an official EXC invitation to France. The unanimous approval of extending the invitation was communicated to the IEA. France was provided with EXC materials and signed the IA on 19 May 1993.
- Support for EXC meeting in Maastricht, including planning, organization and production of Minutes and Summary of Decision and Actions.
- The proposal for widening the distribution of Annex products, revised in cooperation with the Belgian delegate, was further revised after the EXC meeting to include HPC products and included in the Maastricht Minutes.
- Submittal of the Revised End-of-Term Report 1989-1992 to the End Use Working Party for their October 1993 meeting.
- Brochures on the SP and the IEA Heat Pump Programme were produced in time for the 4th IEA Heat Pump Conference. A letter discussing the distribution of these brochures was sent to all members of the network.
- Regarding the CERT review of the Programme, forwarded necessary documents to reviewer (Mr. T. Boström).
- Regarding mission to New Zealand and Australia, contacted EXC delegates regarding their approval for funding Chairman's expenses from the TSSU budget, and assisted Chairman with document preparation.
- The process of finalizing a new Annex was delineated in a document presented at the Maastricht EXC meeting.
- EXC Publications Board (EPB)
    - Logo: coordinated with the Norwegian alternate delegate and member of the EXC Publications Group on development of the logo. Requested suggestions for Programme logo from all members of the network, and forwarded those to Norway. Disseminated proposals from Norwegian design team to EPB.
    - Organized meeting in conjunction with EXC meeting in Rome
    - Submitted several items for EPB consideration including information sheet series and discussion on IA bibliography.

ANNEX COORDINATION AND SUPPORT

- Issued guidelines for Annex Final Reports produced by the Heat Pump Centre, initially intended for use by Annex 21 Operating Agent and contractors.
- Invited countries to participate and attend preparatory meeting of the proposed Annex "Chemical Process for Ecological Thermal Energy Systems" in Fukuoka, Japan on May 26, 1993. Assisted in logistical preparation for the meeting. Finalized, produced and distributed Minutes. Followed up meeting with letter to prospective participants, in conjunction with Japan and with the EXC Chairman.
- Assisted the Operating Agent of Annex 21:
  - Organized and attended Annex 21 informal meeting during IEA Heat Pump Conference, prepared contingency proposal for EXC (accepted).
  - Organized and attended the 3rd Working Meeting in Maastricht (Sept.)
  - financial management, including supervision of contracts and payments, invoicing of participants and follow-up, and financial reports.
  - Provided Mr. Merlin (France) with legal text and other documents to facilitate joining the Annex.

OTHER ACTIVITIES

- Followed up agreement reached at 5 May 1993 meeting of IAs and Information Centres at the IEA to exchange EXC agendas and other documents of interest. Have initiated or maintained contacts with Building and Community Systems, Energy Storage, ETDE, CADDET, District Heating and Cooling, Greenhouse Gas R&D, GREENTIE to ensure exchange of EXC minutes, and also to obtain Annex developmental information from other IAs.
- Assisted Operating Agents and others in the IA network in providing timely news for the IEA Heat Pump Centre Newsletter and articles where appropriate.
- Provided information on the IA (including EXC minutes) to representatives of organizations in non-member countries who have expressed an interest in the activities of the IA (Portugal, Greece, Turkey).
- Drafted TSSU 1994 Work Programme

3. Plans for coming period

Finalization and distribution of Annex 21 Working meeting minutes.

Strategy Plan review process to be developed for at Spring 1994 EXC meeting.

Assist in preparations for Annex 21 Final and Summary Reports and International Workshop.

Reports to be produced in the coming period include an Annex 21 Financial Management report, EXC Minutes and Summary of Actions and Decisions, 1993 TSSU Annual Report, 1993 IA Annual Report.

Heat Pump Centre Publications

With the aim of increasing the spread of information on heat pumps and related technologies, the IEA Heat Pump Centre produces a range of publications:

The IEA Heat Pump Centre Newsletter

Published four times a year, the IEA Heat Pump Centre Newsletter is the only international journal giving worldwide coverage of heat pump technology and issues. A comprehensive news section covers recent events and opinions concerning heat pumps, including technology and applications, market news and research programmes. With articles submitted from its member countries and beyond, each Newsletter issue focusses on an important heat pump topic.

Analysis Reports

The HPC conducts international surveys on subjects affecting the implementation of heat pumps. The results are analyzed by experts and presented in analysis reports.

Workshop Reports

The HPC invites experts to meet together to exchange ideas and knowledge on a theme concerning heat pumps. The presentations and the conclusions drawn at these meetings are published in Workshop Reports.

Promotion Brochures

As part of the HPC's campaign to increase the spread of heat pumps for the benefit of the environment, the HPC produces promotion brochures aimed at those who can influence heat pump use.

HPC member countries

Austria, Canada, Italy, Japan, the Netherlands, Norway, Sweden, Switzerland, USA

Heat Pump Centre Newsletter

1993 Topics:

	No.	
March:	1	Industrial Heat Pumps
July:	2	1993 IEA Heat Pump Conference
September:	3	Heat Pumps and the Environment
December	4	Trends in Heat Pump Technology and Applications.

Back issues:

	No.	
Vol.1 (1983)	1	Inaugural Edition
	2	RD&D and Incentive Programmes
Vol.2 (1984)	1/2	Heat Pumps in Japan and Selected European Countries
	3	Trends and Status in Heat Pump Technology
	4	Heating-only Residential Heat Pumps
Vol.3 (1985)	1/2,3,4	No specific topic
Vol.4 (1986)	1	Environmental Aspects of Heat Pump Application
	2	Industrial Heat Pumps
	3	Sorption Heat Pumps
	4	Ground-Source Heat Pumps
Vol.5 (1987)	1	1987 IEA Heat Pump Conference
	2	Block Central Heat Pumps
	3	Industrial Heat Pumps
	4	Heat Pumps for District Heating
Vol.6 (1988)	1	Air-Source Heat Pumps
	2	Working Fluids
	3	10th Anniversary of the IEA Implementing Agreement on Advanced Heat Pumps
	4	Absorption Heat Pumps
Vol.7 (1989)	1	Prospects in Industrial Heat Pumps - Process Integration
	2	Heat Pumps and the Environment
	3	Heat Pumps - Heating and Cooling*
	4	National RD&D programmes, incentives, codes and standards
Vol.8 (1990)	1	IEA-HPC, National Teams*
	2	3rd IEA-HPC Conference
	3	Gas Engine-Driven Heat Pumps
	4	Sorption Heat Pumps
Vol.9 (1991)	1	Cold Climate Heat Pumps
	2	Programmes and Activities to Find CFC Replacements
	3	Heat Pumps Using Waste Heat
	4	Technical Advancements in Heat Pumps
Vol.10 (1992)	1	Heat Pumps and Heat/Cold Storage.
	2	Utilities and Heat Pumps + Servicing and Maintenance
	3	Space Conditioning
	4	Unitary Gas Heat Pumps

* out of stock

Heat Pump Centre Reports

	Title	Date	Order No.	Price in NLG
	Analysis Reports			
	The Impact of Heat Pumps on the Greenhouse Effect	Sep. '92	HPC-AR1	80
NEW	Domestic Hot Water Heat Pumps for Residential and Commercial Buildings	Apr. '93	HPC-AR2	80
	Workshop Reports			
	Ground-Source Heat Pumps	'87	HPC-WR-2	56
	National Reports on the Status of Heat Pumps	'87	HPC-WR-3	45
	The IEA Heat Pump Centre's Future Activities and Organization	'89	HPC-WR-4	free
	High-Temperature Heat Pumps	Nov. '89	HPC-WR-5	45
	High-Performance Heat Pumps, Wider Applications & Market	Mar. '90	HPC-WR-6	60
	Market Potential & Programmes to Overcome Impediments for Acceptance of Space Conditioning Heat Pumps	Sep. '90	HPC-WR-7	60
	Ground-Source Heat Pumps - Advancements Towards Cost Reduction	Aug. '91	HPC-WR-8	60
	Industrial Heat Pumps	Oct. '91	HPC-WR-9	60
	The Impact of Heat Pumps on the Greenhouse Effect	Oct. '92	HPC-WR-10	80
NEW	Heat Pumps and Thermal Storage	Sep. '93	HPC-WR-11	50
NEW	Domestic Hot Water Heat Pumps for Residential and Commercial Buildings	Nov. '93	HPC-WR-12	50
	Other Reports			
	Heat Pumps RD&D Projects Summary Report	Dec. '86	HPC-R2	56
	Comparison of National Standards, Testing and Rating Procedures for Heat Pumps	Dec. '86	HPC-R3	56
	Inverter-Driven Heat Pumps	Sep. '88	HPC-R4	56
	Application of Heat Pumps in Industry	Dec. '88	HPC-R5	56
	Engine-Driven Heat Pumps	Nov. '89	HPC-R6	56
	The Air Conditioning Equipment Market in Southern Europe (Annex 10 Summary Report)	Dec. '91	HPC-R7	60

Heat Pump Centre Promotion Brochures

Heat Pumps - Better by Nature

Essential reading for energy policy makers, this 12-page full-colour brochure outlines the importance of heat pumps as an energy-saving tool. It gives basic information on the application of heat pumps in industry and buildings, and illustrates how heat pumps can play a central role in an energy system.
Ordering code: HPC-BR2 - free of charge (published April 1993)

Heat Pumps - An Opportunity for Reducing the Greenhouse Effect

This 12-page full colour brochure provides background information on the greenhouse effect and heat pump technology. Using evidence uncovered by the IEA Heat Pump Centre's analysis "The Impact of Heat Pumps on the Greenhouse Effect," the brochure shows that heat pump technology is a significant option for reducing global warming. *Ordering code: HPC-BR1 - free of charge (published October 1992)*

Subscribing to the Newsletter

The Newsletter is delivered free of charge to readers in IEA Heat Pump Centre member countries (see 1st page). Subscribers in non-member countries pay NLG 110 per annum, and 27.50 for a single issue.

Back issues

Back issues of the Newsletter are free to readers in member countries. Subscribers in non-member countries may order back issues from previous years by contacting the Heat Pump Centre. A full set costs NLG 220.

Order Form

Name .... Company ....

Address ....

Country ....

☐ I wish to subscribe to the Newsletter

☐ Please send me the following back issues of the Newsletter (ask for full set or quote Vol. and No.)

....

☐ Please send me the following Reports (quote order no.)

....

Please invoice me for the following amount ....NLG

Currency: NLG = Netherlands Guilder. (In September 1993, 1 NLG was worth about 0.55 US Dollars.)

Please send this order form to:
IEA Heat Pump Centre, P.O. Box 17, 6130 AA Sittard, the Netherlands. Fax: +31-46-510-389

IEA Anneks 20: Arbeidsmediers sikkerhet i kuldeanlegg og varmepumper:

Risiko med ammoniakk og propan er sterkt overdrevet

Av Rune Aarlien

Bakgrunn

Det har lenge vært nærmest "opplest og vedtatt", i hvert fall i enkelte miljøer, at kuldeanlegg og varmepumper som drives med ammoniakk og hydrokarboner (som f.eks. propan) representerer en vesentlig risiko for det nære miljø. Advarsler og høyt skrik om fare for eksplosjoner, brann, forgiftning, og panikk har fått mange brukere til å vegre seg mot kjøp og bruk av slike anlegg, selv om man innser at de naturlige mediene er blant de energimessig og miljømessig beste på markedet. Det faktum at de naturlige mediene er totalt uskadelige for det ytre miljø har nok i den senere tid stimulert interessen hos en del brukere, og fler og fler velger nå faktisk naturlige medier i sine kuldeanlegg og varmepumper. Med en slik utvikling følte mange land at det ville være ønskelig og svært viktig å få fakta om de omtalte mediene på bordet.

På denne bakgrunn ble et anneks innenfor IEA systemet opprettet, blant annet med den hensikt å samle objektiv informasjon som kunne si noe konkret om de erfaringer man virkelig har gjort med disse farlige mediene.

Annekset

IEA's Anneks nr. 20 på varmepumpeområdet fikk navnet Working Fluid Safety (arbeidsmediers sikkerhet), og deltakerne var: Belgia, Japan, Nederland, Norge og Sveits. Belgia, ved Professor Jan Berghmans ved Det Katolske Universitet i Leuven, har hatt operatøransvaret. Målsettingen med annekset var å samle og evaluere internasjonal erfaring på området sikkerhet for kuldeanlegg og varmepumper. Selve arbeidet bestod av tre deler. For det første ble det innhentet statistikk fra deltakerlandene om ulykker i anlegg. Man var på forhånd klar over at det finnes lite offentlig og tilgjengelig informasjon på dette området, derfor ble i stor grad de kjøletekniske og varmepumpetekniske miljøene brukt som datakilder. For ammoniakk viser det seg at risikoen med industrielle kulde- og varmepumpeanlegg er lav sammenlignet med industrielle risiki generelt. For andre medier eksisterer svært lite informasjon. Sammenlignet med bruk av naturgass i husholdninger, viser det seg imidlertid at faren ved bruk av kjøleskap med brennbare medier er for neglisjerbar å regne.

Kuldenormer

Arbeidets andre del bestod i å analysere forskjellige lands standarder eller normer på dette området (eksempelvis Norsk Kuldenorm). Det viste seg at det er store forskjeller i hvordan de enkelte landene ser på de forskjellige risiki forbundet med brennbare, eksplosive og giftige arbeidsmedier.

Software

I neste omgang så man på forskjellige teknikker for vurdering av effektene av branner, eksplosjoner og utslipp der mennesker er innblandet. Beregningsmodeller ble utviklet for å kunne forutsi effektene av trykkbølger etter eksplosjoner i trykkbeholdere, trykkbølger generert under en eksplosjon av en brennbar sky av arbeidsmedium, termisk stråling fra stikkflammer og effektene av å bli utsatt for en sky av giftig arbeidsmedium. Det ble utviklet prosedyrer for beregning av størrelse og karakteristikker for skyer av lekket arbeidsmedium, og software er tilgjengelig for deltakerlandene. Med dette programmet kan man kvantifisere effektene av potensielle ulykker med kuldeanlegg og varmepumper. I tillegg er det utviklet en database med sikkerhetsdata for mer enn 160 forskjellige arbeidsmedier.

Konklusjon

Risiki for de mest anvendte "farlige" arbeidsmediene ble sammenlignet. Konklusjonen på dette arbeidet er at faren for ulykker forbundet med bruk av medier som f.eks. ammoniakk og propan, generelt sett er meget små og sterkt overdrevet slik de ofte fremstilles.

Sivilingeniør Rune Aarlien, NTH/SINTEF Kuldeteknikk

Mer informasjon

Informasjon fra IEAs varmepumpeannekser er åpen og tilgjengelig for alle i de forskjellige deltakerlandene. Under dette annekset ble det laget en rapport (180 sider) og et beregningsprogram for bruk på PC. Med disketten følger også en detaljert brukerveiledning. Begge deler kan bestilles fra NTH-SINTEF Kuldeteknikk i Trondheim.

Global Environmental Benefits of Industrial Heat Pumps

Question:

What can industrial heat pumps do for

The environment?

Productivity?

Energy efficiency?

Answer:

Curb the Greenhouse Effect by reducing pollutants

Conserve primary energy

Improve plant productivity

Maximize cost-effectiveness

How can you support the growth of Industrial Heat Pumping to achieve these benefits?

If your company/organization is....

In a **Process Industry**, whose manufacturing requires a large amount of energy, particularly steam or process heat

A **Manufacturer** of industrial process and/or heat pump equipment, compressors, heat exchangers, etc.

An **Architectural/Engineering** firm that designs industrial processes

A **Utility** selling gas or electricity, with an active industrial customer technical assistance program

An **R & D Funding Organization**, supporting energy-related industrial process efficiency

Then....

Participate in this exciting and ambitious effort to promote the application of Industrial Heat Pumps (IHPs).

Products

- Comprehensive report on global environmental benefits of Industrial Heat Pumps
- Guidelines for IHP Application
- Detailed IHP design manual
- Expert computer program to assist IHP implementation
- International Expert Meetings

Your Input

Describing existing IHP installations and waste heat quality, quantity, and temperature level in industrial processes (where IHPs may be suitable)

Our Output

Illustrating the emission reductions, cost reductions and energy savings of IHPs, with products that benefit you.

IEA
OECD
heat pump centre

Annex Objectives

- Heighten industry's awareness of large energy cost savings associated with industrial heat pumping
- Broaden the information base to further develop IHPs
- Estimate the market potential for various types of IHPs to the year 2010 and illustrate the opportunities for their use.
- Estimate the potential environmental benefits of emissions reduction (including greenhouse gases).

First steps ⟶ Results

This Annex began with an Expert Meeting in June 1991, and is scheduled to conclude in April 1994 with an international workshop.

Analytical Tool

A key product is the development of a computer program designed to evaluate IHP technical feasibility and IHP cost and performance for specified process conditions. This valuable tool will be available to organizations and individuals from participating countries*.

Worldwide Networking

The basis for formulating a full, integrated, and up-to-date information base, this activity consists of 3 Expert Meetings, drawing from industry, utilities, and research institutes to foster development in IHPs.

The Workplan

Includes: IHP technical evaluation (state-of-the-art); process characterizations; determining IHP technical fit with processes; estimating potential number of IHPs, potential energy savings and emissions reduction (SO_x, NO_x, and greenhouse gases CO_2, CH_4, N_2O, and CFCs).

Participating countries* will be asked to contribute information from their respective industrial, equipment manufacturing and utility sectors to assist in executing the study. The results will be compiled and calculated to generate worldwide estimates.

Confidentiality of data provided is assured.

For further information contact the IEA Heat Pump Centre or your Country Contact.

What is the IEA?

Founded in 1974, the International Energy Agency is the forum for 23 countries active in efforts to promote and develop alternative energy sources, increase energy efficiency, maintain information systems and centres, and approach energy developments in a global context through cooperative relations with non-member countries and international organizations.

What is the Implementing Agreement on Advanced Heat Pumps (IAAHP)?

A programme of cooperative research, development, demonstrations, and exchanges of information regarding advanced heat pump systems, organized under the auspices of the IEA and carried out by member countries. All activities are coordinated or supported by the Heat Pump Centre.

What is an IAAHP Annex?

A task identified as significant by the IAAHP membership in the field of heat pumping technology. Conducted by participating countries, one of which acts as the Operating Agent (manager of the task).

What is the IEA Heat Pump Centre?

The international focal point for heat pump information. Contact the Centre with inquiries on heat pump issues, publications and other Heat Pump Centre activities.

IEA Heat Pump Centre
P.O. Box 17
6130 AA SITTARD
The Netherlands
Tel.: +31-46-595-236
Fax: +31-46-510-389.

IEA OECD heat pump centre

Your Country Contact:

SINTEF Kuldeteknikk
7034 Trondheim
Tel.: (07) 593900
Fax: (07) 593926
Kontaktperson:
Svein Grandum

**Signatories: USA (Operating Agent), Canada, Japan, The Netherlands, Norway, United Kingdom and Sweden. Other countries considering joining are France, Germany and Malaysia.*

ANNEX 21:

Global Environmental Benefits of Industrial Heat Pumps

MINUTES

from 3rd Experts Working Meeting
September 29-30, 1993

Maastricht, the Netherlands

§ 1 OPENING

The Operating Agent, Paul Scheihing, greeted all participants and welcomed them to the meeting. He especially welcomed the delegates from France, who participated in this activity for the first time.

§ 2 VERIFICATION OF PARTICIPANTS

All participants presented themselves, their affiliation and their role in the meeting. This information is compiled in the list of participants, **Attachment 1.**

§ 3 ADOPTION OF THE AGENDA

The proposed Agenda, see **Attachment 2,** was adopted. However, during the discussion in some of the subsequent paragraphs, two items were added, namely:

- National Team status reports (added as § 8 in the Agenda and § 8 in the minutes)
- Milestones (added as § 10 in the Agenda and § 13 in the minutes)

§ 4 ADOPTION OF THE MINUTES OF THE ANNAPOLIS MEETING

It was commented there is no mentioning in the minutes about MVR:s for hydrocarbons, as discussed in the meeting. It was agreed that this type of heat pump should be included in the program and a detailed discussion about an approach for this should be taken up under § 6. With this comment taken into account, the minutes were approved.

§ 5 ANNEX STATUS

The discussions under this paragraph were based on written information from the Operating Agent, see **Attachment 3.**

5.1 Participation Status

France has officially joined the Annex. Malaysia has indicated an interest to participate at several occasions but so far no official statement or commitment has been received by the Operating Agent. After a short discussion all agreed that it is now too late for Malaysia, or any other country, to join the Annex. The Operating Agent shall inform the Executive Committee about this decision.

5.2 Workplan and Budgetary Implications

The budget situation was presented in accordance with the information given in **Attachment 3**. Japan, Sweden and France have not yet paid their contribution. The NT representative from Sweden promised to do it during October. For Japan there is no formal problem but an uncertainty about the possible date for delivery. Susan Ross was given the task to communicate with Mr Kato about this. For France no date could be given at the meeting.

US $ 14 000 have been allocated to the final workshop. Jos Bouma from Heat Pump Centre (HPC) reported about some of the findings in the HPC National Teams meeting, held in Maastricht on September 27-28, 1993, see § 10. According to the budget situation presented in **Attachment 3**, there still remains (22-5) = US $ 17 000 to be allocated. After a short discussion it was agreed that one way to use this money is probably in the reporting part of the work, thereby making the final report very comprehensive and highlighting the environmental issues as well as the potential for heat pumping in industry globally. Another way could be to use it partly for updating the Chalmers/ETA program.

5.3 Administrative Overview

The Annex workplan and its status was presented in accordance with **Attachment 3**. It was decided that the proposed schedule for the further work should be discussed and approved under, Milestones, and that the NT status should be presented after the Status of OA work presentation.

§ 6 STATUS OF OA WORK - PRESENTATION BY CHALMERS ETA

Anders Åsblad presented the computer program developed for Task 1, Steps 2, 3 and 4a. A general description is given in **Attachment 4**. He gave the following general comments:

The OA has received many answers on the questionnaire on experience in industry of IHP:s. This information is not included in the computer program. It will be presented in the final report and also distributed to all NTs in advance, so that it can be used in the NT work. The OA has compiled around 120 different process characteristics via the NT:s and the questionnaire. This information is included in the computer program in the form shown in **Attachment 5**. The distribution between different types of industry is as shown in **Attachment 6**. Anders Åsblad presented the computer program menu by menu, as shown in **Attachment 4**. The comments and questions from the participants were as follows:

Question: Is it possible to get more detailed information on the process schemes., i.e. not only stream data but also what each stream consists of, to what unit operation it belongs?

Answer: Unfortunately such information has been included in only 1 or 2 answers. This was asked for in the questionnaire and we had hoped for more information about this.

A discussion about the use and aim of the program followed. All agreed that the main aim is for scanning purposes to identify opportunities in terms of type of IHP, possible temperature lifts and sizes. As a next step a more detailed design study for a certain industry should be carried out, in which more detailed information about the streams must be collected and included in the work.

Question: Data on COPs and capacities for e.g. high temperature closed cycle heat pumps can very well be improved in the future when R114 is replaced by some thermodynamically and environmentally better working fluid. Can such data be changed by each NT in the program?

Answer: The COP of an IHP can be modified by the user. This is done by specifying a correction factor by which the original COP is multiplied. The correction factor is specified by selecting "COP correction" from the menu at the same time the IHP type is selected.

The installation cost can also be modified by the user. This is done by specifying a correction factor by which the estimated cost is multiplied.

Question: Is it possible to include a temperature- dependent price for heat?

Answer: Yes, it is possible. The OA shall explain in writing how to do it. In this context we would like to emphasize, that a negative cost for cooling (due to the decrease in cooling demand with and IHP) should be included when appropriate. This is done in the following way:

A temperature dependent price of heat can be handled by specifying the price interactively depending on IHP delivering temperature.

The negative cost of cooling is handled by specifying the cost of the heat source. The cost of the heat source must be specified by the user. The reduced cost of cooling is handled by subtracting this cost from the heat source cost. Since the heat source cost normally is small, perhaps only the operating cost of an additional circulation pump, the combined cost of heat source and cooling can be negative.

Dealing with heat transformers the cooling cost of the heat pump must also be specified.

Comment: The term "system cost" must be defined in detail, not the least what is included in "installation cost" for different types of IHP.

Comment: A glossary under the help menu should be added. One reason for this is differences in terminology between Europe and North America.

Comment: In order to make some of the graphs in the program easier to understand, identification of type of HP, parameters on the axes, as well as different types of lines (full, dotted, etc) should be added.

Question: What are the two sizes given as output from the program?

Answer: They are full size (i.e. the largest possible) and half size at the given conditions. This should be mentioned in the diagrams. By showing two sizes the influence on the PBP of this variable can be indicated.

Comment from OA: The cost for the extra heat exchangers needed when a HP is introduced varies of course from case to case. In the program a reasonable level is used and is calculated based on the total number of streams and the temperature difference between the condenser/evaporator and the pinch temperature.
This shall be seen as a default value. Any other value can be introduced by an NT by varying the factor for the installation cost.

Question: What operation costs, in addition to the driving energy to the HP, are included?

Answer: Operation costs are maintenance, additional pressure drop and the parasitic electricity consumption. The additional pressure drop cost varies of course from case to case but should in normal cases be very small. This is also the case for parasitic electricity consumption. (Figures for e.g. heat transformers are available and will be included in the report). For maintenance no cost has been included. For detailed calculations this cost must not be excluded (typical figures shall be presented in the report) but for the purpose of this study, to assess reasonable paybeck periods, this is not a crucial parameter.

Question: The temperature lift can be defined in different ways. Which one do you use in the program?

Answer: The temperature difference between the condensing and evaporation temperature when a reasonable ΔT_{min} in the condenser and in the evaporator is assumed. This will be explained in detail in the report.

Question: What global ΔT_{min}s for the industrial processes shall we use. Shall the ΔT_{min} be varied between the different processes?

Answer (after a lenghty discussion): A normal situation would be that an IHP is installed in connection with a more broad retrofit of the whole plant. Therefore it is unlikely that the IHP is introduced in a system with a large global ΔT_{min}, i.e. with a very non-efficient heat exchanger network. The diagram QH versus ΔT_{min}, which can be plotted from the program, gives a rough estimate about the gain in hot utility with increasing heat exchanger network. It can therefore be used to identify a reasonable ΔT_{min}-value in a retrofitted plant. The OA Chalmers/ETA shall give default values to be used in the calculations. Each NT can of course choose their own values. Normally a ΔT_{min} between 10 K and 15 K is appropriate, regardless of the type of industry. This is based on results from real projects. The sensitivity for the results of the calculations in this Annex of a reasonable variation in ΔT_{min} is normally low.

This approach means that the hot utility level for a certain type of industry shall be changed only once during the 15-year period covered in the Hagler Bailly part of the calculations, i.e. at the same time as the IHP is introduced.

The OA Chalmers/ETA reported that also "simple processes" i.e. processes with only one or a few heating and cooling loads such as timber drying and one-column distillation plants, will be included in the program. These can be handled in the same way as complex processes. The only difference is that the Grand Composite Curve will only consist of e.g. two horizontal lines. Information on such processes have been received from e.g. Canada and France.

The OA Chalmers ETA promised to take the comments and questions into account when finalizing the program. The final version shall be ready in three weeks after the meeting. All agreed that Windows 3.1 is appropriate for this version.

The general approach for the Chalmers/ETA program was approved by all NT:s.

§ 7 STATUS OF OA WORK - PRESENTATION BY HAGLER BAILLY

Steve Williams presented the situation for Task 1-Steps 4b, 5, 6 and for Tasks 2 and 3. A spread sheet has been sent out in August, which provides the tool for the NT work. It is shown in **Attachment 7**. The spreadsheet consists of 7 sections. It works at the individual process level and uses inputs from NTs (energy prices, emissions data, process data) and from the Chalmers/ETA program (IHP data). It provides estimates of energy and emission savings per process by the use of IHPs. Hagler Bailly will combine results for each team and across teams.

Questions and comments from the participants were as follows:

Question: In section 1 energy prices shall be given. Is it not difficult to give one figure for the whole country for each fuel, especially for electricity? Electricity prices can vary from plant to plant.

Answer: It is possible to work with different electricity prices for a given year in different plants by using an individual price for each industrial process to be studied.

Question: Shall we use the lower or the higher heating value when making calculations for the different fuels?

Answer: There are obviously different traditions in different countries about this. We must be consistent so that we can compare results from the countries. The OA shall come back on what value to be used.

Question: From where have you got the diffusion rate in Section 2 (market penetration factors) ?

Answer: That is a default value based on a straight line beginning in 1994. Each NT can put its own penetration rate.

Comments: There is some information available about market penetration, for example from France concerning MVR introduction. The acceptance rate chosen as default is rather high, which should be borne in mind by the NTs.

Question: The leakage of refrigerants from closed cycle heat pumps can in some cases (depending on the working fluid) have a global warming effect. This must be included in the calculations. Which annual leakage should we calculate with?

Answer (from OA Chalmers/ETA): A typical reasonable level in modern plants is 5%. (In existing plants it can be considerably higher but with the highest standards of today 5% is the most appropriate.) Then we must also bear in mind that the charge in new plants is in many cases reduced considerably compared with in existing ones, by 80-90%, due to the use of indirect refrigerant systems. The OA shall provide figures about reasonable charge values versus the heat output.

Question: There are about 50 different HP types included in the Chalmers/ETA program. Shall we make economic evaluations for all of these?

Answer: For a given process plant only a few would be appropriate in terms of size, temperature lift and economy. The Chalmers/ETA program will identify these and therefore the amount of work needed in the economic evaluation part is reduced heavily.

Question: Is there a risk that " the winner takes all", i.e. that the second best type of HP can be very close in economy to the best one but that only the best one is penetrated?

Answer: No, by using the level of penetration as a function of the payback period, as is shown in Section 2, different HPs will take their appropriate shares of the total market.

Question: When defining market shares, what percentage shall we put in, % of energy consumption or of number of plants?

Answer: % of number of plants, which in fact means that an average size of plant for each industry sector must be defined in each country.

Question: How shall we handle the competition from cogeneration in the various industry sectors?

Answer: The level of cogeneration and its growth in each sector must be assessed by each NT. Thereby the ratio electricity to fuel price in the country is a major factor.

Question: For the assessment of the possible penetration in each sector, the existing situation concerning HP types, temperature lifts, sizes, etc in the HPs introduced so far is valuable. Can we have the information from the questionnaires on this compiled and distributed to all NTs soon?

Answer: This shall be done by the Chalmers/ETA OA

§ 8 STATUS OF THE NATIONAL TEAM WORK

Canada: Identified processes to analyse and spent time on the Chalmers/ETA program. Needs the final version to go on.

The Netherlands: Survey of Dutch industry in the different sectors. Food and drink, dairy, etc are energy intensive industries. It is difficult to get data for the chemical industry. A report was handed out to all NTs.

Japan: Worked with background material on processes etc. Needs the final version of program to go on.

UK: Studied the present situation about the use of IHPs and evaluated the computer program. So far no process evaluation.

Norway: Collected background material. So far the program has not been evaluated.

Sweden: Prepared a report on the staus in Sweden of IHPs with information on types, temperature lifts, sizes and technoeconomic experience in various industry sectors. A preliminary version of the report, was handed out to all NTs

France: Collected material on processes where IHPs are used today and data for HPs, especially MVRs. This information will be transferred to the OA. Started work with the computer program.

It was decided that each NT shall report to the OA Hagler Bailly, by October 15, which processes it shall evaluate. After that contacts between countries, evaluating the same processes, shall be established with the aid of Hagler Bailly, thereby making the work more efficient in each country.

It was also decided that the OA Chalmers/ETA shall provide 2 worked examples to show how the program shall be used. One example shall be for a complex (in terms of composite curves) industry and one for a simple one.

The contact person in each country for the further work was identified as follows:

Canada	- Dough Cane, Caneta Research
France	- Thierry Dutto, Electricité de France
Japan	- Eiji O'shima, HPC of Japan
The Netherlands	- Jan de Wit, IMET-TNO
Norway	- Rune Aarlien, SINTEF
Sweden	- Mats Westermark, Vattenfall AB
UK	- Norman Maloney, EA Technolgy

§ 9 THE REPORT

It was decided that a description about the situation for industrial heat pumps in each participating country shall be included in the report. This work shall be performed by OA Chalmers/ETA as an additional task and it shall therefore receive US $ 3000 from the available OA funding.

The report shall consist of two parts, a summary one and a more detailed technical one. The content of the latter shall be in accordance with the decisions of the Annapolis meeting. In addition, two other aspects shall be highlighted in the report:

- Spin-off effects of using IHPs, e.g. reduction of pollutions in air and water and opportunities for debottlenecking, which in some cases can be the primary drive for the IHP introduction

- Experiences concerning different technical, economic and legislative barriers and solutions for IHP implementation.

§10 FINAL WORKSHOP

It was decided that the scheduled date for the workshop in spring 1994, will be too tight and that it shall be moved to September '94. The place shall still be the US.

Jos Bouma informed that the Heat Pump Centre National Team Meeting has decided to suggest to the Annex 21 working group to co-sponsor the workshop. This was unanimously approved and details about this cooperation shall be worked out between the OA and the Heat Pump Centre. It was also decided that Chalmers/ETA shall be used for preparing the Agenda and speaker list for the workshop.

It was decided that the timing of the report from the Annex shall be such, that it shall be available to the workshop. The workshop shall be open also to people from other countries than the Annex 21 ones. The parts of the Annex report that shall be made available to participants from other countries are still to be decided.

§11 POSSIBLE FURTHER WORK AFTER THIS ANNEX

It was agreed that the OA shall work out a proposal for a continuation of the work in this annex. For this a Subcommittee shall be formed by the OA. During the discussion it was agreed that one possible continuation would be to develop the Chalmers/ETA program so that it can make more detailed design calculations for a given industrial plant for which stream data, existing heat exchanger network, etc, are known and with the aid of this perform studies in real plants in the participating countries.

§12 INTELLECTUAL PROPERTY

It is still unclear who owns the Chalmers/ETA program and how it can be used in the participating countries in commercial projects. The general IEA rules must be consulted and a proposal for an approach that all participants can approve of must be developed. For this a Subcommittee shall be formed by the OA.

It was suggested during the discussion that profits from commercial use of the program and/or a part of the still available funding in the ongoing Annex shall be used for a more or less continuous updating of the program. It was decided that the Subcommittee shall have a suggestion also on this aspect.

§13 MILESTONES

The following milestones were decided:

Studies begin	Now
Key processes to Hagler Bailly	October 15
Version 1.0 Program from Chalmers/ETA	October 15
Master list of processes from Hagler Bailly to NTs	October 30
Trial sample protocol to project HP potential - one process	October 30
Revised market assessment spreadsheet from Hagler Bailly to NTs	November 1993
Chalmers/ETA request to NTs on current status of IHPs in each country	early January 1994
NT response to Chalmers/ETA on current IHP status	late January 1994
NT studies completed - sent to Hagler Bailly	February 1, 1994
Chalmers/ETA text for technical report completed, sent to Hagler Bailly	March 1, 1994
Draft reports from Hagler Bailly to NTs	April 1, 1994
Comments on reports back from NTs to Hagler Bailly	May 1, 1994
Final reports from Hagler Bailly to the IEA HPC	June 1, 1994
Final reports available from the IEA HPC	August 15, 1994
International Workshop	September 1994

These milestones mean that the work will be slightly delayed compared with the original schedule. Therfore the OA must ask for an extension of the Annex at the next Executive Committee meeting in the spring of 1994.

§14 END OF THE MEETING

Paul Scheihing, the OA, thanked all participants for valuable inputs and ended the meeting.

INTERNATIONAL ENERGY AGENCY
IMPLEMENTING AGREEMENT ON HEAT PUMPING TECHNOLOGIES

VAPOR COMPRESSION SYSTEMS WITH ECOLOGICALLY SAFE WORKING MEDIA

Proposal for a new Annex
Second Version
December 6, 1993

Prepared by the Norwegian National Team

1 BACKGROUND

Most of the replacement refrigerants that are now being developed or used as substitutes for the CFCs and HCFCs are new chemical compounds, foreign to nature. Large-scale use of these man-made compounds may therefore result in unforeseen environmental effects over the years, as already observed with the present generation of CFC and HCFC chemicals. In addition, many of the replacements have negative environmental impacts such as global warming.

By using naturally occurring and ecologically safe substances as working media, all these uncertainties and negative effects can be eliminated. Examples of such media are air, water, carbon dioxide, ammonia, hydrocarbons, nitrogen and the noble gases.

Heat pump and refrigerating systems based on such substances already exist to a certain extent, in a fully developed or at a prototype stage. Under the proposed Annex information will be gathered on existing and planned heat pump systems based on ecologically safe working media, to point out technical possibilities, and to establish a source of information related to the design and operation of such systems.

2 OBJECTIVES

The objectives of the proposed Annex would be to:

a) Establish design criteria and recommendations for operation of vapor compression systems with the following working media; ammonia, carbon dioxide, water, air, propane, butane, and mixtures of propane and butane.

b) Collect, evaluate, and present state-of-the art information on practical experience from systems with the working media in question, in order to point out possibilities as well as the most promising application areas for such heat pump systems.

3 SCOPE OF WORK

The following sections outline the scope of work in the proposed Annex, and at the same time indicates the structure and contents of the final report. Other means for reporting and disseminating results will also be used, e.g. by leaflets, handbooks, computer programs etc.

3.1 Thermodynamic and Transport Properties

Since most of the information needed on thermodynamic and transport properties is already available from various sources, this is a matter of collecting, evaluating and presenting the data in a useful form. e.g. in tables, diagrams and/or computer programs. A complete set of thermodynamic data and transport property data (viscosity and thermal conductivity) must be offered for all media for the entire range of relevant operating conditions. In some cases, the available data must be adapted to the requirements for heat pump analysis and design. Where several sources of information are available, the data offering the best accuracy and suitability must be selected.

3.2 Other Properties and Characteristics

Other relevant information to be collected for the working media are environmental characteristics, data on material compatibility, lubricant selection, cost, availability etc.

3.3 Heat Transfer and Pressure Drop Design Data

In order to design and optimize heat pump and refrigerating systems based on the ecologically safe working media, heat transfer and pressure drop data must be available.

Although some information already exist, there is a lack of good heat transfer and pressure drop recordings, for instance for ammonia, hydrocarbons and CO_2 in relevant tube geometries. Much of the available data are based on large tube diameters (ID 20-25 mm), and the data have been recorded without any lubricant present.

One of the primary tasks in the Annex will therefore be to provide useful heat transfer and pressure drop data, and to propose correlations for the design of systems and components. Measurements should be performed in evaporator and condenser tube test rigs for media and conditions where there is a general lack of available results. For CO_2, the tests should include supercritical conditions.

For systems with hydrocarbons and ammonia, an overall objective is to reduce the refrigerant charge. For such systems compact plate heat exchangers should be investigated.

3.4 Survey of Concepts and Applications

The Annex should provide a summary of existing and possible/promising heat pump applications, where the use of ecologically safe working media may give benefits. In general, concepts giving equal or superior energy efficiency in relation to FC-based systems should be emphasized.

3.5 Practical Experience

Considerable practical experience already exists with some of the working media in certain applications. This information should be assembled to provide a basis for the design and operation of new systems.

3.6 Safety Aspects

Some of the ecologically safe fluids involve certain safety risks owing to their flammability and/or toxicity. The Annex will collect and evaluate existing data and results related to working fluid safety, and present this in a form useful for assessing, designing and operating heat pump systems. It would be a logical approach to build on the results from Annex 20, Working Fluid Safety.

3.7 Design Recommendations

With a basis in the suggested application areas, the existing practical experience and the survey of safety issues, the Annex should be able to give design recommendations for new systems based on the ecologically safe media. These recommendations will include suggestions for practical design, safety measures, and control of new systems.

3.8 Outlook

In a longer time perspective, new applications and concepts for heat pump systems based on ecologically safe media may be developed. By extrapolating the present R&D trends, some indications on new possibilities may be given.

Based on the results from this Annex and the general situation, research needs and areas to be given priority in further investigations can also be identified.

3.9 References and Sources for Further Information

An extensive list of sources for further information should be provided. This will include references to written material, references to completed or ongoing research, development or demonstration projects, and a list of organizations, persons and institutions which may provide more information.

3.10 Commercial Availability of Equipment and Complete Systems

Equipment based on ecologically safe refrigerants is already available from some manufacturers. A brief list of available systems and equipment will be provided.

4 Operating Agent

Operating Agent (OA) of the proposed Annex will be NTH-SINTEF Refrigeration Engineering, Trondheim, Norway.

SINTEF Refrigeration Engineering together with the Norwegian Institute of Technology's Department of Refrigeration Engineering, has for several years concentrated much of its efforts on the natural working media and, consequently, possesses in-depth and state-of-the art knowledge in the field. With NTH-SINTEF Refrigeration Engineering as OA, the participants would benefit from closely related and on-going Norwegian activities such as the NVE's National Heat Pump Program 1993-1996 and the Norwegian CFC Phase-Out Program. In 1993 NTH-SINTEF Refrigeration Engineering was appointed Strong Point Centre of CFC-free Refrigeration and Heat Pumping by a joint research committee at the Norwegian Institute of Technology and SINTEF. This is a five year program already having attracted funding and interest from Norway and abroad.

5 Responsibilities of the Operating Agent

The OA will under the proposed Annex have the following responsibilities:

a) Coordinate all activities.
b) Collect all information.
c) Evaluate and analyze all information.
d) Coordinate the research activities needed to establish the design criteria.
e) Organize three expert meetings for the participants (including the kick-off meeting).
f) Write the final report.
g) Organize a workshop to present the results from the Annex.

6 Responsibilities of the Participants

The participating countries will under the proposed Annex have the following responsibilities:

a) Supply the OA with requested information, for instance case studies.
b) Participants should conduct laboratory work based on own interest.
c) Assist OA in organizing meetings.

7 Financing

The proposed Annex will be operated both on a cost-shared and task-shared basis. The total Annex contribution needed will be NOK 1,500,000 (approximately $214,000 at the prevailing exchange rate). The maximum contribution fee will be NOK 150,000 ($21,500) for the smaller countries and NOK 200,000 ($28,600) for the larger countries.

The total Annex value will be NOK 3 million ($430,000). It is expected that the contribution of the participants will make up 50-60% of the total value, the balance coming from Norwegian sources through related programs running in parallel with the Annex.

In addition it is expected that each participant will put in the equivalent of two months work for each of the year the Annex is in operation.

8 TIME SCHEDULE

If realized, the Annex will start at the latest by the 1994 fall Executive Committee Meeting (October), and the duration will be 3 years.

The preliminary time table for the Annex looks as follows:

Spring 1994:	Kick-off Meeting (together with HPC Workshop?)
August 1994:	First Expert Meeting
October 1994:	Official start
August 1995:	Second Expert Meeting
August 1996:	Third Experts Meeting
Spring 1997:	Closing of the Annex at the EXCO Meeting
Spring 1997:	Workshop to present the results from the Annex

The dates could be shifted forward or backward by a maximum of two months.

9 RESULTS AND INTELLECTUAL PROPERTIES

The overall objective of the Implementing Agreement on Heat pumping Technologies is to disseminate heat pump information to increase market penetration. The products resulting from the annex should, therefore, be made available to non-participants as soon sa possible after closing of the annex. There will, however, be a significant cost associated with obtaining the results and the final report for the non-participants. The price level must be jointly decided upon by the participants.

Referat fra
IEA Heat Pump Centre
5th National Teams Working Meeting

27-28 september 1993
Maastricht, Nederland

Til stede: T.Berntson (SWE), L.Falkenson (SWE), H.Halozan (AUT), T.Tassis (UK), M.Broders (USA), G.Groff (AB), T.Kato (JAP), Y.Sakamoto (AB), R.Rivenæs (NOR), R.Aarlien (NOR), D.Cane (CAN), M.Bell (AB), J.Bouma (HPC), S.Ross (HPC), J.Stene (HPC), B.Stuij (HPC), M.Steadman (HPC), J.Linton (CAN), L.Prista (SUI), J.Bosma (NED), M.Wilpshaar (HPC)

Agenda er lagt ved som **vedlegg 1**.

Resultater fra møtet:

1 Arbeidsprogram for 1994

Newsletter: Fire utgaver med følgende tema ble stemt over og vedtatt:

12/2 Heat Pumps and Demand Side Management
12/3 Waste Heat Recovery Heat Pumps
12/4 Industrial Heat Pumps
13/1 CFC and HCFC Repalcements

Workshops: Følgende tre ble stemt over og vedtatt:

a) "Heat Pumps as Retrofit Alternatives for Hydronic Heating Systems". Denne vil bli organisert sammen med International Power Utility Heat Pump Committee (IPUHPC).
b) "Practical Consequences of Working Fluid Replacements".
c) "Industrial Heat Pumps" i samarbeid med Annex 21.

Reserve: "Energy Management and Energy Control in Residential and Small Commercial Buildings". Denne ble foreslått for andre gang av det USAs National Team.

Analyse: Følgende tittel ble stemt over og valgt:

a) "Heat Pump Energy Efficiency Standards and Labelling Requirements".

2 Workshop om "Promotion"

Det ble gitt to presentasjoner av profesjonelle markedsføringsfolk. Deretter fikk vi en fin diskusjon der medlemslandene ikke var helt enige med de forslag eller den strategi som HPC la frem. Det synes vanskelig å få til et program som vil være dekkende for alle landene. Hvert enkelt land ser ut til å ønske spesielle fremgangsmåter og ønsker å vektlegge forskjellige ting. Hvert NT ble anmodet om å lage et sammendrag av hva som ville være ønskelig mhp. sitt eget land, for så å melde dette tilbake til HPC. Advisory Board anbefalte at man setter opp en Task Force for å komme frem til et program eller biter av et program som kan brukes av alle medlemslandene.

3 National Teams presentasjoner

Medlemslandene (med unntak av Italia, som ikke var til stede) presenterte sine aktiviteter for det foregående året. Nederland og Sverige ser ut til å ha de største utfordringene for øyeblikket; begge landene kjemper for finansiering. Rivenæs gav en fin oversikt over etableringen av NVEs Varmepumpeprogram 1993-1996. Det norske programmet ser igjen ut til å skape interesse blant de andre deltakerlandene.

De viktigste aktivitetene for HPC det foregående året har vært;

Publications Group meeting
4th IEA Heat Pump Conference
Utvikling av Promotion strategi
Mission til Korea, Japan, New Zealand og Australia
Analyse 1992
Workshop om Hot Water Heaters i USA
Sluttrapport fra Analysis 1991
Proceedings fra Workshop om HPs and the Greenhouse Effect
Proceedings fra Thermal Storage Workshop
Nyhetsbrevet
Promotional brochures

4 Andre ting

- Det ytres ønske om at NTWM i større grad må diskutere nye annexer.
- HPC får fremdeles lite feedback på nyhetsbrevet.
- Det foreslås å bruke nyhetsbrevet til å få tak i gode ideer.
- Norge lover å foreslå nytt annex på neste EXCO-møte i Roma.
- AB roser HPC for nok et godt år. Foreslår en Task Force til å se på "promotion".
- Sakamoto fra Tokyo Metropolitan University (tidligere Toshiba) ønsker å få i stand en ordning med utveksling av dr.-studenter, forskere eller professorer. Trenger ca. ett år før ting kan være på lufta.

5 Neste møte

Datoer: 3 og 4 oktober 1994
Sted: Maastricht

93-10-12
Rune Aarlien

NVEs Varmepumpeprogram 1993-1996

NVEs Internasjonale Varmepumpekonferanse 1993

Onsdag, 8. desember 1993
0930-1600

SAS Park Royal Hotel, Fornebu

- 11 toppaktuelle foredrag, 2 på engelsk, 9 på norsk!
- Hva gjør EF-kommisjonen for å fremme bruk av varmepumper i EF?
- Hva blir budsjettet for NVEs Varmepumpeprogram i 1994?
- KFK og varmepumper - hva skjer?
- Sikkerheten av nye arbeidsmedier i varmepumper og kuldeanlegg. Internasjonalt samarbeidsprosjekt presenteres for første gang i Norge!
- Statlig enøk-ordning i 1994. Nye muligheter eller......? Nærings- og energidepartementet orienterer om det aller siste!
- Nytt skjema og veileder for lønnsomhetsberegning av varmepumper blir presentert og delt ut for første gang.

Full lunch er inkludert i konferanseavgiften på 700 kroner, som innbetales til NVEs Varmepumpeprogram innen fredag 26. november 1993.

NVEs Varmepumpeprogram finansieres av:
Norges vassdrags - og energiverk
Norges forskningsråd

NVEs Varmepumpeprogram 1993-1996

NVEs Internasjonale Varmepumpekonferanse 1993

Onsdag, 8. desember 1993
0930-1600

SAS Park Royal Hotel, Fornebu

Foredrag merket * blir holdt på engelsk, resten på norsk

0930-1000	Registrering
1000-1010	Velkommen *Direktør Erik Strømsøe, Formann i programstyret for NVEs Varmepumpeprogram*
1010-1030	Orientering om NVEs Varmepumpeprogram. Hvilke typer prosjekter ønsker varmepumpeprogrammet å samarbeide i? *Programleder Ulf Rivenæs, NVEs Varmepumpeprogram*
1030-1050	IEAs Internasjonale Varmepumpeprogram. Hvilken rolle spiller Norge i dette programmet og hva arbeides det med? *Siviling. Rune Aarlien, SINTEF Kuldeteknikk*
1050-1110	Pause
1110-1130	KFK-situasjonen i Norge i 1994 og senere. Hvilken betydning har den for varmepumpenes konsulenter, leverandører og brukere i Norge? *Tore Kofstad, ICI Norge*
1130-1200	*Safety Aspects of Working Fluids for Heat Pumps and Refrigeration Machines. *Professor J. Berghmans, Katholieke Universiteit Leuven, Belgia.* Professor Berghmans vil presentere resultater fra et omfattende internasjonalt samarbeidsprosjekt (Annex 20), utført i regi av IEA's Internasjonale Varmepumpeprogram, for å kartlegge sikkerheten av ulike arbeidsmedier i varmepumper og kuldeanlegg.

NVEs Varmepumpeprogram 1993-1996

1200-1300	Lunch
1300-1330	**CEN-standardens betydning for bygging og drift av varmepumper i Norge.** *Rådgivende ingeniør Hans T. Haukås, eget firma*
1330-1400	***The role of the Commission of European Communities in promoting heat pumps technology.** *Professor David Reay, Heriot-Watt University, Edinburgh, UK. (Leder for EFs Varmepumpeprogram).*
1400-1420	**Markedsmuligheter for varmepumper - utvalgte nisjer. Presentasjon av en markedsundersøkelse utført av Institutt for energiteknikk i 1993 for NVEs Varmepumpeprogram** *Siviling. Bjarne Horntvedt og Siviling. Ole. A. Flagstad, Institutt for energiteknikk*
1420-1440	**Ensartet og lik presentasjon av lønnsomheten av små og mellomstore varmepumpeprosjekter.** Nytt veiledningsskjema med brukerveiledning utarbeidet av NVEs Varmepumpeprogram blir utdelt til samtlige konferansedeltagere. *Rådgivende ingeniør Terje Olaussen, eget firma*
1440-1450	**Pause**
1450-1510	**Skandinavisk konkurranse om utvikling av varmepumper for småhus (basert på "teknikupphandling").** Konkurransedokumenter blir sendt ut medio desember 1993, med innleveringsfrist august 1994. Konkurransen åpner for nye, spennende muligheter for norske varmepumpeleverandører. Foredragsholderen vil også orientere om "teknikupphandling" generelt og vil gi eksempler på tilsvarende konkurranser innenfor energiområdet. *Arne Løgdberg, NUTEK (Närings- og teknikutvecklingsverket), Sverige*
1510-1530	**Orientering om enøk-ordningene i 1994** Nærings- og energidepartementet har signalisert en omlegging av enøk-ordningen i 1994 i forhold til 1993. Bli oppdatert om det aller siste fra Nærings- og energidepartementet på dette viktige området, som også gjelder varmepumper. *Førstekonsulent Line M. Amlund Hagen, Nærings- og energidepartementet*
1530-1550	**Hvilke prosjekter har NVEs Varmepumpeprogram støttet i 1993?** **Hva blir NVEs Varmepumpeprograms budsjettposter i 1994, og hvilke beløp kan vi forvente oss for de enkelte budsjettposter?** *Programleder Ulf Rivenæs, NVEs Varmepumpeprogram*
1550-1600	**Avslutning**

Brosjyren er trykket på 100% resirkulert papir. Layout/Design: Skarland Press Design Service

NVEs Varmepumpeprogram
1993 - 1996

Deltagerliste for NVEs Internasjonale Varmepumpekonferanse, 8. desember 1993.

Antall påmeldte: 83 personer pluss Programstyret og foredragsholdere, totalt 100 personer.

ALVIK, Olaf	Siviling./høgskolelektor	Møre og Romsdal Ingeniørhøgskole, Ålesund
AMLIEN, Anders	Siviling.	FM-Enøk, Sandsli
AMUNDSEN, Rolf	Siviling.	Skienfjordens komm. kraftselskap, Porsgrunn
ANDERSEN, Jens	Direktør	Lodam energi a/s, Sønderborg, Danmark
ANDERSEN, Espen	Avd.ing.	Firma Per Andersen, Oslo
ANDERSEN, Torben	Direktør	NILAN A/S, Hedensted, Danmark
ARNTZEN, Yngve	Avd.ing.	Ringtek A.S., Narvik
AUNE, Espen	Siviling.	Schløsser Møller Kulde A/S, Oslo
BAKKEN, Ove	Lektor	Agder Ingeniør- og Distriktshøyskole, Grimstad
BERG, Ola	Teknisk sjef	Friganor A/S, Oslo
BERGGREN, Agnar	Siviling./overing.	Det norske Veritas Industri A/S, Høvik
BORN, Svein	VVS-ing.	Fyen & Hillestad Rørleggerbedrift A/S, Oslo
BRANDVOLL, Rune		Moderne Kjøling A/S, Oslo
BRANDT, Per	Salgssjef	Vesttherm, A/S Vestfrost, Esbjerg, Danmark
BRASKERUD, Per Magnus	Siviling./Daglig leder	CA-NOR Kjøleindustri A/S, Oslo
BRYHN, Haakon	Siviling./Prosjektleder	ABB Alfsen og Gunderson AS, Oslo
BÜNGER, Jan	Siviling.	Energistyrelsen, København, Danmark
CLAUSEN, Trond	1.amanuensis	Telemark ingeniørhøgskole, Porsgrunn
CHRISTIANSEN, Idar	Tekniker	Klima- & Varmeteknikk A/S, Moss
DRAGLAND, Tormod	Avd.ing.	Sørum kommune, Sørumsand
EGGEN, Geir	Seksjonsleder	SINTEF Kuldeteknikk, Trondheim
ENGEBRETSEN, Per	Direktør	Friganor A/S, Oslo
ERI, Svein	Lærer	Sjøforsvarets reg.tek. skole, Hundvåg
FENGESTAD, Erik	Teknisk sjef	Flebu - Bergen A/S, Laksevåg/Bergen
FRAAS, Tom	Salgssjef, Prosjekt	Brødrene Dahl A/S, Oslo
FYEN, Tormod	Rørleggermester	Fyen & Hillestad Rørleggerbedrift AS, Oslo

Deltagerliste for NVEs Internasjonale Varmepumpekonferanse, 8. desember 1993.

Antall påmeldte: 83 personer pluss Programstyret og foredragsholdere, totalt 100 personer.

GISKE, Turid	Salgssjef	Energi og Miljø, Oslo
GRØNNEVIK, Einar	Teknisk sjef	Normann Energiteknikk A/S, Oslo
GUDMESTAD, Ove	Ingeniør	Den norske Bank, Oslo
HAGLUND, Kent	Marknadsøkonom	Vattenfall, Motala, Sverige
HAMSTAD, Arnfinn		Hamstad A/S, Flatåsen
HANSEN, Henry Alf	Teknisk driftsbetjent	Norges Idrettshøgskole, Oslo
HANSSEN, Reidar	Rørl.mester/dagl.leder	Fyr & Flamme AS, Narvik
HAGEN, Jon Anders	Siviling./energirådgiver	Akershus Energiverk, Rånåsfoss
HAUGETUN, Robert	VSS-ing.	Energimatic AS, Vaksdal
HENRIKSEN, Knut	VVS-ing.	Brødrene Dahl A/S, Oslo
HERMANSEN, Rolf	Maskining.	Østlandskonsult AS. Fredrikstad
HOLE, Tom Erik	Styremedlem KELF	Kuldeentreprenørenes Landssforening, Sandvika
HOLTHE, Kjell	Ingeniør	Holthe's Kjøleservice A/S, Trondheim
HUSER, Arne	Ing. - varmepumper	ABB Guthus & Iversen AS, Lillestrøm
HJERMSTAD, Espen	Avd.leder - kulde	ABB Guthus & Iversen AS, Lillestrøm
IVERSEN, Per	VVS-ing.	Brødrene Dahl A/S, Oslo
JAREFORS,Bengt-Göran	Adm.direktør	Svenska Vattenpumpföreningen, Stockholm, Sverige
JOHANNESSEN, Arne	Distriktssjef	A/S Union (Union Co.) Div. Eiendom, Drammen
JOHANSEN, Jan Erik	Disponent	J. Wessel Johansen A/S, Sundbyfoss
JOHANSEN, Morten	Ingeniør	Siv.ing. Carl H. Knudsen AS, Drammen
JOHANSON, Frank Ø.	Overing.	Statsbygg, Oslo
KARLSEN, Svein	Siviling.	O. Hegge a.s., Oslo
KRISTENSEN, Daniel	Mester/daglig leder	Asker Bærum Kuldeteknikk AS, Rud
LAMPTEY, Joseph	Ingeniør	Lørenskog
LARSEN, Erling Piil	Lærer	Osebakken v.g. skole, Porsgrunn
LARSEN, Knut	Driftsleder	Forsvaret/Bygg og Anlegg, Gardermoen Flystasjon
LARSEN, Oddvar	Ing. teknisk sjef	Clima-Comfort A/S, Sandnes

NVEs Varmepumpeprogram
1993 - 1996

Deltagerliste for NVEs Internasjonale Varmepumpekonferanse, 8. desember 1993.

Antall påmeldte: 83 personer pluss Programstyret og foredragsholdere, totalt 100 personer.

LYSTAD, Tor	Forsker	SINTEF Kuldeteknikk, Trondheim
MOEN, Oddbjørn		Edvardsen Elektro A/S, Hamar
OLSSON, Bjørn	Kundeansvarlig	Aquaterm AS, Molde
OLSSON, Leif		Thermin AB, Arvika, Sverige
PETTERSEN, Jan	Seksjonssjef	Det Norske Veritas Eiendom AS , Høvik
ROMSTAD, Jan	Daglig leder	Klima- & Varmeteknikk A/S, Moss
RUSTAD, Per	Gårdbruker, ing.	Ådalsbruk
RØN, Jørgen J.	Ingeniør	EV-Plan, rådg.ing., Hamar
SANDBAKK, Marit	Forsker	SINTEF Kuldeteknikk, Trondheim
SCHINNES, Roar	Direktør	A/S Union (Union Co.) Div. Eiendom, Drammen
SLETTEBERG, Ansgar	Driftstekniker	Norges Idrettshøgskole, Oslo
SPILLBERG, Petter	Avd.sjef	NOVEMA A/S, Hagan
STEEN, Rolf	Vedlikeholdsansvarlig	Coates Coating AS, Mjøndalen
STUGE, Svein B.	Avd.sjef	NOVEMA A/S, Hagan
SVEDER, Ove	Prosjekting.	Teknoterm AS. Eidsnes
SVENNINGSEN, Tom	Daglig leder	Normann Energiteknikk A/S, Oslo
TANGÅS, Øyvind		Kjølemontasje & Service, Grimstad
THORSEN, Rolf R.		Miljøvarme, Tolvsrød
TILLER, Kari	Avd.ing.	Sørum kommune, Sørumsand
TOKLE, Trude	Forsker	SINTEF Kuldeteknikk, Trondheim
TORNØE, Frode	Tekn. avd.	Sjølie & Birch A/S, Oslo
VÅGE, Magne	Lektor	Agder Ingeniør- og Distriktshøgskole, Grimstad
WALEN, Tor S.	Ing./avd.leder	K. E. Kolberg AS, Høvik
WATHNE, Arne	Avd.sjef	Det Norske Veritas Eiendom AS, Høvik
WISLØFF, Hans Christian Sandvik	Produktsjef/siviling.	Variant VVS Norge AS, Skjetten
ØVERLAND, Olav	Disponent	Hordaland Kulde AS, Norheimsund

Deltagerliste for NVEs Internasjonale Varmepumpekonferanse, 8. desember 1993.

Antall påmeldte: 83 personer pluss Programstyret og foredragsholdere, totalt 100 personer.

ØYEN, Per	Lærer	Osebakken v.g.skole, Porsgrunn
AAGAARD, Hans Chr.	Ing./Prøvestasjonsleder	DTI-Energiteknologi, Prøvestationen for Varmepumper, Taastrup, Danmark
ÅKERMAN, Per		Oslo
ÅRØEN, Audun	Driftsing.	Ålesund og Sula Everk, Ålesund

NVEs Varmepumpeprogram
1993 - 1996

Deltagerliste for NVEs Internasjonale Varmepumpekonferanse, 8. desember 1993.

Antall påmeldte: 83 personer pluss Programstyret og foredragsholdere, totalt 100 personer.

Etteranmeldte:

ARNTZEN, Rolf	Overing.	Forsvarets bygningstjeneste, Bodø
BERG, Cato	Daglig leder	Bodø Kjøle og Fryseservice A/S, Bodø
FINSRUD, Terje	Rådg. ing.	Erichsen & Horgen A/S, Oslo
JESPERSEN, Keneth	Avd. leder	Ing.Fa. Trygve Jespersen A.S., Narvik
RANDBY, Stein	Siviling.	Oslo Energi AS, Oslo
BERGLI, Arne	Disponent	Brødrene Bergli A/S, Nordli
OLSSØN, Hans Petter	Daglig leder	Energi Partner A/S, Oslo

Antall påmeldte med etteranmeldte og avbud:
89. ~~87~~ **personer pluss programstyret og foredragsholdere, tilsammen** 106 ~~104~~ **personer.**

Avbud:

LARSEN, Oddvar	Ing. teknisk sjef	Clima-Comfort A/S, Sandnes

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Vol. 11, No. 1, March 1993

IEA Heat Pump Centre

NEWSLETTER

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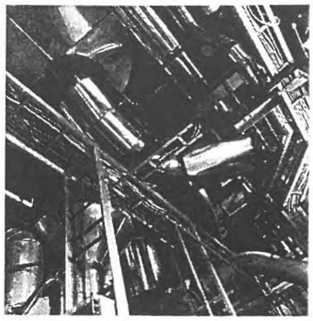

Front Cover: *These intertwining pipes form part of a 4 MW_{th} heat transformer which uses waste heat to supply steam to a steel plant. Further details are given in the article on page 17.*

International Energy Agency
The International Energy Agency (IEA) was established in 1974 within the framework of the Organisation for Economic Cooperation and Development (OECD) to implement an International Energy Programme.

A basic aim of the IEA is to foster cooperation among the 23 IEA participating countries to increase energy security through energy conservation, development of alternative energy sources, new energy technology, and research and development (R&D). This is achieved, in part, through a programme of energy technology and R&D collaboration currently within the framework of 35 Implementing Agreements, containing a total of more than 60 separate collaboration projects. This publication forms one element of this programme.

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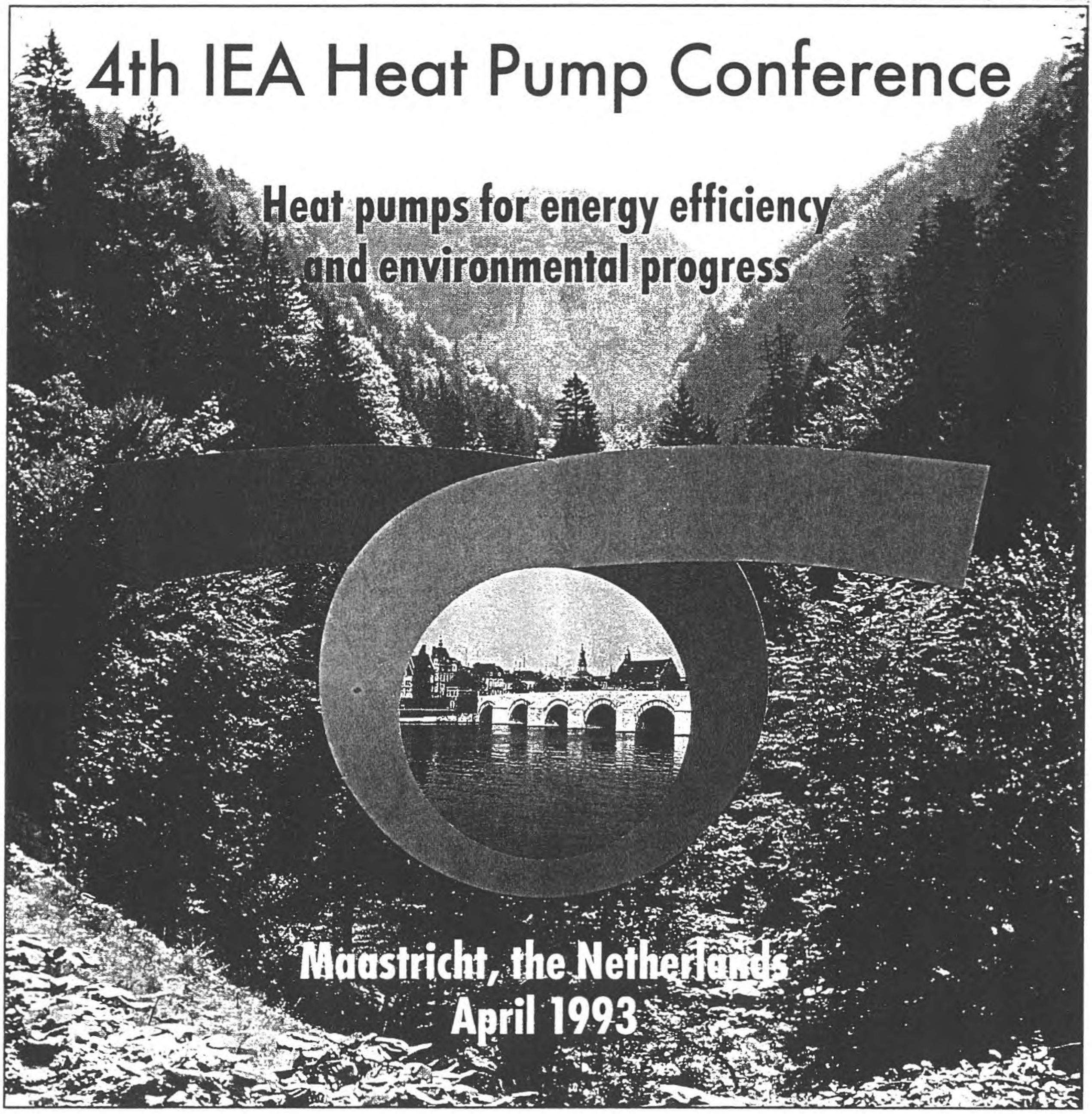
IEA Heat Pump Centre

NEWSLETTER



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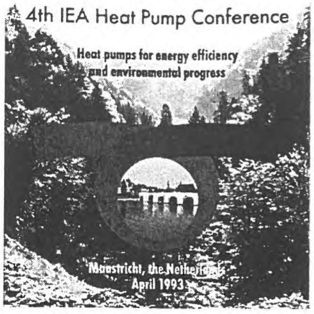

Front cover: The 4th IEA Heat Pump Conference - Maastricht takes centre stage in the drive to improve energy efficiency and benefit the environment. *(Photo Maastricht courtesy of Roel Vossen, Maastricht.)*

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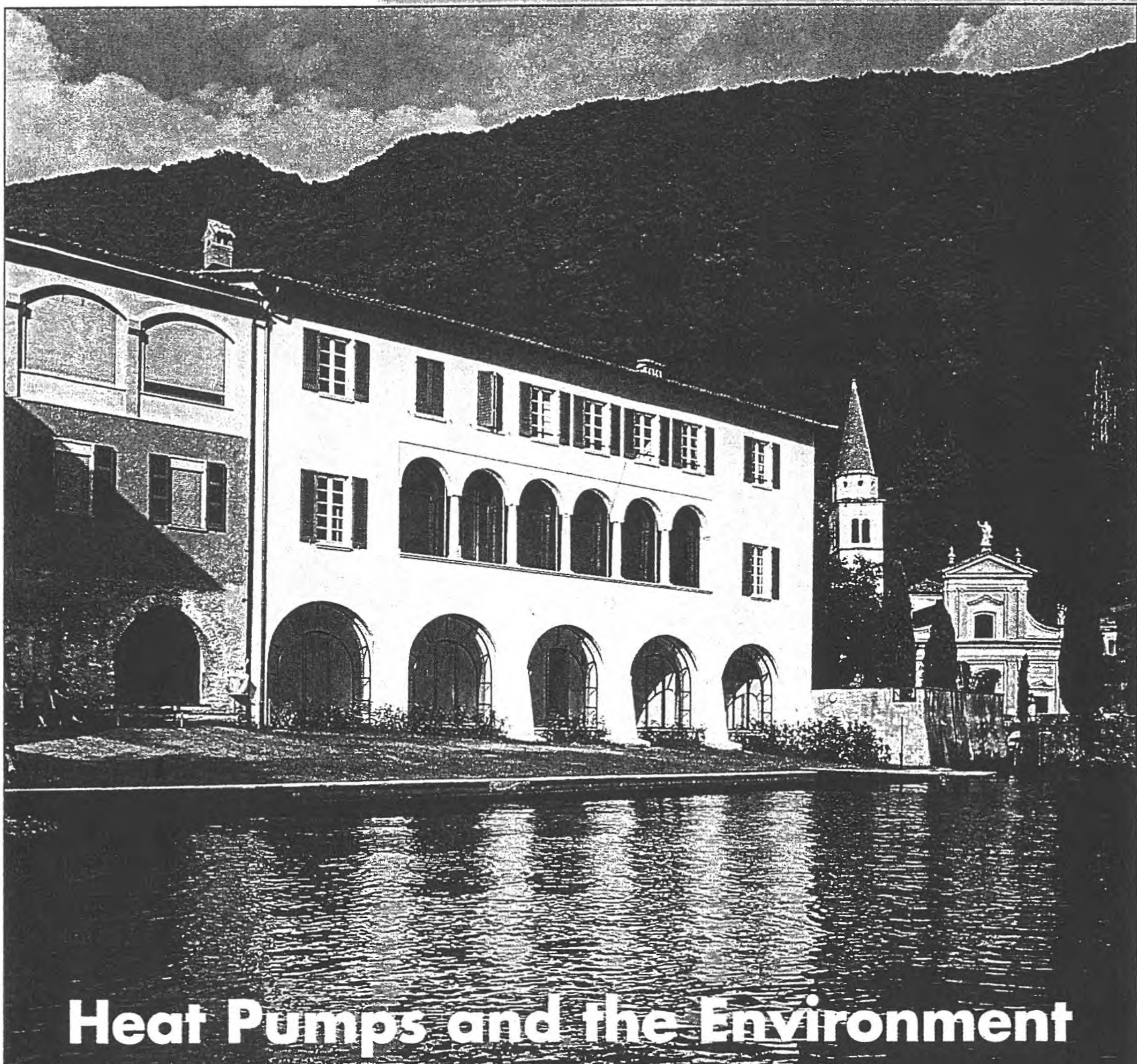

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Non-Topical Article

Regular Features

Front Cover: *Installing a water-to-water electric heat pump in this recently restored 19th century building, at Lugano Lake, Switzerland, benefitted the environment by avoiding an annual emission of 4.8 tonnes CO_2.*

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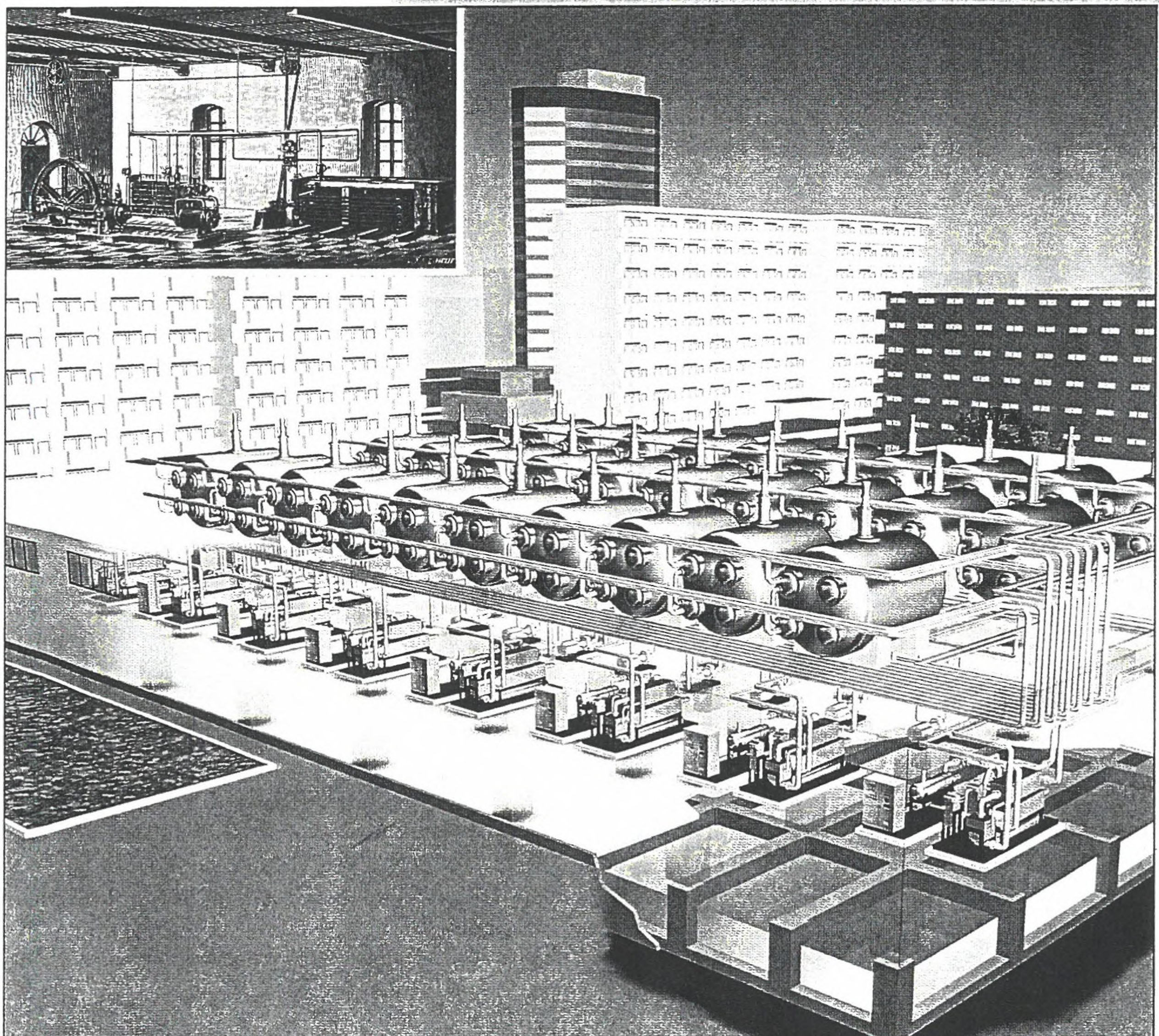
IEA Heat Pump Centre NEWSLETTER



Developments and Trends

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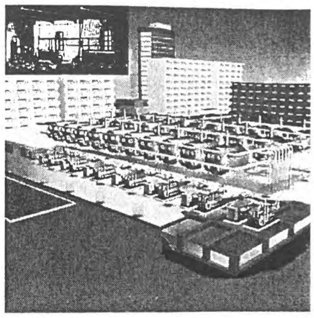

Front Cover: *Separated by 150 years, the concepts of Peter Ritter von Rittinger and the Japanese Super Heat Pump Programme, show how the heat pump continues to set new trends in heating technology. (Sources: ÖZE, Austria and NEDO, Japan.)*

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Session 1 - Plenary Opening

Mike Steadman, IEA Heat Pump Centre

On Monday 26th April, around 275 participants from over 25 countries, gathered at the Maastricht Exhibition and Conference Centre for the 4th (tri-annual) IEA Heat Pump Conference. A wide spectrum of professions were represented, including researchers, manufacturers, energy experts, utility managers and government officials.

Already in the opening speeches of the conference, it became apparent how widely heat pumps are viewed as a promising technology for limiting the environmental impact of energy use.

* * *

In his welcoming speech, **Mr Stan Dessens**, the Director General for Energy at the Dutch Ministry of Economic Affairs took up the theme of the conference - "Heat Pumps for Energy Efficiency and Environmental Progress". He looked forward to a time when heat pumps would enable a 30 - 40% reduction in CO_2 and NO_x emissions generated by space heating systems in Europe as has been suggested in detailed studies. But is this prediction a view of Utopia or reality?

Next Generation

Clearly, the Dutch view the heat pump for buildings as a "next generation" technology and do not expect widespread application until after the turn of the century. Currently, the Dutch are turning to other technologies, such as cogeneration, in their energy conservation programme. They aim to reduce CO_2 emissions by 3-5% of the 1990 values and improve energy efficiency by 2% a year. But the years 2000 to 2020 will see a dramatic increase in heat pump penetration which could contribute over half of the energy savings that need to be achieved to meet European goals for CO_2 reduction. Mr Dessens went on to say that "energy savings could be feasible with a heat pump which exceed the energy savings of cogeneration by a factor of three." He emphasized the need to avoid a blinkered view of heat pump technology and to consider heat pumps as an integrated part of all energy conservation opportunities. He summed up by stressing the importance of international cooperation and hoping that the participants can help turn Utopia into reality.

Richness

Dr. Kenneth Friedman of the IEA, addressed the participants on behalf of the IEA. He stressed the significance of non-OECD nations to energy policy, since energy consumption in these countries is now one half of global consumption and rising. The IEA sees the use of waste energy as a critical goal for saving energy and one that can be facilitated by heat pump technology. More efficient energy use will also stretch resources and ease pressure on energy markets. The IEA feels that in the long term, the richness of applications for heat pumps will make them a targeted next-generation technology for the heating and cooling area.

Keynote Adresses

Keynote speakers from UNEP (The United Nations Environment Programme), Mitsubishi Heavy Industries Ltd and the IEA addressed the conference. Their speeches are summarized in the following pages.

Mr Dessens: "Heat pumps can contribute over half of the total energy savings that need to be achieved"

Keynote Address: Environment

Rajendra Shende, United Nations Environment Programme

Mr Shende began his environmental theme by summarizing the shift in environmental policy in the recent past. He noted that the sixties policy of merely diluting pollutants to a harmless level was followed by pollutant treatment in the seventies and recycling in the eighties. Today, the emphasis is on prevention of the generation of waste and pollutants. At Rio in '92, 'sustainable development' was introduced as a core concept of Agenda 21 meaning: 'meeting the needs of present generation without compromising the ability of the future generation to meet their own needs'. Mr Shende had a message for decision makers and stake-holders in industry:

"The bottom lines in the balance sheets are not burdened due to environmentally sound processes. In fact, ecology strengthens economics to sustain development."

Mr Shende then went on to examine the present state of the environment.

Ozone Depletion

"Ozone levels measured a few months back were 105 Dobson units over the Antarctica as compared to a world average level of 300 Dobson Units. Observations in the last quarter of 1992 showed that the ozone hole now extends for 15 million square km which makes it 15% larger than the area of the hole measured in 1991. Indeed, ozone depletion is now wider, is deeper and takes place in both hemispheres, in the winter as well as in spring and summer. There are no longer quasi biannual oscillators which mean that it now takes place every year and earlier than expected. Incidence of UV-B radiation have been observed in conjunction with the Ozone Depletion.

The yellow signal of the 1980's has now nearly turned red. The situation is getting worse by the hour.

The world responded at Copenhagen last winter by agreeing to further advancing the schedule of ODS [Ozone Depleting Substances -Ed.] phase-out. For the first time in the history of civilization, the substances invented by man will soon be phased out for the protection of the environment. Within 32 weeks from today [December 1993 -Ed.] we will be closing the shutters of Halon producing plants and at the same time 75% of the production of CFCs will cease in the developed world."

Global Warming

"The current rate of net increase of CO_2 in the Earth's atmosphere is 0.5% per year which represents a net increase in carbon of about is 3000 million tonnes per year. Together with CFCs, methane and nitrous oxide emissions, this increase has caused the global mean temperature to rise by 0.3 to 0.6 °C over the past 100 years. The five warmest years in the human history have been in the last decade.

The yellow signal is glaring. Many feel that it has not turned red. But should we wait for that to happen? Uncertainties are intrinsic in any science. But those uncertainties cannot be an excuse for inaction, specifically when the consequences are prohibitively costly."

Challenges and Opportunities

Mr Shende then considered the challenges posed by these concerns and noted the importance of global partnership and the role of the IEA and UNEP. For heat pumps, the environmental challenge has already lead to many new developments for using ozone-benign fluids and reducing the emissions of CO_2. These developments have lead to other benefits such as better efficiencies and improved operational convenience, which more than compensate the

Mr Shende: "Ecology strengthens economics to sustain development"

resources spent. UNEP appreciates the efforts to utilize waste heat as input for heat pumps while recognizing that utilizing waste heat formed due to inefficient heat generating equipment is really an end-of-pipe solution and calls for remedying the root problem.

Clearly there is a need for good environmental management. Mr Shende went on to explain UNEP's role:

"In many cases information about environmentally sound technologies already exists. There is a need to have knowledge sharing networks to disseminate such information. We catalyze such networks. OzonAction Information Clearing House and International Cleaner Production Information Clearing House are such knowledge sharing systems which have various elements like computerized information exchange system, publication of technical documents, newsletters, etc. There is also a need to impart training to use the shared knowledge for societal benefits. UNEP's activities have a training and education thrust. Dissemination of information and providing training will contribute to 'capacity building' which is particularly important in the case of developing countries who intend to follow environmentally sound technologies. UNEP IE/PAC is one of the implementing agencies to assist developing countries in their plans and actions related to the phase-out of Ozone Depleting Substances.

UNEP also facilitates the technical co-operation between developed and developing countries in the area of ozone benign technologies. The Heat Pump Industry through IEA has already started collaborative programmes in the area of environmentally sound options.

Technology transfer now should give way to technology co-operation and technology partnership. Time has come not to hold the cards too close to the chest. We have to forge global partnership. Our OzonAction Programme would provide you with the assistance to facilitate such partnership with developing countries through our information exchange networks. At UNEP, as the Executive Director Ms Elizabeth Dowdswell, puts it, 'we strive for preventive diplomacy to get countries to recognize the need for co-operation in utilizing scarce resources and ensuring that the co-operation does happen'.

If the concept of Agenda 21 is to gain momentum, industry will be required to set out on totally different ways of development. Fortunately, these ways have economic and social spin-offs. Environmental Management should be an essential element of "*sustainable development* and *sustained use of natural resources*".

Mr Shende ended his address by describing an event related to the sustained use of natural resources:

"The great Mahatma Gandhi at the turn of the century was asked if he would like a free India to become like Great Britain. 'Certainly not' he replied, 'if it took Britain half the resources of the globe to be what it is today, how many globes would India need?'"

Speaker:

Mr Rajendra M. Shende
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United Nations Environment Programme (UNEP),
Industry and Environment Programme Activity Centre,
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□

Keynote Address: Future Vision of Heat Pump Technology and Global Environment

Yoshitake Makise, Japan

Mr Makise opened his keynote address by highlighting a number of ongoing technological developments, which are increasing the environmental significance of the heat pump. He mentioned new refrigerants which reduce ozone depletion, rising COPs which reduce fuel use, higher output temperatures which improves the heat pump's applicability, and the development of systems which make more effective use of unused energy.

Heat Pump Use in Japan

Focussing on Japan, Mr Makise illustrated the impact of a rising heat pump penetration on fuel consumption and associated emissions. "Table 1 shows the estimated heat pump use in Japan. The Heat Pump Ratio is a ratio between supply by heat pump and total heat demand. The Heat Pump Ratio was 1.6% in 1985. In year 2000, the Heat Pump Ratio will be 8.8% at present conditions and can be

increased to 16.2% when heat pump usage is accelerated by technological development and government policy. This will reduce energy consumption by about 2%; CO_2 discharge by about 4%; SO_x discharge by about 5% and NO_x discharge by about 3% and can save energy and improve the global environment."

Performance Trends

Taking compressor technology as an example, Mr Makise described how heat pump performance is continuing to improve:

"Hermetic compressors for heat pumps have achieved 30% higher efficiency during the past 20 years. In the year 2000, by the following measures, improvement by 20% can be made and a COP of 4 in ARI [Air Conditioning and Refrigeration Institute, USA -Ed.] conditions may be obtained:

Mr Makise: "The global environment should be preserved to enable sustainable development"

- Improving motor efficiency;
- Decreasing mechanical loss by using new materials and refrigerant oil with lower viscosity;
- Improving mechanical structure."

Alternative Refrigerants

Mr Makise highlighted the aims and achievements of AREP (the Alternative Refrigerants Evaluation Programme) and stressed the importance of striking a balance between ozone depletion, global warming potential and energy efficiency when selecting alternatives to HCFC. He commented on some of the HFC alternatives investigated under AREP as follows:

- HFC-134a: Already available, and good efficiencies will be reached. An immediate alternative.
- HFC-32/125/134a (30/10/60 wt%): A non-azeotrope alternative with good potential efficiency. How to cope with leaks needs consideration. A medium term alternative.
- HFC-32/125 (60/40 wt%): A high pressure azeotrope. Easy to handle but requires an equipment redesign. Miniaturization is possible. A long term alternative.

Table 1: Estimated heat pump use in Japan.

(Unit: %)

Case		Residential		Commercial		Industrial		Heat Pump
		Heating	Hot Water	Heating	Hot Water	Heating	Process Heating	Ratio
(1985)		8	-	13	-	-	-	1.6
2000	Max	64	17	68	9	68	5.0	16.2
	Min	40	7	39	3	39	2.3	8.3

Note: Heat Pump Ratio is the ratio between heat supply by heat pump and total heat demand in Japan

Max: When accelerated by government policy and by technological development
Min: at present conditions

Vision

Drawing the wider picture, Mr Makise then described the Japanese Government's 'Global and Long-Term Vision Extending over the Next Hundred Years'. The Japanese government has announced a revival plan for a greener earth by which the world CO_2 discharge is controlled to or below 6 billions tonne (the 1990 level) over the next hundred years by the promotion of various measures. The measures are categorized according to effectiveness as energy saving, substantial clean energy introduction, revolutionary environmental technology development, CO_2 absorption source extension, second-generation energy technology development. Only energy saving is promising in the next 10 to 20 years which will only serve to reduce the *rate* of increase in CO_2 levels. Consistent with this vision of a greener earth, a number of technological development programmes have been initiated.

Super Heat Pumps

The first one of these programmes discussed by Mr Makise was the 10 year, 10 billion yen budget, Super Heat Pump Energy Accumulation System Programme, which will be concluded this year. For heating/ cooling, two times the existing efficiency has been confirmed in a Lorentz cycle pilot plant using the non-azeotropic refrigerant of HCFC-22/142b and a two-stage economizer system with a screw compressor. Another system developed under the programme realized a heating COP of 8.1, at a heat source temperature of 50°C and an output temperature of 85°C by a Lorentz Cycle with 3-stage condensation and 4-stage turbo-compressor, and by using non-azeotrope HCFC-123/HFC-134a.

Using Unused Energy

Mr Makise then described the Japanese programme 'Technological Development to Utilize Unused Energy' which is being carried out in cooperation with the Ministry of International Trade and Industry (MITI) and private organizations under a 1 billion yen budget for a 7 year period from 1991 to 1997.

The development of a heat pump system using river water is estimated to realize a 34% energy saving compared with a conventional air-source system. Features include plate heat exchangers, a high-density heat transfer system and ice storage.

Another system under development includes an absorption chiller driven by high-temperature steam from a garbage incinerator. A 25% energy saving is estimated compared with a conventional system using a steam driven absorption chiller for cooling and a steam/water exchanger for heating.

Mr Makise expects the programme to "realize an increase in heat utilization efficiency by leaps and bounds and contribute to the reduction of consumption and load-levelling for private-use energy."

Broad Area Energy Utilization

Another Japanese programme of interest is the Broad Area Energy Utilization Network System which looks at industrial waste heat utilization in urban areas:

"Part of the New Sunshine Project, this programme has been planned by MITI at 50 billion yen by year 2000. Technology such as a heat pump utilizing night electric power, waste heat recovery by chemical heat pumps utilizing hydrogen absorbing alloys, and multiple function heat supply by hydrogen absorbing alloys needs to be established."

Summary

To sum up, Mr Makise listed the following points:

- "Heat pumps are one of the key technologies to achieve sustainable development and to solve problems concerning energy and environment simultaneously.
- Refrigerants for heat pumps can be replaced by alternative refrigerants such as HFC which have an ozone depletion potential of zero.
- Heat pump efficiency can be made two times the current efficiency by developing technology such as Lorentz cycle using non-azeotrope refrigerants.
- Owing to the development of high-density heat transfer technology, triple-effect absorption heat pumps and high-efficiency 'turbo' type heat pumps, a total system making effective use of unused energy can be developed to realize energy savings.
- In order to develop efficient utilization of energy in the future by establishing new infrastructure such as eco-energy urban systems, the use of high-efficiency type electric heat pumps should be promoted along with the development of chemical heat pumps utilizing hydrogen absorbing alloys.
- It is the duty of advanced nations to rapidly transfer to developing nations various environmental protection technology, thus promoting ozone layer protection and global warming prevention."

Speaker:

Mr Yoshitake Makise
President of the Heat Pump Technology Center of Japan and Executive Vice President of Mitsubishi Heavy Industries, Ltd., Japan. Tel.: +81-3-3212-3111; Fax: +81-3-3212-9855.

☐

Keynote Address: Meeting Energy Demand by Energy-efficient Technologies - a Market Approach

Helga Steeg, International Energy Agency

Speaking on the final day of the Conference, Mrs Steeg began by discussing developments and challenges in the energy sector as they are expressed in the IEA's latest report 'World Energy Outlook to 2010'. This shows that the world's energy supply will remain essentially carbon based, with a projected share of fossil fuels of 90 per cent in 2010:

"Energy use in the OECD countries will rise, but it will rise even faster outside the OECD. By 2010 we foresee that the OECD will account for less than half of the world's energy consumption. How can we achieve sustainable economic growth throughout the world, maintain a secure energy supply and - at the same time - improve environmental protection?"

While all these questions present many political challenges, the IEA has a clear role in addressing the latter two questions. According to Mrs Steeg, 32% improvement in energy intensity of final consumption achieved by IEA member countries since 1973 can most probably not be repeated unless there are considerable and drastic energy price increases or more stringent regulations.

Heat Pumps

Mrs Steeg had some important remarks on heat pumps:

"It is quite clear to me that advanced heat pumps do belong to those technologies which can exploit the energy savings potential. To me it seems that they have, of course, a potential for the residential building sector, but that their development and application for commercial and public buildings seems more important, since space heating and air-conditioning systems are a major user of electricity in commercial buildings. Also, industrial heat pumps seem to offer the most immediate commercial applications. With some research and development such as in the field of super heat pump systems, high-temperature and high-performance heat pumps with natural gas-driven compression or directly-fired absorption and with chemical heat storage - just to mention some items - heat pumps would appear to be one of the key next-generation technologies for the heating and cooling area.

With the use of substitutes to the CFCs and environmentally benign refrigerants, heat pumps should above all reduce the environmental consequences of energy production per unit of end-use service provided in a way that need not interfere with or alter the desired performance characteristics of such service."

Mrs Steeg also noted the benefits of heat pumps as highlighted in the IEA HPC's analysis 'The Impact of Heat Pumps on the Greenhouse Effect.'

Mrs Steeg: "Energy prices should reflect real costs and thus enable markets to work"

Realistic

"Despite these positive factors one has to be realistic. A widespread lack of knowledge about this technology as well as high investment and maintenance costs are still a major obstacle to their application. Institutional and market constraints have still to be overcome.

The IEA has always attached great importance to a free market approach within all energy sectors. Making markets work, unleashing competitive forces, encouraging trade for goods and technologies, removing fuel subsidies, getting prices right and improving the transparency of costs - in my view - would also contribute to exploiting the potential for energy-efficient technologies.

I am well aware that reliance on market forces alone, however, is unlikely to achieve the necessary level of efficiency improvement implicit in most environment-oriented energy policies. Innovative and bold approaches to energy efficiency programmes are needed. These have, however, to be based on careful analyses. Therefore - before embarking on intensive programmes of this kind - governments should be aware of the costs of new technologies and the actual energy efficiency potential they offer. Such market information is an essential prerequisite to evaluating the effectiveness of efficiency programmes and to developing policies to accelerate energy efficiency improvement in the economy."

Taxes

Referring to proposals currently under discussion by policy makers in the EC and USA, Mrs Steeg had this to say on taxes:

"What is clear is that those taxes will not be sufficient to stabilize CO_2 emissions by 2000. There is a need for additional regulation, and at the end of the day we need comparability of the different measures which are taken by OECD countries according to the different conditions and circumstances.

I am convinced that while raising fuel prices might in the short term lead to a slight decrease of energy consumption, it will not necessarily mean that new technologies such as heat pumps will penetrate the market easily. This will only be achieved if such technologies are well adjusted to market needs - which might need more research, development and demonstration - and if information on them is more widely disseminated."

Research and Development

"Energy technology implementation on a scale sufficient to make a significant contribution is often time-consuming and may involve substantial investments. Therefore it has to be supported by governments. Private industry can only be expected to invest in technology projects that offer prospects for satisfactory capital return or business expansion.

Energy technology progress has become increasingly international, both in R&D and in application. Basic science was always a matter for the international research community, but today there is international co-operation for technological innovation more broadly. Also the national approach might not be sufficient for gaining or maintaining competitiveness on a global market. This globalization calls for international co-operation beyond the borders of single countries.

The best form to take account of these facts is to embark on collaborative R&D where costs are shared, expertise is pooled and benefits are widely dispersed throughout the marketplace. I would like to recall that the IEA is sponsoring some forty international collaborative agreements - the so-called Implementing Agreements - since R&D on advanced heat pumps is one of them, and I must add one of the most successful with regard to the aspects I have just mentioned."

Mrs Steeg stressed the importance of attracting non-member countries of the IEA to participate in Implementing Agreements such as the IEA Heat Pump Programme. She also mentioned the newest feature of the IEA technology programme - GREENTIE (the Greenhouse Gas Technology Information Exchange). Operating from the same location as the IEA Heat Pump Centre, this centre will help to give all countries of the world access to the institutions and agencies where information is available on technologies already applied and developed.

Closed Shop

"And - to come back to the free market approach - I would like to add: if there is any area where a closed shop must be avoided, it is in the field of energy technology co-operation. Competition is the healthiest and most efficient way to enhance technological innovation, but such innovations must be free to penetrate markets when they become available. We should also not be afraid to speak of broader technological co-operation which transcends the industrialized West and offers real prospects for developing countries and economies in transition to participate in and share the benefits of innovation."

Essential Elements

Mrs Steeg finished her speech by summarizing the most essential elements of a market-oriented energy efficiency strategy:

- "Given the perspective of worldwide increasing energy consumption during the next 20 years, improved energy efficiency and environmental protection are major challenges in the energy sector;
- Advanced energy-efficient technologies can promote both environmental protection and energy security in a cost-effective manner;
- Continued research, development and market deployment of new and improved energy technologies make a critical contribution to achieving energy efficiency objectives;
- Energy prices should reflect real costs and thus enable markets to work;
- A mix of measures and instruments should be applied to facilitate the exploitation of the potential new technologies have for improving energy efficiency."

Speaker:

Mrs Helga Steeg, International Energy Agency, 2 rue André-Pascal, 75775 Paris, Cédex 16, France.

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Session 2 - Environmental Overview

Mike Steadman, IEA Heat Pump Centre

Global warming and ozone depletion. Describing, arguably, the most significant environmental threats perceived today, these two terms affect the development of heat pump technology. In this session, which was chaired by Mr Zegers of the Commission of European Communities, delegates heard papers on both issues. The papers relating to ozone depletion limited themselves to the current status and requirements of the CFC phase-out measures. The consequences for heat pumps and their working fluids were considered in more detail in Session 3. On global warming, various methods for assessing the impact of heat pumps were presented along with results indicating the significant potential of heat pumps.

* * *

As with any energy consuming system, no discussion on heat pump technology is complete without an examination of its environmental consequences. But for heat pumps, environmental issues play a particularly important role in their development. While the global warming issue has become a major driving force for increasing heat pump use, the ozone depletion potential of the most well-used refrigerants is holding them back. But the introduction of new measures to the Montreal Protocol means that the elimination of ozone depleting substances from heat pump systems is no longer a matter of academic discussion, but a matter of legislation.

Phase Out

Mr Reed of Environment Canada, outlined the changes to controls on CFCs and HCFCs agreed at the 4th Meeting of the Parties in Copenhagen in November 1992. For heat pumps, the most significant agreement was to freeze HCFC consumption from 1996 and to reduce consumption in steps leading to virtual elimination in 2020 (see Figure). Also significant is that the phase-out date for CFCs has been brought forward four years to 1996. Notably, Mr Reed suggested that the phase-out dates for HCFCs are likely to be brought forward in the next meeting of the Parties in 1995.

The Parties also agreed to encourage recycling by exempting trade and consumption in recycling ozone depleting substances (ODS) from the phase-out agreements. Also all practical measures must be taken to prevent the release of ODS into the atmosphere by recycling or destroying recovered ODS and minimizing refrigerant leakage.

What are the consequences of these new decisions? Perhaps surprisingly, **Mr Bivens** of Du Pont de Nemours, sees an increasing role for HCFCs in the near term. Taking chillers as an example, the estimated 90,000 units using CFC-11 globally, cannot be replaced in the near-term with new units using alternative refrigerants, when the estimated world production capacity for chillers is only 4500 units per year. Using recycled CFCs, or retrofitting with HCFCs, are the only reasonable options if the accelerated phase-out dates for CFC production are to be met.

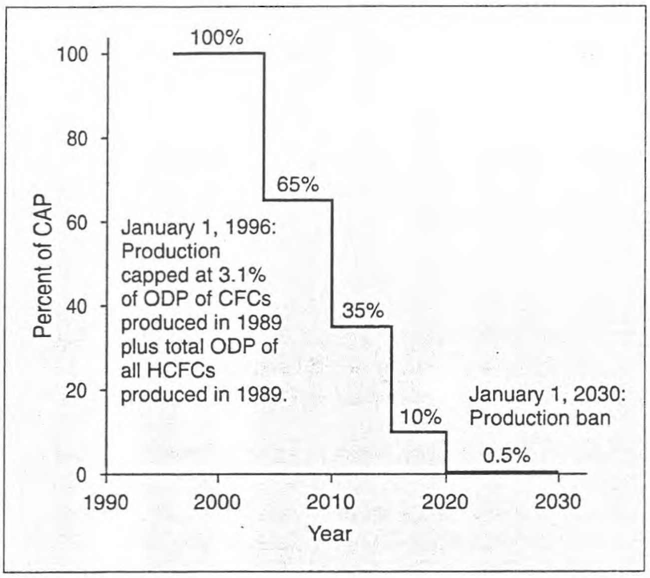
For the longer term, alternative refrigerants must be found. When deciding on alternatives, a balance must be struck between safety, environment, performance and economic issues. Both the direct (emission) and indirect (efficiency) impact of the refrigerant on global warming must be considered. Also, the atmospheric lifetime of the emitted refrigerant must be properly taken into account: the choice of the time period used (known as the Integrated Time Horizon) when assessing the Global Warming Potential of refrigerants is currently in dispute.

Fuel Cycle

With the new drive towards finding technologies for reducing global warming, it's vital that the potential of the heat pump is properly examined. **Prof. Laue** of the German Information Centre for Heat Pumps and Cooling Technology (IZW) used the concept of "Fuel Cycle Analysis" to compare heat pumps with conventional heaters. This takes account of all energy demands including those at the `front-end" such as fuel exploitation, processing and transport. These appear to add around 10% to the CO_2 emissions of boilers and heat pumps using fossil fuels. They are less significant for electric heat pumps.

Quality of Energy

Mr Kleinbloesem of the Netherlands utilities organization Sep, looked at the more wider energy system and posed the question "How should energy supply be optimized?" Urging delegates to bring essential knowledge on energy transformations to the attention of policy makers, Mr Kleinbloesem introduced the concept of exergy or "Quality of



Steps in the phaseout of HCFC refrigerants agreed upon under the Montreal Protocol (Source: EPRI Heat Pump News Exchange).

Energy". He used it to illustrate the benefits of providing low-temperature heat by the combination of a CHP (combined heat and power) system and electric heat pumps. When applied to a whole country, the concept shows that, in contrast to popular belief, an increase in electricity consumption will lead to reduced energy consumption when the waste heat from power generation is utilized, and electric heat pumps are integrated into the system.

Potential

So what is the heat pump's potential? **Mr Bouma** of the HPC summarized the findings of the HPC's Analysis Report and Workshop on "The Impact of Heat Pumps on the Greenhouse Effect." While the analysis showed a clear benefit for electric heat pumps in some countries, in others, some performance improvement in both the heat pump and power generation efficiency is needed before they can better the CO_2 emissions of the best conventional gas boilers. Also, the value of heat pumps as devices for reducing global warming will be further enhanced when they are integrated into an energy system and when they are fully utilized for heating, cooling, heat recovery and thermal storage. **Mr Okken et al.** of the Netherlands Energy Research Foundation (ECN) submitted a very thought provoking poster paper which showed results from a study made within the framework of the IEA Energy Technology Systems Analysis Programme (ETSAP). This looked at all options for reducing CO_2 emissions and showed that by 2030, heat pumps would supply more than half the heating needs for large office buildings. In the residential sector, heat pumps could supply up to 80% of the heat demand in a scenario where CO_2 emissions are reduced by 50% or more.

Convincing the Market

Once the environmental benefits of heat pumps have been established, a way must be found to convince the market to buy them. And since heat pumps are generally more expensive than the conventional technology, governments must be convinced of the value of incentive or tax systems. **Mr Jones** of the OECD Environment Directorate outlined various methods whereby environmental benefits can be given economic value. Techniques for estimating the cost of environmental damage are becoming more sophisticated and their use is increasing, especially in Germany and the USA. Mr Jones urged proponents of heat pump technology to demonstrate how much heat pumps might contribute to reducing these damage cost estimates.

Global Awareness

Poster papers by **Mr Amundsen et al.** of the Norwegian Water Resources and Energy Administration and SINTEF Refrigeration Engineering and by **Mr Srivastava et al.** of the MARA Institute of Technology in Malaysia illustrated the awareness in many different countries of heat pumps as a technology for tackling environmental problems. The Norwegian paper presented results from that country's Heat Pump Prototype and Demonstration Programme which has so-far covered around 50 projects. Future projects will focus on heat pumps using natural refrigerants. In Malaysia, heat pumps are seen as an important technology for reducing CO_2 emissions. While space heating applications are non-existent, heat pumps are being considered for combined air conditioning and hot water production. Heat pumps can also be applied in the timber, fishing, dairy and palm oil industries.

Progress for the Environment?

The environmental benefits of heat pumps are complex and vary enormously according to location, technology and application. Indeed heat pumps are not environmentally beneficial in every situation. But unlike most technologies, the environmental benefits of heat pumps will surely rise over the coming years, as heat pump efficiencies rise, as power plants become more efficient and clean, and as working fluids are better managed and are replaced by less damaging alternatives. But heat pumps also have a major role to play today, in the many applications and areas where they can significantly reduce the greenhouse effect. The analysis methods presented in this session should be used to convince a wider public of these benefits.

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Session 3 - New Refrigerant Technology Status

Bert Stuij, IEA Heat Pump Centre

The environmental benefit and safe operability of a heat pump system depends to a large extent on its life-blood: the working fluid. In the not-so-distant past, toxicity and flammability concerns lead to the massive introduction of 'safety refrigerants', as the CFCs were then called. We now know that these working fluids damage the ozone layer and aggravate the greenhouse effect. Vigorous efforts are currently ongoing to analyze, develop and stimulate the use of those working fluids that have negligible environmental drawbacks. The papers of Session 3, which was chaired by Prof. Watanabe of Keio University and Dr. Kuijpers of UNEP, addressed the potential and properties of the most promising options. These include HFCs and 'natural' fluids such as ammonia, CO_2 and air and hydrocarbons such as propane.

* * *

Working fluids have to meet a variety of possibly conflicting demands. The ideal fluid first of all allows a maximum efficiency of the employed heat pump system. This minimizes the energy consumption of the system, with the obviously associated economic and ecological benefits. Secondly, release of the ideal fluid poses no risk to either the direct or the global environment. This means that the ideal fluid is a non-toxic and non-flammable medium, with zero ozone depletion and zero global warming potential.

New Generation

Faced with these challenging demands HFCs have been identified as promising alternatives.
Mr. Fujiwara of Daikin Industries started the session with a comprehensive overview of these fluids. Most of the essential areas were covered, including thermophysical properties, toxicity, environmental impact, and material and lubricant compatibility. In view of the fact that pure HFCs rarely satisfy all demands, Mr. Fujiwara highlighted the significance of mixtures, where the defects of one component can be compensated by another.

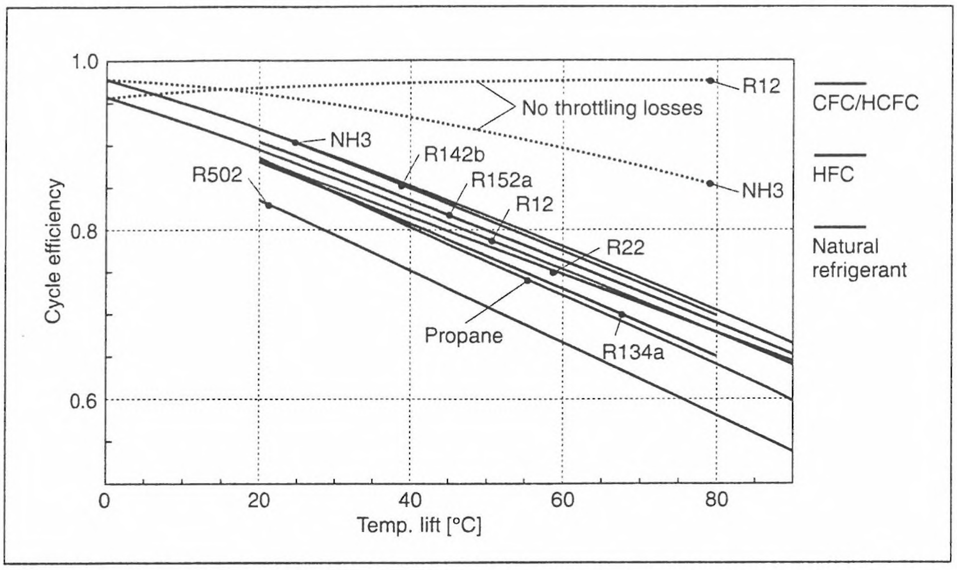
Prof. Kruse of Hannover University, Germany, discussed the perspectives for chlorine-free working fluids from a European viewpoint. In his discussion of the HFCs, he noted that for heating-only heat pumps only two pure HFCs appear to have immediate significance: HFC-134a and the propane derivative HFC-227. He supported Mr. Fujiwara's view on the advantages of mixtures, but argued that the possibilities for using HFCs in heat pumps remain limited. In Europe, hydrocarbons and other natural refrigerants such as ammonia, CO_2, and air are considered to be more promising. Prof. Kruse noted that the German Environmental Agency, UBA, has made an environmental ranking of working fluids, and found that hydrocarbons and other natural refrigerants rank better than HFCs. He urged a re-think on the flammability issue, which is currently a barrier to the use of hydrocarbons.

Conversion

A major concern is to find a replacement for the massively employed HCFC-22. Some 37 companies from North America, Europe and Japan joined forces in the Alternative Refrigerants Evaluation Program (AREP), a programme which was initiated by the Air Conditioning and Refrigeration Institute (ARI) in 1991. **Mr. Menzer** of the ARI presented an outline of the activities undertaken under this programme. He gave an overview of the first results obtained and discussed the currently perceived advantages/disadvantages of all identified potential alternatives. The results from the programme will be made public, and entered in the ARTI Refrigerant Database.

The retrofitting of existing installations with new refrigerants was discussed by **Mr Kaneshima** from the Shimizu Corporation, Tokyo. With a questionnaire to five leading manufacturers of chillers in Japan, the current use of CFCs was charted and used to develop retrofitting strategies. The current emphasis is on the replacement of CFC-11 with HCFC-123, but the longer-term perspective is replacement with non-HCFCs. Mr Kaneshima noted that the improvement of environmental performance of a heat pump system needs more than just the replacement of its working fluid. Minimum environmental impact also requires, for instance, excellent design of the heat pump for optimum efficiency, and proper design of the building energy system so that the heat pump meets cooling and heating demands with minimum energy consumption.

Prof. Granryd of the Swedish Royal Institute of Technology continued the theme of practical experiences with alternative refrigerants, focusing on the replacement of CFC-12. He showed a



Cycle efficiency for different refrigerants with basic cycles with no sub-cooling of liquid or super-heating of vapour. The condensing temperature is 40°C.

(Note: throttling loss, which is the main reason for cycle inefficiencies with organic refrigerants, can be reduced using sub-cooling or, theoretically, by using an expansion motor which assists in driving the compressor.)

comprehensive comparison of the thermodynamic characteristics of CFC-12 with those of the alternatives (see Figure). He then discussed Swedish experiences with alternatives such as HFC-134a and HFC-152a, in a variety of applications, ranging from car air conditioning to district heating and industrial heat pumps. Prof. Granryd expected a rapid rise in HFC-134a conversions as experiences from successful conversions penetrate. Finally, he emphasized the importance of the 'next step': away from the HFCs to natural refrigerants such as ammonia or propane.

Collaboration

Illustrating the benefits of international collaboration through the IEA network, **Dr. Vamling** of Chalmers University in Sweden presented highlights from Annex 13 and 18 of the IEA Heat Pump Programme. Both Annexes address the need for good data and models of basic thermodynamic and transport properties of pure compounds and mixtures of new, more environmentally friendly refrigerants. Annex 13, which closed in 1992, dealt with the state and transport properties of high-temperature working fluids. Dr. Vamling noted that Annex 13 has highlighted the need for measured property data, since prediction methods are not yet well developed enough to allow accurate heat pump performance calculations. Annex 18, which started in 1990, addresses the thermophysical properties of the environmentally acceptable refrigerants. Its final goal is the publication of a comprehensive, internationally accepted properties bulletin. Given their importance, initial efforts are concentrating on HFC-134a and HCFC-123 (see the news section, page 13, of this Newsletter, for an update on Annex 18).

A number of related topics were addressed in the **poster sessions**, such as the heat transfer of zeotropic refrigerant mixtures, practical experiences with HFC-134a, and recent results of thermodynamic research on CFC and HCFC alternatives. A US paper dealt with the modification of compressors to maintain heat pump efficiency and capacity with alternate refrigerants. A Norwegian poster illustrated a 20 kW prototype heat pump with ammonia as refrigerant.

Continued Efforts

Session 3 highlighted the aggressive worldwide drive to replace CFCs and HCFCs by refrigerants with negligible environmental impact. The pace is forced by international agreements such as the Montreal Protocol, by national legislation, and by public opinion. Furthermore, international collaboration is yielding significant results.

HFCs were presented as important medium-term alternatives, but especially in Europe, there is a growing interest in natural refrigerants including hydrocarbons. Significant hurdles remain to be overcome, such as flammability and toxicity concerns, and novel technologies may be required to use some of these refrigerants. In all cases the efficiency of the heat pump system should remain a prime concern.

There is no doubt that the continued replacement of CFCs and HCFCs will improve the standing and quality of the heat pump as an environmentally benign device. That in itself will be a stimulus for more widespread implementation.

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Session 4 - Technology Advances

Jos Bouma, IEA Heat Pump Centre

The 25 papers presented at this session reflected the enormous amount of work being carried out in the field of heat pump R&D. Chairman Mr Sellberg of the Swedish Council for Building Research and co-chairman Mr Sakamoto of Toshiba Corporation, Japan heard the six oral presentations. Broadly speaking, the papers focused on two aspects: improving the performance of heat pumps for existing applications, and widening the applicability of heat pumps to areas where their use is limited, or non-existent at present. Air-to-air heat pumps fall in to the first category - they are becoming more efficient and now offer hot water heating as well. The second category applies to heating-only heat pumps for use with hydronic type distribution systems. For industrial heat pumps, the diversity of applications offers a wide scope for fundamental heat pump R&D. Common to all industrial applications however is the concept of Process Integration which must be applied if heat pumps are going to be used in an optimal manner.

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Those involved in promoting heat pumps face the dilemma of presenting heat pumps as on the one hand a mature, reliable, commercially viable technology, and on the other a technology with a huge potential for improvement in efficiency and environmental benefit. **Mr Göricke** of the major German electric utility (RWE), clearly feels that emphasis should be given to the first point. In his paper 'Heat Pumps for Widespread Use are Available Today!', he stated that technical improvements should not be emphasized in promotional campaigns since they will be implemented anyhow.

Heating-only

Mr Göricke's paper focused on heating-only heat pumps for low-temperature water-based heat distribution systems in Germany and similar regions. In these regions, there is no cooling demand in homes and reversible heat pumps would unnecessarily increase energy consumption when they are used for cooling. Instead, the heating-only heat pump should be marketed and promoted as a mature technology, commercially available today. To overcome the economic impediment of heating-only heat pumps, the first step must be to stress their energy and environmental benefits (CO_2 emission reduction) in advising the public and policy makers.

Mr Göricke reported on ongoing tests at RWE on heating-only heat pumps using propane as the working fluid. As well as being highly attractive from a global warming and ozone depletion point of view, the tests show that propane can enable higher condensation temperatures.

At present there are approximately 45,000 bivalent air-source heat pumps in operation in Germany. The majority of them supply the heat to a 'high' temperature (70/90°C) hydronic heat distribution system. These heat pumps may be disconnected from the electricity grid during winter peaks. In new homes, mainly monovalent heat pumps will be applied since a second (back-up) system is not accepted anymore for cost reasons. In addition to a considerable reduced heat demand, these new homes are equipped with low-temperature heat distribution systems (air and floor heating). Floor heating in new homes is considered by RWE to be the most promising heat distribution system in Germany, air systems being too expensive and not needed for cooling. Floor and other types of low-temperature heating systems were also examined in a poster paper by **Mr Kilkis**. The most suitable heat source gaining growing interest is the ground (groundwater can cause operational problems).

Exhaust air

Heat recovery from buildings with exhaust-air heat pumps has proved to be highly effective and energy efficient, according to **Mr Fehrm** of Elektro Standard, Sweden. In Sweden, these heat pumps have gained a 50% market share of new single-family homes. Most supply hot water for heating and domestic purposes. In some applications they heat the building structure for technical and comfort reasons. Back-up is usually provided by resistance heating, but for regions in Sweden with natural gas an integrated exhaust-air heat pump and gas boiler has been developed. By recovering heat from the boiler exhaust, high COPs (>4) are achieved leading to an overall energy efficiency of more than 130%. Another advantage is that there is no need for a conventional chimney. Exhaust-air heat pumps are also used for multi-family homes and communities in Sweden. In one case, a 4 MW system supplies 2500 flats, a school, a daycare home and small commercial buildings.

Water Heating

The theme of reducing water heating costs in homes and buildings was taken up by **Mr Reedy** of Nordyne, USA. With heating and cooling demand in new houses reduced by improved design and construction, water heating now accounts for a considerable share of a home's utility bill. Heat pumps can take advantage of this energy saving opportunity by integrating the functions of space conditioning and water heating into a single system.

Several approaches to achieving this have been tried in the USA. The Carrier/EPRI Hydrotech 2000 was the first commercialized fully integrated system to demonstrate technical feasibility. A less sophisticated but cheaper system, known as Powermiser, has recently been introduced by Nordyne/EPRI. Both these systems heat water coincident with both space heating and cooling, and in addition will provide water heating on demand without the need for space conditioning.

Control

Mr Sakamoto of Toshiba, Japan, outlined recent developments in the control technology of electric heat pumps for residential space conditioning equipment in Japan. The impact of capacity control technology on energy savings and comfort improvement contributed to the fast market growth in the 80s. High-speed inexpensive microprocessors, now employing fuzzy logic, have further improved the performance of speed-controlled reversible heat pumps. Today, all control functions such as part-load control, evaporator control, and start/stop control are carried out by a microprocessor. This has improved COP, especially at part-load conditions. A new challenge is to overcome stability problems associated with the use of some new refrigerants. Control strategies must be found to optimize the tradeoff between reliability and efficiency.

Industry

Mr Berntsson of Chalmers University of Technology, Sweden, showed that by using Process Integration, the potential for industrial heat pumps is clearly higher than has been assessed in previous studies. He showed how Pinch Technology can be used to find the proper placement for various types of heat pumps in industrial processes. Tools such as the Composite Curve and the Grand Composite Curve can be used to find the appropriate design in terms of type, size and source/sink temperatures. Methods for optimizing the main parameters in both a new design and a retrofit situation were explained.

High Temperature

Mr Linton of NRC, Canada, gave an overview of high-temperature (>80°C) heat pump technology development from a global perspective. Industrial applications of closed-cycle vapour compression systems using HCFC-142b were reported. Systems reaching condensing temperatures of 90°C have been tested. Another heat pump in Sweden uses HFC-134a and delivers 80°C heat. This temperature level is probably the highest achievable with this working fluid. Mr Linton also discussed R&D work in relation to new working fluids or mixtures capable of raising output temperatures to the 150°C range. For vapour compression heat pumps the following high-temperature working fluids are proposed: HCFC-123,

Compresssion-absorption heat pump installations.

Installation	Type of heat source	Heat source temperature	Heat sink temperature	Heat capacity (kW)	Comp. & pump power (kW)	COP
TCH No. 1	sodium carbonate	t_{in} = 95°C phase change	115°C 1.7 bar steam	1000	110	9.1
TCH No. 2	water	t_{in} = 85°C t_{out} = 80°C	138°C 3.3 bar steam	1000	275	3.6
TCH No. 3	water	t_{in} = 52°C t_{out} = 30°C	t_{in} = 60°C t_{out} = 95°C water	280	63	4.4
Bergmann	water	t_{in} = 25°C t_{out} = 5°C	t_{in} = 15°C t_{out} = 85°C water	1000	230	4.3

ethyl chloride, E-134, HCFC-124, HFC-152, HFC-143, HF-245ca and mixtures.

R&D in absorption (type I/II) heat pumps focuses on improving cycle efficiency and economic factors by developing new multi-stage cycles and using new working pairs. High temperature heat transformers show greater potential. In Japan, the New Energy and Industrial Technology Development Organization (NEDO) have bench tested a H_2O-LiBr heat transformer with a 170°C - 200°C output temperature.

The Table summarizes several compression-absorption installations, all of which use an NH_3/H_2O working pair. These systems can achieve better performance than vapour compression cycles, particularly at high temperature lifts and output temperatures. Higher temperatures and performance increases are aimed at by developing new working pairs.

Posters

While 150°C is generally considered to be an upper limit for today's heat pumps, **Mr Le Goff** of France proposed, in his poster paper, an absorption heat pump operating between 223°C and 450°C for use in an electric power plant. The separator is inserted between the combustion chamber at 1100°C and the steam evaporator super-heater at 450°C. The system uses a calogen based working pair and increases the efficiency by 22%.

Many other poster papers were presented, covering a wide range of heat pump technologies. Their titles are listed on page 38.

An Advancing Technology

While it is important to stress that heat pump technology is readily available for use in many applications, the fact that so much R&D work is underway, leads the way to increased application of heat pumps in the future. And with efficiency levels continuing to climb, heat pumps will compete more strongly with other measures for reducing energy consumption and reducing environmental damage.

With so much work in progress, it is important that engineers and researchers are well informed of R&D progress in their area of interest. The IEA Heat Pump Centre is playing a lead role in this matter by maintaining and improving communication through its network of National Teams and links with international organizations. In this way, it is hoped that progress in R&D will lead rapidly to an increased use of heat pump technology.

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Session 5 - Markets Electric Driven Heat Pumps

Mike Steadman, IEA Heat Pump Centre

With so many new developments reported, and much discussion on the potential environmental benefits of heat pumps, the casual observer may, by this stage in the conference, have been given the impression that a heat pump is a futuristic device whose relevance to the real world has yet to come. But in Japan and the USA, heat pumps are every-day objects of significant economic importance. This session, which was chaired by Mr Groff, chairman of the Advisory Board to the IEA Heat Pump Programme, and Mr Lucas of the International Institute of Refrigeration, included reports on the current market trends for electric driven heat pumps in various regions. Papers were also included on the wider issue of heat pumps in relation to the total energy market and on some application examples, where new technology has been applied to adapt heat pumps to meet specific market needs.

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European Market

With Japan and the USA leading the world in heat pump sales, Southern Europe, with its warm climate and advanced economies, has long been seen as having a high potential for heat pump sales. **Mr Wright** of Carrier Ltd. (UK) presented some new figures on the market situation in France, Italy and Spain. Taking air conditioning as a whole, a survey by BSRIA (Building Services Research and Information

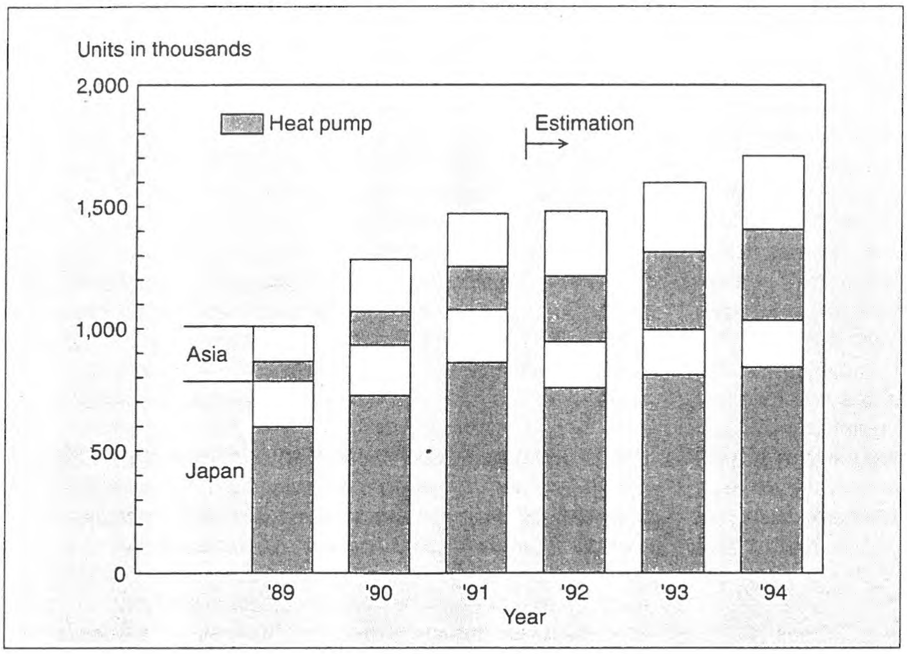

Figure: Unitary air conditioner market in Asia and Japan.

Association (UK)) shows that these countries still have the largest market potentials in Europe, although the current recession and an over-supply in office space have severely restricted growth. For heat pumps, however, an average increase in sales of 25 - 30% is predicted in the next three years. In answer to a question from Mr Groff, Mr Wright stated that manufacturers would welcome minimum efficiency ratings for heat pumps in Europe, and that this was a prerequisite for improving COPs in a market driven more by cooling demand than by environmental concern.

In Central and Eastern Europe, heat pump sales are showing signs of a revival after several years in sharp decline. In this region, where air conditioning is of little interest, nearly all heat pumps are used to supply hydronic heating systems. **Mr Zaugg** reported that heat pump sales in Germany are still well below their peak of 1980. However, a slight revival appears to be underway, supported by 20-30% incentive schemes in some German states. In contrast to Germany, the Swiss government ranks heat pumps highly in its energy policy. In 1991, one in four new homes built in Switzerland installed a heat pump. Heat pumps also feature strongly in Austrian energy policies. Here, in contrast to Germany and Switzerland, direct-expansion ground-source heat pumps are the most common. In Poland, 200-300 heat pump systems are installed annually.

N. American Market

The air-source single-speed electric heat pump, supplemented by resistance heating remains the mainstay of the US heat pump industry according to **Mr Lannus** of EPRI, USA. This is due to the significance of the warm Southern states on heat pump sales. The efficiency of these systems has improved significantly since the late 1970s as manufacturers have strived to meet and surpass government efficiency standards. The more advanced variable-speed air-source heat pumps have still not gained widespread market acceptance, despite their high performance. And ground and water-source heat pumps represent a much smaller market than air source types. In Canada, ground-source heat pumps are equally significant to air-to-air systems with about 7,400 thought to have been installed in 1992, many of them direct-expansion systems.

Mr Lannus noted that while US heat pump shipments total about 1 million units per year, their market share has given way to the gas furnace over the last half decade. This is due, in his view, to the misguided policies of some regulatory authorities. The phase-out of HCFC-22 also appears to work against the heat pump, although the search for alternatives may act as a boost for heat pumps by leading to improved efficiencies.

Asian Market

Mr Ikomoto of Mitsubishi Heavy Industries reviewed the Asian market for room and unitary air conditioners, and chillers. Despite the current downturn in the market, the significance of Japan's room air conditioner market is remarkable, representing 44% of world demand in 1991. In 1992, 3.9 million mini-split type heat pumps were installed. 60% of these were inverter driven. In the rest of Asia, less room conditioners are installed than in Japan, although demand is rising rapidly. Nowhere more than in China, where demand rose from 800,000 in

1991, to 1.8 million units in 1992, providing a significant export market for Japanese manufacturers. Thirty per cent of these were heat pumps.

Sales of unitary air conditioners have also suffered a downturn in Japan, but as shown in the Figure, this has been compensated by increased sales in other parts of Asia. In 1992, 20% of unitary heat pumps sold in Japan were inverter type. Multi-zone systems, where one outside unit serves 2 to 8 inside units, are on the increase (16% of all unitary air conditioners in 1991) including heat recovery types which can cool one room and heat another.

Sales of reciprocating and screw chillers with capacities in the 30 to 90 kW range, are expected to remain steady at around 17,000 a year throughout Asia in the coming years. About 30% are of the heat pump type, providing heating, hot water and also snow melting on roads. Annual sales of the larger centrifugal chillers have halved since the late eighties to around 300 units. Around 30 of these are heat pumps. Absorption chillers are far more significant.

Energy Market

Mr van Wunnik of KEMA, the Netherlands, looked at how heat pumps could fit in to the total energy market in his country. Using the concept of energy quality, he demonstrated that a system based on combined-cycle power generation and district heating gave the highest exergetic efficiency for heat supply. However, in practice, a second energy supply chain is needed and the electric heat pump has several advantages over its close rival (in energy efficiency terms), the gas engine CHP (Combined Heat and Power) system. Unlike CHP, electric heat pumps only compete with combined-cycle power generators on the heating market. Also, heat pumps improve the elasticity of the electricity market by providing a market for any excess electricity produced in the district heating power plants. Another advantage of this system is that it provides the opportunity for mono-energy supply (electricity only) for buildings in difficult terrains.

Computer Control

Mr Lotz of HCF Industries, France, stressed the importance of matching heat pump designs to customer needs, and to provide tools to service people for easy and efficient maintenance. Modern computer control techniques have been applied by HCF to meet both these needs. In one project, a set of dampers are controlled to recycle air or provide fresh air according to building occupancy and outside temperature. A glycol water loop recovers heat from expelled air. Maintenance work has been significantly improved by a system which transmits diagnostic information over a modem to a central maintenance station, where remote trouble-shooting is carried out. In a separate poster paper, Mr Lotz also reported on how HCF have successfully introduced water loop heat pumps to the large-building market, most notably in the supermarket sector. Again, computer control systems have played a major role in improving efficiency, operability and serviceability.

In Norway, computer technology is being used to improve the efficiency and performance of district heating heat pump systems. **Mr Årøen** reported in his poster on the SCADA (Supervisory Control and Data Acquisition) system which monitors temperature and valve positions in all buildings and adjusts the temperature of water in the district heating grid for optimum performance. A poster by **Mr Røsvik** reported on another Norwegian project which uses river water as a thermal source for heating and cooling a complex of industrial buildings (approx. 150 years old).

Hidden Demand

In summing up this Session at the end of the conference, Mr Groff welcomed the good news from Europe, where heat pump sales are rising. But he was not convinced that the true impact of heat pumps in that region are being fairly portrayed, since unit sales are often lost in air conditioning statistics. Furthermore, the European resistance to air conditioning is holding back support for heat pump technology which can play a major role in meeting the rise in cooling demand, and in reducing environmental damage.

While actual heat pump sales are currently being hit by recession in many areas, the upward trend will continue in the future. However, a more pronounced rise in heat pump installations will only come when there is greater recognition of the benefits of heat pumps by policy makers. Measures such as incentive schemes and efficiency regulation will raise the significance of electric heat pumps in world markets.

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Session 6 - Thermally Driven Heat Pumps

Bert Stuij, IEA Heat Pump Centre

The thirteen papers (6 oral, 7 posters) of Session 6, confirmed that a great deal of research, development and commercialization of thermally driven heat pumps is ongoing. There are several good reasons for this. In the heating season, engine driven heat pumps have the potential for high efficiency since they allow utilization of the waste heat from engine cooling water and exhaust gases. In the cooling season, gas driven systems can reduce the summer peak in electricity demand, caused by electric air conditioning which is a huge problem in some areas. The CFC/HCFC issue has provided a window of opportunity for sorption heat pumps which use environmentally benign working fluids. Significant strides have been made to overcome impediments against more widespread use of thermally driven heat pumps, which in general have to do with the technical reliability of gas driven systems, and their price. Dr. Sweetser of the American Gas Cooling Center and Prof. van der Ree of the Technical University of Delft, the Netherlands, chaired the oral presentations.

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Opportunities for thermally driven heat pumps exist, because of their high potential efficiency, their ability to achieve load levelling for electric utilities, and in the case of sorption systems, their use of environmentally harmless working fluids. Challenges exist mainly in the areas of equipment reliability, NO_x emissions and costs.

Meeting the Challenge

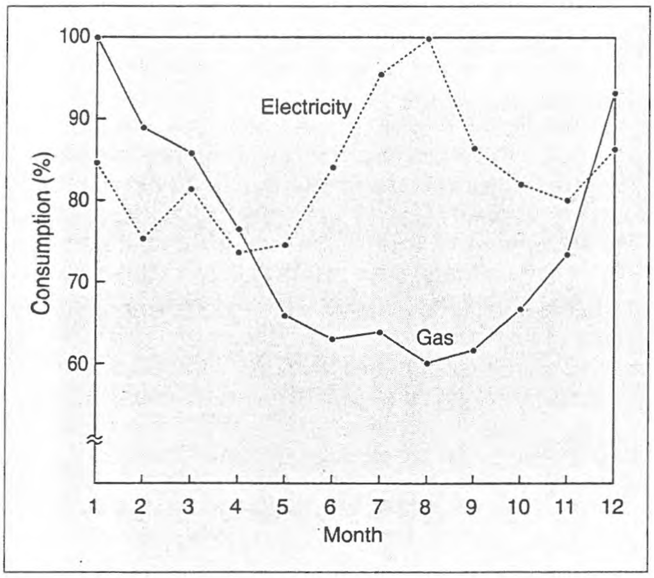
Mr Sakata of the Sanyo Electric Co., Japan, discussed the development and market penetration of the domestic gas engine driven (GEHP) heat pump in Japan. First introduced in 1985 to offer a gas-fired alternative to the electric air conditioner, annual sales of the GEHP reached 30,000 in 1992, and a continued rise is expected. The models on the market in Japan now cover a similar range of capacities and possibilities to electric heat pumps. The employment of gas engine heat pumps is in line with government and utility policies. It can reduce summer peaks in electricity demand and achieve a gas consumption which is more evenly spread over the year (see Figure). Goals for future development include reduced NO_x emissions from the gas engines, improved product reliability and a reduction of costs.

On a more fundamental level, **Prof. Steimle** of the University of Essen, Germany, reviewed both the engine driven heat pump and the absorption heat pump. He noted that the gas engine heat pump uses some 25% less primary energy than its electric equivalent, but that reliability and prices have been hurdles for a more widespread implementation. As for the absorption technology, he stated that the conventional working pairs NH_3/H_2O and $H_2O/LiBr$ both have some problems, and that promising alternatives are still worth investigating. As an added advantage of absorption systems he highlighted the potentially very low maintenance cost, given the absence of moving parts.

National Efforts

The development and market introduction of gas fuelled space conditioning technologies is vigorously pursued in the USA. **Mr Freedman**, of the US Gas Research Institute, gave a comprehensive overview of the efforts in this field. Both engine driven and sorption systems are now close to commercialization. A residential 10 kW gas engine heat pump, developed with York, has successfully completed a 10 unit field test, and is now entering a 50 unit demonstration phase, in a concentrated endeavour to commercialize this technology. Reliability targets are exceptionally high with 50 to 60,000 hours operation hoped for (this is equivalent to a car engine running for 3 million km!). Even though no exhaust catalyst is used, NO_x emissions are kept below 2.7g/kWh. Sorption technologies, including absorption, adsorption and chemisorption of ammonia vapour are in various stages of development. An ammonia/water absorption GAX system is expected to enter a field test this year. Prototypes of the system have shown excellent efficiencies. The aim is to develop a heat pump with a size and cost to compete with existing heating and cooling systems, and a reliable operating lifetime of at least 20 years. All developments face economic trade-off issues regarding cost and performance.

Mr Yoshida, of the Japanese Gas Association, presented a Japanese R&D programme on small-sized gas driven heat pumps - in the range of 2.5 to 7 kW. The 40 million USD programme is sponsored by the Japanese government (one half), four gas utilities (one quarter), and 11 manufacturers (one quarter). It will run for four years: the first two years will be mainly



Gas and electricity consumption patterns in Japan.

devoted to the development of components; performance testing of prototypes is expected in 1994, and field tests will commence in 1995. The research efforts include H_2O/LiBr and NH_3/H_2O absorption systems, gas engine driven heat pumps, and Vuilleumier systems. Minimum efficiency targets are modest (heating COP more than 0.75, cooling COP more than 0.7). The main drive is to come to a reliable and competitive device which can find extensive market penetration. The government's first aim is to reduce the summer peak in electricity demand caused by electric air conditioners.

Encouraging

Highly encouraging operational experiences with a significantly larger system were presented by **Dr. Bassols**, of Colibri BV, the Netherlands. In the spring of 1993, an ammonia/water absorption heat pump, with a cooling capacity of 110 kW and a heating capacity of 250 kW, was installed in a government building in Maastricht. The river Maas provides the heat source together with heat recovered (30 kW) by cooling computer equipment. The heat pump uses advanced plate fin heat exchangers. Heat exchange between absorber and generator is utilized (GAX), and the design of the unit is such, that it can continuously vary between a single-stage and double-stage 'mode', depending on the operating temperatures. The single-stage mode allows relatively high temperature lifts to be achieved, while the efficiency rises rapidly if temperatures allow operation in the preferred double-stage mode. The first measurements show an excellent heating COP of 1.8, boosted by the relatively warm river water and moderate heat demand in spring. Over the entire heating season an average heating COP of 1.55 is expected. Gas consumption of the building will be reduced by one third to one half, or more than 100,000 m^3 per annum.

A distinctly different angle was covered by **Mr Bin Yassin** from the utility Tenaga Nasional Berhad, Malaysia. He discussed opportunities for large-scale thermally driven heat pumps, to be integrated in agro-based process and power plants in the tropics. Total process efficiencies in the tropics are often low because of the inherent high back-end temperatures. Large amounts of heat are currently lost to the environment. Mr Bin Yassin argued that thermally driven heat pumps are one way to make good use of this heat. Heat transformers can be integrated in processes to enhance overall efficiencies, and there are district heating or cooling opportunities which can be served by waste heat driven heat pumps. In conclusion he stated that, contrary to common belief, industries located in the tropics offer immense potential for the application of heat pumps.

The application of thermally driven heat pumps in industry was given further attention in the **poster session**. An Italian paper showed that absorption heat pumps have several advantages over compression heat pumps in industrial applications including the potential for higher temperature lifts. Experiences with a steam generating heat transformer at a steel plant in the Netherlands were also presented (see HPC Newsletter Vol.11 No.1). Another poster highlighted the latest developments with the Dutch adsorption system known as SWEAT (Salt Water Energy Accumulation and Transformation; see HPC Newsletter Vol. 10 No. 1). This low-cost system is now in a field test where it provides building cooling using heat from a district heating system. Other posters were presented on a combined absorption/compression cycle, a dynamic test rig for heat pumps, and prototype tests on an absorption heat pump with the new working pair trifluoroethanol-pyrrolidone (TFE/Pyr).

Strides and Hurdles

Session 6 made clear that a variety of thermally driven domestic heat pumps are under development or near commercialization. In particular, to reduce the summer electricity demand, gas fired space conditioner systems currently receive intense attention in the USA and Japan. Costs, reliability, size and NO_x emissions are some of the hurdles to be taken, and significant strides are reported in these areas. Large-scale absorption systems are now showing excellent performance, which increases hope for a more significant market penetration. The application of thermally driven systems in industry is beneficial in many cases, and systems which are both technically advanced and commercially attractive have been realized.

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Session 7 - Market Influences: Regulatory, Institutional and Governmental

Bert Stuij, IEA Heat Pump Centre

In previous sessions, the significant potential of heat pumps to enhance the efficiency of energy systems and thus benefit the environment was confirmed. However, these positive effects can only be realized if the market penetration of heat pumps is substantially increased: the heat pump will have to 'beat the competition' on many more occasions. Of course the competitiveness of heat pumps is greatly influenced by its economic performance compared to the alternatives. But it is clear that when governments and utilities adopt focused energy policies, they can strongly influence the market potential of energy saving technologies - including heat pumps. These market influences were surveyed in session 7 which was chaired by Prof. Frivik of SINTEF, Norway, and Mr Narita of TEPCO, Japan.

* * *

Instruments to influence the market for heat pumps include standards and regulations, subsidies and incentives, sponsored research, and promotion. Governments, utilities and international organizations all have a role to play.

Standards

Mrs Mondot of CETIAT, France noted that, as the market for heat pumps increases, the need for standards grows with it. Standards may concern the whole product or just some of its components, for instance for safety or environmental reasons. In general, a method to determine performance will have to be standardized, to allow a harmonization and meaningful comparison of manufacturer catalogue data. Standards can be developed nationally, on a European level (CEN), or worldwide (ISO). Efforts in all these areas are ongoing. Mrs Mondot presented highlights of the main international standards (CEN and ISO) which cover performance testing, environmental quality assessment, and general and electrical safety. In conclusion she stated that standardization efforts are inevitably ongoing, in particular to cover new technologies.

Confirming the industries interest in good standards, **Mr Pritchard** of York, UK, presented the Eurovent certification programme for unitary air conditioners. Eurovent, founded in 1959, is a European association of fourteen national associations representing air handling and air conditioning equipment manufacturers. Addressing a widely shared concern about the inaccuracy of published performance data of many products marketed in Europe, the certification programme is now achieving an agreed basis of comparison between the air conditioners of all manufacturers. This will clearly benefit the image and marketing position of the industry. If products comply with Eurovent requirements they are entitled to apply the 'EUROVENT Certified Performance' label to their products. A similar programme for heat pumps does not yet exist, but the Eurovent model could be used since the market logic for heat pumps is similar.

Mr Knipscheer, chairman of the Dutch HPC National Team, stated that the traditional lack of appropriate standards and regulations for heat pumps has already had dire consequences, in particular when heat pumps are matched with a hydronic heat distribution system. In the Netherlands, the lack of adequate standards in this field has lead to a disturbing list of poorly designed heat pump systems, and has hampered further penetration. Energy savings in 17 surveyed projects were less than half of what was calculated, heat pump performance was on average 20% below the estimates, and maintenance costs were twice as high as expected. The following problems need to be addressed:

- inappropriate heat load calculations lead to massively over designed heat pumps;
- the standard heat distribution systems operate at too high a temperature to allow effective matching with a heat pump;
- 'standard' heat pump test data do not relate to actual field conditions.

Mr Knipscheer argued that wide ranging improvements to design standards for heat pumps, heat load calculations and hydronic heating systems are a pre-requisite for meaningful heat pump penetration. A proper design may well lead to the conclusion that a heat pump is not suitable in a particular situation, but that outcome is of course to be preferred above a wrongly applied and economically disastrous heat pump installation.

Programmes

In Japan, the drive of the Japanese government to accelerate the development of heat pumps for energy efficiency is typified by the 'Super Heat Pump Energy

Accumulation Systems' programme. **Mr Yoshimura** of the Japanese Ministry of International Trade and Industry highlighted the progress made in this trend-setting nine year project, which was finished in March 1993. Some of the results are shown in the Table. Innovative technologies incorporated in the Super Heat Pump include advanced screw compressors, multi-stage condensers, and plate fin heat exchangers for minimum temperature difference. Chemical heat storage units have also been developed with a performance exceeding predicted values. Now the government sponsored research is finalized, the challenge is for industry to commercialize the developed systems, so that their promise of increased efficiency and environmental benefit is realized.

In the USA and Canada, government agencies, utilities and major manufacturers are collaborating on research in both industry and government laboratories. **Mr Baxter**, of the Oak Ridge National Laboratory, USA, noted that the required phase out of CFCs and HCFCs has added new urgency to this work. These phase-out requirements are seen as an opportunity to develop advanced refrigeration and heating systems, with very high efficiencies. Zeotropic refrigerant mixtures as replacements of HCFC-22 are one way towards this goal. Thermally driven heat pumps also receive intense attention (see Session 6). Longer-term developments include work on Stirling engine driven heat pumps and solid-gas adsorption systems.

Activities to support and promote heat pumps on a multi-national level are performed under the auspices of the European Community. Highlights from these activities were presented by **Prof. Reay**, UK, chairman of the European Commission's Concerted Action Group on Heat Pumps. European initiatives have thus far mainly taken the form of sponsored RD&D work. Such activities, which include work on alternative refrigerants, heat pipe heat pumps, absorption/ adsorption heat pumps, and other new technologies, take place in a variety of research establishments across Europe. Recently these activities have been supplemented with more explicitly market oriented actions such as making a market study and producing promotion material such as a multi-language brochure. The group will also be advising the European Commission on strategy, implementation and evaluation.

Mrs Steeg, executive director of the IEA, gave her keynote address in this session. She discussed the relationship between markets and the stimulation of energy efficient technologies such as heat pumps, and emphasized that innovative and bold approaches to energy efficiency programmes are needed. Extensive hightlights from her address are given on pages 19-20 of this newsletter.

A poster presented by **Mr Rivenaes** of Energy Communication Systems, Norway, highlighted the achievements of the Norwegian National Heat Pump Programme. By giving courses and developing educational material, the programme has played an important role in increasing heat pump usage in Norway. A strategy plan for 1993-2000 has been developed and includes the development of heat pumps using natural refrigerants such as ammonia, air, CO_2 and propane.

Utility Schemes

The efforts of utilities to advance heat pumps were first addressed by **Mr Narita** of the Tokyo Electric Power Co. Ltd (TEPCO). He noted that electric utilities are interested in heat pumps for two reasons: Firstly, the high efficiency of heat pumps reduces the overall energy requirement, especially if they replace resistance heaters. Secondly, they improve the load

Item		Output Temp. °C	Heat Source Temp. °C	COP
High Efficiency Type Heat Pump	for Heating	85 65	50 35	8.1 8.2
	for Heating & Cooling	45 7	10 32	6.2 7.1
High Temperature Type Heat Pump	for Low Temp. Heat Source	150 150	50 95	3.0 5.0
	for High Temp. Heat Source	300 300	150 200	3.0 6.0*
* not confirmed				

Performance experiences under Japan's Super Heat Pump Programme.

factor. Cooling demand causes an electricity peak in the summer. If heat pumps are used for heating in winter, rather than alternative energy sources, a relatively high electricity demand is achieved in winter as well. The problem of daily load fluctuations remains, and the utilities are now promoting heat pump systems combined with thermal storage. The actions of TEPCO include the distribution of free bulletins on heat pumps, free open seminars, and visits to buildings equipped with thermal storage heat pumps. Joint technical developments between utilities and manufacturers are also taking place. The utilities take active part in Japan's IEA activities in this field, coordinated through the Heat Pump Technology Center of Japan.

The efforts of American electric utilities were discussed by **Mr Taylor** of Kemper Management Service. He focused on incentive schemes, and noted that while the costs of these schemes are normally paid by the utilities, their implementation is closely guarded by the regulatory authorities. These schemes aim at load levelling, energy saving, and very often an improved market position of electricity versus alternative energy sources. Some utilities link the height of an incentive to the performance of the heat pump installed. Mr Taylor emphasized that 'threshold subsidies' (e.g. a fixed amount if a heat pump meets a minimum efficiency requirement) are clearly not stimulating technology advances. Better are schemes where the incentive continues to rise with improved performance. Touching on demand side management (DSM), Mr Taylor noted that DSM can increase rather than decrease total kWh demand. In some states DSM has the clear and stated objective to reduce energy consumption, while in others the main aim is to increase electricity sales. Mr Taylor noted some mixed feelings in the debate, caused by the realization that increased efficiencies will reduce total kWh demand, and by the fact that gas and electric utilities seek primarily to enlarge their market shares, rather than to reduce energy consumption.

A European perspective was provided by **Mr Moreau** of Electricity de France (EdF). The heat demand in France is already moderate rather than high, and it continues to fall with improving insulation. Combined with the low energy prices this hampers a widespread penetration of the heating-only heat pump. Economic possibilities remain, especially in hospitals, nursing homes, public amenities and large houses. An installed power of only 40% can cover 70% of the heat demand, and achieve significant savings - especially when compared with resistance heating which is dominant in France. Yet the economic decision remains difficult, unless use can be made of the ability of heat pumps to cool for comfort in summer. Recognizing that France, given its climate and economic development, looks rather 'under developed' with regards to comfort cooling, EdF has embarked on a promotion campaign for air conditioning with emphasis given to reversible types. If successful, this promotion should result in a significantly expanding heat pump market in France.

Joint Forces

The last speaker of Session 7 was **Mr Fleming** of The Fleming Group, USA. He argued that Demand Side Management (DSM) and heat pump programmes must result in transparent benefits to the consumer. Only then will the free market demand for heat pumps and other energy saving technologies be fast and effective. To achieve this, he urged the HVAC industry and utilities to join forces in a spirit of common interest and common sense. They should form a partnership, which in cooperation with regulators and consumers should ensure that DSM and heat pumping technologies benefit everyone. This partnership should, for instance, present accurate and relevant information to consumers, and ensure maximum benefits of the programmes to utilities, the HVAC industry and consumers. Furthermore it should continuously seek and evaluate alternative technical options to further enhance these benefits. The 'easy' DSM actions have already been implemented. The future will be more difficult, and an effective partnership will ensure that new initiatives in this field are realistic, practical and beneficial in a broad sense.

Take the Lead

The role governments and utilities can play, to accelerate the market penetration of heat pumps for energy efficiency and environmental benefits, is large and important. It is encouraging to see how much positive efforts are already undertaken around the globe, both in the national and international arena. However, much work remains to be done before the heat pump will come close to realizing its potential. Summing up the session, **Prof. Frivik** urged the IEA Heat Pump Programme to consider taking the lead in formulating internationally accepted standards for heat pumps.

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Session 8 - Plenary Closing

Bert Stuij & Mike Steadman, IEA Heat Pump Centre

The oral papers presented over the four days, and now summarized by the chairmen of the various sessions, aroused much debate. Indeed, for the uninitiated, it must have come as a surprise to witness just how many contentious issues can arise on the apparently narrow subject of the heat pump. In the final session, chaired by Mr John Ryan of the US Department of Energy, the audience took the chance to debate some of these issues. Should air conditioning be considered a necessity or an unnecessary luxury? Should power generation be made more efficient before promoting the use of heat pumps in developing countries? Why is the market for heat pumps in Europe so small? What are the prospects for natural refrigerants that are toxic or flammable? On what heat pump issues should the IEA concentrate? Some highlights from an animated debate.

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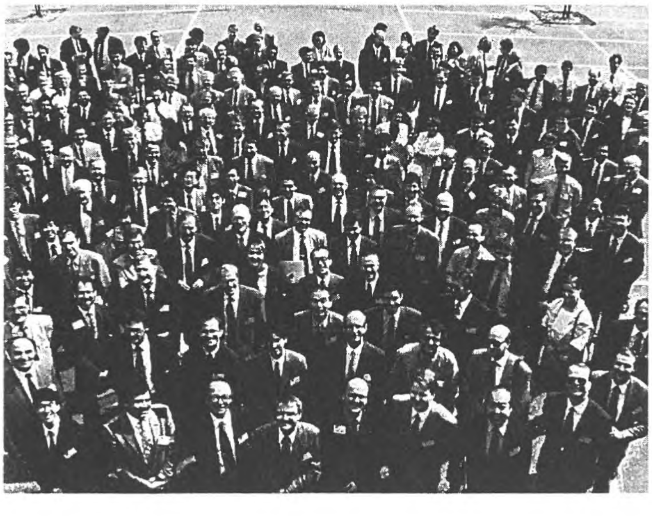
Mr Gilles, of Lennox Industries, USA, argued that the image of air conditioning as a luxury item only is unrealistic, and hampering heat pump sales. In reality, air conditioning has often important benefits which go well beyond luxury, for instance for education and people at work.

Mr Kleefkens of the Dutch Government warned against the rapid introduction of electric heat pumps in developing countries such as China, where the power plant efficiency is very low. The net result will be an increase in CO_2 emissions. He pleaded for the introduction of more efficient electricity generating equipment along with heat pumps.

Participants of the 4th IEA Heat Pump Conference.



On the observed low heat pump penetration in Europe Mr Groff, chairman of the advisory board to the HPC, noted that the European market is bigger than indicated by the statistics, since heat pump sales are often hidden in the figures for air conditioners. Both Dr Halozan of Austria and Prof Frivik of Norway argued that effective collaboration by utilities, governments and the industry is required to accelerate penetration. Mr. Bosma of NOVEM, the Netherlands, highlighted the economic opportunities for heat pumps in European industries.

On the natural refrigerant propane Mr Linton, of the National Research Council of Canada, voiced the views of many North American members of the audience when he argued that the use of flammables in North America is unlikely, due to liability concerns. Prof Frivik stated the Norwegian view, that eventually only those refrigerants should be used, which nature has proven that it can handle - such as hydrocarbons, ammonia, water, and CO_2. Dr Sellberg, from Sweden, suspected that ammonia would find increased application in Sweden. Mr Ryan observed that the working fluid issue may be soon solved in Europe, if the safety aspects of natural refrigerants are adequately controlled and then accepted.

Speaking on the role of the IEA Heat Pump Programme, Prof Frivik made a strong call to deal actively with heat pump standards, since 'standards should not become an area of competition'.

Mr John Ryan concluded the plenary session, thanking all sponsors, organizers, speakers and participants for a valuable conference. He called for comments on the conference, which will be used to make the 5th IEA Heat Pump Conference an even greater success. Closing the conference Mr Floor van Nielen, chairman of the Dutch national organizing committee, expressed gratitude and pride in an excellent conference, which will form the basis for further exchange of knowledge on heat pumps.

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Scandanavian-Style Heat Pumps - The Pre-Conference Tour

Rune Aarlien, Norway

In conjunction with the conference, a five-day tour of heat pumps in Scandinavia was organized in the previous week. Twenty participants from around the world toured the southern parts of Norway and Sweden - at a pace which exhausted even the youngest. Tour leader, Rune Aarlien reports.

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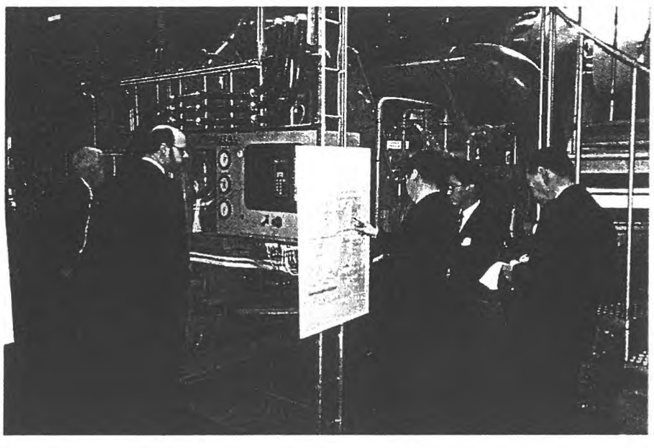
The main consideration in organizing a tour for friends and foreign colleagues, is that they will be able to experience as much as possible. This often means a very tight schedule with little relaxation and very few hours of sleep. Accordingly, this trip was no exception.

The intention of the tour was to create a good balance between sightseeing and technical visits. In Sweden, most of the time was devoted to the heat pumps. The Swedes, with many years of experience in, for instance, heat storage and district heating, offered a series of interesting presentations, and several of the highly advanced installations were thoroughly examined by the group. In addition to the visits to installations in Malmoe and Gothenburg, the group also attended a lecture about current research at the University of Lund.

Enthusiastic participants investigate a heat pump installation in Kungälv, just outside Gothenburg, Sweden.



Olympics

In Norway, the tour was centred around the sites for the 1994 Winter Olympics. The magnificent "Viking Ship" indoor speed-skating rink at Hamar and the impressive rock cavern ice hockey rink at Gjøvik were two of the places that will be well remembered - not only for the technical installations, but also for their architecture and building concepts. In addition, plants in Sarpsborg and Bærum (outside Oslo) were visited.

The participants knew, even before the tour, that heat pumping is an important subject, and upon arrival at Lillehammer the group really believed that the rest of the world had discovered this, too. The group was met by a film crew from the BBC (British Broadcasting Corporation), and most of us began exercising mental preparations for an interview about the benefits of the heat pump to the rest of the world. It is not every day you are given the chance to communicate on an international channel. However, to our disappointment, we found out that the main interest from the BBC crew was neither heat pumps nor the Conference in Maastricht, but the upcoming Winter Olympics. At any rate, the BBC crew did travel with the group while shooting scenes of pre-olympic visitors, and that in itself was fun.

Pleasure

Planning a one week programme for a group of 20 people is a large undertaking, and for a tour like this to be a success, the input of several individuals and organizations is crucial. The organizers, the Norwegian and the Swedish National Teams, would like to deeply thank all of the persons involved for their contributions: everyone from the hosts of lunches and dinners to those receiving us at their plants. Without your help the tour would have been impossible - with your help, the tour was indeed a pleasure to lead.

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Welcome

We sincerely welcome you to the Scandinavian Pre-Conference Tour leading up to the 4th IEA Heat Pump Conference in Maastricht, the Netherlands.

The Pre-Conference Tour is jointly prepared and organized by the two National Teams for heat pumps in Norway and Sweden. The idea of inviting the world's heat pump experts to our countries was born at the Executive Committee meeting in Chicago, USA, in May 1992. Since then we have put much effort in composing a tour that will be interesting, rewarding, and memorable for all of you. The program is relatively tight, so we are afraid it will be a busy schedule.

For a long time we were thinking about giving up our plans, simply because there were no participants. It was only three weeks ago, that we finally had reached the critical limit, and could start the last preparations. Therefore, it feels extremely good to have all of you here today, and that we finally are able to take off.

We hope that you will find the program interesting. On our tour we will visit several heat pump installations, most of which are located in Sweden. For years Sweden has been a forerunner on heat pump implementation, and now you are able to see some of the results.

As you all know, Norway will be the host of the Winter Olympics in 1994, so we thought you would be interested in seeing some of the sites and arenas for next years competitions. In addition we will, of course also see some heat pumps in Norway.

Please, feel free to ask questions on *anything* during the entire trip. We promise to do our best to satisfy your high expectations and needs. The Group Leaders are here to help and assist *you*.

HAVE A NICE WEEK HERE WITH US IN SCANDINAVIA!

Sincerely,

Bjørn Sellberg and Rune Aarlien

April 19, 1993
Malmø

Participants

	Participants' Name	Affiliation	Country
1	Mr. Mitsugŭ Ibano Leader of Delegates	Techonology Research Assn. of Super Heat Pump Energy Accumulation System Managing Director	Japan
2	Mr. Takanobu Inoue	Kyuden Sangyo Co., Ltd. Director & General Manager Environment Dept.	Japan
3	Mrs. Sumie Inoue	Travel with the above	Japan
4	Mr. Masayasu Ohashi	Takenaka Corporation Manager, Mechanical & Engineering Section	Japan
5	Mr. Shigeru Sakata	Sanyo Electric Co., Ltd. Senior Manager Commercial Equipment Systems Business Headquarters	Japan
6	Mr. Norikazu Sasaki	Kandenko Co., Ltd. Team Leader, Design Team Environment Protective Equipment Dept.	Japan
7	Mr. Kichio Shirai	Tokyo Electric Power Co., Ltd. Manager, Market Development Dept.	Japan
8	Mr. Mitsuru Sekizawa	Tokyo Electric Power Co., Ltd. Ass't. Manager, Market Development Dept.	Japan
9	Mr. Hiroto Takahashi	Hokkaido Electric Power Co., Inc. Dept. of Research & Development	Japan
10	Mr. Kazutoshi Nishiyama	Fukuoka Energy Service Corp.	Japan
11	Mr. Naoki Haginoya	Tohden real Estate Maintenance Co., Inc. General Manager, DHC Dept.	Japan
12	Mr. Masayuki Fukushima	Technology Research Assn. of Super Heat Pump Energy Accumulation System Technical Manager	Japan

13	Mr. Katsuki Fujlwara	Daikin Industries Ltd. Chemical Division, Alternative Flurocarbons R & D Team	Japan
14	Mr. Kiyotsugu Matsushita	Kyushu Electric Power Co., Inc. Research Laboratory Electricity Utilization Research Section	Japan
15	Mr. Tadashi Yamaguchi	Ebara Corporation Deputy General Manager Refrigeration Products & Systems Division	Japan
16	Mr. Tetsuro Kato	Heat Pump Technology Center of Japan Director	Japan
17	Mr. Peter Sako Interpreter	Overseas Tour Promotion Inc. Kojimachi Office General Manager	Japan
18	Mr. Keith Snelson	National Research Council Deputy Head Cold Regions Engineering	Canada
19	Mr. Jeff Linton	National Research Council Senior Researcher	Canada
20	Mr. Stefan Camitz Group Leader, Sweden	NUTEK	Sweden
21	Mr. Rune Aarlien Group Leader, Norway	SINTEF Refrigeration Engineering	Norway

Time Schedule

Monday, April 19:

Group Leader on the Swedish part: Mr. Stefan Camitz, NUTEK

0900-0930	Welcome and registration at Sheraton Hotel Malmø
0940	Bus transfer to Lomma
1000-1100	Visit to Lomma Contact Person: Dr. Olle Andersson
1110	Bus transfer for lunch
1130-1245	Lunch at VBB VIAK Host: Dr. Olle Andersson
1250	Bus transfer to Triangeln
1300-1420	Visit to Triangeln Contact Person: Dr. Johan Landberg
1430	Bus transfer to Lund
1450-1600	Visit to Papyrus Nymølle Project Contact Person: Mr. Ingemar Fastmark, NUTEK
1610	Bus transfer to Gothenburg
1900	Arrive at Hotel Panorama
2000	Dinner at Hotel Panorama Host: Mr. Stefan Camitz, NUTEK

Tuesday, April 20:

0700-0750	Breakfast
0800	Bus transfer to Ryaverken
0830-0940	Visit at Ryaverken Contact Person: Mr. Kjell Eriksson
0950	Bus transfer to Kirkbyn
1010-1120	Visit at Kirkbyn Contact Person: Mr. Tomas Hallén, EPRO

1130	Bus transfer for lunch
1145-1245	Lunch at Tidbloms Krog Host: Mr. Stefan Camitz
1250	Bus transfer to Sevenås
1300-1430	Visit at Sevenås Contact Person: Mr. Carl A. Pedersen
1440	Bus transfer to Øjersjø Storegård
1500-1630	Visit to Øjersjø Storegård Contact Person: Mr. Mats Fehrm, Elektrostandard
1630	Bus transfer to Hotel
1900	Dinner at Sea Magazine Host: Mr. Stefan Camitz, NUTEK

Wednesday, April 21:

0700-0815	Breakfast
0830	Bus transfer to Komarken, Kungelv
0900-1030	Visit at Komarken Contact Person: Professor Thore Berntsson, Chalmers University
1040	Bus transfer to Sarpsborg, Norway
1330-1430	Lunch at Rica Saga Hotel, Sarpsborg Host: Mr. Rolf Eilertsen, Eilertsen & Lund Co
1430-1530	Visit to Air-Raid Shelter in Sarpsborg
1540	Bus transfer to Oslo
1640	Arrive Hotel Royal Cristiania, Oslo
1900	Dinner at Hotel Host: Dr. Ulf Rivenæs, Head of Norwegian National Team for Heat Pumps

Thursday, April 22:

Group Leader on the Norwegian part: Mr. Rune Aarlien, SINTEF Refrigeration Engineering

0700-0800	Breakfast
0815	Bus transfer to Hamar
1000-1130	Visit to the Viking Ship Contact Person: Mr. Bjørn Lundstøeng
1140	Bus transfer for lunch
1145-1250	Lunch at Inter Nor Hotel, Hamar Host: Rune Aarlien
1300	Bus transfer to Gjøvik
1415-1530	Visit to Gjøvik Rock Cavern Ice Rink Contact Person: Ms. Eli Sveen
1540	Bus transfer to Lillehammer
1600-1800	Sightseeing of Lillehammer
1800	Arrive Oppland Hotel
2000	Dinner at Oppland Hotel Host: Ms. Eli Sveen

Friday, April 23:

0615-0650	Breakfast
0700	Bus transfer to Bærum Energiverk
1000-1120	Visit at Bærum Energiverk Contact Person: Dr. Atle Nørstebø
1130	Bus transfer for lunch at SAS Fornebu Hotel
1145-1300	Lunch at SAS Fornebu Hotel Host: Mr. Magne Amundsen, Norwegian Water Resource and Energy Adm.
1310	Bus transfer to Bygdøy
1320-1450	Visit to the Norwegian Folk Museum
1500	Bus transfer for Japanese delegation to Fornebu Airport (arrive at 1510).

NATIONAL POSITION PAPER

NORWAY

PRESENTED TO THE HEAT PUMP CENTRE

BY

THE NORWEGIAN NATIONAL TEAM

PREPARED BY SINTEF REFRIGERATION ENGINEERING

PREFACE

The Norwegian National Position Paper (NPP) on heat pumps is prepared for the IEA Heat Pump Centre's 1994 analysis, "International Heat Pump Status and Policy Review". The main objectives of this analysis is to provide an authoritative assessment of: the achievements of policy measures regarding heat pumps, the current and expected penetration of heat pumps in all market segments, and the technological status of various heat pumping technologies.

The NPP for Norway is worked out by M.Sc. student Kjetil Evenmo in cooperation with Mr. Jørn Stene, Mr. Geir Eggen and Mr. Rune Aarlien at SINTEF Refrigeration Engineering, and includes the following surveys:

Important Basic Factors determining the impact of heat pumps including energy resources and energy use, energy prices in various market sectors, climatic conditions, building stock and prevailing heat and cold distribution systems with typical distribution temperatures.

The Norwegian Energy and Environmental Policies and the position of heat pumps therein including the accomplished Heat Pump Implementing Programme, the Norwegian Strategy Plan for the Heat Pump Sector, national regulations relevant to heat pumps, and national regulations/legislation with regard to refrigerants.

Heat Pump Technology Status and RD&D including the state-of-the-art heat pump technology, status on refrigerant use, and ongoing/accomplished research and development programmes and projects.

The Norwegian Heat Pump Market including heat pump types in various market sectors, important market constraints, heat production from heat pumps and heat pump investment costs.

SINTEF Refrigeration Engineering
Trondheim, September 1993

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1. Basic Factors

1.1 Climate

The climatic conditions in Norway are presented in terms of degree day curves for 4 representative regions; Oslo (fiord climate - Southern Norway), Bergen (coastal climate - South Western Norway), Røros (inland climate) and Tromsø (coastal climate, Northern Norway), Figure 1.1.

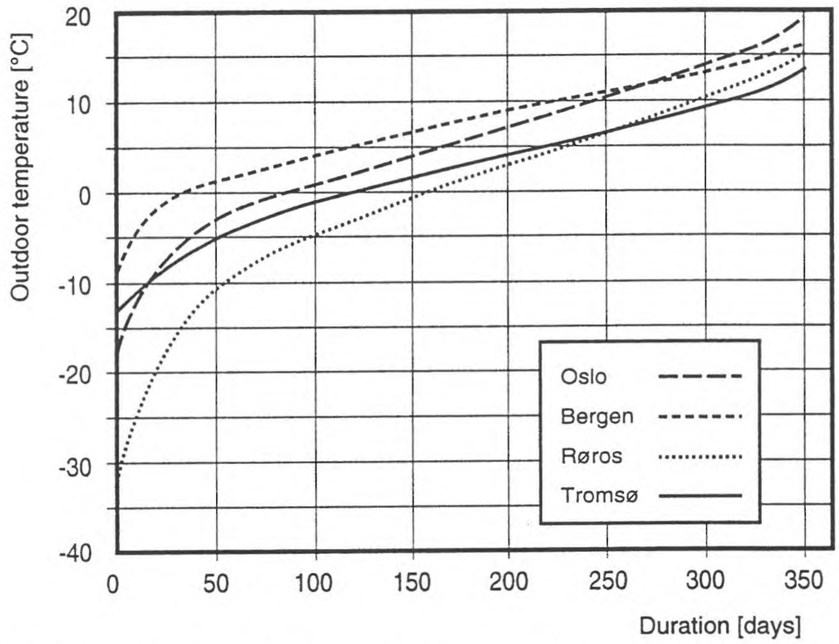


Figure 1.1: *Cumulative Degree Days for 4 representative climatic regions in Norway.*

The design outdoor temperature, DOT (three days minimum) and the seasonal average temperature, SAT for the same regions are listed in Table 1.1.

REGION	DOT	SAT
Oslo	-20°C	5.9°C
Bergen	-10°C	7.8°C
Røros	-40°C	0.5°C
Tromsø	-12°C	2.9°C

Table 1.1 *Design outdoor temperature (DOT) and seasonal average temperature (SAT) for 4 representative climatic regions in Norway.*

Appendix A : *Ground water temperatures in Norway*

Appendix B : *Sea water temperatures in Norway*

1.2 Energy Resources and Energy Use

Table 1.2 shows the annual domestic production and consumption of primary energy in Norway in 1992. The difference between domestic production and consumption represents the net export of primary energy. Norway's production of crude oil and natural gas in the North Sea is significant, and more than 90% of the oil and 95% of the gas is exported. Another import aspect is the electricity generation from hydro power, which comprise more than 60% of the total annual domestic energy consumption in Norway. About 10 TWh electricity is exported to Denmark, Sweden, and Finland.

	Annual Domestic Production	Annual Domestic Consumption
Oil [1000 metric tonnes]	118,866	5,481
Natural Gas [1000 Sm^3]	27,732,000	103,000
Pit Coal [1000 metric tonnes]	391	1,519
Hydropower [TWh_{el}]	117.7	96.6
Renewables (Windpower) [TWh_{el}]	0.007	0.007
Biomass (Fuelwood, black liquor, garbage) [TWh]	11.6	10.6

Table 1.2: *Primary energy resources and consumption - annual national consumption and production in 1992.*

The primary energy mix for electricity generation is presented in Table 1.3. Virtually all electricity in Norway is generated from hydro power, and most of the water turbines yield a high energy efficiency. About 0.4% of the electricity is generated by combustion of black liquor in paper mills, while a negligible share is generated in wind generators etc.

	Share [%]	Average turbine efficiency [%]
Hydropower	99.6	92
Renewables	0.006	-
Others (black liquor)	0.4	-

Table 1.3: *Primary energy mix for electricity generation in 1992.*

Final energy resources result from primary energy after transformation into forms suitable for use in industry, transport, buildings, agriculture etc. They include electricity, district heat, solid fuels and petroleum products. Table 1.4 on the following page indicates the final energy use in Norway in 1992, with particular reference to energy applications where heat pumps could be relevant, ie. space heating, space cooling, hot water heating and industrial processes operating below 200°C. The Higher Heating Value (HHV) is used to determine the energy content of fuels. Feedstocks are not included.

	Total Energy Consumption [GWh/yr]	Space Heating [GWh/yr]	Space Cooling [GWh/yr]	Hot Water Heating [GWh/yr]	Process Heat [GWh/yr]	
					< 200°C	> 200°C
Electricity	96,600	22,000	120	8,700	2,300	10,000
District Heat	1,030	726	0	290	0	0
Oil (based on H.H.V.)	66,100	11,700	0	1,600	6,400	2,800
Gas (based on H.H.V.)	0,800	0	0	0	0	0
Coal (based on H.H.V.)	12,800	400	0	100	1,500	8,600
Other (biomass etc.)	11,100	3,000	0	0	0	0

Table 1.4: *Final energy use in Norway (1992) - total, and use in areas relevant to heat pumps.*

Table 1.5 indicates the end use energy prices ($/kWh) in various market sectors (1993).

	Oil [$/kWh]	**Coal** [$/kWh]	**Electricity** [$/kWh]		**District Heat** [$/kWh]
			Low	**High**	
Homes	0.035-0.04	-	0.015	0.065	0.04-0.065
Commercial/Inst. Bldgs.	0.035-0.04	-	0.015	0.065	0.04-0.065
District Heating	0.04-0.065	-	0.04-0.065	0.04-0.065	0.04-0.065
Industrial	0.025-0.04	0.034	0.015	0.020	0.04-0.065

Table 1.5: *End use energy prices in various market sectors in 1993 (1$ = 7 NOK). The Higher Heating Value (HHV) of fuels is used to determine their energy content. LOW= occasional power, HIGH =firm power.*

1.3 Houses and Buildings

Table 1.6 gives the size of the residential and commercial/institutional building stock, both new (ie. built in 1991), and existing. The average heat demand (including heat for hot tap water) and cooling demand is indicated for the various types of buildings.

	Building Stock [number of flats]		**Av. Heat Demand** [MWh/yr]		**Av. Cooling Demand** [MWh/yr]	
	New	Existing	New	Existing	New	Existing
Single Family Homes	7,000	972,000	19	20	0	0
Multi Family Homes	14,500	808,000	10	11	0	0
Commercial/Inst. Buildings (m^2)	$2*10^6$	$85*10^6$	1)	375 2)	1)	1)

Table 1.6: *Building stock and average heating/cooling demand in 1991. 1) There are no available statistics - total heat demand incl. hot tapwater 12.5 TWh, and total cooling demand 0.12 TWh. 2) MWh/year.*

Table 1.7 and 1.8 indicate the share of the prevailing heat and cold distribution systems in homes and commercial/institutional buildings in 1991, respectively. It is distinguished between *new* (1991) and *existing* homes/buildings.

		New Homes				Existing Homes			
		Heating[1)]		Cooling		Heating[1)]		Cooling	
		Temp. [°C]	Share [%]	Temp. [°C]	Share [%]	Temp. [°C]	Share [%]	Temp. [°C]	Share [%]
Heat Distribution System	Air	30-40	10	-	-	30-40	10	-	-
	Floor	30-50	10	-	-	30-50	5	-	-
	Radiators	50-80	20	-	-	50-80	10	-	-
Cold Distribution System	Air	-	-	-	-	-	-	-	-
	Water	-	-	-	-	-	-	-	-
Electric radiators		-	60	-	-	-	75	-	-
None		-	0	-	-	-	0	-	-
TOTAL:		-	100	-	-	-	100	-	-

Table 1.7: *Type, typical delivery temperature and percentage share of heat and cold distribution systems in homes. [1)] Most homes have a combination of heating systems (2.3 heating systems per house in average). 80% of the households have a combination of electric heating (electric radiators and/or electric boiler) and other heating systems (oil, firewood etc.), while 20% have electric heating only.*

		New Commercial/Institutional Buildings				Existing Commercial/Institutional Buildings			
		Heating[1)]		Cooling		Heating[1)]		Cooling	
		Temp. [°C]	Share [%]	Temp. [°C]	Share [%]	Temp. [°C]	Share [%]	Temp. [°C]	Share [%]
Heat Distribution System	Air	30-50	25	-	-	30-50	35	-	-
	Floor	30-50	35	-	-	30-50	5	-	-
	Radiators	50-80	25	-	-	50-80	40	-	-
Cold Distribution System	Air	-	-	15	30	-	-	15	30
	Water	-	-	13	70	-	-	13	70
Electric radiators		-	15	-	-	-	20	-	-
None		-	-	-	-	-	-	-	
TOTAL:		-	100	-	100	-	100	-	100

Table 1.8: *Type, typical delivery temperature and percentage share of heat and cold distribution systems in commercial/institutional buildings. 55% of the buildings have electric heating only (electric radiators and/or electric boilers), 40% have a combination of electric heating and oil fired boilers, while 5% have no electric heating at all.*

1.4 Industry

Table 1.9 lists energy intensive industry sectors, and indicates processes at moderate temperatures suitable for the application of heat pumps.

Industry Sector	Process	Temperature range [°C]
Aqua culture (fish farming)	• Heating of process water	5-15
Fish products	• Drying • Evaporative concentration	5-30 (100) 80-100
Pulp and paper	• Drying • Evaporative concentration	50-70 100-120
Leather	• Drying	40-60
Dairies	• Drying • Evaporative concentration	15-25 60-80
Chemical industry	• Steam production	110-120

Table 1.9: Energy intensive industry sectors and processes suitable for the application of heat pumps.

1.5 Future Trends

The most important basic factors in the future (other than policy measures), which are expected to affect the market penetration of heat pumps and competing heating system in Norway are expected to be:

- In new houses and buildings in all market sectors the insulation standard is constantly improved, consequently resulting in reduced spesific heating requirement [kWh/m^2]. Older buildings are also renovated to a large extent including improved insulation standard, new windows etc. Generally, a reduced specific heating requirement makes it less interesting to install heat pumps because the absolute energy saving potential is lowered.

- The indoor climate in both residential and commercial/institutional buildings has been given stronger priority the recent years, thus increasing the potential for exhaust air heat pumps in single/multi family houses and heat pumps for space conditioning (heating/cooling) in commercial/-institutional buildings. The market penetration of the latter type of systems is also influenced by the fact that internal heat gains in this kind of buildings is getting more significant due to increased use of heat emitting technical installations, such as computers and lighting systems. It is also a trend towards glass ceiling and glass front constructions in commercial buildings, which results in high specific heating and cooling requirements.

- Stipulated increase in oil prices, 1.6% per year. The oil price is expected to remain low in the coming 3-5 years. A low oil price favour use of oil fired boilers in central heating systems, both in industry and the commercial/residential sector.

- Stipulated increase in electricity prices, 3.5% per year. Norway has established a free market on electricity, which means that consumers in industry and commercial sectors (residential sector later) can buy electricity where they are offered the lowest price and the best conditions. This has contributed to *lower electricity prices* due to free competition between the various energy utilities (no regional monopoly situation). As a general consequence it has become more difficult to carry out energy saving measures by means of eg. heat pumps. A high electricity price will always favour heating with fossil fuels, while a very low electricity price will favour electric radiators and electro boilers.

2. Energy and Environmental Policy Relevant to Heat Pumps

2.1 General

This chapter gives a general overview of the Norwegian energy conservation and environmental policy relevant to heat pumps and competing systems. It is also describes the role of heat pumps in the national and utilities policy.

Norway is in general, strongly involved in energy and environmental policies both nationally and internationally. The authorities have given financial support for research and training on the energy conservation area since 1974. The most important strategies and objectives today are listed below:

- Loan- and subsidy arrangements for:
  - *Accomplishment of energy conservation attempts, including consultancy and analysis.*
  - *Research and development in the energy conservation area, including heat pumps.*
  - *Research and development of new, renewable energy sources, such as sun-, wind-, wave- and biomass energy.*

- In 1993 the Government distributed NOK 421 mill. ($ 60 mill.) in grants for activities within the energy conservation area.

- Financial support for establishment of Energy Conservation Centres.

- Introduction of a "free" electricity market. Due to the surplus energy this has resulted in lower electricity prices.

- The Energy Utilities are instructed to inform the consumers about the energy conservation attempts that possibly can be accomplished in their buildings.

- Today Norway is exporting electric power to Sweden, Finland, and Denmark, and is evaluating the possibilities for export of more power, eg. to Germany.

- The authorities are evaluating a new financial programme for energy conservation attempts where the value of the energy saving will be used to cover the financing. Hence, those who are selling the products are guaranteeing energy savings.

- The energy conservation attempts which are profitable today will be realised within 2005.

- Continued active participation and cooperation through the International Energy Agency (IEA).

The Authorities have in the recent years been giving improved frame requirements in the energy conservation area, namely for heat pumps. This is due to the fact that installation of heat pumps is considered to be a very important measure in saving energy and reducing environmental harmful emissions. *However, due to a general cut down in the Norwegian National Budget for 1994, the economic situation for heat pump research/development and promotion is considerably deteriorated, ie. very low budgets.*

2.2 Heat Pump and Energy Programmes/Policies

2.2.1 The Heat Pump Implementing Programme

The "Heat Pump Implementing Programme" was divided into 3 sub-programmes: HP-INFO (information, dissemination), HP-P&D (prototype and development) and HP-IEA (international activity through the International Energy Agency).

a) Goals of the programme:

- To promote the use of heat pumps as a part of an efficient, economic and environmentally acceptable energy system in Norway.

- To create a market for Norwegian suppliers and ensure that the suppliers deliver high qualitiy products which satisfy users' operating and maintenance requirements.

- To exchange information and cooperate in international fora in order to benefit from and contribute to international efforts to boost the use of heat pumps.

- To establish 3 major heat pump installations (over 5 MW), 10 medium-sized heat pump installations (2-5 MW) and 20 smaller heat pump installations (0.2-2 MW).

b) Type of programme: Technology transfer programme (promotion).

c) Total budget of NOK 23 mill. ($ 3.3 mill.)

d) Duration: 1989-1992 (4 years)

f) Results/achievements:

- About 20 heat pump courses with more than 600 participants from energy utilities, consultants, industry etc. were held during the programme period.

- Interest in heat pumps increased during the programme period, and suppliers reported a steady increase in sales of heat pumps in Norway.

- The programme has presented comprehensive reports on forty different heat pump installations monitored before or during the programme period.

- The programme has contributed to make the transition to approved refrigerants easier for everyone concerned.

- The programme has prepared comprehensive teaching material, including various text books, computer programmes, hand books, manuals, brochures etc.

- The heat pump programme has participated in the IEA's Implementing Agreement on Advanced Heat Pump Systems.

2.2.2 The Norwegian Strategy Plan for the Heat Pump Sector

This is a continuation of the Promotion Programme described in the previous section 2.2.1.

a) Goals of the programme:

ENERGY CONSERVATION:

- Technology and knowledge dissemination;
- Increase the number of heat pump installations;
- Heat supplied from heat pumps in 1996 - 3 TWh/year;
- Heat supplied from heat pumps in 2000 - 4 TWh/year.

ENVIRONMENT:

- Within year 2000 natural refrigerants including ammonia, CO_2, and hydrocarbons (propane etc.) should be the dominating refrigerants in new heat pump installations.

INDUSTRY DEVELOPMENT:

- Development and market introduction of at least two new export-related heat pump products by the end of 1996.
- Development of the Norwegian trade and industry for the heat pump sector.

b) Type of programme: Research, development and technology transfer.

c) Budget for 1993 is NOK 6.65 mill. ($ 1 mill.)

d) Duration: 1993 - 1996 (to be continued in 1997 - 2000).

Due to a general cut down in the Norwegian National Budget for 1994, the Heat Pump Programme is more or less postponed, and only a small activity will take place in 1994.

2.2.3 National Regulations Relevant to Heat Pumps

1) The energy prices are regulated by environment taxes and the new Energy Legislation (1991):
   - Environment taxes on fossil fuels (Appendix C).
   - The Energy Legislation introduced open competition on the Norwegian energy market. In a "normal year" Norway has surplus of electric power, and this leads to cheaper electricity (both firm and occasional power). This situation may easily change in the future.

2) The subsidy programme:
   - Energy conservation investments/projects are subsidised by 15-20%;
   - Heat pump investments in the private sector have been subsidised by 30% from 1993.1.1.

3) Environmental pollution regulations for the industry:
   - Infringement of this regulation will result in penalty.

2.2.4 Energy Policies and Programmes Indirectly Relevant to Heat Pumps

a) Programme for Cleaner Technology and Energy Conservation

a) Goals of the programme:
- To develop a methodology for integrated technical energy- and environment analyses.

b) Budget for 1992 : NOK 2.8 mill. ($ 0.4 mill.).

c) Duration: 1991 - 1994.

b) Programme for Trade Network

a) Goals of the programme:
- Reduce the specific energy consumption in the industry sector.
- Influence the industry groups in such a way that they set realistic energy-saving goals.
- Improve the communication between the industry and the authorities.

b) Duration : 1990 →

c) Results: Today it is 325 member achievements spread over 12 trades.

2.3 Environmental Programmes and Policies

2.3.1 Reducing the Emission of Environmental Harmful Gases

a) Goals of the programme:

CO_2 : Human affected emissions of carbon dioxide (CO_2) in the year 2000, shall not exceed the emission in the year 1989.

SO_2: Sulphur dioxide - 50 % reduction of 1980 level within 1993.

NO_x: Nitrogen oxides - 30 % reduction of 1986 level within 1998.

CFCs: ChloroFluoroCarbons - The Norwegian CFC-regulations from July 1991 bannes all installation and sale of *new* heat pumps using CFCs as refrigerants. From 1st of January 1995 all import of CFCs will be prohibited. A small amount of recovered/recycled CFC will be commercially available in a transition period.

HCFCs: Regarding HCFC-22, Norway has ratified the 1992 Copenhagen Amendment, but it is expected that more stringent regulations will be imposed in the coming years as in Germany (ie. accelerated phase-out schemes). This will include prohibition of HCFC-22 in *new* heat pump and refrigeration installations.

2.3.2 National Regulations and Legislations w.r.t. Refrigerants

As described in the previous chapter it will still be possible to buy recycled CFCs from retrofitted and scrapped heat pumps after 1995.01.01, but the amount available will be sufficient to cover only a minor part of the total CFC demand. Thus, most heat pumps using CFC-12, CFC-114, R-500 or R-502 have either to be retrofitted to non-CFC refrigerants or replaced with new equipment within a reasonable period of time (5 years).

The new national regulations on ammonia from 1993 are rather strict. Depending on the total refrigerant charge in the heat pump system and other system characteristics, special safety measures are required. This includes eg. two stage gas alarm system, enhanced ventilation system, sprinkler system etc. The use of ammonia in heat pumps is also prohibited in certain applications, eg. in *direct* ventilation systems in commercial buildings.

The use of flammables (eg. propane and HFC-152a) in heat pumps in Norway is still rare, and is only applied in installations with low refrigerant charge. The necessary safety precautions are stated in each case by the local fire station officer, following the more general regulations on flammables. Guidelines for handling of flammable refrigerants in heat pump installations have been worked out by SINTEF Refrigeration Engineering in cooperation with the Norwegian authorities.

3. Heat Pump Technology Status and RD&D

3.1 Heat Pump Performance

Table 3.1 gives typical seasonal performance factors (SPFs) for *heat pumps in buildings* (family houses and commercial/institutional buildings) as well as for heat pumps installed in district heating systems. District heating heat pumps utilize either sea water or untreated sewage as heat sources. In Norway the electricity is entirely based on hydro power, and *all heat pumps are electrically driven* due to relatively low electricity prices.

		Air source (ambient)	**Ground source** (soil, geotherm.)	**Water source** (sea water, rivers, lakes, groundwater)	**Waste Heat source** (sewage, ventilation air, industrial waste heat etc.)
Family Houses	**Electric**[1)]	2.0-2.5	2.5-3.5	3.0-4.0	3.5-4.0
District Heating	**Electric**	-	-	3.0-4.0	3.0-4.0
Commercial/Inst. Bldgs	**Electric**	2.5-3.5	3.0-3.5	3.0-3.5	3.5-7.0

Notes: [1)] For Electric Heat Pumps: SPF defined as $\frac{\text{Heat Out [MWh}_{th}\text{/yr]}}{\text{Electricity In [MWh}_{el}\text{/yr]}}$

Table 3.1: *Typical SPFs for heat pumps installed in family homes, commercial/institutional buildings and district heating systems.*

Table 3.2 gives a range for typical performance factors (mean COP in the operating period) for *industrial heat pumps*. It is indicated a range of heat source temperatures and achieved temperature lifts. Industrial heat pumps in Norway are either mechanical vapour recompression (MVR) systems or closed electrically driven systems.

	Performance Factor Definition	**Source Temp. (range)** [°C]	**Temp. Lift (range)** [°C]	**Performance Factor (range)**
Open (M.V.R.)	$\frac{\text{Heat Out [MWh}_{th}]}{\text{Shaft Energy In [MWh]}}$	50-100	10-40	10-25
Closed - electric driven	$\frac{\text{Heat Out [MWh}_{th}]}{\text{Electricity In [MWh}_{el}]}$	10-70	20-70	3-10

Table 3.2: *Performance factors and temperature ranges for industrial heat pumps in Norway.*

3.2 Refrigerants (Working Fluids)

Table 3.3 gives an estimate of the various refrigerants (working fluids) used in installed compression type heat pumps in various market sectors (tonnes). In new heat pump installations *HCFC-22* and *HFC-134a* are the dominating refrigerants in the residential and commercial/institutional sector, while *ammonia* is frequently used in large heat pump installations. *Blends* are mainly applied when retrofitting existing heat pump and refrigeration plants using CFC-12 or R-502.

Market Sector	CFCs [tonnes]	HCFCs [tonnes]	HFCs [tonnes]	NH_3 [tonnes]
Residential	5	5	0	0
Commercial/Institutional	25	150	0.1	2
District Heating	20	0	0.2	2
Industrial	5	50	0	20

Table 3.3: Use of refrigerants in compression type heat pumps in various market sectors (total refrigerant charge, 1993).

Figure 3.1 shows the same figures as Table 3.3, presented as share in each market sector.

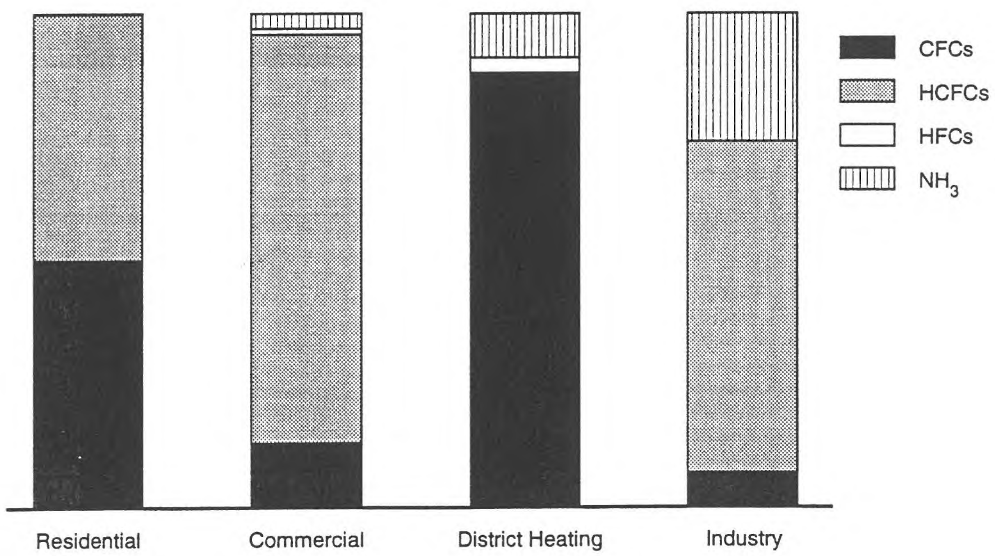


Figure 3.1: Refrigerants used in existing heat pumps in various market sectors (percentage in each market sector).

3.3 Research, Development and Demonstration (RD&D)

In Norway the focus is on the utilization of *natural substances* as refrigerants (working fluids), ie. *ammonia* (NH_3), *hydrocarbonss* (eg propane) and *carbon dioxide* (CO_2). The research and development activity is currently concentrating on low-charge ammonia heat pump systems and compact heat pumps with propane as refrigerant. Design rules for heat pumps using ammonia or flammables as refrigerants are being worked out as well.

The recent years a high-efficient air-conditioning system for automobiles using *carbon dioxide* as refrigerant has been developed. Carbon dioxide is also considered a very promising refrigerant in various refrigeration systems, hot water heat pumps and large heat pump applications.

17 heat pump installations using ammonia, propane and HFCs are built as prototype and demonstration plants, Table 3.4. The heat pumps are installed in commercial/institutional buildings, district heating systems, ice rinks and industry, and their thermal output range from about 30 kW to 2,500 kW.

PLANT	HP-OUTPUT (kW)	REFRIGERANT
SEA WATER BASED HEAT PUMPS:		
1. HP - district heating, Bodø	2,000	ammonia
2. Sjøkrigsskolen, Bergen	400	HFC-134a
3. Vallersund Farm	40	HFC-152a
4. The University of Bergen[1)]	2,500	ammonia
5. Research Centre of Statoil	900	ammonia
AIR BASED HEAT PUMPS		
6. Bjørnheim Borettslag	45	HFC-152a
7. Statens Kjølemaskinistskole	30	ammonia
GROUND COUPLED HEAT PUMPS		
8. Bølerskogen Borettslag	45	HFC-134a
9. Skaarsetlia church, Lillehammer	40	propane
10. Desentralized HP system, Birkenes[1)]	200	HP62
ICE RINKS		
11. Hamar Olympiahall	800	ammonia
12. Hamar Ishall	375	ammonia
13. Haakonshallen, Lillehammer	500	ammonia
INDUSTRIAL HEAT PUMPS		
14. TIMAR (fish farming)	585	ammonia
15. Tromsø Aqua Culture Research Centre	725	ammonia
15. Melbu Fiskeindustri (supercharge heat pump)	150	ammonia
16. Hallingsdalsbruket (drying of wood)	200	ammonia

Table 3.4: *Main data on R&D installations using non-CFC refrigerants. The heat pumps will be monitored in 1993/94.*
1) To be built in 1994.

Table 3.5 on the following page presents main data on 40 R&D heat pumps installations built and monitored by SINTEF Refrigeration Engineering in the period 1980-89.

PLANT	HP-output (kW)	HP energy prod. (MWh/yr)	Equivalent operating time (h/year)	Supply/ return temp. (°C)	SPF	Investment HP-system (1000 NOK)	Spes. inv. HP-system (NOK/kW)	Refrigerant
SEA WATER BASED HEAT PUMPS								
Marientek, Sandefjord	90	550	6,100	50/40	2.5	400	4,400	HKFK-22
Favusgården, Harstad	120	600	5,000	43/35	3.5	480	4,000	HKFK-22
Ljones Greenhouse, Hardanger	750	3,000	4,000	50/40	3.4	1,500	2,130	HKFK-22
Ålesund Townhall	310	800	2,600	43/35	3.0	1,050	3,400	HKFK-22
Royal Garden Hotel	800	3,200	4,000	50/40	4.0	1,185	1,500	HKFK-22
Hadsel Folkehøgskole	200	700	3,500	70/60	2.9	700	3,500	KFK-12
Gamvik Kommune	300	1,500	5,000	60/50	3.0	1,600	5,330	KFK-12
Polplast, Tromsø	70	122	1,750	50/40	2.1	395	5,640	HKFK-22
Hotal Maritim, Haugesund	310	1,000	3,230	70/60	2.9	300	1,000	KFK-12
Fylkesbåtane i Sogn- og Fjordane	45	195	4,330	45/35	3.2	247	5,500	HKFK-22
Protan, Haugesund	6,800	45,000	6,620	50/35	4.0	10,000	1,470	HKFK-22
Stokmarknes Hospital	400	2,300	5,750	70/60	2.7	1,700	4,250	KFK-12
Widerøes Airplane Hangar, Bodø	530	1,600	3,000	50/40	3.3	1,450	2,750	HKFK-22
HP district heating, Ålesund	6,000	27,000	4,500	90/60	3.5	27,000	4,500	KFK-12
AIR BASED HEAT PUMPS								
Sintef Adm. building	130	410	3,150	80/45	2.5	850	6,500	KFK-12
Common air/water-HP, Heimdal	16	61	3,810	60/50	2.5	150	9,400	HKFK-22
Air/air-HP, detach. house, Heimdal	3.5	11	3,150	-	2.4	30	8,600	KFK-12
Air/air-HP, detach. house, Heimdal	4.5	12	2,700	-	2.4	30	6,700	HKFK-22
Exhaust air HP - hot water prod.	1	4	4,000	50	2.4	10	10,000	KFK-12
Heat exch. + HP - hot water prod.	1	4	4,000	50	2.2	12	12,000	KFK-12
Grude Greenhouse	45	180	4,000	-	3.0	150	3,330	HKFK-22
Dalaker Greenhouse	108	410	3,800	-	3.0	224	2,070	HKFK-22
Medhus Greenhouse	28	142	5,070	30/20	3.9	52	1,860	HKFK-22
Gruben Road Station	56	175	3,130	50/40	2.6	374	6,680	HKFK-22
Mosjøen Road Station	90	360	4,000	-	2.5	713	7,920	HKFK-22
Air/air-HP, detach. house, Askim	4.7	19	4,000	-	2.4	35	7,500	HKFK-22
Alexandra Hotel, Loen	400	2,000	5,000	54/45	2.9	1,400	3,500	R-500
Bjørnheim B/L, Oslo	65	350	5,400	55	2.5	850	13,000	HFK-152a
GROUND COUPLED HEAT PUMPS								
Soil/water-HP, detach. house	12	18	1,500	55/45	2.4	80	6,700	HKFK-22
Holmin Greenhouse	250	1,000	4,000	55/45	3.3	430	1,700	HKFK-22
HP District heating, Målselv	52	207	4,000	55/45	2.7	530	10,000	HKFK-22
Sagen, Kristiansand	50	212	4,200	55/45	2.7	400	8,000	R-502
Brødrene Muhre, Jevnaker	12	34	2,800	40/35	2.9	100	8,300	HKFK-22
Søsterheimen B/L, Stord	18	66	3,700	55/45	2.3	148	8,200	HKFK-22
WASTE WATER BASED HEAT PUMPS								
HP District Heating - Skøyen Vest	2,200	12,000	5,500	90/60	3.0	-	-	KFK-12
HP Distr. Heat./Cool., Sandvika	13,000	65,000	5,000	90/60	3.8	-	-	R-500
Industriarbeidermuseet, Rjukan	240	820	3,400	45/35	5.6	1,465	6,100	HKFK-22
Matre Akva (fish farming)	490	1,925	4,000	-	6.6	520	1,100	HKFK-22
Timar, Slørdal (fish farming)	585	1,670	2,900	-	7.7	900	1,500	ammonia
Midt-Finnmark Smolt (fish farm.)	390	780	2,000	-	5.8	800	2,000	HKFK-22

Table 3.5: *Main data on 40 R&D heat pump installations built and monitored in the period 1980-89.*

Research and Development Programmes and Projects

Development of non-CFC Heat Pumps (Compact-Aggregate with HFC-152a)

The project was carried out in 1991. The main goals were: 1) To prove practical heat pump design with CFC-free refrigerants so they safely can be recommended for commercial use. 2) To test a compact-aggregate with HFC-152a (flammable/explosive) under normal and "stressed" operating conditions.

The main results achieved are: 1) After 1,200 hours in operation only moderate contents of acid in the refrigerant and lubricant was found. 2) Because of the explosion hazard, various safety measures have to be implemented in heat pump installations using HFC-152a.

CFC Reduction in Existing Heat Pump and Refrigeration Installations

The programme was carried out in the period 1991-92 (2 years). The main goals were: 1) To detect refrigerant leakage by means of adding tracer gases. 2) To reuse (recycle) CFC refrigerants.

The main results achieved are: 1) The refrigerants in ordinary installations are little polluted with the most harmful pollutions, namely acid, and this is favourable for the recycling process. 2) It is necessary to clean the refrigerants before reuse (remove oil and water), and the actual cleaning methods are filtration and decoction. 3) All tracer gases (smell substances) functioned well for leakage detection at the liquid side.

Development of a New Ammonia Technology for Small and Medium-sized Heat Pumps and Refrigeration Installations

The programme was started up in 1991 and will be accomplished medio 1994. The main goals are: 1) To develop an ammonia heat pump that fulfil the necessary safety demands, and which is able to compete technically with conventional heat pumps with CFC or HCFC refrigerants. 2) To minimize the refrigerant charge in heat pump installations.

The main results achieved are: 1) One ammonia-based prototype heat pump has been built (25 kW thermal output, 17 kW cooling capacity). Refrigerant charge in the region 50-100 gram/kW is practicable. 3) The physical size of the installation is, compared with eg. traditional heat pump installations using CFCs and HCFCs, considerably reduced.

4. Heat Pump Markets

4.1 Heat Pumps Installed, 1989 - 1992

Table 4.1 indicates the number of heat pumps installed in the period 1989 - 1992.

Market Sector	1989	1990	1991	1992
Single Family Homes	800	1,000	1,200	1,316
Multi Family Homes	20	20	20	25
Commercial/Institutional Buildings	300	300	300	310
District Heating Systems (< 100 users)	1	0	0	1
Industry	50	50	50	50

Table 4.1: Number of heat pumps installed in various market sectors, 1989 - 1992.

Figure 4.1 provides a more detailed overview of types and sizes of heat pumps sold in 1991 and the total number of heat pumps installed.

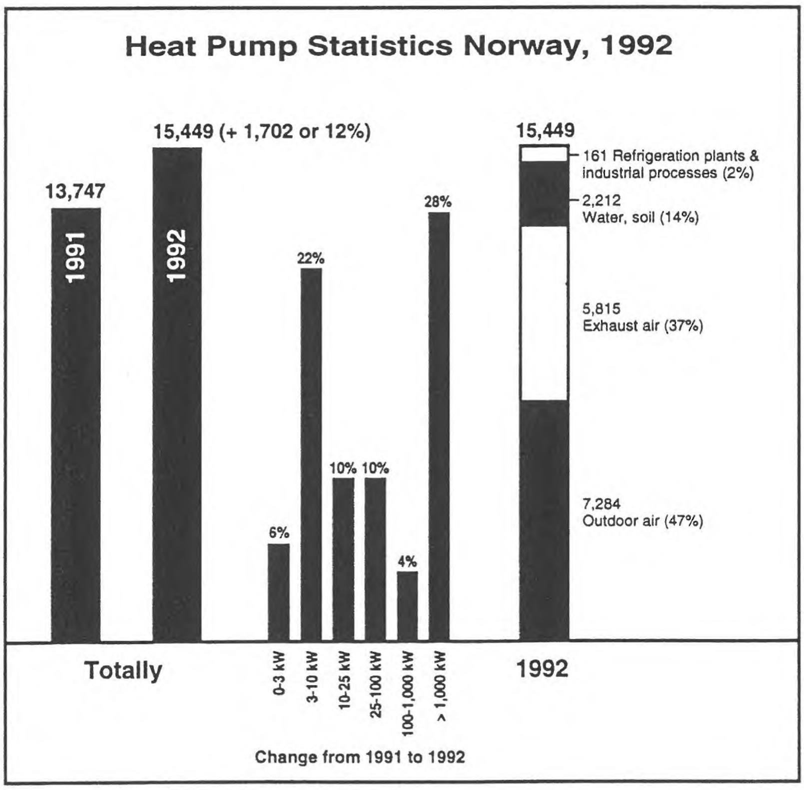


Figure 4.1: Number of heat pumps installed in Norway in 1992. It is distinguished between various sizes (0-3 kW, 3-10 kW, 10-25 kW, 25-100 kW, 100-1,000 kW and > 1,000 kW) and heat sources (industrial, water/soil, exhaust air and outdoor air).

4.2 Heat Pump Types in Various Heat Pump Market Sectors

Table 4.2 indicates the number of various heat pump types currently installed in *homes* (1992). It is distinguished between heat sources and sinks, room or central heat pumps, water heater heat pumps, integrated systems, monovalent or bivalent installations, and new or retrofit installations (replacement of heating systems in existing buildings).

Heat Source		Air Source (ambient)	Ground Source (soil, geotherm.)	Water Source (sea water, rivers, lakes, groundwater, etc.)	Waste Heat source (e.g. ventilation air, sewage, industrial waste heat)
Heat Sink:	Air	2,500	0	0	2,300
	Water	200	1,000	100	2,900
Drive Energy:	Electric	2,700	1,000	100	5,200
	Room HPs	2,700	0	0	0
	Central	0	1,000	100	5,200
Water Heater Heat Pumps		0	10	0	2,700
Integrated Systems		100	900	80	0
	Monovalent	0	500	0	0
	Bivalent	300	500	100	5,200
	New	200	500	50	5,000
	Retrofit	2,500	500	50	200

Table 4.2: Number of various types of heat pumps currently installed in homes in Norway (1992).

All heat pumps in the residential sector are *electrically driven* and most of the systems are bivalent, using firewood, oil fired boilers, electro boilers or electric radiators as auxiliary heating (peak load). Room heat pumps are reversible air-to-air heat pumps, while central heat pumps using other heat sources than outdoor air are installed in central heating systems, ie. hydronic systems (radiators or floor heating) or ventilation systems. The vast majority of water heater heat pumps utilize ventilation exhaust air as heat source. Integrated systems are heat pumps combining tap water heating and space heating (no space cooling).

Table 4.3 on the following page indicates the number of heat pumps currently installed in *commercial/institutional buildings* (1992). It is distinguished between heat sources and sinks, whether a central, multi-zone or loop system is installed, and whether the heat pump is a stand-alone heater or not. All heat pumps in the commercial/institutional sector are *electrically driven*.

Heat Source		Air Source (ambient)	Ground Source (soil, geotherm.)	Water Source (sea water, rivers, lakes, groundwater, etc.)	Waste Heat source (ventilation air, sewage, industrial waste heat)	Other
Heat Sink:	Air	3,000	0	0	100	400
	Water	300	500	500	600	0
Drive Energy:	Electric	3,300	500	500	700	400
	Central	300	500	500	400	0
	Multi-Zone	3,000	0	0	300	0
	Loop	0	0	0	0	400
Water Heater Heat Pumps		0	0	10	50	0
Integrated Systems		200	200	200	100	0
	Stand-alone	0	100	100	100	200
	Combined with boiler	3,000	400	400	600	200
	New	300	250	250	600	200
	Retrofit	3,000	250	250	100	200

Table 4.3: Number of various types of heat pumps in commercial/institutional buildings in Norway (1992).

About 400 heat pumps are installed in swimming pools for dehumidification (loop systems), while 700 integrated systems provide combined tap water heating / space heating or combined tap water heating and space conditioning (heating/cooling). Bivalent, central heat pumps are installed in hydronic systems, and supply heat to radiators, floor heating systems and ventilation aggregates. Auxiliary heating (peak load) is provided by oil fired boilers and/or electro boilers.

Table 4.4 indicates the number of various types of district heating heat pumps. All heat pumps installed in district heating systems in Norway are *electrically driven*, and utilize either sea water or untreated sewage as heat source.

Heat Source		Water Source (sea water)	Waste Heat source (sewage)
Drive Energy:	Electric	3	2

Table 4.4: Number of various types of district heating heat pumps in Norway (1992).

Industrial heat pumps in Norway are either open mechanical vapour recompression (MVR) systems using process vapour as working fluid or traditional closed-cycle systems. All industrial heat pumps are *electrically driven.* Table 4.5 indicates the number of the main types of heat pumps in the most important industry sectors where heat pumps are used. Some 650 heat pumps are installed (1992), and they are mainly applied for various drying purposes (lumber, fish, leather), evaporation processes (dairies, paper mills), heating of process water i fish farms and for heat recovery from refrigeration plants, mainly in the fish industry.

Industry Sector:	Fish Farming	Fish Industry	Wood conver-sions	Meat products	Dairies	Leather
Open (M.V.R.)	0	3	5	0	10	0
Closed - electric	250	100	200	50	10	50

Table 4.5: *Number of various types of industrial heat pumps (1992).*

Figure 4.2 provides a more detailed graphical presentation of industrial heat pump installations in Norway.

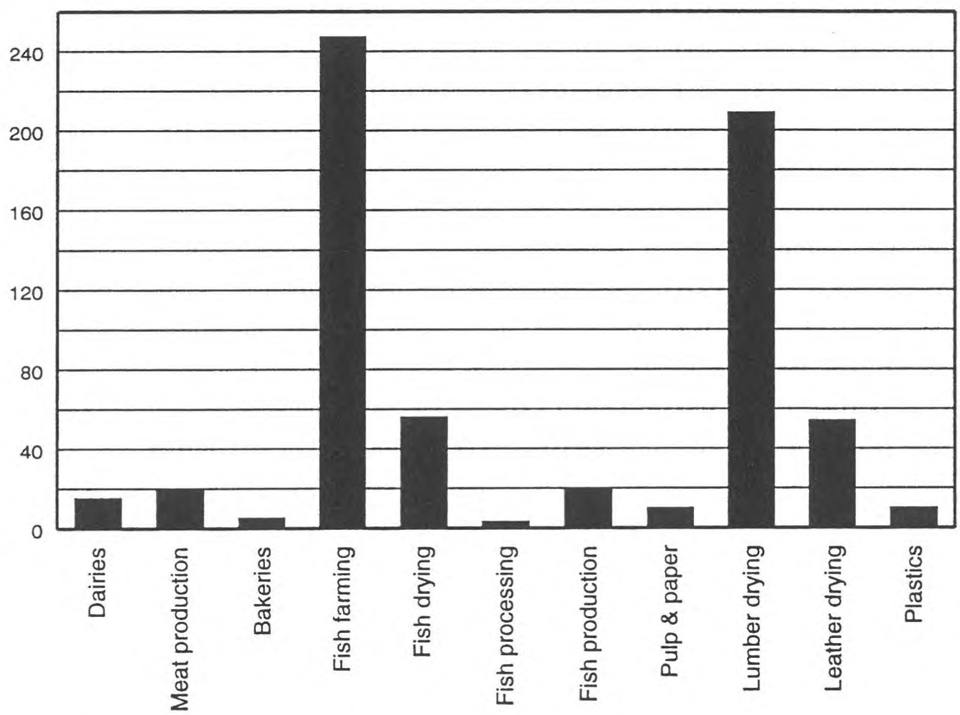


Figure 4.2 *Number of heat pump installations in various industry sectors (1992).*

4.3 Heat Pumps and the Total Heat Demand

Table 4.6 indicates the total heat demand in various market sectors in 1992 (residential, commercial/-institutional, industry), and the heat demand which is covered by heat pumps.

	Total Heat Demand [TWh/yr]	Provided by Heat Pumps [TWh/yr]
Single Family Homes	16	0.4
Multi-family Homes	10	0.4
Commercial/Institutional buildings	12	0.6
District heating systems (< 100 users)	0.15	0.12
Industry	15	1.2

Table 4.6: Heat demand in Norway and heat delivered by heat pumps in various market sectors (1992).

4.4 Heat Pump Investment Costs

Table 4.7 indicates the range of investment costs for heat pumps per kW installed thermal capacity for various heat pump sizes and for various applications (1993). The ranges are rather wide due to variations in heat sources (water/air), heat distribution systems (water/air), use of standard or tailored units, complexity of the plants etc. Extra costs for installing a possible new heat distribution system is not included in the figures.

	< 5 kW [$/kW]	5 - 25 kW [$/kW]	25 - 500 kW [$/kW]	0.5 - 1 MW [$/kW]	> 1 MW [$/kW]
Residential	1,000-1,700	900-1,400	600-1,300	-	-
Commercial/Institutional	1,000-1,700	200-1,400	150-1,100	150-500	150-500
Industrial	-	700-1,200	150-900	150-400	150-500

Table 4.7: Indication of the range of investment costs for heat pumps (1993). Extra costs for installation of a possible new heat distribution system is not included.

4.5 Market Constraints

The most significant market constraints are regarded to be:

In General for all Sectors:

- Heat pumps are still considered a "new" technology by consulters, contractors, building owners etc., and general statements as; "Heat pumps are expensive and they are less reliable in operation than traditional heating systems", are common. As a consequence oil fired boilers, electro boilers and resistance heating are normally the first (traditional) choice. This problem was one of the main tasks dealt with in The Heat Pump Implementing Programme (section 2.2.1).

- The low energy prices (electricity/oil) makes heat pumps less profitable than conventional heating systems.

- The Energy Utilities have an important position in implementing energy conservation in Norway. At the same time they are, however, in the energy business and they are interested in selling as much electricity as possible, and energy saving is given second priority.

- Uncertainty concerning refrigerants (CFCs and HCFCs).

Residential Sector:

- Roughly 60% of the households in Norway are single family homes. In most of the older, residential buildings, there are other energy conservation measures than heat pumps that first have to be accomplished, eg. improved insulation standard, installation of new windows etc.

- Residential heat pumps are in general very expensive (>1,000 $/kW output), and high investment costs (long pay-back time) is a limiting factor.

- The majority of residential heat pump installations in Norway are ambient air-to-air heat pumps for space heating or systems utilizing exhaust air as heat source for combined tap water heating and space heating. Most of the ambient air heat pumps in the market have unsuitable evaporator design for cold climates, insufficient defrosting systems (yields low COP) and last but not the least, they should only be installed in houses where proper air circulation is achievable. Moreover, exhaust air heat pumps require a ventilation system for being installed.

Commercial/Institutional Sector:

- The rather high investment costs is a limiting factor.

- About 80% of the existing buildings and 85% of the new buildings have installed central heating systems (hydronic systems). There is, however, a general problem with high temperature requirements, normally in the range from 60°C to 80°C, resulting in poor seasonal performance factor (SPF) for the heat pump installations and less profitability.

Industrial Sector:

- Industry have in general access to cheap occasional power (electricity), and this often implies in a too long pay-back period for heat pumps (> 3 years).

4.6 Market Trends

Residential Sector:

- The most common heat pump aggregates in the residential sector are small ambient air-to-air heat pumps, delivered as compact aggregates with low refrigerant charge (~0.2 kg/kW). Exhaust air heat pumps for combined tap water heating and space heating (integrated systems) are also popular.

Commercial/Institutional Sector:

- There is a general trend towards integrated space heating and space cooling systems (combined heat pump/chiller systems).

Industrial Sector:

- Integration of heat pumps in different industrial processes is becoming more and more common. The most common processes are drying and evaporative concentration. Fluidized bed drying at both high and low temperatures is also a promising technology.

5. Potential International Activities

In order to establish projects and programs between a group of several participants representing different countries, one needs good ideas. As soon as interesting *ideas* for joint projects pop up, there is no problem getting a group together with the purpose of solving challenges and problems.

Suggestions for potential international cooperation could be:

1) Heat Pump Reliability

   An annex on heat pump reliability with the aim of analyzing different causes for heat pump failures and breakdowns could be very interesting. All kinds of heat pumps should be investigated. The results from this annex would give answers that could be of invaluable benefit to heat pump designers and installers. Many experts maintain that the main problem with heat pump failures is located peripheral to the heat pump itself, and that poor workmanship done by installers and plummers is what really causes the trouble.

2) Cost Reductions

   An ever returning and strong incentive to forget about investing in heat pumps is their high investment cost. What it finally comes down to for most people, is economics, and perhaps is this the largest barrier for the heat pump industry today. Set a goal of 33 percent cost reduction, and create an annex around the question: How can heat pumps be produced with a price tag 33 percent lower than today, while at the same time the maintaining healthy profit margins for manufacturers?

3) Statistics

   The Heat Pump Centre could act as a resource center on heat pump statistics. Continuously updated, such information could be of importance to many countries in their argumentation for heat pumps in general. Among other things, there should be information on world total number of heat pumps (also broken down for the different countries), types and sizes of heat pumps, working fluids (types and volumes), manufacturers, etc.

The issue to be discussed here should not only be ideas for potential collaboration projects, but also, the issue of how we can ensure a constant flow of new ideas, that could result in new projects. In other words, how do we organize our work in order to encourage new ideas and innovation?

Suggestions on how to facilitate this could be:

4) Annual Idea Competition

   Ask people for suggestions and ideas regularly, and all the time. A critical issue here is that if one wants something in return, one also got to give something. Therefore, good suggestions must be rewarded. One could, for instance, institute a World Annual Heat Pump Award for the overall best idea contributing towards the Implementing Agreement objectives. This price should be handed out at a larger conference (for example, the International Heat Pump Conference).

5) "New Annexes": First Agenda Item at EXCO Meetings

If we really would like to stress the necessity of establishing new annexes, put "New Annexes" on top of the meeting agenda of each EXCO meeting, and make the delegates come prepared.

6) Brainstorming Sessions

Organize brainstorming sessions in connection with workshops, conferences, and other meetings, and demand *action* from *someone*, and reward action with benefits that could not be obtained otherwise (for instance, financial support to the meeting).

6. Discussion and Conclusion of National Situation

The conditions for using heat pumps in Norway are favourable. The climate yields a long heating season, the minimum outdoor temperatures are moderate in most of the country and a large part of the population is living along the coast, where the sea water is an excellent heat source (relatively high temperatures due to the Golf Stream). Because the electric power generation is entirely based on hydro power, only electric heat pumps are applied in Norway. Compared with electric or absorption heat pumps in countries where power generation is more or less based on fossil fuels, the overall efficiency of the energy system is considerably higher.

The penetration of heat pumps in Norway is closely linked to the electricity and oil prices. A generally high price level and similar prices between oil and electricity favour the use of heat pumps. Low oil prices and cheap firm electricity favour traditional heating systems such as oil fired boilers, electro boilers and resistance heating (electric radiators).

Another important aspect is the lack of knowledge among consultants, contractors, building owners etc. Heat pumps are still considered a "new" technology, and general statements as; "Heat pumps are too expensive and less reliable in operation than conventional heating systems", are quite common. As a consequence oil fired boilers, electro boilers or electric radiators are often chosen instead of heat pumps. It is therefore important to continue the work from "The Heat Pump Implementing Programme" (section 2.2.1) by means of general heat pump promotion, technology transfer, courses etc.

Norway has through international agreements set a limit for emission of various harmful gases, ie. CO_2, SO_2, NO_x and CFC's. One of the means to reach these objectives is to influence the use of heat pumps through favourable support arrangements. Investment in and installation of heat pumps are supported by 30 % from 01.01.93. These arrangements have not yet given the effects as expected, but by amended financial frame requirements (prices, taxes) this can change.

The uncertainty around the refrigerant situation, creates uncertainty about investments in heat pumps. It is therefore of great importance to develop environmentally benign refrigerants for heat pumps that neither affect the ozone layer nor the greenhouse effect (ODP=GWP=0). In Norway there is a considerable activity going on regarding natural refrigerants, ie. ammonia (NH_3), carbon dioxide (CO_2) and hydrocarbons (propane etc.). The ammonia heat pump technology is already highly developed.

Through the Heat Pump Implementing Programme it is built all together 40 prototype and demonstration installations. The aim of the activity was to test, survey and monitor the operation of various types of heat pumps in different parts of the country with different climatic conditions, and the program was proven successful. It has been performed many useful and important experiences regarding design, installation and operation of the heat pumps. These experiences are available in different reports.

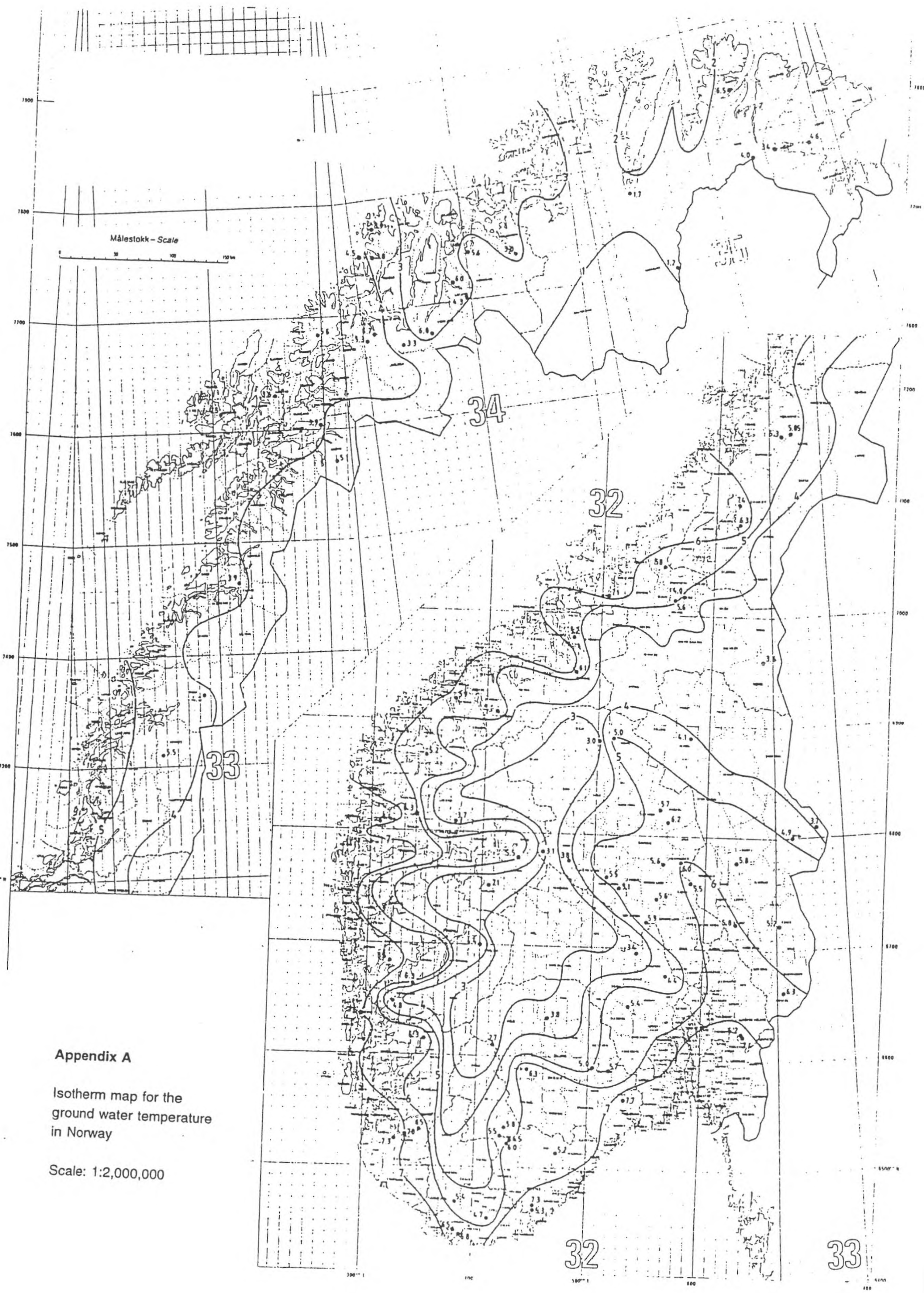
More than 60 % of the households in Norway are single family houses, where a heat pump investment will have a long pay-back period (10-15 years). At present price condition (investments and energy coditions), less than 5% of the technical heat pump potential (1 TWh) is stipulated to be profitable for the house owners. Stimulating attempts as investment subsidies and environmentally motivated taxes are already introduced to increase the heat pump rentability, but so far this has not resulted in a real breakthrough. A continued work in this region is necessary.

The buildings within the commercial/institutional sector often have a big and steady heat demand. Due to internal heat gains, external cooling is often required, and today about 30 % of this kind of buildings have space cooling installations. This enable heat pumps with excellent economy to be installed due to the combination of heating and cooling. As much as 35% of the technical heat pump potential (4 TWh) in this sector is stipulated to be profitable for the building owners.

Heat pumps for industrial applications become more and more common. In addition to space conditioning (heating/cooling) and heating of process water, this applies to drying and evaporation. The economy regarding these installations are generally good due to large, highly efficient heat pump units with long annual operating hours. A generally low price on occasional power (electricity) is, however, a market constraint. In the industrial sector almost 60% of the technical heat pump potential (2 TWh) is calculated to gain the companies economy.

APPENDIX A

Ground Water Temperatures



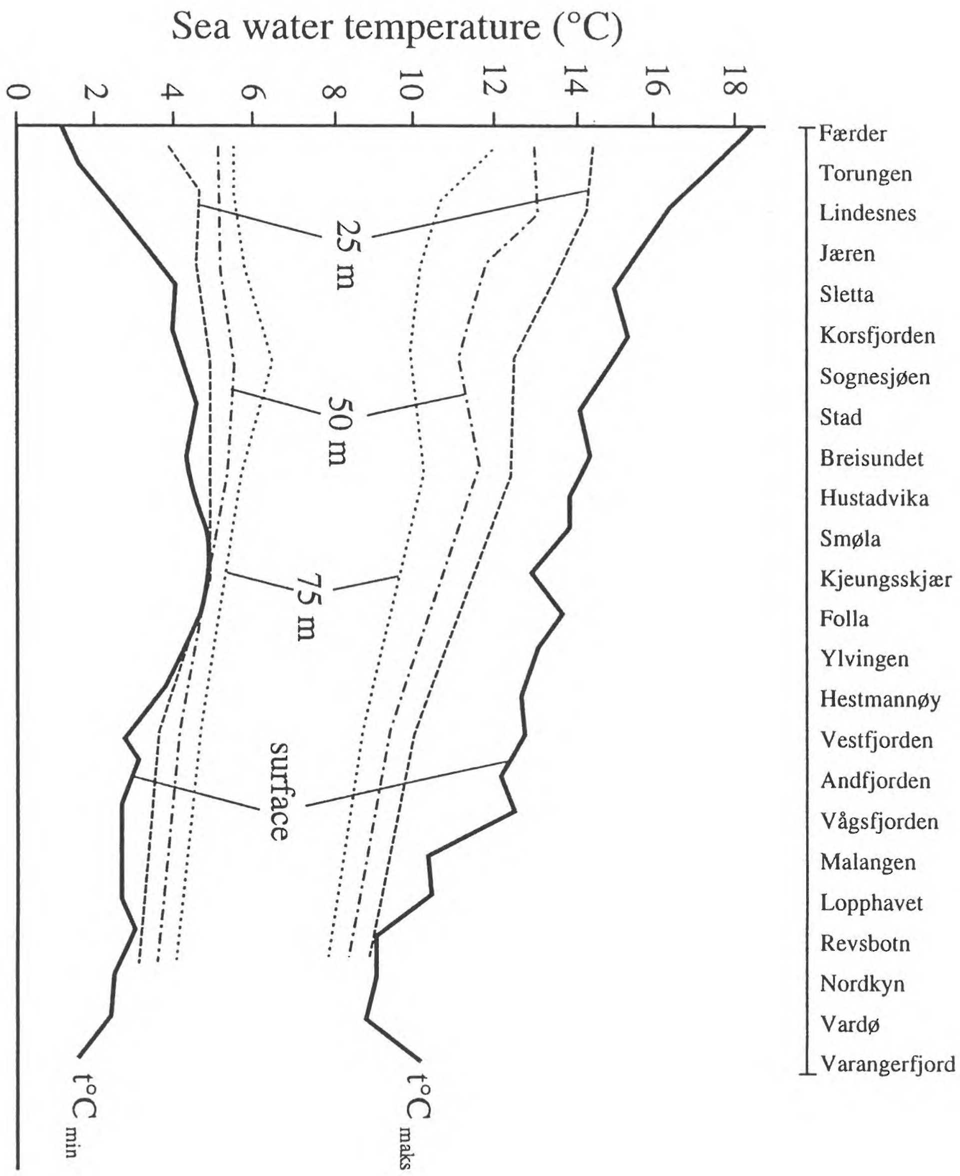
Appendix A

Isotherm map for the ground water temperature in Norway

Scale: 1:2,000,000

APPENDIX B

Sea Water Temperatures


Sea water temperature (°C)
0
2
4
6
8
10
12
14
16
18
25 m
50 m
75 m
surface
$t°C_{min}$
$t°C_{maks}$
Færder
Torungen
Lindesnes
Jæren
Sletta
Korsfjorden
Sognesjøen
Stad
Breisundet
Hustadvika
Smøla
Kjeungsskjær
Folla
Ylvingen
Hestmannøy
Vestfjorden
Andfjorden
Vågsfjorden
Malangen
Lopphavet
Revsbotn
Nordkyn
Vardø
Varangerfjord

APPENDIX C

Environmentally Motivated Taxes

Environmentally motivated taxes in affect in Norway 1993

Tax applies to	Type	Rate[1)]
Mineral oil	• basic rate • CO_2-tax • sulphur tax: $/litre per 0.25% sulphur content	0 $/litre 0.06 $/litre 0.01 $/litre
Continental shelf	• CO_2-tax natural gas • CO_2-tax petroleum	0.11 $/Sm^2 0.11 $/litre
Petrol tax	• basic rate: - leaded - unleaded • CO_2-tax	 0.53 $/litre 0.44 $/litre 0.11 $/litre
Coal/coke	• CO_2-tax	0.06 $/kg
Electricity tax	• production • consumption	0.002 $/kWh 0.007 $/kWh

1) 1 $ = 7 NOK

HEAT PUMP SUPPORTING GROUP.

THIRD MEETING.

BRUSSELS, 24 & 25 MARCH, 1993.

MEETING MINUTES.

The third meeting of the Heat Pump Supporting Group was held in Brussels, hosted by the CEC, on 24 & 25 March 1993.

Those attending were as follows:

Prof. D.A. Reay (Chairman).
Ir. P. Zegers, DGXII, CEC.
Dr. G. Deschamps, DGXII, CEC.
Ir. J. Knobbout, The Netherlands.
P.A. Oostendorp, The Netherlands.
J. Andersen, Denmark.
M. Guittard, France.
M.F.G. van der Sagt, The Netherlands.
Prof. H.J. Laue, Germany.
Prof. J. Berghmans, Belgium.
Dr. P. Coda, Italy.
Prof. J. McMullan, United Kingdom.
O. Kleefkens, The Netherlands.
G. Korn, Italy.
I. Dordolo, Italy.
F. Valle, Spain.
F. van Nielen, The Netherlands.
R. Aarlien, Norway.
B. Sellberg, Sweden.

Apologies for absence were received from R. Maier, N. Maloney, S. Kerr, M. Zogg, and H.U. Scharer. Mr. Maloney submitted some written comments on the strategy document and brochure, and these were taken into account in the appropriate discussion periods.

The affiliations of those attending, with addresses, is given in Appendix 1 to these minutes. Also given in the Appendices is the programme of the meeting and notes distributed by speakers at the meeting, as received by the Chairman.

CHAIRMAN'S INTRODUCTION.

The Chairman introduced the meeting by welcoming the new members of the Group, including those who had been unable to attend previous meetings. Mr. Oostendorp of TNO was a new member, and Mr. Andersen of Lodam Energi was making his first visit.

The minutes of the second meeting were approved with no ammendments.

The agenda for the third meeting was presented, and adjustments to the programme discussed and approved.

The new position of 'corresponding member' of the Group was introduced. Mr. Brian Buchanan of Scottish Hydro-Electric wished to participate in this way, attending meetings when feasible. This was seen by the Chairman as being a realistic way of increasing the role of the Group and knowledge of its activities.

(Subsequent to the Meeting, Mr. John Pritchard, Marketing Manager of York UK, has asked to be associated with the Group, and will be included in future mailing. Mr. Louis Lucas, Director of the International Institute of Refrigeration will also be introduced to the Group activities).

The Chairman was invited to make members aware of the 4th IEA Heat Pump Conference, held in Maastricht in May, 1993. The Chairman was presenting a paper ' The Role of the Commission of the European Communities in Supporting and Promoting Heat Pump Technology' at this meeting, and this is included as Appendix 2 of these minutes. At the next Supporting Group Meeting, it is proposed to have a discussion on the data presented at the sessions of the 4th IEA HPC.

PRESENTATION BY PETER OOSTENDORP.

Mr. Oostendorp of TNO was asked to summarise his activities in the area of heat pumps. These were primarily concerned with the programme of the Dutch Ministry of Economic Affairs.

Heat pumps were seen as having a high energy-saving potential, and their use was inevitable if the energy saving target in the Netherlands was to be achieved. Much R&D had been done, both locally and internationally. The Netherlands was believed to be a little behind in such developments. This was indicated by a series of bad demonstrations in the 1980's, and it was felt that the success rate of projects could be improved.

The objective of the programme in the Netherlands was to create conditions such that heat pumps could fulfil a role within a mix of energy-saving options. Within this overall aim, a number of other targets were seen: Overcoming a lack of knowledge, improving the image of heat pumps, and gaining an insight into possible policy instruments.

In the case of the built environment, a heat pump handbook was being written, with co-operation with

Norway. Standards were being developed, and low temperature hydronic systems were being studied. For the industrial sector, process integration was targeted, and again with Norewegian co-operation it was proposed to write an industrial heat pump handbook.

In both these areas, demonstration projects were to be identified, and the Netherlands supported the IEA heat pump activities and policy review aspects. Other specific activities included tuning of methods of techno-economic evaluation, international co-operation, the holding of a symposium in early 1996, public relations and publicity, the preparation of a data base on heat pumps in the Netherlands, and educational course modules.

The approach was on the basis of managed project activities, (eg TNO et al), and co-operation (eg with NOVEM, KEMA, IEA HPC, CEC etc.).

A question was put concerning the source of the funding for the database. PO said that it came from the Ministry of Economic Affairs.

A note on the work of TNO in this programme is given as Appendix 3.

A EUROPEAN STRATEGY FOR HEAT PUMPS.

Mr. Kleefkens introduced the document 'A European Strategy for Heat Pumps', which had previously been circulated to members of the Group. It is copied as Appendix 4. OK summarised the aim of the discussion on this document (Appendix 5), to achieve a concensus on the approach to be adopted.

DAR reported, together with OK, on the outcome of discussions they held earlier in the year with P. Fernandez Ruiz, Head of the Energy Technologies Division of DG17, Directorate-General for Energy, in Brussels. In general, this indicated that the CEC might support a targeted project in the field of heat pumps, (see later discussion).

The discussion on the first day centred on modifications to the document, which could be incorporated in a final version.

BS queried as to whom the strategy was targeted. DAR and PZ responded that it was to inform appropriate Directorate Generals within the CEC, to encourage industrial involvement, to promote heat pump technology, and to support the bringing together of a group of experts in the field. It should also help to encourage collaboration between CEC and national programmes. Mission Statement

With regard to points in the document, MFGvdS commented on the cost of CO2 storage, and if it was acceptable, the case for electric heat pumps served by efficient power stations could be helped. JMcM pointed out that with 45% plant efficiency (of generation) the PER would be 1.3. On page 4 of the document an existing heat pump would not save energy.

PZ said that there was a long term strategy which had three components, firstly electric heat pumps would be compatible with energy from renewables; secondly when all electricity generation was of high efficiency, electric heat pumps would be compatible. Thirdly, the use of hydrogen via fuel cells would give impetus to absorption cycle heat pumps. MFGvdS pointed out that biomass was also compatible with this scenario. PC suggested that cogeneration with heat pumps might give us too much heat. JMcM said that there was a problem associated with the identification of the heat load at the point of generation. The heat pump can help to distribute it.

JB suggested that a list of members of our Group and organisations should be included, and the list of CO_2/kW.h data should be extended. These data are available from HJL.

JMcM said that a lot of electricity generation plant is old and will need replacing in the next 15-20 years. This will lead to higher efficiency lant.

On a cautious note, MG said that there was no market for heat pumps at present. MFGvdS felt that it was too early to stimulate European industry. However, PO pointed out a difference between the short term strategy, which was determined largely be economic factors, and the long term strategy, which would be governed by other influences. DAR highlighted the interest of the electric utilities, even now, of heat pumps in forced ventilation systems in houses, but PO thought that this was a niche market.

HJL took a more optimistic view. He said that the German Heat Pump Centre had recently negotiated its next three year support programme, and in asking for support from industry, was able to raise 25% of the necessary budget from the utilities and industry. There were also offers from Japan to participate. This was therefore encouraging.

BS said that an Executive Summary was needed in the document, outlining the aims and scope. Pages 2-7 should be summarised in one CHapter. There should be additionally a chapter on the market potential, information on R&D, collaboration, national programmes, suggestions for collaborative projects and the target for the Group.

RA highlighted the experience of SINTEF in Norway. For the document he recommended that the 'essence' needed to be extracted and presented as a mission statement, with goals on one page. Each goal should be looked at in isolation, with each associated strategy. Extra data should be included as appendices.

It was **agreed** that the comments would be considered by all and OK for incorporation in a draft to be presented on the second day.

PRESENTATION BY JENS ANDERSEN.

Mr. Andersen of Lodam Energi, Denmark, made a presentation on the status of heat pumps in his country. He is Chairman of the Danish Heat Pump Producers Group.

Three years ago there was effectively no market. The government has now agreed to include heat pumps in its plans. Heat pumps can reduce CO_2 emissions by 18% minimum, and every heat pump installation receives a grant of 10% of the total investment, to a maximum of 6000 Danish Crowns (DCr). The heat pump must, to qualify, have been tested by the Danish Technical Institute, and this costs typically 85,000 DCr, of which 80,000 DCr is paid by the government.

The Institute has tested heat pumps for 10 years. Test conditions must be carefully planned and controlled. Tests are done at 10 different conditions.

The priority for heating is always water.

They are studying the quality of installers. 40 are required, and they are currently being taught. They will be provided with tools such as software packages to calculate heat losses in houses.

There are 10 manufacturers at present, making 1000 units per annum. There are 35,000 installations, most being electric drives to 15 kW. The maximum water off temperature is 55 deg.C, and as this is low for water heating systems, good insulation is essential. 90% of new houses have underfloor heating. Payback periods for the heat pumps are 4-5 years.

PRESENTATION BY RUNE AARLIEN.

Mr. Aarlien presented information on the brochures and other documentation used to promote heat pumps in Norway.

The brochure 'Heat Pumps in Norway' was directed at answering criticism of the R&D spend level, and gives information on prototype and demonstration plant. It is shown that one industrial heat pump can save more per year than the R&D spend. The brochure started with case studies, and later educational pages were added. It covers all application areas.

Under the Norwegian National Heat Pump Programme a 4 page ABC of heat pumps was prepared. This was in simple language, eg for children, and 40,000 copies were made. the 'How to Choose the Right Heat Pump for a House' was given a 20,000 print run, as was the 'CFC Brochure'. A computer simulation was prepared, and people paid to use it. It was targeted at heat pump suppliers.

THE HEAT PUMP BROCHURE.

Dr. Coda introduced the work he has been continuing on the heat pump brochure. This is presented as Appendix 6.

During discussion on the brochure, JK said that it needed to be kept short and simple. HJL had mixed feelings, DAR suggested that buildings and industry should not be mixed. BS stated that if the contents were equal for each sector, it was acceptable to have one brochure. The introduction would state that heat pumps would be the solution to a general problem.

PO pointed out that each country, eg the translator, could adapt the brochure to local conditions. OK asked whether there would be adequate information for installers. Is it part of the strategy?

MFGvdS said that it should be directed more at the decision-makers. Strategy was specific to each country. BS said that in Sweden they have brochures for installers in the domestic sector.

PC pointed out that the brochure must contain a synthesis of European experience. PZ asked what was the target? We have different target groups.

**** Action: Members of the Group were asked to send their national brochures to PZ.**

OK cited the IEA HPC brochure, which was similar to our first brochure. RA recommended that we restrict the target to decision makers, and leave it general, not country-specific. It is important to show that the CEC is active. The second step would be targeted and technical brochures. A mission statement was critical in each brochure.

JA agreed, but suggested that on Page 1 we should state the reason for spending money on heat pumps and the Support Group.

GdC said that firstly we should promote heat pumps for decision makers etc. This should be a short brochure (2-4 pages). Secondly, technical brochure(s) could follow.

HJL agreed. In Germany there was a primary need to present the benefits of heat pumps to decision makers.

MFGvdS said that the input of a marketing expert was needed. DAR offered to act as editor for the English drafts. RA said that instead of using a marketing expert, the draft should be sent to some of those to whom it is targeted for comments.

**** Action: Comments are to be sent to Dr. Coda at ENEA by 15 May 1993.**

THE MARKET STUDY.

M. Guittard presented information on the current status of the market study. (See minutes of secong meeting for plan of action). The study commenced on 2 February 1993 and was currently in the first phase. They were analysing existing studies and preparing interviews in different studies. Information on the BSRIA study was still needed, (some data on this was obtained from the IEA Heat Pump Conference - DAR). It is proposed to complete the first phase by the end of April, and data will be integrated after the IEAHPC. It may be possible to comnplete the study before the Summer of 1993.

The areas to be investigated should include effluent treatment, the food industry and district heating and cooling. Propsals are to be submitted to the CEC by MG for the second phase of the study.

JOUE-0046 PROJECT.

The final report on the above project had previously been circulated to members by PZ. The report was well received and in response to queries it was said that the intention was to publish it as a CEC report. KN suggested that a summary report should be published, with remarks that the full report could be made available.

CANJOULE COMMITTEE.

PZ circulated a list of names of the members of the national teams on the CANJOULE Committee. These people assist in planning and implementing the JOULE programme for DG12. This is included as Appendix 7, together with a list of Commission services and Directorates-General.

JOULE 2 EXTENSION.

PZ and GdC gave provisional information on a supplementary JOULE 2 programme for R&D, including work on heat pumps. The Supplementary call for proposals has now (1 May 1993) been published, and the relevant data are included as Appendix 8. Note paragraph 4.2.10 of this Appendix.

FURTHER ACTION ON CONCERTED ACTION GROUP.

Considerable discussion followed on the proposals of OK, and OK, in conjunction with JMcM, prepared a draft document for submission to the THERMIE programme managers and committee on a targeted project. The first draft is attached as Appendix 9.

Subsequently, members of the group have been lobbying THERMIE committee national representatives with a view to obtaining support for this in the next THERMIE call.

DATE OF NEXT MEETING.

The date of the next meeting of the Supporting Group has been set for 12 & 13 October 1993. The venue has yet to be set, and will be communicated to members with the meeting programme in due course.

Prof. D.A. Reay,
3 May 1993.

HEAT PUMP SUPPORTING GROUP,
(IN FUTURE TO BE KNOWN AS HEAT PUMP CONCERTED ACTION GROUP).

FOURTH MEETING.

BRUSSELS, 12 & 13 OCTOBER, 1993.

MEETING MINUTES.

The fourth meeting of the Heat Pump Concerted Action Group (CAG) was held in Brussels, hosted by the CEC, on 12 & 13 October 1993.

Those attending were:

Prof. D.A. Reay, United Kingdom (Chairman).
Ir. P. Zegers, DGXII, CEC.
Dr. G. Deschamps, DGXII, CEC.
D. Gilliaert, DGXVII, CEC.
P.A. Oostendorp, The Netherlands.
Prof. J. Berghmans, Belgium.
F. Guittard, France.
Dr. P. Riesch, Germany.
E. Merlin, France.
S. Kerr, United Kingdom.
Prof. H.J. Laue, Germany.
N. Maloney, United Kingdom.
U. Rivenaes, Norway.
O. Kleefkens, The Netherlands.
F. van Nielen, The Netherlands.
Dr. P. Coda, Italy.
F. Canci, Italy.
Ir. J. Knobbout, The Netherlands.
G. Korn, Italy.

A list of attendees, giving addresses, telephone and fax numbers, is attached as Appendix 1.

Apologies for absence had been received from W. van der Veen, The Netherlands; J. Andersen, Denmark; J. Zaugg, Germany; F. Valle, Spain; Prof. J. McMullan, United Kingdom; B. Sellberg, Sweden; Dr. H. Scharer, Switzerland, R. Aarlien, Norway; and J. Pritchard, UK.

The programme of the meeting is included as Appendix 2.

CHAIRMAN'S INTRODUCTION.

The Chairman introduced the meeting by welcoming those who were present for the first time. Mr. Merlin from ADEME in France had a particular interest in the Concerted Action Project discussed during the meeting, Ulf Rivenaes, who ran the Norwegian National Heat Pump Programme, has, together with Rune Aarlien, had a considerable influence on the promotional activities of the CAG, and Florence Guittard is to be responsible for the second stage of the market study on heat pumps. Dr. Riesch was present because of his involvement in DGXII-funded R&D on absorption heat pumps, and Mr. Gilliaert, representing DGXVII, the Energy Directorate, was welcomed, in particular as a representative of a complementary programme (THERMIE) which features in our strategy document.

INVITED PRESENTATIONS.

Dr. Riesch presented information on the research of his Group, under Prof. Alefeld in Munich. He described the activities on the high efficiency triple effect absorption chiller and claimed that the use of a single effect machine, in conjunction with combined heat and power plant, could give energy savings of the order of 80%. This would be achieved by using the heat for district heating, and an absorption heat pump with a COP of 1.7. Also being studied was the cogeneration of heat and refrigeration.

Information on the activities of the ZAE Bayern Group is given in Appendix 3.

Ulf Rivenaes described the Norwegian National Heat Pump Programme, under the auspices of the Norwegian Water and Energy Administration (NVE). This programme has a current phase scheduled for three years (1993-1996).

The main motivation was the CFC issue, CO2 reduction not being important in Norway because of the large hydro-electricity generation capacity. The heat pump programme was managed by a Board which involved industry, the Research Council, consultants and the Heat Pump Association. The budget was US$ 1 million in 1993, and this is the spend rate planned for the subsequent years of the current programme. One feature is a 30% support investment subsidy.

The programme on heat pumps is large relative to other energy-related programmes in Norway. In 1993 600 heat pumps were installed, larger units being the most poular. With one million homes in Norway, a realistic target for domestic heat pump installations is seen as 36,000 over a ten year period. The size of these units would be 2-4 kW. Market penetration is seen as being limited by the low electricity prices in Norway.

Mr. Gilliaert described his role on behalf of the Energy Directorate, DG17. In particular he works for the THERMIE programme, which is an energy technology programme directed principally at the promotion of energy technologies to assist penetration into the marketplace. Relevant to DG12 activities was the fact that successful R&D could be routed into the THERMIE programme.

There is an annual call for proposals under THERMIE, and the current call closes on the 1st December 1993. This covers the rational use of energy in both industry and buildings. Heat pumps feature in the call, more specifically for cooling.

He emphasised that the programme did not deal with prototypes, rather the promotion of commercial projects which might otherwise not get into the marketplace because of financial or technological risks. Up to 40% of the cost of the innovative content was possible as support.

In the longer term, Mr. Gilliaert stated, DG17 wanted some structure in this area, in the form of targeted projects. However, the competition for such projects was considerable, and it was necessary to show to DG17 the benefits from using heat pumps. These should address a number of points:

a) Energy saving potential.
b) Benefits for European industry - either by being highly innovative or offering modest improvements compared to existing US/Japanese competition.
c) Employment benefits.
d) The priority areas should be identified.

In response to a question, it was stated that under the current call the heat pumps were not just for cooling. Absorption cycle units driven by waste heat could be for heating and/or cooling, but the European benefits had to be demonstrated.

Ir. Zegers pointed out that there was closer collaboration now between JOULE and THERMIE, and this was likely to grow in the future. Mr. Kleefkens said that the CAG could help with decisions to put heat pumps into THERMIE. Ir. Zegers said that some of the activities discussed today were more appropriate to OPETs than THERMIE. Prof. Reay asked if the subject of environmental protection was significant for THERMIE. It was stated that this was now reflected in the programme. In reply to a question from M. Guittard concerning the location of projects, it was said that these should be done in Europe unless a strong benefit for European industry could be seen. Prof. Laue said that national government support was needed to influence the acceptance of heat pumps into THERMIE.

At this point Mr. Gilliaert invited the CAG to consider a strategy and topics which might be included in THERMIE, were a budget of 2-5 MECU available for heat pumps. It was agreed that ideas would be presented in the session on the second day of the CAG meeting, when Mr. Guilliaert would again be present. (See later and Appendix 10).

JOULE 2 SUPPLEMENT PROJECT: A CONCERTED ACTION ACTIVITY.

Currently at the stage of contract negotiations, this proposed project was described by the co-ordinator, Prof. Reay.

The aim of the project is to ensure that the results of the R&D in the area of heat pumps (and related technologies) can be effectively transferred to potential users and others, in particular in the buildings sector. Five initiatives form the project, the core being the Concerted Action Group - effectively continuing the Supporting Group initiative.

The Technical Annex to the proposed project, which describes the work packages, is detailed in Appendix 4. One work package, the market study, was presented later at the CAG meeting.

Mr. Gilliaert pointed out that there were no participants from Southern Europe. It was stated that Southern European countries would be included in the market study, and representatives from Italy and Spain are members of the CAG.

THE HEAT PUMP BROCHURE.

Dr. Coda introduced the current version of the heat pump brochure, (see Appendix 5).

In the discussion, Mr. Kerr recommended that some statistics be included, eg the current installation rate in Norway and Switzerland, and their targets. The figure implied that heat pumps were only associated with large houses. Ir. Zegers felt that the brochure needed to direct the reader to sources of further information. Mr. Gilliaert suggested that heat pumps in buildings should be integrated in a more general context - there are other solutions to the building energy problem. Mr. Kerr said that simple illustrations were needed. Dr. Deschamps agreed - the type of building for a heat pump should be a general one. Mr. Gilliaert said that before one comes to the heat pump solution, best use should be made of energy management and 'good housekeeping'. The current house figure implies a heat pump (vapour compression type) gives no pollution. It was agreed that a smaller cloud should be shown!

Mr. Kerr said that people would not install heat pumps (or make them) for altruistic reasons, it would be done to make money. Florence Guittard pointed out that there was no proof of money saving. Dr. Coda said that the brochure was addressed to installers and percentage savings figures would be useful. Mr. Gilliaert said that the activity fell within the framework of the Rational Use of Energy programme, and therefore one needed to give realistic general information. Factors such as payback needed to be indicated. It was also pointed out that the picture on the first page was too complicated.

Mr. Kleefkens said that examples of cost-effective heat pump use from demonstration programmes should be included at the end of each section. The address of the IEA Newsletter should be included, said Mr. Rivenaes, and Ir. Zegers said that additionally OPETs and EUREKA references should be given.

It was agreed that English editing should be carried out, and contact points were needed for each European country. Ir. Zegers pointed out that we need to accept US and Japanese equipment if the aim is energy saving. We also need to stimulate European industry. Mr. Maloney said that more information was needed on European heat pump manufacturers.

It was agreed that contact points for each country be incorporated and reference be made to the data base. Payback data for installers was needed, and discussions would be held with the IEA re reference to their Newsletter.

Action: All CAG members are to give a short summary of a suitable project to Dr. Coda as soon as possible (4-5 lines).

The figures need to be given captions and a title is needed for the brochure.

Action: Suggestions for these to be sent to Dr. Coda.

Action: Prof. Laue, Mr. Kerr, Ir. van Nielen and Dr. Riesch are to consider an appropriate 'scheme' (figure for the Summary.

The table on page 6 was felt to be too negative.

Action: The brochure would be sent to Prof. Reay for editing, once the comments had been received by Dr. Coda and incorporated into the brochure.

THE ENERGY POLICY OF THE NETHERLANDS.

Mr. Kleefkens outlined the energy policy in the Netherlands, for 1994, as it affected heat pumps.

The programme has a target of achieving a 2% increase in energy efficiency per annum. In particular, it is believed that more needs to be done in the buildings sector to meet this target. It is recognised that it is a long term process getting new technologies into the marketplace, thus one needs long term programmes to implement this.

The energy savings goal is 5-10 PJ in 2000, and 50 PJ by 2010. Target groups are essentially classified as market/technology 'clusters', affecting industry, energy networks for buildings and information and technology transfer and standardisation. The tasks cover demonstration, R&D, technology transfer, schooling and the establishment of design rules.

M. Merlin queried whether the Netherlands had a heat pump industry, or whether it intended to. In reply, Mr. Kleefkens said that some were made there already, and it was part of the policy to encourage local manufacture. The budget for the programme was not available at this time.

HEAT PUMP STRATEGY DOCUMENT.

Mr. Kleefkens then introduced a modified version of the heat pump strategy document which was discussed at the last meeting. (This is given as Appendix 6). The document was introduced, for discussion during the second day of the meeting (see later).

THE MARKET STUDY.

Florence Guittard then introduced the market study, the second phase of which is scheduled to commence at he beginning of January, 1994 and to take 6 months. The study falls within the framework of the concerted action activity under JOULE 2 Supplement, as outlined in Appendix 4.

The overheads presented are given in Appendix 7.

Discussion centred on the need to attract people to the group discussion sessions to be held in each country. It was felt necessary to mail information to potential participants on the approach to be adopted during the interviews. The aim is to qualify the market and to discuss ways to be used to attract customers to heat pumps.

Mr. Maloney pointed out that a follow-up activity was needed. It was felt that this might be in the form of a demonstration. Mr. Rivenaes mentioned the use of a heat pump performance competition in Scandinavia, for heat pumps for small houses. This might be of interest as a THERMIE activity.

Another suggestion was to solicit the assistance of appropriate OPETs throughout Europe to assist with the identification of people who might be invited to the meetings.

Action: Ir. Zegers was to approach the Head of the OPET Programme about this possibility.

DAY 2.

PROPOSALS FOR THE THERMIE PROGRAMME.

The Chairman invited each member of the CAG to put forward proposals which might meet the criteria set by Mr. Gilliaert for suitable THERMIE projects in the area of heat pumps. Each person present gave his comments, as follows:

Mr. Rivenaes believed that it was difficult to differentiate between goals and activities. Prototype demonstration had been strongly supported by THERMIE. There should be a common goal for all participating countries, and it was necessary to identify these common goals. Both the building sector and industry were considered important.

Mr. Canci felt that an important consideration was to direct activities at areas where the aim was ultimately mass production of the units. Gas fired systems which could operate throughout the year (ie for both heating and cooling in Southern Europe) were important.

Dr. Coda highlighted the use of waste heat in towns to increase the COP of heat pumps. All heat sources should be considered, for both absorption and vapour compression cycle heat pumps. Both heating and cooling duties should be addressed in the same unit. This resembled the Japanese activity. He felt that the priority should be given to buildings. For industry, he believed that heat pumps operated at too low a temperature.

Ir. van Nielen pointed out that THERMIE had a relationship to the national programmes. The Dutch strategy was to look for good projects. The Rendamax absorption project was in the national programme. Absorption was also needed in THERMIE.

There was a need to strengthen the industry in Europe. Thus one needed to cover the projects having the best benefit fopr Europe. He believed that absorption heat pumps and heat transformers should be included. Also, a project involving a large number of electric heat pumps would benefit European industry. Projects would be appropriate for either industry or the buildings sector.

(Mr. Kleefkens commented here that the photovoltaics programme had a parallel initiative. Projects are needed in the sectors which can lead to the best benefits).

Ir. Knobbout felt that encouragement should be given to the mass production of compressors for new refrigerants, in particular compressors suitable for heat pumps. Instruction and education were very important. Adsorption should not be neglected in the THERMIE programme. He also recommended that an energy bus be used to promote heat pumps by going to process plants.

M. Guittard stressed that the starategy should concentrate on projects capable of giving the most promotion - eg city-type installations in several buildings. This was compatible with the propsals of Dr. Coda.

Mr. Korn felt that the promotion of residential heating and cooling systems was important. In a written submission he felt that it would be appropriate to have a homogeneous and coherent methodology for calculating efficiency in order to use electricity, natural gas or Diesel oil for heat pumps. In fact it would be useful to consider the losses in production, transport and distribution of all energetic sources, and not only for electricity (see page 6 in the first heat pump brochure). This might form a separate task outside the THERMIE programme, and could be appropriate to DG12.

Prof. Reay felt that 'good practice' type projects involving multiple installations of heat pumps in conjunction with forced ventilation heat recovery might be appropriate. If done on a regional basis, these could cover heating-only and heating/cooling applications. For industrial applications, he felt that drying was an important area. Perhaps to be carried out initially as R&D, the use of heat pumps on continuous dryers was felt to offer significant energy savings, and this could be based on a consortium of European dryer manufacturers. Promotion of heat pumps in effluent concentration was also believed important.

With regard to strategy, he suggested that a 'letter of intent' to tender for targeted projects might enable a preliminary sifting to identify the most suitable projects to be put forward for a final consideration. It might be appropriate to offer some support for the preparation of short-listed proposals.

Dr. Deschamps said that THERMIE complements JOULE activities, projects in the latter should lead to suitable THERMIE projects. He would include all application sectors. He felt that the idea of a performance competition was a good one, and would also include quality assurance as a criterion.

Ir. Zegers recommended that one should aim for applications where a market could be shown to exist. For example, heating and cooling in buildings was considered important. Japan was very strong in vapour compression cycle units. In Europe we had a good group on adsorption, and were relatively strong in this technology. A targeted project could be urban networks, with heat pumps using waste heat.

Ir. P. Oostendorp believed that THERMIE should focus on heat transformers for high temperature applications. New working fluid pairs could be used (eg alketrates), in conjunction with a process user in the EEC. It could be employed possibly as part of an urban network, giving a temperature lift from 180 deg.C to 220 deg.C.

Mr. Kleefkens considered the policy aspects. He pointed out that in the past here had been a lot of isolated demonstration projects. Now the trend was towards (fewer) targeted projects. There was a need to demonstrate an 'energy infrastructure', of which heat pumps could be a part. Additionally, targets should be set at the outset for each project.

He felt that the SAVE programme could deal with quality and regulations, integrated with THERMIE and JOULE. Subsidiarity was important, there existing a responsibility at national levels for stimulation. The OPET network should be examined with a view to employing it to promote heat pump technology.

Mr. Kerr, speaking as a UK manufacturer, said that people were still not using heat pumps, and this needed to be corrected. At present the payback period was too long. This was particularly true with regard to industrial heat pumps (showing a good payback). One should also not reinvent the wheel and the available and new technologies should be carefully studied in selecting projects. One should also encourage European manufacture.

Dr. Riesch felt that for space heating duties greater than 500 kW a single effect absorption system would be suitable. In the 50-500 kW range, one needed mass production of single or double effect machines. These could have a cooling role too. For smaller duties an ammonia cycle could be used. Advanced cycles could be demonstrated for using waste heat from cogeneration plant to give temperatures of -20 to -30 deg.C. The absorption heat transformer with a booster compressor could be used for drying waste etc. With regard to absorption cycles, efficiency improvements were needed, particularly for cooling.

Mr. Maloney considered industrial heat pumps. He saw opportunities for promotion for effluent treatment/drying, where there were also environmental implications. For example, the use of waste heat from CHP units for drying/evaporation of effluents.

M. Merlin said that in France there were 150 mechanical vapour recompression units and >450 vapour compression systems, so no demonstration was needed. Working fluids are a problem, but this is not an energy efficiency area. He saw absorption and adsorption systems as having new application areas, such as high temperature duties in industrial processes. He felt there was a missing link between research and demonstration - ie industrial development.

Prof. Berghmans recommended fostering international evaluation (in the EEC) of promising heat pump applications. He commented on 4 specific areas:

1) Experimental networks. Eg buildings. For houses the experience of exhaust air source heat pumps in Northern Europe could have possible applications in Southern Europe for air conditioning. Central Europe (eg Belgium) could benefit from these studies.

2) For small heat pumps the safety of alternative working fluids such as propane could be investigated, as a vehicle for the large scale application of these systems.

3) Supermarkets were seen as an application area, as large heating and cooling loads are coincidental.

4) Industry was seen as a decreasing heat pump market, as evidenced by the trend in recent years. Heat pumps with CHP were a possible future exception.

Prof. Laue stressed the need for a better link between JOULE and THERMIE. The JOULE projects which could go to THERMIE should be identified. Marketing and SMEs were becoming important. With regard to specific projects he cited Dresden, where heat pumps could be combined with district heating and fuel cells. Engine-driven compression and absorption systems need further investigation and the stimulation of European suppliers is needed. He has seen no OPET projects directly related to heat pumps.

THE JOULE 2 SUPPLEMENTARY PROGRAMME.

Dr. Deschamps then outlined the projects which were currently the subject of contract negotiations under the JOULE 2 supplementary programme.

The data presented, and the review of the overall submissions in other areas of JOULE, are given in Appendix 8.

THE DATABASE HPEC AND PAPER ON THE IMPACT OF HEAT PUMPS ON GLOBAL WARMING AND OZONE DEPLETION.

Prof. Laue presented information on the current status of the database project under JOULE 2, HPEC. This now involves ENEA and TNO, as well as FIZ. The overheads are given in Appendix 9.

He then presented a summary of his paper given as a keynote address at the CHISA Congress in Prague in August

1993, where the 4th International Workshop on Heat Pumps formed part of the Congress. This is given as Appendix 10.

(Note that the Chairman was absent during this presentation, to produce a summary of the THERMIE discussion for presentation later - hence the paucity of notes!).

DISCUSSION ON THE EUROPEAN HEAT PUMP PROGRAMME DOCUMENT.

Members of the CAG had an opportunity to read the strategy document prepared by Mr. Kleefkens and Ir. van Nielen. There were a considerable number of comments and these are given below.

Dr. Coda said that the European challenge was not satisfied. He suggested that we should compare what we want and then compare this with the USA and Japan.

Mr. Kerr said that more data were needed. Eg on the NOx SOx CO2 problem, vis a vis national and EEC targets. This may make it more acceptable politically. The Laue table in his paper might give these data. One could then say that "the introduction of heat pumps on such a level would contribute.....". With regard to barriers, he felt that unreliability was emphasised too much. There was an incomplete perception of 'return on investment'.

Prof. Berghmans felt that 'Barriers' should go into the introduction. CAG was a Programme Tool. He suggested:

1. Introduction.
2. Mission statement.
3. Strategies (a separate section was important here).
4. A European Heat Pump Programme.
5. Programme Tools.

On 1.1, he agreed with Dr. Coda. There should be a European reason, and no mention of AD Little.

Dr. Riesch wanted absorption and adsorption heat pumps to be mentioned, as well as electric units, on Page 1, where reference is made to higher COPs. Mr. Kleefkens said this was a summary of Japanese and US positions. On Page 4, fluids are still important, eg additives. (Dr. Riesch). Ir. Zegers suggested appendices for R,D&D and dissemination. Mr. Kerr said that on Page 2 the US and Japanese position should be qualified. These are heat pumps for standard applications, and are small and medium sized units.

Prof. Berghmans said that one should include the positive, as well as negative, points in the Introduction. These are relevant (also) to air conditioning and refrigeration. M. Guittard said that reference should be made to programmes on the way, for example some of the tasks in these. Prof. Laue highlighted Altener - the SAVE programme for renewables. Dr. Coda said that in the Strategy, reference should be made to CEN and other Concerted Action Groups.

Prof. Laue said that under Barriers, we have compressor suppliers but not so many small gas engine manufacturers, and fewer absorption equipment suppliers. Mr. Rivenaes said that in future in Norway they were proposing to deal directly with heat pump suppliers in order to help them sell good heat pumps. This was also the case for other energy-efficient technologies.

M. Guittard said that the document should emphasis the setting of GOALS, not the highlighting of BARRIERS. Mr. Oostendorp said that one should leave in the barriers, but follow each one with a goal which would overcome the barrier. Also, the environmental goal (page 4) was not so instrumental, the goal was more operational. M. Guittard said that what were identified as barriers were really challenges. Mr. Maloney said that there was no consistent government policy on heat pumps - for example in the UK heat pumps were not considered as renewable energy.

Dr. Deschamps said that as well as the EEC and EFTA, one should now add Eastern European countries, and Ir. Zegers said that as well as JOULE, BRITE etc, the OPETs should be added. M. Guittard said that COP, THERMIE etc should be explained, in the form of a list of abbreviations. Mr. Rivenaes said an Appendix listing addresses and main country contacts should be included.

Ir. Knobbout said that on page 4 under Technical Goals, one was the search for acceptable working fluids, <u>not</u> improving existing ones.

Ir. Zegers asked what would be done with the document. Mr. Kleefkens said that it would be directed at high and low policy makers. It will explain what we as a Group has in mind, and mention should be made of the CAG. The topic has not yet been discussed in CANJOULE and THERMIE committees, in the context of the CAG, and should be discussed in both.

Prof. Berghmans said that on page 5 the sentence beginning: "The emphasis is on..." should be removed.

Mr. Kerr said that we should get editorials on the strategy in trade journals. Ir. Zegers wanted to see the composition of the CAG in the document. Mr. Oostendorp said that in Section 6.3 end users should <u>be shown that</u> heat pumps are reliable. Mr. Maloney queried whether system cost reductions should be included in the Mission Statement. It was felt that they should, as they were key words. Mr. Rivenaes asked whether each country would be encouraged to translate the document. It was agreed that this was a good idea. Dr. Deschamps said that it could be arranged to have this done externally, or each country could do it.

Ir. Zegers asked that targeted projects should be mentioned where reference is made to THERMIE.

Actions: **A new version would be produced in 2-3 weeks. Prof. Reay would circulate this version. Mr. Kleefkens said that publication would be by the end of January or early Febuary 1994.**

DISCUSSION ON IEA/CEC RELATIONS.

Dr. Coda introduced the topic of collaboration between the IEA and the CEC. He proposed that the CAG participates in the IEA Implementing Agreement on Heat Pump Technology. The aim would be to avoid duplication of effort, to represent CEC interests and to increase and diffuse heat pump knowledge.

He said that this question arose at the last meeting of the IEA Executive Committee, and in order to participate, a fee of $7,000-10,000 would need to be paid as an 'administration fee'. (In order to join an annex such as the IEA Heat PUmp Centre, the fee woud be greater, in addition).

Prof. Berghmans said that if the CEC became members, smaller countries would be able to participate. Ir. Zegers said that this would not be acceptable to the IEA. Mr. Rivenaes said that all countries have a national team and receive invitations to participate in IEA heat pump projects. He felt that countries may receive better proposals from the CEC, leading to a possible shift in support.

Mr. Oostendorp said that an observer from the CEC might be appropriate, and Prof. Berghmans said that an observer had been invited some 5 years ago, while Mr. Kleefkens felt that some of the CAG members could represent both interests. Ir. Zegers said that there were practical problems in joining Annexes, there was a lot of red tape and only a small staff to handle this and other activities.

M. Merlin felt that participation in the IEA Executive Committee would not be very interesting. Ir. Zegers proposed that the CEC accepts observer status. Mr. Rivenaes pointed out that he will participate in the IEA for the next four years. He would be prepared to give presentations in Norway and to the CAG on this topic, and report to the IEA on our activities. He also said that there may be specific annexes the CEC could join in the future. The CAG felt that this was a good solution, and no formal action on the part of the CEC is needed.

SUMMARY OF RECOMMENDATIONS FROM THE CAG TO THERMIE.

Following the invitation on Day 1 from Mr. Gilliaert for the CAG to make suggestions concerning the strategy of THERMIE and possible project areas in the heat pump field, the Chairman presented a summary of the recommendations. These are given as Appendix 11.

In replying to the presentation, Mr. Gilliaert emphasised that THERMIE does not aim to support prototypes. It now concentrates on promotion, but the technical risk involved is relative. THERMIE is also competitive between sectors, and proposals for funding are received from each sector.

Ir. Zegers stated the example of fuel cells, where for MCFCs the economic feasibilty was not always demonstrated, but THERMIE hesitated in supporting a prototype. Mr. Gilliaert confirmed that there needed to be a strong involvement of the equipment manufacturer, and for education etc. the OPET structure could be involved in collaboration.

Prof. Laue had read the evaluation report of the THERMIE programme and there were some isolated projects. There was a suggestion of joint JOULE/THERMIE contractors meetings. Ir. Zegers requested that THERMIE supply short descriptions of THERMIE heat pump projects for distribution to the CAG.

Mr. Gilliaert said that targeted projects on average received 15-20% funding from the CEC.

RETIREMENT OF STEWART KERR.

Stewart Kerr of Howden Compressors is to retire shortly. The Chairman thanked him for his active participation in the meetings of the CAG, and on behalf of those present wished him a happy retirement.

ANY OTHER BUSINESS.

The Chairman pointed out that a Concerted Action activity on advanced heat exchangers, albeit on a limited scale, was due to commence at the beginning of 1994. He undertook to keep the CAG informed of relevant developments, eg on compact heat exchangers, in this area.

The Chairman also expressed the view that it was difficult to act as both Secretary and Chairman. He had therefore approached Mr. Kleefkens with a view to his taking the chair, for the next two meetings. Mr. Kleefkens is to consider this.

Referat
fra

Executive Committee Meeting
IEA Implementing Agreement for Heat Pumping Technologies

2. og 3. mai, 1993
Maastricht, Nederland

Til stede: B.Sellberg (SWE), E.Granryd (SWE), P.Coda (ITA), R.Aarlien (NOR), U.Rivenæs (NOR), S.H.Ross (TSSU), G.Groff (Advisory Board), J.Ryan (USA), T.Tatsis (UK), F.v.Nielen (NED), G.Maass (IEA), J.Berghmans (BEL), Schacht (GER), Yasin (MAL), H.Halozan (AUT), Merlin (FRA), D.Cane (CAN), Yoshimura (JAP), Kato (JAP), Sakamoto (Advisory Board), K.Snelson (Chairman), J.Bouma (HPC)

Det følgende er et utdrag av de viktigste punktene (nummerering jfr. agenda). Agenda er vedlagt som **vedlegg 1**.

4 Ingen kommentarer til forrige referat, som dermed godkjennes.

5.1 Vår End Use Working Party vil gjennomføre en analyse av de forskjellige Implementing Agreements (IA) effektivitet og suksess, med det mål at samarbeid skal forbedres og overlappende arbeid unngås. Det er også et mål med analysen at informasjonsflyten mellom de forskjellige IA skal forbedres. (**vedlegg 2**).

5.2 Finland ønsker å trekke seg fra IA. Alle landene godtar dette ønsket. Frankrike har blitt med i IA, og vil innen kort tid bestemme seg for hvilke annexer de vil ta del i. Spania og Portugal har vist interesse for å bli med i HPC. Mr. Youshimura er oppnevnt som ny delegat fra Japan.

5.3 IEA har ennå ikke hørt noe fra Malaysia. Malaysias observatør melder at det ennå kan ta tid før saken blir avgjort. Man forhandler med både energidepartementet og miljøverndepartementet. Forventer svar ved utgangen av året.

5.4 Ryan foreslår å gjøre et annex under vår IA på "Dessicant Cooling". Man kunne invitere Torbjørn Bostrøm (SWE) til å lage et forslag. Rundt bordet er 60-70% interessert i å være med i et slikt annex.

5.5 GREEN-TIE er startet, men er ennå ikke noen IA. En styringsgruppe med T.Bostrøm som formann er oppnevnt og NOVEM har ansvaret for driften. Oppstartperioden vil ta ca. to år. Foreløpig er 13 land med, og hensikten for å begynne med er å lage en database over adresser hvor man få svar på spørsmål om drivhusproblemet. Prosjektet vil være operativt fra midten av 1993. Vil bli cost-shared. Avtalen er undertegnet på regjeringsnivå.

IA på Process Integration er også under oppstart. Prosjektet, som ikke vil ta av i år, vil bli et relativt dyrt (cost shared). Chalmers (SWE) og UMIST (UK) er aktuelle til å etablere senteret.

6 Et av våre mål er å styrke samarbeidet med andre IA og organisasjoner. Som et ledd i dette arbeidet presenterer Sellberg "Energy Storage IA" og v.Nielen presenterer "EFs støttegruppe for varmepumper".

7.1 Møtet er enig i at strategiplanen nå får ligge til høstmøtet, og at oppdateringer gjøres da.

7.2 Bouma går igjennom alle "actions" og forklarer status. Det ender opp med en lang diskusjon om de forskjellige aktivitetene - om de i det hele tatt burde være med, og om de er satt opp med riktig antall timer.

8.1 Ingen har noen innvendinger mot "IAs Legal Text".

8.2 På det siste møtet i Merligen fikk man problemer med at møtet på slutten av den andre dagen ikke var beslutningsdyktig fordi flere delegater hadde reist hjem. Regelen er at 50% av deltakerlandene pluss ett må være til stede for at møtet skal være beslutningsdyktig. Formannen foreslår at man heretter setter kl. 1600 som et tidspunkt da møtet skal være avsluttet den andre dagen. Deltakerne får da legge opp sine reiseplaner deretter. Man vil også forsøke å legge saker til beslutning tidlig på agendaen. "Any Other Business" tas ut.

8.3 IA årsrapport godkjennes med et par små bemerkninger (**vedlegg 3**).

9.1 Pga. alvorlig sykdom trodde man at Annex 8 og Annex 15 ikke ville bli avsluttet med rapport. Canada var operating agent for begge. I ettertid har man fått god hjelp og støtte fra de andre deltakerlandene (spesielt Østerrike og Dr. Halozan), slik at rapporter nå er sendt ut for kommentarer. De vil forhåpentligvis være klare til neste møte.

9.2 Rapportene - inkludert den for annex 20 - godkjennes (**vedlegg 4**).

Annex 17: Ferdigstillelse av rapporten har tatt lengre tid enn forventet og man trenger en formell utsettelse.

Annex 18: Annexets første periode er avsluttet, og man har bl.a. kommet frem til internasjonalt anbefalte og aksepterte tilstandsligninger for R-134a og R-123. I forlengelsen vil man konsentrere seg om alternativer til R-22 og om ammoniakk. Ellers er det opp til hvert enkelt land å bidra med det de vil.

Annex 20: Rapportutkast deles ut til deltakerlandene. Ønsker kommentarer innen én måned. Det vil bli arrangert en workshop for deltakerlandene for opplæring i bruk av software. Kan muligens bli én i japan og én i Europa.

Annex 21: Man strir fremdeles med det problem at kun sju land har konfirmert sin deltakelse. Malaysia kan bli det åttende, med ting tar tid. Frankrike er 95% sikker på at de blir med og formelt svar vil bil avgitt innen utgangen av mai. Plan for evt. løp med kun sju land diskuteres.

9.3 Professor Berghmans presenterer hovedkonklusjonene fra Annex 20: Working Fluid Safety. Med det underlag Berghmans har hatt til rådighet fremstår ammoniakk som et lite farlig medium. Det er også laget software for beregninger av farlige situasjoner som kan oppstå ved lekkasjer. Berghmans mener at arbeidet nå må rettes inn mot riktig produktdesign for å unngå farlige situasjoner. Kopi av rapporten finnes hos undertegnede. Flere land som ikke har vært med ønsker å få kjøpe rapporten. Dette lar seg ikke uten videre gjøre, men kan bli aktuelt hvis alle deltakerlandene er enige om å frigi den.

9.4 Ingen rapport foreligger fra Annex 17 og kun foreløpig rapport foreligger fra Annex 20. Begge operating agents ber om å få utsettelse til høstmøtet med å avslutte annexene. Utsettelse vedtas.

10.1 Japan presenterer sitt forslag til nytt annex på "Chemical Processes for Ecological Thermal Energy Systems" (**vedlegg 5**). Dette vil bli et delvis cost-shared og delvis task-shared prosjekt. USA, Canada og Japan er de eneste som er sikre på at de vil delta, mens Sverige og Frankrike vurderer. Endelig avgjørelse på om annekset vil bli startet ventes på neste møte.

10.2 Bouma presenterer forslag til nytt annex på lav-temperatur energisystemer i bygninger (**vedlegg 6**). Ønsker på dette tidspunkt at landene vurderer forslaget og at man kommer tilbake til saken på neste møte. Det kan også bli aktuelt å kjøre forslaget som et Special Task eller en Analysis.

10.3 Forslag til godkjenningsprosess for annexer presenteres og godkjennes (**vedlegg 7**).

11 Undertegnede presenterer vårt National Team og det som er gjort under Program for Anvendelse av Varmepumper. Får skryt for det vi har gjort!

12.1 Årsrapport for TSSU godkjennes (**vedlegg 8**).

12.2 Bouma presenterer status for TSSU (**vedlegg 9**).

12.3 Distribusjon av rapporter fra annexer diskuteres (**vedlegg 10**). Man blir etter hvert enig om at den generelle politikken bør være at så mye som mulig skal gjøres åpent og tilgjengelig for alle IA landene så tidlig som mulig. OA og deltakerlandene skal imidlertid ha mulighet til å ta ut "følsom" informasjon, og til syvende og sist så er det disse som bestemmer.

13.1 Advisory Boards rapport til Executivkommiteen (**vedlegg 11**) presenteres av Groff, som er meget godt fornøyd med HPCs arbeid det siste året. Spesielt bemerkes at finansene har hatt en positiv utvikling, og at denne situasjonen ikke bør resultere i lavere kontingenter for deltakerlandene. AB støtter fullt ut en bredest mulig distribusjon av annex rapporter. Videre anbefaler AB at en gruppe blir nedsatt for å sikre at publikasjoner får den standard de bør ha. Gruppen blir bestående av formannen, en representant fra USA, Norge og Japan. Gruppen får også ansvaret for å lage en logo for IA (Norge har utspillet). AB vil fra nå gi råd til hele IA og ikke bare Annex 16 (HPC).

Formannen og AB ønsker å skifte ut ett av gruppens medlemmer (Mike Bell) for å få inn mer "faglig erfaring og tyngde", samtidig som man ønsker én til fra Europa for å få en mer riktig geografisk fordeling. Flere kandidater nevnes, og man bestemmer seg for å prøve å få med Schneeberger fra OKA og Østerrike. Schneeberger representerer IPUHPC. Det er et poeng at man ønsker noen fra denne organisasjonen, som selv har nominert Mike Bell til jobben. Formannen vil nå prøve å få med Schneeberger. Det gamle AB fungerer til neste møte.

13.2+3 Rapportene fra HPC (**vedlegg 12**) presenteres av Bouma og godkjennes. Ryan ønsker imidlertid mere detaljer mhp. hvor mange henvendelse HPC får fra de forskjellige land. Ryan ville generelt ha hatt en noe fyldigere rapport. Antall henvendelser vil bli tatt med neste gang.

13.4 Cane presenterer resultatene fra Analysen Domestic Hot Water Heat Pumps. Rapporten vil snart bli sendt ut til de forskjellige National Teams. Undertegnede har en kopi.

14 Ryan oppsummerer Den 4de Internasjonale Varmepumpekonferanse. Det hele ser ut til å gå rimelig bra i hop økonomisk. Arrangørene får skryt for det arbeider de har gjort på så kort varsel.

15 Formann og vise-formann foreslås gjenvalgt, og blir gjenvalgt. Ingen andre forslag.

16 Andre saker:
- USA forplikter seg til tre nye år som medlem av HPC.
- Sverige kan ennå ikke forplikte seg fullt ut. Det ser ut til at man kan klare å finne midler til direkte støtte til HPC og TSSU, men det er mer usikkert med eget National Team.
- Italia kan ikke forplikte seg ennå. Lover samtidig at det ikke skal bli noen repetisjon av forrige gangs problemer av samme art.

17 Italia inviterer til neste møte:

Sted: Roma

Dato: 27. og 28. oktober, 1993

Det vil bli arrangert omvisninger på en produksjonsfabrikk i Bari og på ENEA før møtet (25. og 26. oktober).

Neste års vårmøte foreslås holdt i Frankrike siste uken i april.

93-05-09

Rune Aarlien

IEA Implementing Agreement on Advanced Heat pumping Technologies

Referat fra Eksekutivkommitemøtet i Roma
26. og 27. oktober, 1993

Vert: ENEA

Til stede: Snelson (chairman, CAN), Bouma (HPC), Schacht (GER), Merlin (FRA), Frivik (NOR), Rivenæs (NOR), Aarlien (NOR), Scharer (SWI), Berghmans (BEL), Halozan (AUT), Coda (ITA), Vellone (ITA), van Nielen (NED), Vamling (SWE), Tassis (UK), Sellberg (SWE), Camitz (SWE), Groff (AB, USA), Ryan (USA), Kanzawa (JAP), Igarashi (JAP), Ross (TSSU)

Det følgende er et sammendrag av de viktigste punktene fra møtet.

Agenda er lagt ved som **vedlegg 1**, og nummereringen under refererer seg til agendaen.

2.1 Ingen representant fra sekretariatet i Paris er til stede. Vi bør uttrykke vårt ønske om at dette ikke skjer ofte. Viktig at bindeleddet er til stede.

Fra Sekretariatet har det kommet et ark med tittel "Shared Goals" (**vedlegg 2**) som er myntet på alle Implementing Agreements (IA). Viktig i strategisk planlegging.

Aktivitetene under vår IA er under vurdering (review). Bostrøm fra Sverige er reviewer, og oppfordres til å være aktiv (=ta initiativ).

Regler for eierforhold for produkter fra annexer, spesielt der software utvikles, vil bli gjenstand for diskusjon. Må ta bestemmelse på hvilke regler som skal gjelde.

2.2 Frankrike har offisielt sluttet seg til vår IA, og er for tiden med i Annex 21. På oppfordring er sendt informasjonsmateriell til Spania og Portugal. Jos og Keith har besøkt Australia og New Zealand. Malaysia trenger ennå mer tid før de kan bli med. Burde tenke på markedsføring også mot andre land i "the Pacific Rim".

3.1 Undertegnede refererer fra EXCO-møte for District Heating and Cooling sist mai i Ålesund. Det er fra deres, så vel som vår side ønskelig å få i gang et samarbeid om annekser. Ingen avgjørelse om handling tas.

3.2 Det er foreløpig ingen formell avtale om samarbeid mellom EFs Varmepumpegruppe vår IA. Rivenæs vil fungere som reporter ("liason") begge veier mellom de to gruppene. Vil utveksle referater fra våre møter.

4.1.1 Advisory Board (AB) er fornøyd med HPCs drift det siste året, og anbefaler at det program som er fremlagt aksepteres. AB har hatt to møter sist år. Anbefaler at de forskjellige National Teams tar mer ansvar for generering av nye annekser. Kunne arrangere en workshop for å identifisere nye annekser. Anbefaler også at en "task force" blir etablert for å se på "promotion". Anbefaler at vi samarbeider med IPUHPC da "ting skjer" der for tiden. AB burde fungere for hele IA og ikke bare HPC. Forslag om nytt annex på "Energy Efficiency and Labelling Standards" slår ikke helt an og foreslås kjørt som Analysis.

4.1.2 Groff ønsker et nytt medlem slik at man alltid vil være 4 stk på møtene. Man ønsker også å skifte ut ett medlem for å få inn en ny med industrierfaring fra Europa. Man enes til slutt om at man kjører videre med de 4 medlemmene man har.

4.2.1 Rivenæs presenterer logoforslag som er utarbeidet i Norge. Ligner mye på den som allerede er i bruk, men nå enes man om de minste detaljer som skrifttyper og -størrelser. De forskjellige landene vil få tilsendt diskett. Forslaget blir godt mottatt og akseptert.

4.3.1 Italia og USA har ikke betalt avgiften til TSSU. Progressjonsrapporten godkjennes.

4.3.2 Arbeidsprogram og budsjett for TSSU godkjennes og vedtas. Det viser seg vanskelig å få aksept for å øke avgiften til TSSU på dette tidspunkt. Bedre å la den være uendret ut perioden '93-'95 siden dette faktisk ble vedtatt ved opprettelsen (TSSU har eksistert kun ett år).

4.4 Strategisk Plan vil bli oppdatert innen ett år. Til godkjenning på neste høstmøte.

5.1.1 Rapporten for HPCs fremdrift godtas. Hvert NT må spille inn til HPC om hvordan man skal gjøre promotion.

5.1.2 Arbeidsprogram og budsjett for HPC godtas under forutsetning av at man ikke kutter hele poster men heller skjærer jevnt over mange poster. Det vil bli nødvendig å budsjetterer med NGL 90.000 mindre siden Sverige ikke kan være med i HPC lengre pga. manglende økonomi.

5.2 Annex 15 avsluttes. Rapport er levert.
Annex 8 mangler ennå sluttrapport og kan ikke avsluttes.
Annex 20 avsluttes. Rapporter og software er sendt ut. Blir antakelig workshop på opplæring i bruk av dataprogram. Berghmans vil foreslå hvordan resultatene skal kunne spres (hvem skal få tilgang til materialet og hvor mye av det, samt pris.

5.3 Østerrike har trukket seg fra forlengelsen av Annex 18. Muntlig progressjonsrapport for begge anneksene godkjennes.

5.4 Vamling presenterer resultatene fra Annex 17. Rapport sendes til deltakerlandene i disse dager. Det vil bli laget forslag på videreføring. I så fall blir det viktig å lage noe som industrien kan ha praktisk nytte av (mindre akademisk rettet). Kompakte varmevekslere kan være aktuelt. Mest restriktive holdning til spredning av resultatene er 6 måneders karantene. Annekset avsluttes.

5.5 Annex 21 vedtas forlenget til utgangen av 1994.

5.6.1 Japans anneksforslag (Chemical Processes for Ecological Thermal Energy Systems) får oppslutning av kun Canada, Sveits, og Japan selv. Det vedtas at Japan har retten til å etablere dette annekset frem til neste EXCO-møte. Den lave oppslutningen gjør at man vil vente å se om Nederland, UK, USA og Italia (som ikke avviser muligheten for deltakelse helt) vil bli med. Med kun tre land blir det ikke noe av annekset. Formelt er annekset opprettet.

5.6.2 Det foreslås at anneksforslaget på "Systems" gjøres om til en workshop. De aller fleste er enige.

5.6.4 Aarlien presenterer norsk anneksforslag, som blir godt mottatt. Flere deltakerland ber oss få dette på banen raskest mulig, og noen sier samtidig at de ikke tror det vil by på store problemer med å skaffe finansiering. Forslaget går på å utvikle designkriteria for de mest lovende anvendelsesområdene for naturlige arbeidsmedier.

Sverige presenterer et lignende forslag, som ikke tar med CO_2 og vann. Forslaget virker lite gjennomarbeidet og bærer preg av at man "ligger etter Norge i løypa". Sverige ønsker seg også operatøransvaret. Kan også tenke seg å dele dette med Norge. Sverige og Norge vil snakke sammen om dette etter møtet og komme frem til en avgjørelse på hvem som skal ha ansvaret og hva innholdet i forslaget skal bli. Norge lover å sende ut revidert forslag innen 1. desember. Deretter vil en foreløpig avgjørelse tas i februar.

Ryan foreslår en idé om et anneks på Dessicant Cooling. Får liten oppslutning, men kan likevel være et samarbeidsanneks mellom to eller flere IAs. Vil forfølge ideen, og forslag vil komme til neste møte.

6.1 Neste møte: Paris, 25-27 april, 1994.
Deretter: UK, 14-16 november, 1994.

7.1 Da flere parter ennå ikke har betalt det de skylder eller har lovt, og en del regninger utestår, er man ikke i stand til å avslutte regnskapet for *Den 4de internasjonale VP-konferanse.* Arrangementet vil gå med overskudd så lenge alle betaler.

7.2 Canada vil arrangere neste VP-konferanse, og har laget en handlingsplan. Det oppfordres til at man allerede nå setter full fart, slik at man unngår det stresset som var sist.

8 Italias National Team presenterer seg. OH pakke finnes.

9 Hvert lands National Team får heretter i oppgave å stille med ett forslag på nytt annex til hvert møte. Dette skal stort sett være tittelen. Ut fra de mest interessante forslagene kan man så finne ett eller to som man jobber videre med frem til et vanlig forslag. Forslagene kan også samles i en anneksbank av HPC.

93-11-05
Rune Aarlien

Report
from the
Executive Committee Meeting
of the
Implementing Agreement on District Heating and Cooling

May 13/14, 1993
Ålesund, Norway

In Attendance:

M. Wiggin (Chairman, Canada)	G. Maass (IEA)
H.C. Mortensen (Denmark)	T. Makela (Finland)
N. Schacht (Germany)	M. Klopsch (Germany)
J.H. Langseth (Norway)	R. Ulseth (Norway)
A. Årøen (Norway)	R. Aarlien (Norway)
L. Uhri (Hungary)	S. Camitz (Sweden)
S. Andersson (Sweden)	F.J. Collins (USA)
Kepler (Switzerland)	P.A.M van Lyyt (The Netherlands)
J.C. Resing (The Netherlands)	P.J. Davidson (United Kingdom)

Mr. Rune Aarlien attended this meeting as a designated observer from the Implementing Agreement on Heat Pumping Technologies. The IA on Heat Pumping Technologies' (IAHPT) participation at this meeting is a way of reaching out to "new" environments and an effort of bringing related Implementing Agreements closer together. The purpose of such an effort is to avoiding duplication of activities, benefitting from one anothers' experiences, and possibly establishing joint projects or common areas of activities.

How the IA on District Heating and Cooling is Organized

The IA on District Heating and Cooling (IADHC) is organized differently and operates in a way different from the IAHPT. First of all, the IADHC works only one Annex at a time. The IADHC was established at the end of 1983, and presently three annexes are completed. These annexes have been concentrating on the following activities:

Annex I:
- Development of Heat Meters
- Cost Efficient Distribution and Connection Systems for Areas of Low Heating Density
- Small Sized Coal Fired Hot Water Boilers
- Medium Sized Combined Heat and Power Plants
- Low Temperature Applications in District Heating Systems

Annex II:
- R&D Projects
- Consumer Installations
- Piping
- Advanced Fluids
- Advanced Heat Production Technology
- User Friendly Turbine Selection

Annex III:
- District Heating and the Environment
- Supervision of District Heating Networks
- Advanced Transmission Fluids
- Piping

- District Energy Promotional Manual
- Consumer Heating System Simulation
- Information Exchange

Each country contributes a fee to the Annex, and the fee is based on the country's GNP. It is then up to the different countries to make project proposals and budgets for the upcoming three year period. These proposals are presented, discussed, and voted over in order to obtain a prioritized list of the most popular projects. The top ranking projects, with an accumulated budget within the total Annex budget are then accepted. For each project, an Expert Group (EG) is established. The EG has a chairman and is responsible for the project work. Each of the subheadings under the annexes above represent the work title of the different EGs under each Annex. For Annex III (now completed) the efforts of the different EGs have been focused on the following:

a) *District Heating and the Environment*
This was a three-phase project; a brochure, a report and a consequences model were produced. The brochure "A Clean Solution? It is Also Your Responsibility" was published. The report "IEA Manual on the Environmental Benefits of District Heating and Cooling" (DHC) will promote the concept of DHC and will stress the environmental benefits. The Consequence Model will demonstrate the benefits of DHC when introduced in a well defined area. The model also includes an economical analysis.

b) *Supervision of District Heating Networks*
Under this project a "Quantitative Heat Loss Analysis of Heat and Coolant Distribution Pipes by Means of Thermography" was undertaken. Thermography is a diagnostic method for detecting leaks at an early stage or even just damages in the piping insulation.

c) *Advanced Transmission Fluids*
The objective of this task was to accelerate the application of additives and slurries as a means of reducing energy losses and increasing the performance of district heating and cooling energy transmission networks.

d) *Piping*
This project dealt with: "Plastic jacket pipes with CFC free foam", "Compression resistant components for plastic jacket pipes to sustain displacements", and "Polybutene and polyethylene mesh medium pipes for pipelines of small diameters".

e) *District Energy Promotional Manual*
This manual provides practical assistance to those promoters and developers attempting to solicit support for a new, expanded or modernized district energy system. Contents: an overview of district heating, guidance for promotion, and reference sources for further information.

f) *Consumer Heating System Simulation*
The objective was to develop of a dynamic simulation model of consumer heating systems, to be used to ensure that systems are properly designed and that control systems function correctly. Characteristics of the tool are: modular structure for adaption to actual system concept, possibility to vary design parameters, suitable for implementation on a PC.

g) *Information Exchange*
The objective was to extend the 1989 published catalogue "R&D projects Review", which contained some 200 R&D projects on district heating in the IEA countries. In addition

work was undertaken to have projects published and workshops organized.

For further details, see **Appendix 1**.

The Meeting

The main objective of this meeting was to report on, and conclude, the current Annex III activities and start up Annex IV. The following is a brief summary of the meeting. Meeting Agenda and Minutes from the previous meeting are enclosed as **Appendix 2** and **Appendix 3**, respectively.

1 **Opening**
The chairman opens the meeting by welcoming the participants, and especially Mr. Uhri, representing Hungary and the Eastern Block Countries, and Mr. Aarlien, who is an observer from the IA on Heat Pumping Technologies.

6 **Report from IEA and the Chairman**
Ms. Gudrun Maass basically presents the same information as was presented at our meeting in Maastricht on May 2.

The Chairman reports from a joint meeting of the four current Canadian IA chairmen, and stresses the desire of cooperation between the related IAs. He looks forward to the presentations from Mr. Uhri and Mr. Aarlien, as well as discussions.

The Chairman hands out a questionnaire regarding the structure of the EXCO meetings. The questionnaire is later in the afternoon returned to the Chairman, who presents the results the next morning. The questionnaire with the results is enclosed as **Appendix 8**.

7 **Reporting on Annex III activities (see numbering above):**

a) The project is completed. Brochure has been sold in 2000 copies.
b) Final report is available.
c) Final report is printed and distributed.
d) Work was completed last year. Report is printed and leaflet enclosed.
e) Report will be ready for printing in a couple of weeks.
f) Report was finished two months ago, diskette is included. The work will be very helpful in Annex IV continuation.
g) Projects review is completed. Workshop in Odense, Denmark was cancelled due to the small number of participants.

As far as finances are concerned, the Italian contribution is still unpaid, i.e. a deficit of $120.000. It is decided that the fee must be paid before further participation can be accepted, and that the final reports from Annex III will be held back. Since ENEA only has been the Contracting Party for the last year, one third of the full fee is acceptable to the committee.

8 **Annex IV**

- All countries present (Denmark, Norway, Finland, Canada, Germany, USA, The Netherlands, United Kingdom, Sweden) confirms their intent to continue their participation.
- The total budget for the new Annex is $1.020.000. France and Italy is not

included.

- Before the ranking, project proposals totalling $2.368.000 were received by the EXCO. The following is a brief description of the projects that were accepted:

  a) ***Design Guide for Integrating District Heating with Combined Heat and Power:*** The objective of the project is to provide guidance to designers of district cooling systems in identifying the best options for integrated district cooling with combined heat and power and district heating. The trade-offs inherent in alternative approaches need to be illuminated in a way that helps a system designer make the best choice under a specific set of circumstances. USA will lead the work, and the budget of $120.000 is accepted (**Appendix 4**).

  b) ***Transmission Fluids for District Heating and Cooling:*** This is a continuation of the work done under Annex III. The proposal includes the following projects: *i)* Modeling of the location and requirements for heat exchangers in DH networks using friction reducing additives (FRAs), *ii)* Assessment of the risk to the environment of FRAs in DH networks, *iii)* Testing of the effect of FRAs on the performance of small substations and consumer heat exchangers, *iv)* Effects of FRAs on the thermal energy storage system, and *v)* Development on environmentally safe friction reduction methods for DHC applications. USA will lead the work. Projects *i)* and *iii)* are accepted plus $10.000 for information exchange - a total of $129.000 (**Appendix 5**).

  c) ***Piping:*** This is also a continuation of work from Annex III. The following projects are included: *i)* Connections under operation, *ii)* Pipe bend studies, and *iii)* Manual on DH pipelines. The project is further described in **Appendix 6**. The proposed budget of $156.000 is accepted.

  d) ***Network Supervision:*** Continuation of earlier work. The overall objective is to facilitate easier service and maintenance of DHC networks. Sweden leads the project, and the budget of $175.000 is accepted.

  e) ***Exergy Efficient Substations:*** The goal is to identify the most efficient combination of substations and installations for different building categories in DH systems. The system will be documented and evaluated by system buildups and analyses by the CHESS concept developed under Annex III, supplied by necessary measurements. The findings will be presented in a general catalogue and in a report which gives a detailed account of the best system designs. The project will focus on system concepts that meet the requirements for low supply and return temperatures in DH networks. Norway leads the project. The budget of $160.000 is accepted.

  f) ***Manual of DH Piping Design:*** With this manual expertise from well-developed DH countries will become available for countries in the introduction stage. The European Standard for DH pipelines will be involved in the manual. Project Leader is Germany. The budget of $64.000 is accepted.

9 Strategy Document

- The document is accepted as the final version (not handed out). The End-Use Working Party will now evaluate the strategy plans from different IAs in order to avoiding duplication of work and identifying opportunities for cooperation.

10 Cooperation with Eastern European Countries

Mr. Uhri is invited to present the DH situation in Hungary. The idea behind this invitation is that it is wiser to first listen to experts from the Eastern Europe, instead of just going in and doing what we think is right.

Mr. Uhri:
Two million people (640.000 flats) rely on DH in Hungary. DH was introduced during the 60s, and was based on prefabrication from Russian factories. Networks are most commonly found in the outskirts of the larger cities. Systems are operated with constant water flow and small temperature drops. The real problem today is the economy for the DH companies. Problems started one and a half year ago when the authorities removed the subsidies. Customers are often poor, and can not afford to pay more than one third of the actual price. The price is roughly half of that in Western Europe, but when wages are taken into account, the price is approximately five times that in Germany. Hiking the price would not help the DH companies, since the customers would not be able to pay. This situation has resulted in severe losses for the companies. Technically the networks are in relatively good shape. There is only a small amount of combined heat and power, and the electricity rate is low. The hope is that the economic situation gets better in the future - if not several DH companies will be forced out of business. Due to a decrease in the industry activity level, the overall demand for electricity is reduced over the last years. Mr. Uhri suggests that one way of helping would be to approach the Ministry of Energy. The Chairman encourages all participants to think about how the IA can help the Eastern Countries.

11 Cooperation with Related IAs

The Chairman says that the group of four Canadian chairmen of the related IAs will continue to have joint meetings. He also encourages the regular exchange of observers. The IADHC will participate in a "Think Tank" organized by the IA on Building Community Systems on the September 13-15, in Amsterdam. In addition, he also suggests that members of different IAs in a country should come together to discuss cooperation.

Mr. Aarlien presents the IA on Heat Pumping Technologies. He concentrates on how the IA is organized, how it works, current annexes/activities, and the strategy plan.

12 Promotional Activities

A framework for an outreach program attempting to answer the questions: why?, how?, to whom, and what? is being put together. Several participants stress the importance of starting such a program. The project could be organized in cooperation with UNICHAL. The EXCO is considering producing PR sheets for direct mail marketing of products from the IADHC.

A leaflet on Annex IV will be produced as soon as one knows the correct description of the projects. Will start producing the lay-out. The leaflet will be of the same type as Appendix 1.

14 Future Meetings

November 10-12, 1993:	New Orleans, USA
May 11-13, 1994:	London, United Kingdom

Remarks on Potential Cooperation

One area of potential cooperation could, according to the Chairman, be the new project on "Integrated District Cooling with Combined Heat and Power" (see Appendix 4). Under "Scope" the text reads:

> Heat pumps also offer an opportunity for synergy between district heating and district cooling. The range of circumstances under which this approach is feasible should be identified. Another possible synergy between district heating and cooling is use of absorption chillers in individual buildings using district heat to generate cooling, thereby avoiding the need to construct a separate chilled water distribution system.

Other potential areas could be (from discussions with the chairman after the meeting):

- Use of extracted heat from return lines in DH networks
- Distribution of heat at intermediate temperatures in a single pipe system
- Different types of heat pumps for DH systems
- Slurry production - different components
- Fuel cycle analysis
- Desiccant cooling
- Low temperature systems
- Thermal storage systems

My personal impression from discussions with the chairman is that the IADHC is very eager to get going with a few (maybe only one) collaboration projects. It is nice to talk about cooperation, but more important is getting things done, and between our two IAs, there should be ample opportunities for joint projects.

The chairman was invited to join our next meeting in Rome in October. The invitation was appreciated, and if not the chairman, perhaps someone else from the IADHC will be represented at our meeting.

General

The meeting lasted from 9 am to 6 pm. During that time there had been a lunch break and three coffee breaks. Needless to say, the first impression of the meeting is that it was arranged in a very smooth and efficient manner, and both the Chairman and the participants were all well prepared. Unnecessary details were hardly discussed. Having second thoughts, one can always argue that a group meeting only twice a year, should spend more time together and perhaps discussing more details.

93-05-27
Rune Aarlien