SUMMARY OF RESEARCH ACTIVITIES
1990-1993

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Preface

Introduction
The International Energy Agency (IEA) was established in 1974 in order to strengthen the cooperation between member countries. As an element of the International Energy Programme, the participating countries undertake cooperative activities in energy research, development and demonstration.

District Heating is seen by the IEA as a means by which countries may reduce their dependence on oil. It involves the increased use of indigenous or abundant fuels, the utilisation of waste energy and improved energy efficiency. With the same objectives District Cooling is getting a growing interest. The positive environmental effects of improved energy efficiency will give an additional and very strong impulse to raise the activities on District Heating and Cooling.

Annex I
IEA's Programme of Research, Development and Demonstration on District Heating was established in 1983 at a meeting in Stockholm. In the first phase (Annex I), ten countries took part in the programme; Belgium, Canada, Denmark, Federal Republic of Germany, Finland, Italy, The Netherlands, Norway, Sweden and USA.
The National Energy Administration, Sweden, has been the Operating Agent for the first Phase, in which the following technical areas have been assessed:
- Heat Meters
- Cost Efficient Distribution
- Heat Production
- Use of Low Temperature Heat Sources in District Heating Systems
- Conversion of Building Heating Systems to District Heating.

A Summary Report of all research activities carried out under Annex I in the period between November 1983 and December 1987 was published in 1988 by the National Energy Administration Sweden (report Statens energiverk; 1988: R16).

Annex II
In 1987 Annex II was started up. Under that Annex the following technical areas have been included:
- Consumer installations
- Piping
- Advanced Fluids
- Heat Meters
- Advanced Heat Production Technologies
- Thermal Energy from Refuse.

The Netherlands Agency for Energy and the Environment (NOVEM) has been acting as the Operating Agent for Annex II. Nine countries have participated in this Annex, i.e. all countries of Annex I except Belgium.

The Summary Report of all the research activities carried out in the time period between May 1987 and November 1990 was published in 1990 by NOVEM (Report NOVEM 1990 R-12).

Annex III
In May 1990 decisions were taken about an Annex III, in which all participants of the second Phase continued their participation for another three-year period.
Items for Annex III were:
- R&D Project Review
- Promotional activities
- Piping Techniques
- Consumer Heating System Simulation
- Supervision of District Heating Networks
- Advanced Transmission Fluids.

Also for this Annex the Netherlands Agency for Energy and the Environment (NOVEM) has been acting as the Operating Agent. The report you are reading, contents the summaries of all research activities carried out during May 1990 and November 1993.

Annex IV

In May 1993 it was decided to continue the activities; Annex IV was started up. In Annex IV all countries of the third Phase participate, except Italy. In 1994 Korea decided to take part in the programme. The Executive Committee decided upon the following items for the programme under Annex IV:

– Design guide for integrating District Cooling and combined Heat and Power
– Advanced Transmission Fluids
– Piping Technology
– Supervision of District Heating networks
– Efficient substations and Installations
– Development of longterm cooperation with East European Countries
– Temperature variations in preinsulated district heating pipes, Low Cycle Fatigue.

Again the Netherlands Agency for Energy and the Environment (NOVEM) will be acting as the Operating Agent.

Available Budget

The total budget for Annex I was US $ 525,000. For Annex II a budget was available of US $ 675,000. For Annex III a budget of about US $ 1,000,000 has been agreed by the participating countries. For Annex IV the preliminary available budget amounts to approx. US $ 1,250,000.

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Executive summary

Background
One of the major aims of the IEA's activities was and still is to reduce the vulnerability of member countries to the interruption of imported energy supplies, particularly their depence on oil. The war-situation in the Gulf-Area has shown in which scale disturbances of the supply of energy could be created by international political conflicts.

Encouraging the increased use of indigenous fuels and, where energy has to be imported, ensuring that the sources of such supplies are spread as widely as possible, will stay some of the measures that have to be promoted in a still stronger effort than was utilised up to now. An expansion of district heating activities would make it possible to more easily choose between alternative fuels in order to realize the most efficient energy supply. Where feasible, the combined production of heat and power will have to be promoted as the first option, as it integrates the environmental savings of centralised production units and the energy saving of the combined production. One of the easiest ways to release the environment is to diminish the use of energy. With combined production this goal can be realised apart from efforts to diminish the energy-consumption of the end-users.

In North American countries also District Cooling has got a growing interest. For that reason also attention has been given to the specific aspects of this kind of technology, in relation to energy savings and amelioration of the environment.

For several years the IEA have worked on evaluating the possible advantages of District Heating. Comprehensive material from governments, utilities, research institutes, manufacturers and individuals has been collected and studied. The work undertaken was presented in a 1983-report 'District Heating and Combined Heat and Power Systems'. That report pointed to a number of areas where more knowledge was needed and made suggestions to be taken up in the 'District Heating Research and Development Project'. The 1983-report still is of importance for those who are interested in this field.

Organisation and Participation
Cooperation between the participating countries is governed by an Implementing Agreement. Decisions on the work programme and budget are taken by the Executive Committee which has representatives from all participating countries. For the meetings of the Executive Committee international organisations in the field of District Heating and Cooling from Europe (Unichal) and North America (IDEA) are invited to attend on an observatory basis.

Projects are defined in Annexes to the Agreement. The Operating Agent acts in the interest of all countries and coordinates the activities, negotiates contracts etc. within the budget and programme limits decided upon.

For each of the projects an experts group has been created, in which experienced representatives of the participating countries have contributed to the project-definitions and to the progress of the activities.

The results of all these projects are published in separate reports and are summarised in the following chapters of this report, 1993-P10. The project review, report 1992 P6, is part of the information exchange activities between the participating countries.

In order to reach a large audience in the district heating and cooling field, an agreement was made with the editor of 'Fernwaerme International' (FWI) to use this magazine for publishing periodical information about the ongoing activities, results of studies and other publications.

In the Annex III, which results are described in this summary report, the following projects have been included:

Project title	Lead country	Project management
1. District Heating and Cooling R&D project Review	Denmark	Rambøll, Hanneman & Højlund A/S Mr. Peter Randløv Bredevej 2 DK 2830 VIRUM, Denmark
2. Promotional activities	Denmark	Rambøll, Hanneman & Højlund A/S Mr. Peter Randløv Bredevej 2 DK 2830 VIRUM, Denmark
	USA	IEA Consulting Group Mr. Gordon Bond Suite LL4 289 Great Road Acton, MA 01720-4739, USA
3. Piping Techniques	Germany	GEF Ingenieurs Gesellschaft für Energietechnik und Fernwärme mbH Mr. Manfred Klöpsch Ferdinand Porsche Straße 4a D-6906 LEIMEN, Germany
4. Consumer Heating System Simulation (CHESS)	Norway	SINTEF, Division of Applied Thermodynamics N-7034 TRONDHEIM, Norway
5. Supervision of District Heating Networks	Sweden	Fjärrvärmeutveckling FVU AB Mr. Heimo Zinko S-611 82 NYKÖPING, Sweden
6. Advanced Transmission Fluids	USA	Earth Resources, Ltd. Mr. James Murray 962 Wayne Avenue, Suite 750 Silver Spring, Maryland 20911 USA
	Canada	Energy Resource Laboraties Dept. of Natural Resources Mr. Michael Wiggin 555 Booth St. Ottawa K1A 0G1, Canada

In the ’DHC News’, the official newsletter of the International District Energy Association (IDEA) also attention is given to the IEA-activities.
At international conferences and symposia on District Heating presentations have been set up, providing information on the activities and their results.
All country-representatives extended the promotional activities in their home-countries. Mutual information exchange between IEA and Unichal, for the European region, and the IDEA for North America will be firmly supported to reach a wide range of interested people.

Most of the Annex III-reports have been printed in 500 copies. Of these, 400 copies were to be distributed in the participating countries by the national representatives. The remaining copies have been produced for distribution by the Operating Agent on request to those who are interested.

Area 1
District Heating and Cooling R&D Project Review

1992 P6: District Heating and Cooling R&D Project Review

Information Exchange is an important part of the activities in the International Energy Agency (IEA) District Heating Project. As a part of this activity a R&D Project Review was prepared. Under Annex II the first District Heating and Cooling R&D Projects Review based on contributions from the member countries was published in 1989 (Report 1989 R1).

This first review contained 258 R&D projects covering almost all aspects of district heating and cooling.

In 1991 the Executive Committee decided to up-date the R&D Project Review including R&D projects where the major topic is District Heating and Cooling (DH&C) and combined heat and power (CHP) covering all aspects including:

- energy conversion
- transportation (transmission and distribution)
- end-user
- operation and maintenance.

The objectives of this second R&D review are:

- to inform about R&D activities in the member countries
- to inspire to contact between researchers working with the same field to reduce parallel work
- to maximize the benefits of national work.

The participants in the IEA District Heating Project have contributed to the review as follows:

MEMBER COUNTRY:	PROJECTS:
Canada	9
Denmark	41
Federal Republic of Germany	37
Finland	14
Netherlands	17
Norway	3
Sweden	11
USA	5
Total number of R&D projects:	137

The projects are sorted according to country and within the each country according to the first key word. Looking up a specific topic is best done by means of the key word index in the back of the book.

The full text of this review and of the first review published in 1989 are available on 3,5” (1.44 MB) diskette in ASCII format. The diskette can be ordered from the Operating Agent.

As an example, the first project description of the R&D Project Review Report is shown on page 9.

The projects, summarised in the Review Report are listed in Appendix I of this Summary-report.

DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: IEA advanced fluids project. Subcontract for ice slurry transport.

Key Words: Advanced fluids. Ice Slurry. District Cooling.

Key Activity: District heating and cooling. Development.

Objective: To continue the measurement of transport properties for ice slurries and relating those properties to particle size, shape and ice slurry loading (i.e., percentage of ice in the slurry). The tests are conducted for both pure ice slurry and for fluids containing corrosion inhibitors and other additives such as glycol for freeze point depression.

Technical Approach: Calibration of an expanded test loop with water to establish pressure drop and heat transfer characteristics as a reference point for ice slurry testing. Undertake further tests of water with other additives that might be realistically included in a district cooling system. All tests include the full range of flows that might be considered in a system (approx. 3 to 4 m/sec). The original loop has been expanded and now includes nine 17-metre-long test-sections with diameters ranging between 12 mm and 100 mm.

Program Implications: The use of ice slurries in district cooling systems can provide several benefits, including the increase in capacity of existing systems, the reduction of pipe sizes in new systems and improved load management through ice slurry storage - either at the ice slurry generator or distributed in buildings.

Current Status: All testing in the original loop has been completed for water, with and without additives. Testing of ice slurries up to about 35% ice has been done and the results reported. The expanded loop is in the process of commissioning.

Future Activities: Comparison of the data with existing slurry models. Development of ice slurry models.

Research Product: Data reports and an ice slurry manual to form the basis for use of slurry technology in full scale cooling systems.

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Area 2
Promotional activities

The objective of the activities under Annex III at the field of ’Promotion’ is to demonstrate the environmental and economic benefits of introducing District Heating and Cooling (DH&C) and Combined Heat and Power (CHP) schemes.

The activities in this area resulted in a brochure and three reports:

- The brochure ’A Clean Solution?’
- 1992 P1: The environmental Benefits of District Heating and Cooling
- 1992 P1.1: DETECT, the IEA Consequence Model
- 1993 P9: Promotional manual for district energy Systems.

THE BROCHURE ’A CLEAN SOLUTION?’

The brochure is a policy paper in which the environmental advantages of District Heating and District Cooling are presented. The paper has been published in cooperation with the Worlds Energy Council’s Committee on District Heating, Combined Heat and Power Systems as a brochure titled:

> *A Clean Solution?*
> *It is also Your Responsibility!*
> *Cogeneration of Heating, Power and Cooling - an Answer to Pollution from Energy.*

The brochure introduces the technology of DH&C and CHP to politicians, decisionmakers and technicians who have little or no knowledge of the technology.

THE ENVIRONMENTAL BENEFITS OF DISTRICT HEATING AND COOLING (1992 P1)

Introduction

This report examines the environmental benefits of district heating and cooling, and is one of several summary reports on particularly relevant topics. This report has been prepared on behalf of the IEA for information and education exchange.

District heating and cooling is the distribution of heating (hot water, steam) and cooling (cold water) energy transfer mediums from a central energy production source, to meet the diverse thermal energy needs of residential, commercial and industrial users. Thermal energy needs or demands include space heating and cooling systems for maintaining human comfort, domestic hot water requirements, manufacturing plant process heating and cooling system requirements, etc. In many of the systems that have been established around the world, both district heating and district cooling have not been provided. For example in Europe, where moderate summer temperatures prevail, most district thermal energy systems provide heating capability only. District cooling has only recently become more widespread, with the most prevalent application being in North America, where summer temperatures can, over extended periods, reach extremes of 30 °C to 40 °C.

There are a number of factors which must be weighed when determining whether or not a district heating (DH) or district heating and cooling (DHC) system should be implemented in a particular community. These factors include local economic and climatic conditions, viability of competing alternative energy supply systems, local energy production and utilization efficiency considerations, local environmental benefits, and differing producer and user perspectives on the significance of benefits of district systems.

The subject of this report, environmental benefits of DHC, must be considered pre-eminent on the list of district energy system assessment factors, considering the industrialized countries increasing emphasis on reducing and avoiding the negative impacts that various human activities, including technological developments have had, and continue to have, on the global environment.

This report is broken down into the following major sections:

- Section 2.0 discusses the environmental impacts that are associated with the various heating and cooling systems in use today. Impacts discussed include global climate change, ozone depletion and low level environmental impacts such as acid rain and local air quality.
- Section 3.0 examines specific aspects of district heating and cooling systems, outlining the components associated with these operations and the environmental benefits that can result when such systems are adopted.
- Section 4.0 illustrates, through 8 actual case studies, the environmental benefits which are experienced through the use of district heating and cooling systems. The benefits discussed in this report relate primarily to the environmental impacts identified in Section 2.0.

As an example, one of the case studies is listed below.

Energy-efficient Technologies combined with modern DHC Concepts employed at California State University, Fullerton

1. Case Study Significance
   This study examines the environmental benefits associated with the upgrading of an existing DHC plant at California State University, Fullerton. These benefits, which include dramatic reductions in plant emissions particularly NOx, elimination of the use of refrigerants having non-zero ozone depletion potential, and substantial energy savings, are all indirectly a result of the centralized plant being readily and cost-effectively capable of implementing developing technologies and modern operating concepts. This study is a summary of a report entitled 'Thermal Energy Storage, Energy Conservation and DHC at California State University, Fullerton' authored by Henrikson.

2. Project Background
   The California State University, Fullerton campus was initially built during 1961 - 1963 and consists of twelve major buildings of approximately 150,000 m^2. The additional buildings are scheduled to be constructed between the present time and the year 2000, giving the campus a total operational building area of 230,000 m^2. A single central plant serves, and will continue to serve, all campus buildings with chilled water for space cooling and hot water for space heating and domestic hot water heating.

   The Cal State Fullerton central plant generates high temperatures hot water (HTHW) for campus space heating and cooling needs. Three HTHW generators produce 177 °C water at 41 kPa, of which the majority is used to drive single-stage absorption chillers that generate 7 °C chilled water. Hot water is also distributed to campus where the temperature of the hot water is stepped down to 82 °C in building heat exchangers. This hot water is then delivered to heat exchange coils to maintain 35 °C air for space heating and 60 °C domestic hot water (DHW).

   Presently there are three 8.8 MW HTHW boilers, each capable of firing either natural gas or No. 2 fuel oil. All three boilers are the watertube type with thermal efficiencies of 75-80% when firing natural gas.
   The central plant has a total of three chillers consisting of one 2,638 kW and one 4,045 kW, HTHW, absorption chillers, and

one 2,638 kW electrical centrifugal chiller in conjunction with a eutectic salt thermal energy storage (TES) system. The Cal State Fullerton central plant utilizes four cooling towers for condenser loop heat rejection. There are three 175 L/s cooling towers and one 265 L/s cooling tower utilizing respectively three 30 kW and one 60 kW cooling tower fans. The cooling towers were built in the early 1960's and are considered beyond their useful life.

When compared to modern DHC plants, the nearly 30 year old Cal State plant is relatively inefficient. In terms of achieving high energy efficiency, to create the 177 °C HTHW is inherently wasteful, considering the ultimate use of the energy is to produce 35 °C water for space heating and 60 °C water for DHW. Also, there is no capability in the present system to reallocate available waste heat energy and in fact the chillers operate around the clock to get rid of this heat. With the existing plant beginning to exceed its useful life and with the campus poised for a major expansion, the University decided to upgrade the central plant into a more energy efficient and environmentally friendly facility.

3. Measures Taken to Achieve Environmental Benefits Upgrading of the Cal State DHC system, which is currently underway, incorporates both energy efficient technologies and modern operational concepts to improve overall efficiency. These are summarized below.

The new distribution systems at Cal State will distribute hot water and chilled water to the campus, and will be variable flow distribution systems. Unlike a constant flow system, where the distribution system pumping capacity is selected for, and often operates continuously, at a rate corresponding to a peak hour condition, a variable flow system tracks the demand, delivering only enough flow to satisfy the short-term cooling and heating demands. The savings in pumping horsepower are substantial since horsepower is reduced as the cube of the reduction in flow. In addition, the existing 5.6 °C delta T chilled water system is being converted to a high delta T chilled water distribution system, with a delta T of 13.3 °C. This has the effect of reducing the flow by almost 60% since every litre of chilled water carries almost 150% more cooling energy.

The original relatively insufficient single-stage absorption chillers, arranged in parallel, are being replaced with more efficient electric motor driven centrifugal chillers arranged in series. The series arrangement is the most efficient since, unlike a parallel arrangement, only one of the three chillers must produce the cold 4.4 °C chilled water output required of this system. The other two chillers operate at higher output temperatures and consume less energy.

The heat generated through normal activity in campus buildings, which would normally require rejection through chiller/cooling tower packages, is under the new system captured for space heating at other needy locations on campus. To accomplish this, the first chiller in the series line-up is a heat recovery chiller. This unit is used to extract the available heat from 18 °C chilled water return. At the same time, this same unit, without increasing its electricity demand produces chilled water supply for space cooling and low temperature hot water supply (recovered from elevated condenser heat) for space heating and DHW heating.

Furthermore, all chillers at the plant will operate on R-134a refrigerant (an HFC) which has an ozone depletion potential of zero.

With time-of-use electrical rates, generating chilled water for space cooling in the middle of the day is an expensive proposition. Chilled water thermal energy storage (TES) was identified as a key central plant component to alleviate this concern. The centrepiece of this system is a 10,000 m^3, above-ground, chilled water TES tank. This tank is sized with sufficient storage so that the electric driven chillers will be completely off-line during on-peak electrical rate periods. As a result, there will be almost no central plant electrical demand contribution to the campus peak electrical demand. Other benefits fall out of this TES strategy. With TES in place, chiller and cooling tower operation can be regulated to cooler periods of the day, thus their operation becomes more energy-efficient. Chiller operation also occurs during the higher heating demand periods of the day thereby maximizing the prospect of useful heat recovery.

In that space heating and domestic hot water heating are to be accomplished with recovered chiller condenser heat, creating a coincidence of chiller operation and the heating demand is important. Also, with only one heat recovery chiller, the ability to store heat for later use is important. Therefore, 1,140 m^3 of hot water TES is also being implemented.

With both chilled water TES and hot water TES, the campus has an excellent level of flexibility in the use and reuse of its energy resources. This flexibility translates into cost-effectiveness and energy efficiency of the DHC system.

4. Summary of Environmental Benefits

The now under construction all electric central plant involves a drastic reduction in air pollution emissions - 97% NOx reduction over that of current emissions attributable to the Cal State Fullerton central plant. This is accomplished by removing the combustion processes from the local site and instead using electricity generated at the utility power plant where efficient, large scale, industrial grade Best Available Control Technology is used.

Several central plant development scenarios are presented below to illustrate the NOx emissions associated with each scenario. Scenario 1 represents the central plant as it was before any upgrading began. Scenarios 2, 3 and 4 represent possible alternative

Central Plant Development Scenario NOx Emissions (kg/yr)

1. Year 1990 central plant with 90 ppm NOx HTHW generators and single-stage absorption chillers	7,270
2. Year 1992 central plant with 40 ppm NOx HTHW generators and single-stage absorption chillers (after installation of low NOx burners and flue gas recirculation)	3,230
3. Year 2000 central plant (expanded campus) with 40 ppm NOx HTHW generators and single-stage absorption chillers (after installation of low NOx burners and flue gas recirculation)	4,820
4. Year 2000 central plant with 40 ppm NOx HTHW generators, electrical centrifugal chillers, and TES (after installation of low NOx burners and flue gas recirculation)	2,180
5. Year 2000 all-electric central plant with electrical centrifugal chillers, TES, and a heat recovery chiller (excludes off-campus power generation - local utility's contribution to NOx emissions)	190

upgrades that could have been considered at different time frames. Finally, Scenario 5 represents the central plant now under construction at Cal State, Fullerton.

The source report for this case study does not quantitatively report the magnitude of energy savings expected due to the upgrades discussed.

DETECT, THE IEA CONSEQUENCE MODEL (1992 P1.1)

What is DETECT?

DETECT stands for District Energy, The Environmental Considerations & Taxes. The name describes the programs ability to include the environmental considerations in the economic analysis e.g. as extra expenses for equipment for smoke purification or graduated taxes on polluting fuels.

The DETECT computer program is mainly intended for the non-specialist, but the options build into the program also make it possible to make more detailed calculations. The methodology used makes it possible for the non-specialist to perform a preliminary feasibility study for a specific site - your own city or area, thereby allowing a demonstration of the potential reduction in emissions if a DH&C and CHP scheme were to be introduced in your area. In this way specialists have placed at your disposal their knowledge of the advantages of district energy systems, such as the possibility for:

– less local air pollution,
– reduced contribution to the global greenhouse effect,
– increased fuel-use efficiency,
– reduced energy consumption,
– competitive energy costs.

The output graphs and tables will be useful when demonstrating to politicians and other decision-makers what the potential for fuel savings and emission reductions are when a DH or DH&C scheme is introduced.

DETECT can also be a valuable tool for a DH&C specialist for completing more feasibility studies. However, more advanced tools should be used for the final study. This is especially true for the evaluation of construction and maintenance and operation costs.

Why use DETECT?

DETECT performs a preliminary study using a number of economic parameters (investments, energy prices) and calculates the reductions in emissions compared to a reference alternative (the evolution of energy costs and emissions if the development continues without change in energy sources).

DETECT does not replace the need for a specialist’s detailed calculations, but it does provide information suitable for preliminary planning purposes.

Therefore, if DETECT shows that DH&C is a promising alternative in your area you are encouraged to perform more detailed studies or to contact consultants or energy offices who are specialists in DH&C and CHP.

The Washington State Energy Office (WSEO) has developed a computer program called HEATMAP, which is one possible tool for a more detailed study.

A special feature of DETECT is that it allows you to put a price tag on the environmental impact e.g. an excise tax on pollution from exhaust fumes resulting from burning fuels for heating and cooling. This price on the environmental impact can be included in the economic and financial analysis.
The figure for this tax can be fixed in many ways:

– The marginal expenses for flue gas purification
– Capitalizing of the harm done by emissions to the environment
– Actual emission or fuel taxes.

For each case story or study you carry out a project file is generated. This file contains all the data necessary for the study, and the study can always be reproduced with these data.

As you have received your copy of DETECT at the printing price or maybe even free of charge, you are invited to mail a diskette with these input files from your studies to NOVEM in return.

A form for submitting files to NOVEM is enclosed as appendix VII. Please note that the project files will only be used for study purposes. The submitter does not have any responsibility for the contents of the files or for their use. In case the results are published it is guaranteed that the projects can not be identified.

Expecting that a sufficient number of files will be received, the IEA Executive Committee plans to publish a report with a comparative study of the case stories received.

How does DETECT work
Performing a DH&C feasibility study involves the handling of much data. DETECT provides most of the necessary data as default data.

There are default data files for each of the countries participating in the IEA District Heating and Cooling Project. These data have been prepared by national experts.
For a start, the user of DETECT only has to provide the data which is specific to the project in question.

This data can be entered when ’Data Requirements: SUMMARY’ has been selected in the program setup (the program default is ’SUMMARY’).

The complete data set can be studied and modified when ’Data Requirements: DETAILED’ is chosen in the program setup.

It is highly recommended that you always run the ’SUMMARY’ version first, whenever a new study is begun.

DETECT compares the proposed DH&C project to a **reference alternative** in the section called ’Reference Scenario’, i.e. the situation of the area being studied if the current development continues without the introduction of DH&C.

PROMOTIONAL MANUAL FOR DISTRICT ENERGY SYSTEMS (1993 P9)

Part A of the manual explains why the manual was prepared and its role in assisting developers and promoters of District Heating Systems with their promotion activities. Important terms are defined related to the preparation of a promotion plan.

The purpose of the manual
District heating and cooling (DHC) systems are a well proven approach for meeting the thermal energy requirements of buildings in an efficient and reliable manner. DHC systems compete in the market for thermal energy services with individual building technologies. Competitive success for DHC is determined by the extent to which the district system approach is preferred by decision makers to individual building heating and cooling options which are available.

The installation and operation of DHC systems can provide significant economic, energy and environmental benefits to the community in which they are located as well as to the customers of the system. Both the extent and desirability of these social benefits are being increasingly recognized by many national governments. This recognition has been translated into support for DHC systems by many governments and energy-related organizations.

In recent years, the International Energy Agency (IEA), through the District Heating Implementing Agreement, has provided support to many technology development projects related to district energy systems. The technology development project supported by the IEA and national government have made significant contributions related to technical issues of DHC system design and operation.

It has become increasingly clear, however, that the most significant obstacles to the implementation of new or expanded district energy systems can come from institutional rather than technical issues. The goal of this district energy system promotion manual is to address one set of institutional issues, those which are related to the effective promotion of new or expanded district systems.

Proponents of major district system project may work for several possible types of organizations. In many cases, the general manager of an existing system will take the initiative to identify a major expansion project. In other cases, an older system which requires renovation may be purchased and revitalized by a DHC company. Other project proponents may be elected officials or administrative managers within municipal governments.

What all of these project proponents have in common is the challenge of gaining support for their district system concept from a diverse group of organizations whose interests may be affected by its implementation. Many different types of organizations, such as municipal governments, utilities, owners and managers of large buildings and private developers, are affected by district systems. Each of these organizations has its own mandate, interests and method for making commitments for capital investments. Each also has its perceptions and, in many cases, misperceptions of district heating and cooling systems.

A major challenge exists, therefore, for the proponent or ’champion’ of a district system project to gain the acceptance and support from this diverse set of organizations for a project being proposed. Similarly, an established DHC system must also maintain support for its ongoing operations from those groups whose interests it affects.
Gaining support for a new district system or maintaining support for an established system requires the effective promotion of the benefits of the district system approach in general and the proposed or established DHC system in particular. More specifically, the proponent must clearly and credibly communicate the ways in which district systems can contribute to meeting each group’s self-interest.

Most of the people who are involved with district heating and cooling have a sound understanding of the technology and are eager to operate a business which provides efficient, reliable thermal energy to their subscribers. However, many do not have experience in marketing and promotion and have difficulty seeing themselves in the role of promoters. It is not surprising that the business disciplines required to organize and deliver activities to persuade others of the merits of district systems are quite different from the technical disciplines required to plan, install and operate the system itself.

The IEA has therefore identified the need to provide practical assistance to those people who are attempting to solicit support for proposed or established district energy systems. The most useful form for this assistance has been judged to be a promotion manual.

The purpose of the promotion manual which follows is to help promoters and developers first identify the groups which must be approached and then organize a set of targeted promotion activities which will communicate the most factual and persuasive evidence available. Through these activities, the promotion objectives of awareness, credibility and ultimately support for the project being developed can be achieved among the target groups and organizations.

In order to organize promotion activities, it is important to understand that three types of decisions determine the degree of success of district systems in penetrating the market for thermal energy services. These three types of decisions provide the basis for organization of this manual:

- First, building owners must decide to connect and remain connected to the DHC network. They must be persuaded that their needs will be better met through connection to the district system than through individual building systems. The decision process of building owners and how promotion activities can influence this process are discussed in Part C of this manual.
- Second, the DHC system itself must be conceived, implemented and supported on an ongoing basis. For municipal systems, many organizations and business firms, various municipal government departments, political officials and the electric and gas utilities serving the community, are affected by the implementation of a DHC system.

The decision makers in each of these groups must be persuaded that a district system represents a sound approach. The steps associated with the establishment and continued viability of district systems and the role of promotion in this process are discussed in Part D.

- Third, the attractiveness of district systems to decision makers is strongly influenced by governments policies and programs at the state/provincial, national and international levels. These policies and programs can take several forms:
  - Regulatory measures, such as energy efficiency standards or environmental controls
  - Economic instruments, such as taxes, subsidies and price controls
  - Informational programs, which can distribute data on technologies or provide moral support for technologies viewed as desirable. As discussed in Part E of this manual, the net result of these policies and programs can be either to enhance or to inhibit the market prospects for district systems.

Planning a Promotion Campaign

The term ’promotion’ can have different meanings in everyday usage. Furthermore, it is possible to confuse promotion with the terms ’marketing’ and ’sales’. For the purpose of this manual, a simple definition of promotion will be followed, a definition which is consistent with that found in marketing courses and textbooks.

Promotion consists of communication which is initiated between district system developers and operators and those groups whose interests are affected by the district system operation. The purpose of these communication activities is to influence the attitudes and decision behaviour of these groups in order to maintain or increase their level of understanding, acceptance and support for district systems. Due to the nature of many promotion activities, sales and public relations can be seen as major components of promotion.

Promotion can be seen as one of several activities performed within the more general function of marketing. In addition to promotion, marketing is concerned with such issues as the determination of a district system's competitive positioning, setting priorities among new customer prospects, establishing a customer service orientation and managing the system's pricing policy.

A promotion plan is required to organize an effective set of promotion activities. To prepare a promotion plan, the developer or operator of a DHC system must carry out four steps:

1. Identify target groups for promotion activities and understand their current attitudes and behaviour patterns.
2. Establish realistic promotion objectives based on current attitudes and behaviour patterns of the target group.
3. Select the specific promotion activities to reach the objectives.
4. Utilize the most persuasive benefits and examples in communication activities.

Each of these components of a promotion plan is discussed below.

1. Target Group Attitudes and Behaviour

The groups with whom communication takes place are many and varied. When a promotion effort is directed at a particular group, it can be referred to as a target group. As depicted in Figure 1-1, groups can include:

Groups which provide resources to the system:

- Employees
- Suppliers of Goods and Services
- Customers
- Capital Markets

Groups which provide the regulatory and fiscal environment and business direction for the system:

- Public Authorities
- The System's Board

Groups whose attitudes affect the system's success:

- Employees' Family and Friends
- Mass Media
- Potential Customers
- Engineers and Architects
- Interest Groups

An additional group - competitors - is also associated with the world within which the district system operates. However, district systems will rarely initiate communications with this group.

2. Attitudes and Current Behaviour

The starting point for the development of a promotion campaign is to determine existing attitudes and behaviour patterns among the DHC system's target groups. For example, some groups may have no knowledge of district systems, others may have misperceptions about the DHC concept and still others may be enthusiastic supporters.

Clearly, the nature and extent of appropriate promotion activities will vary for each of these situations. Through formal and informal surveys of a cross-section of members of each group, it is possible for a DHC system proponent to identify and understand the current attitudes and behaviour patterns which affect DHC.

3. Promotion Objectives

The communication activities which comprise a promotion program should be based on clearly stated objectives. These statements of objectives can ensure that there is a realistic expectation of what the communication program seeks to achieve with each group of decision makers who are targeted. Furthermore, when realistic specific objectives are established, it is possible to measure the extent to which intended results have been attained.

Appropriate objectives for a promotion program will vary depending on the nature of current attitudes and behaviour found among each target group. However, general objectives can be established for new systems or for established systems.

For new systems or systems which seek major expansions, the general promotion objective can be expressed as follows:

- To establish awareness and support among those groups whose interest are affected by a major district system project.

For systems which are mature and well-established, the promotion goals can be stated as follows:

- To maintain support among those groups whose ongoing backing is needed for continued system viability.

In addition to a general objective, specific objectives are needed to guide the communication activities established for each target group. These objectives are based on the premise that the role of promotion is to influence the current attitudes and behaviour patterns of the various target groups. Based on an understanding of which current attitudes are supportive of DHC and which are not, precise objectives can be established.

Several types of specific objectives may be required. Examples of these types of objectives include the following:

To Create Awareness of Strategic Opportunities

Examples:

- Operators of existing group systems may be made aware of the possibilities for using their system as a base for a new municipal (subscriber) system.
- Municipal planners may be made aware of the opportunities to incorporate energy from municipal or industrial waste as energy sources for district systems.

To Suggest New, Relevant Criteria Which Highlight DHC Benefits

Examples:

- Municipal planners may not have considered the relationship of building space heating systems to outdoor air quality levels as a relevant criterion or factor which should be included as they prepare long range plans for their community.
- Building owners may not have realized that district systems may offer their tenants increased comfort, leading to the addition of comfort levels as a criterion in the selection of heating and cooling systems.

To Provide Factual Information on Technology Options

Examples:

- Representative costs for alternative approaches to chilled water systems may be provided to consulting engineers.
- Statistics on the improvement in air quality in Scandinavian cities which have implemented extensive district systems may be given to government officials.

To Correct Misperceptions and Inaccurate Information

Examples:

- Engineers and others may hold the incorrect belief that the principal heat source for a district system must be within a few kilometres of the heat load. This misperception could be corrected by the communication of credible evidence that, where a very large heat load is available, thermal energy can be transported cost effectively through hot water piping for distances of 10-20 km or more (such as the 17 km pipeline which links Mannheim, Germany with a large power plant).
- Building owners may believe that district systems are less reliable than individual building systems, a belief which can be countered with such evidence as the high

levels of maintenance at central plants and the availability of back-up boilers.

To Enhance Credibility
Examples:

- Descriptions of successful systems, such as those in Helsinki, Finland Malmö, Sweden, Copenhagen, Denmark, St. Paul, Minnesota and New York City, can increase the level of confidence that district systems do represent a proven, low risk approach.
- Site visits to established plants can show local officials, building owners or consulting engineers that district systems represent a dynamic, contemporary approach which can adapt and grow to meet the community's thermal energy needs.

It should be stressed that the specific objectives for each promotion program must be developed based on the circumstances of each situation. Further guidance for the establishment of appropriate objectives is provided in Parts C, D and E which follow.

Promotion Activities
Communication activities which are carried out as part of DHC promotion are typically simple and straightforward. Most, for example, consist of one-to-one meetings, during which the advantages of district systems are discussed with influential members of key groups. Other communication activities may consist of plant tours and group presentations.

Communication materials, such as periodic newsletters, sales brochures and position papers for specific issues or projects, are also frequently used to support promotion activities.

Benefits of DHC Systems
A DHC system can provide significant benefits to system customers as well as to the community in which it is located. For building owners, important economic and non-economic advantages will accrue upon connection to the system. These advantages are highlighted in the '8 Reasons' selling sheet prepared by the International District Energie (IDEA) Association, shown at page 22.
The benefits to customers are discussed more completely in Part C.

For the community and society in general, the benefits offered by a DHC system include:

- The positive economic impacts of construction investments and retention of energy expenditures within the community.
- Energy impacts of substitution of imported energy sources such as oil with locally available resources such as biomass and municipal waste.
- Environmental impacts such as the improvement of local air quality and reduction of CO_2 emissions. A more detailed discussion of DHC's benefits to a community and society is presented in Parts D and E.

How to use the manual
This manual seeks to provide assistance for those who are learning about DHC for the first time as well as those who have been in the DHC industry for many years. Thus, Part B, an overview of DHC, should be of interest primarily to the first group. Parts C, D and E, which discuss Promoting to Customers, Promoting a Municipal System and Promoting at the Level of National Governments and International Organizations, should be of widespread interest.

The appendices include case studies, project examples and list of additional sources of information. These sources of information include a bibliography of reports, studies and other material, a directory of district energy associations and a list of government agencies and departments with interests in district systems. The use of this part of the manual will depend on the specific areas of interest of the reader.

Through the use of this manual, the system proponent can learn about the ’basics’ of district systems and prepare an effective promotion plan. The manual should serve as a useful ongoing reference as the proponent participants in the development and ongoing operation of a district system.

Why District Heating and Cooling should be utilized is shown in the ’Eight Reasons Sheet’ as prepared by the IDEA (page 22).

Part B of the manual provides an introductory overview of district heating and cooling (DHC) systems. Numerous terms are defined which are used throughout the remainder of the manual. An overview with description of the various types of district systems is given. After that, a summary of the principal benefits or advantages offered by district systems is presented. Furthermore the range of available technology options is high-lighted. A discussion of market acceptance - past, present and future - concludes this part of the manual.

8 REASONS YOU SHOULD UTILIZE DISTRICT HEATING AND COOLING

FOR YOUR BUILDING

Plan to save money, energy, and reduce pollution with district heating and cooling

For the prospective building owner/manager, district heating and cooling (DHC) service provided by a central thermal energy system offers a number of short- and long-term economic and technical advantages by eliminating or greatly reducing many of the operating, maintenance, staff and capital costs associated with boilers and chillers in individual buildings.

1. Plan on lower capital costs

The principal and interest payments, property taxes, and insurance costs associated with new boiler and chiller installations are all eliminated with district heating and cooling. The only initial costs in most buildings opting for DHC service are for a heat exchanger and related piping and valves.

2. Plan on lower energy costs

With district thermal energy, a building purchases only the energy it needs to meet its requirements. There is no ongoing capital expense to upgrade, rebuild, or maintain excess capacity. In-building boilers and chillers typically carry excess capacity to meet occasional peak demand, which leads to inefficient partial boiler and chiller loading during most of the year. This results in poor seasonal efficiency. By contrast, central boilers and chillers are operated to achieve the highest seasonal efficiency possible.

3. Plan on lower operating and maintenance costs

With district energy a building has less need for highly trained on-site maintenance and operating personnel, and costly annual maintenance contracts. Boiler and chiller operating expenses (i.e. electricity, water treatment chemicals, insurance, refrigerant and make-up water) are all eliminated.

4. Plan on stable competitive energy rates

Central DHC systems can convert to the least costly and most available fuel, and thus achieve economies of scale with volume purchasing. Systems are able to take advantage of municipal solid waste systems where they are available. They can also utilize waste heat from electrical generation plants, which is not practical with in-building systems due to an imbalance of electric and thermal loads.

5. Plan on more revenue generating space

Elimination of production system and their auxiliaries within a building frees up valuable floor space for income-producing purposes, and increase architectural flexibility. The use of DHC reduces vibration and noise problems and eliminates the need for stacks going up through a building.

6. Plan on reliable heating and cooling service

Central utility systems typically are better maintained and operated than in-building systems. They are manned 24 hours a day by highly qualified operators, are on strict maintenance schedule, and can be switched to a reserve fuel source as needed. Backup capacity, and backup energy plant redundancy is always readily available, without the need for in-building reserve boilers.

7. Plan on lower costs through system expansion

As more customers join each DHC system, the fixed capital and operating costs are spread over a large base, and individual energy bills are reduced or stabilized.

8. Plan on a cleaner environment

Central energy service from a thermal plant reduces the number of smokestacks throughout a city, and protects air quality by rigid control of emissions. DHC eliminates problems associated with fuel delivery through a city's congested streets, concerns over fuelavailability and storage, as well as other operating and maintenance responsibilities. Many central heating and cooling production plants have oil or gas pipelines to facilitate volume fuel delivery. When they are fuelled with coal or municipal waste, central plant typically have state of the art combustion and pollution control systems.

Area 3
Piping Techniques

Under Annex III the activities on the item Piping Techniques were concentrated to the following subtasks:

A: CFC-free Plastic Jackets Pipes for District Heating
B: District Heating Piping with Plastic Medium Pipes; Status of the Development and Laying Costs
C: Bends for Plastic Jacket Pipe Systems able to withstand high transverse Loadings.

CFC-FREE PLASTIC JACKETS PIPES FOR DISTRICT HEATING (1992 P6)

Introduction
For many years plastic jacket pipes proved worldwide to be an economic and reliable laying system for district heating pipelines. Especially during the 80's the state of knowledge was documented in numerous investigation reports. For the production of the pipes up to now the blowing agent CFC-11 was used, which as cellular gas was also responsible for the good heat insulation of the PUR-foam.

Considering their ozone-depleting effect, CFC-11, as well as other fully halogenated chloric chemical compounds were adopted into the Montreal Protocol, which means that their further application is limited. As a consequence, individual countries issued laws and regulations regarding the banning of these substances during the next few years.

Searching for alternatives for the CFC-containing foam the industry followed different methods, the most importants of which are described.

In view of new investigation results (climate measurements) and the political pressure, the Montreal Protocol as well as the national regulations are subject to constant changes. The present (February 1992) state of the plastic jacket pipes is described on the basis of a Swedish IEA-survey and a new German study.

The assessment of these alternatives is in most cases based on values obtained by the application of the proved CFC-containing foam. In the report a description is given of the technical prerequisites for new foams, paying special attention to:
– shearing resistance
– compression strength
– temperature resistance
– aging resistance (service life).

During the last years numerous investigations on the new foams have been carried out. The most important investigations and the corresponding results are presented.
Since the end of 1991 it is tried to internationally coordinate the investigation programmes. In view of the cross-border co-ordination in connection with investigated foam systems, the applied stresses and the testing temperatures, there is the prospect, that single investigation results may form part of a useful global assessment.

Summary
Within the next years, the application of CFC-11 will be forbidden in all of the investigated countries. In the district heating markets there are three alternative foams for plastic jacket pipes offered today by commercial production:

– CO_2-foam from different manufacturers
– M90-foam from ABB I/C Möller, blown with 1.1.1-trichlorethane and HCFC-22
– 'green foam' from TARCO, blown with HCTC-142b and CO_2.

Internationally there are no restrictions regarding the application of CO_2-foams. Foams containing 1.1.1-trichlorethane (such as M90) may be used for some more years; still, there has been determined a deadline in all of the investigated countries (depending on the

country there will be a ban between 1994 and 2005).

Foams based on HCFC-142b and CO_2 are still allowed in most countries except Switzerland; here, all HCFC's are banned from the year 2000 onwards. According to international statements and national legal projects there is a trend that the production or application of all ozone-relevant foams shall be reduced.

For the safe operation of plastic jacket pipes with CFC-11-free foams it is indispensable that the technical requirements resulting out of the thermo-mechanic stresses are met. These requirements regard:

– shearing resistance
– compression strength
– temperature resistance and
– aging resistance (service life).

During the years 1987 to 1991 several countries carried through intensive investigations on CFC-free foams, but these investigations were substantially impaired by the following facts:

– during the above mentioned period the foams were still in a nascent stage;
– in many cases the test methods were not suitable for CFC-free foams;
– neither the investigated foams nor the test conditions were coordinated between the testing agencies.

Not until in 1992, coordinated investigations on reference foams started. The agreement on reference foams and the coordination of the test conditions constitute important prerequisites for a global assessment. Thanks to the cooperation, investigations carried through at different testing agencies and with pipes and test cubes can be compared.

There are plans to adopt the new test concepts, which are independent from blowing agents, for the European standardization. Then, the required design approval tests for the marketed foam from the various manufacturers may be carried through. The only gap in the new test programmes which are accompanied by the European Project Group is the fact that investigations on the axial shearing resistance are missing. The axial shearing resistance is the most important characteristic of plastic jacket pipes, i.e. it allows endless-laying without expansions joints.

It would be a pity if conclusions on the axial shearing resistance could be drawn only from tangential creep tests. If there should be any financial means available for the investigation of CFC-free foams, these should be allocated for the determination of the axial shearing resistance.

There remains the hope that the development of the CO_2 -foams continues the trend shown during the last years, reaching gradually a higher temperature resistance so that this type of foam which is most favourable for the environment meets all the thermo-mechanic requirements.

DISTRICT HEATING PIPING WITH PLASTIC MEDIUM PIPES; STATUS OF THE DEVELOPMENT AND LAYING COSTS (1992 P3)

Introduction

The medium pipe of a conventional district heating system is made of steel since this material is particularly suitable for withstanding thermal and pressure loads. Plastic medium pipes can be more favourable than steel for small pipelines, even though they can only stand lower temperature and pressure loads. The assembly procedure can be so advantageous that cost reductions for pipeline construction result even though the pipe material itself is often more expensive than steel pipes. To reduce the high investments costs of pipeline construction an attempt must be made to use these possible savings to the full. They are offered in the area of small pipelines and service connections for nominal diameters under DN 100.

Suitable pipeline systems with plastic medium pipes are being offered for sale in all the countries being considered here in Western, Central and Northern Europe, although not always to the same extent. For this reason, a comparison of the user practice and construction costs between the countries would be worthwhile. The work is an extension to an IEA-report, based on the status in 1985/86 which concerned the construction of pipelines in areas of low heat density. A comparison of pipe systems on the market today with those considered at that time makes the rapid development experienced in this area quite clear. In fact, not one system is still being offered on the market without changes having being made. The many new developments mean that it may be assumed that there is still a considerable potential for a further development of these systems.

The status of the development today can be summarized in three sentences:

1. The experiences made by the manufacturers and from applications have produced a positive effect on the market, which has increased the expected turnover of established manufacturers and has also attracted new suppliers.
2. Manufacturers and users are following difficult development objectives. Plastic pipe systems will be open to professional applications and manufacturers will be able to increase their turnover only when all remaining application problems have been correctly solved.
3. The turnover of pipeline material based on cross-linked polyethylene is many times higher than the turnover of polybutylene systems.

These statements must be explained more in detail. The established manufacturer of plastic systems assesses the changes of these systems as positive. In addition, a competent company from Switzerland, Kabelwerk Brugg, has joined these suppliers and has introduced a new system. It is also interesting to note that manufacturers of conventional systems, i.e. of plastic jacket pipes, are increasingly extending their palette of products including plastic systems, e.g. Lögstör and Dansk Rörindustri. Wirsbo has even introduced a complete system although this company already has a very high position on the market as manufacturer of basic material.

Plastic medium pipes have been applied in a large number of reference ’networks’ which, for several products, have already shown periods of utilization of up to 12 years. It is noticeable that the main area of sales is the small, household-oriented construction of pipelines which are served by plumbers. In the case of professional pipeline planners of the supply for communities, these systems have only been introduced in isolated projects where this type of design has been regarded as advantageous as a result of special experiences with plastic or for reasons of intentional industrial cooperations. In particular, the long-term experience is not sufficient for district heating suppliers. In general, it can be said here that the main problem lies in the permeability of gases through plastics. Even if one regards oxygen diffusion into the heating water as a problem that was originally feared but which can be solved with today’s designs, the scientific discussion is being fed as a result of the fact that even water vapour escapes. The supplier can only expect frictionless sale of his products when this question has been clearly answered and the new systems show advantages when composed with the proved building constructions.

A final decision on the advantages of competing materials polyethylene PE-X (formerly VPE) and polybutylene PB cannot be made. The decisive advantage of PB lies in its weldability which makes jointing easier. However, this advantage has disappeared since the mechanical jointing elements for PE-X are meanwhile regarded as reliable. The connecting strainers, available today, have been classified both by the user as well as the manufacturer as so reliable that they can be buried in the ground. Further developments on these connectors are no longer concentrated on a reliable function but on reducing costs by means of saving material and simplifying assembly.

Scope of the Task

The work presented here had the objective of describing the systems which are offered today and to present the status of development which they have achieved. Problems which still hinder an unconditional application should be outlined. A large part of this work is devoted to cost considerations which compare which laying costs would be incurred by a particular system in a particular country.

In addition, this work includes a static consideration of the life of plastic medium pipes. This was needed because of the fact that system manufacturers were giving different load limits for the same pipe.

Summary

District heating pipelines with plastic medium pipes can offer advantages in public supply systems with diameters less than DN 100. The standard design with medium pipes of cross-linked polyethylene PE-X (previous VPE) and polybutylene (PB) seem to be suitable for loads of an operating pressure of 5 bar and variable supply temperature up to 90 °C.

Pipelines with plastic medium pipes have brought cost advantages of up to 40% compared with today’s standard design of plastic compound jacket pipe with steel medium pipe. These advantages vary considerably from manufacturer to manufacturer; they differ in the northern and middle European countries considered here as a result of the level of the civil engineering costs. Savings are a result of the fast and flexible method of laying.

The low proportion of plastic pipelines in public district heating networks is primarily a result of the sensitivity to temperature and pressure and the lack of experience of the longterm behaviour. The use of these flexible systems will increase as long as the cost advantages remain and further positive operational experiences are made and temperature/pressure levels are decreased.

BENDS FOR PLASTIC JACKET PIPE SYSTEMS ABLE TO WITHSTAND HIGH TRANSVERSE LOADINGS.
(1992 P4)

Earlier Design of Bends and Angular Deviations
Today, most of the district heating pipelines are manufactured as plastic jacket pipes. These consist of a steel medium pipe, a thermal insulation of PUR-foam and a HDPE jacket pipe. Characteristic feature of this design is the fact that district heating networks are conceived for a service life of 30 to 50 years and that the statically stressed plastics - due to the influence of age and time - are subject to strong ageing. Therefore, for design of the plastic components, material properties which are reduced due to ageing have to be applied.

Regarding the normal maximum medium temperatures between 90 °C and 140 °C, the transverse loads may act on the PUR-foam at a very small extent. In case of high outgoing temperatures such as 130 °C or 140 °C, the necessary permissible compressive strain of the PUR-foam is as high as 0.15 MPa. Accordingly, the transverse displacement occurring at bends has to be absorbed in cavities (expansion unit) or in expansion pads (foamed cushions) in order to protect the pipe against high soil resistance forces. For conventional plastic jacket piped, angular deviations have to be limited to maximum values of 3 ° and 6 °, depending on the line situation.

Scope of the Study
In spite of the constructional improvements, expansion pads are regarded as ’weak points’ of the plastic jacket pipe system for several reasons:

- so far, the long term operativeness of the expansion pads has not been proved;
- expansion pads constitute an additional thermal insulation which causes that the plastic pipe’s jacket temperature is increased;
- when the expansion pad is compressed, considerable reset forces are activated, which cause a considerable load on the steel service pipe and PUR-foam;
- at road sections, the application of expansion pads causes additional problems, because the recommended bearing capacity cannot be reached at road surface level if the depth of covering is low;
- large pipe diameters and non-preheated piping result in large expansions and large variations of expansion zone lengths. In most cases those expansions cannot be absorbed inside the expansion pads, because the permissible expansion pad thickness are limited by soil mechanics and heating up of the PE-jacket.

Another problem are the angular deviations between about 8 ° and 80 °, which normally cannot be realized with the former plastic jacket pipe system. This makes it either rather difficult to find the lines, or cost intensive compensation elements are required.

Aim of the Study
Part of the investigation project ’New Testing Techniques and System Components at the Plastic Jacket Pipe’, carried through by Gas-Elektrizitäts- und Wasserwerke Köln AG (GEW) is to exclude out the usual expansion pads at bends.

GEF (Ingenieursgesellschaft für Energietechnik and Fernwaerme GmbH) which is entrusted with the performance of the study, assumed that this was not possible with the usual components of the plastic jacket pipe, because the increased loads cannot be withstood by neither the sleeve joints, nor the foam or the steel pipe.

Therefore, pipes have to be developed which can be loaded especially in transverse direction and which, with permissible stresses, can carry these loads. For this purpose, the development of a foam with high radial compression resistance takes the limelight. Such ’polyurethane-lightweight concrete’ would have to be able to transfer the transverse loads, which are caused by the bedding reactions at the changes in directions, to the medium pipe during its total service life.

Summary
In an international cooperation a new component for the plastic jacket pipe system has been developed, which allows a design without ’weak point’ expansion pads and which makes it possible to realize any change in direction between 0 and 180 °. This will lead to lower laying costs, to higher operational safety and - last but not least - to a longer service life.

The new component, for which GEW Cologne applied an international patent, is based on a German invention. Today, it is manufactured by the Danish system manufacturer TARCO. The soil reaction which is the main basis for the design is based on series of measurements from the ASCE (American Society of Civil Engineers).

The bend able to withstand high transverse loadings is totally conformal to the system and is connected to the straight plastic jacket pipe with the usual joint - like a standard pipe. A leak detecting device may be kept inside the bend too.

The bend’s ability to withstand higher transverse loads is due to a reinforcement of the foam with expanded glass beads. This reinforced foam has a permissible compressive stress which is 10 times higher than that of the non-reinforced foam. Therefore, bends able to withstand high transverse loadings can definitely withstand the soil reactions which occur as a consequence of the transverse displacements of the pipe.

The PUR-foam has to be reinforced only in those sections, where the radial compressive stress is too high for normal foam. Due to the high soil reaction, the transverse displacements decline already after a short distance. In case of smaller and medium diameters only slightly lengthened, reinforced bend sides are required. Normally, bend leg lengths of 1 to 1.5 m are sufficient.

After 3 years of testing in laboratories and pilot plants the new components are considered ready for the market and are applied in several European test sites. A systematic test is carried through at two test sites in Cologne applying cold laying DN 150 to DN 40. Here, occurring displacements of the system are collected with mm-accurates. Besides, the steel stresses are measured both, in longitudinal and in circumferential direction, at the highest loaded cross-sections at 8 circumferential points with the help of wire strain gauges.

A further application will take place in 1992 with cold laid lengths DN 300 in Copenhagen. Here, the occurring forces and displacements are reduced by lowering wall thickness of the straight pipe.

The bends for plastic jacket pipes able to withstand high transverse loadings are able to take up - under coexisting load and temperature - high radial compressive stresses.

Here, the non-ageing expanded glass foam transfer the forces starting from the medium pipe onto the plastic jacket pipe. In case of the new bends for plastic jacket pipes able to withstand high transverse loadings, the function of the foam, which loses most of its resistance characteristics under temperature and time, is reduced to the bedding of the beads. There is good hope that the plastic jacket pipe’s service life can be increased by the application of bends for plastic jacket pipes able to withstand high transverse loadings in

the area of changes in direction, and can help to reduce the costs.

Regarding its technical and economical advantages it has to be assumed that the new component will soon prove its worth in the market and that it will be applied more often from 1993 onwards.

Area 4
Consumer Heating System Simulation

CONSUMER HEATING SYSTEM SIMULATION (1992 P5)

Introduction
The objective is to develop a dynamic simulation tool for consumer heating systems especially designed for district heating. Compared to traditional HVAC systems, those connected to district heating systems differ due to flow control and focus on temperature difference of the primary water. In this report two system concepts are described, one radiator system and one system for ventilation air heating. These two systems are combined as consumer installations and linked to a consumer substation heat exchanger. The total system concept is described.

Some test simulations are presented to give an idea of the alternative applications of the simulation tools.

Summary
CHESS is a PC-based dynamic simulation tool for Consumer Heating Systems especially designed for District Heating.
The tool is also very useful for Heating Systems in general where a great cooling of the hot water is important like in systems with heat pumps.

The CHESS-concept is based on a modular structure where the system you want to analyze can be built together from separate models of the actual components in the system.
The basic models take care of the effect of varying water flows and its influence on the heat transfer coefficients.

At this stage of the programme development the linking procedures have to be done by experts. More developing work is needed to enhance the user friendliness to a level where a non-expert may build his own system configurations.
The programme in hand contains two separate executive program-versions of a chosen 'reference system'. These executive programmes may be operated very easily by non-experts.

The CHESS-concept may be used for several purposes like:
- Optimization of temperature differences and the water cooling in the system
- Evaluation the regulativity of the system
- Choosing the right regulator
- Adjusting the regulator
- Evaluating of regulating valves
- Choosing the right values
- Choosing the right place for the sensors
- Evaluating the regulating consequences of hysteresis etc.

The concept makes it possible to evaluate the whole system operation on the designstage and thereby eliminate bad system configurations at an early stage. The CHESS-concept may also be used to analyze existing bad working systems to see the effects of possible changes of the system.

The simulation program is adapted from a simulation tool named CYPROS SIM which is a program for solving nonlinear dynamic problems.

Ordering of diskette
A diskette with the executive programmes that are developed may be requested from the member of the 'Executive Committee' from your own country of from NOVEM, The Operating Agent.
The following reference is recommended:
'IEA-District Heating and Cooling Project', Annex III 'Consumer Heating System Simulation (CHESS)' November 1992.

Area 5
Supervision of District Heating Networks

QUANTITATIVE HEAT LOSS ANALYSIS OF HEAT AND COOLANT DISTRIBUTION PIPES BY MEANS OF THERMOGRAPHY. (1993 P8)

Background
In those countries which have a long tradition of district heating, a new concern has arisen recently: certain district heating networks are approaching the end of their technical lifetimes and the heat loss in older culvert networks are increasing significantly. In order to chart the requirements and resources for maintenance measures, it is important to be able to diagnose the conditions of the piping network.

One method increasingly used for heat loss detection is based on airborne and groundborne thermography. In this method the mapping of the ground temperature can be used to give qualitative information about the network conditions, mainly with the aim of finding leaks. With the help of more refined analytical methods it is possible in the long run not only to trace leaking media pipes, but also to determine the condition of the insulation. In that way it will be possible to draw conclusions about any damage to the protective casing of the culvert by determining the amount of heat loss quantitatively.

For the last couple of years Studsvik has been working on the development of a method for quantifying heat losses from district heating pipes by means of thermography, reference [4], [5]. An overview of different parts of the earlier and present projects which have led to the heat loss interpretation model is shown.

Aim of the project
The aim of this project was to verify a model for quantitative determination of heat losses using the temperature profile on the ground surface above a pair of hot water district heating pipes. In practical applications, this profile can be generated by means of thermographic methods.

A second aim of the project was to extend the model to include pipes for steam distribution and district cooling.

Scope of work
The work to be carried out deals with the following problems:

- refining the model by systematic sensitivity studies including second order effects due to varying ground properties
- modification of the model for steam pipes
- development of model extension for coolant distribution pipes
- experimental verification of the model on a test pipe with controlled heat supply, simulating hot water and steam pipes, respectively
- application of the model to a thermographic evaluation system.

Conclusions

- The model for quantitative thermography analyses has shown to enlarge the range of applicability compared with conventional thermography evaluation. Under ideal conditions the heat loss from district heating pipes can be analyzed within an accuracy of ± 10%.
- The interpretation model was applied in a field experiment in Västeras showing its usefulness in the further analysis of questionable sections as detected in the course of a general thermography survey.
- The interpretation model needs an input value of the trench depth with a higher accuracy than often available from drawings. In this case the use of electronic sensor techniques for pipe detections might be a possibility.
- The thermal conductivity of the soil has - in contrast to a common opinion - only a relative small influence on the heat loss.
- The ground must be dry, otherwise evaporation of water on the ground will affect the temperature profile. However, well wetted surfaces can, under some

circumstances, also be used for qualitative evaluation of the pipe standard.

- A drying surface will cause misleading results due to latent heat transport.
- Thermography during exposure to long wave and solar radiation is possible if the surface is uniformly exposed to the radiation and if it has a homogeneous emissivity within the surface area to be analyzed.
- The prevailing wind conditions affects the temperature profile for several hours. This effect can be included in the interpretation model with further analysis.
- The TX factor measured at a certain moment represents the insulation status (and temperature condition) from a period starting about one week prior. Hence, changes in the insulation status which are more recent than this, can not be correctly analyzed. Similar, if the distribution temperature changed drastically within the preceding week or so, one must be careful in interpreting the thermography results.
- The interpretation model can also be used with high accuracy for steam distribution systems. Its higher temperature level compared to hot water distribution systems facilitates the evaluation of the thermography picture.
- It is difficult to quantify the heat gain in district cooling applications by means of quantitative thermography analysis due to the small temperature differences at the ground surface.
- Quantitative thermography analysis can be used for leakage detection in district cooling systems. However, the process of leaking water soaking the ground must be further analyzed.

Area 6
Advanced Transmission Fluids

Under Annex III the activities on the item Advanced Transmission Fluids were concentrated to the following subtasks:

A: Advanced Energy Transmission Fluids for District Heating and Cooling
B: The Design and Operation of Ice-Slurry based District Cooling Systems

ADVANCED ENERGY TRANSMISSION FLUIDS FOR DISTRICT HEATING AND COOLING (1993 P7)

Introduction
Under Annex III of the International Energy Agency's Implementing Agreement on District Heating and Cooling, the Experts Group on Advanced Transmission Fluids continued its program of research, development, and testing that was originally initiated in 1987. Member country representatives from Canada, Denmark, Finland, Germany, The Netherlands, Sweden and the United States developed a research program that addressed major concerns relating to the use of friction reduction additives (FRAs), and looked further into the problems associated with advanced district cooling technologies. Based on a review of proposals submitted by several research groups, the member country representatives selected four projects to be carried out under this annex, and activities were initiated in early 1991.

The performance of heat exchangers in systems utilizing friction-reducing additives was identified as an area of concern, since earlier testing had shown that FRAs caused a degradation in heat transfer performance proportional to improvements in friction reduction. Bruun & Sorensen was therefore asked to undertake a project to test heat exchanger performance in a system using these additives, and to develop alternatives to overcome any losses in heat exchanger performance.

A second concern of the Expert Group centered on the potential environmental and health effects associated with surfactant friction-reducing additives, the leading candidate chemical under consideration for use in district heating systems. The University of Dortmund performed a comprehensive literature review and assessment of the environmental effects of surfactants, and performed tests to determine their adsorption properties in various soil types as a means of assessing the potential impacts of district heating system leakage and spills on the local environment.

In Annex II, the Experts Group performed a preliminary evaluation of the potential for increased corrosion of district heating and cooling system metals due to their exposure to friction-reducing additives. Under Annex III, the Ohio State University expanded this evaluation to test several candidate additives in a variety of water compositions and in combination with corrosion inhibitors. Testing was also carried out at two temperature ranges common to district heating system operation.

Also under Annex II, research and testing of ice slurry mixtures as a means of improving the energy transport capability of district cooling systems was carried out. In an effort to move this exciting technology out of the research stage toward practical consideration as a viable concept for building cooling, Annex III supported Energy, Mines and Resources Canada in the development of a manual which provides design guidelines and alternatives for the use of ice slurries in district cooling systems.

Each of these four research projects has been completed, and the results of the efforts are presented in the report. In addition, a fourth annex addressing advanced transmission fluids has been approved, and several new research and testing projects will be initiated in the technology area in the near future.

Summary

This report describes the results of research and testing undertaken by the International Energy Agency (IEA). Under Annex III of the IEA's program, the Experts Group on Advanced Transmission Fluids for District Heating and Cooling Applications undertook four research projects that addressed: performance of plate heat exchangers operating with friction reduction additives; environmental effects of surfactant friction reduction additives; use of ice slurries in district cooling systems; and corrosion effects of friction reduction additives.

Performance of Plate Heat Exchangers operating with Friction Reducing Additives. Bruun & Sorensen Energiteknik AS of Risskov, Denmark undertook an investigation of the effects of friction-reducing additives on the performance of plate heat exchangers. An experimental plate heat exchanger (.7MW) was installed in the district heating centre in Lind, Denmark, in parallel with the existing main (10 MW) heat exchanger at the centre. Over a ten month period, tests were conducted using the friction reduction additive 'tenside' at concentrations of 100, 215 and 400 parts per million (ppm). Supply and return temperatures and flow rates were measured, as was the pressure loss across the primary (additive) side of the experimental heat exchanger. The heat transfer coefficient (a) and heat transmission coefficient (k) of the heat exchanger were then calculated.

The results of testing showed that the calculated heat transfer coefficient for the plate heat exchanger operating with tenside can approximate that of pure water, if flow velocity across the exchanger plates is increased. The higher the concentration of tenside, the more the velocity must be increased, however. This same characteristic is also apparent for the exchanger heat transmission coefficient, with the K-value being improved at the same overall flow rate by reducing the total gap area of the heat exchanger plates.

In order to compensate for the reduction in heat transfer associated with the use of friction-reducing additives, higher flow velocities through the exchanger must be employed while maintaining the required effective exchanger surface area. Three design alternatives can be considered:

1. Utilize longer plates. Elongated plates will compensate for the reduced heat transfer coefficient without significantly changing other exchanger parameters. By allowing the exchanger to remain as a single pass system, this alternative minimizes total pressure losses across the heat exchanger and maintains all piping connections on the same side of the plate exchanger for ease of installation and servicing. In a new plant installation where sufficient space can be made available for the longer plates, this alternative would appear to be the most practical.

2. Increase the number of plates. If an existing plant is being modified to utilize friction-reducing additives, it may be possible to add additional plates to the heat exchanger to compensate for the reducted heat transfer coefficient. However, preliminary calculations indicate that the number of plates required to maintain return temperatures in the primary district heat system may be substantial (up to 100% more).

3. Convert to a two-pass system. In an existing plant where space and cost constraints may be apparent, converting the plate heat exchanger into a two-pass configuration may be possible. The associated velocity and turbulence increases will improve heat transfer coefficient and lower primary side return temperature. The negative aspects of

this alternative include a significant increase in system pressure loss, and problems associated with more complex piping connections.

Environmental Effects of Surfactant Friction Reduction Additives.
The use of friction-reducing additives in district heating and cooling systems must take into consideration their impact on the environment, and the health and well being of all living organisms that may come into contact with the additives during their use and disposal. The University of Dortmund therefore undertook an investigation of one popular class of friction reducing additives, cationic surfactants, to assess their hazard potential when used in district heating and cooling applications. This effort included a comprehensive review of the available literature pertaining to cationic surfactants, combined with testing of the adsorption characteristics of surfactant solutions in selected soil types.

The structure of the cationic surfactants under consideration for use in district heating systems is very similar to that of other cationic surfactants in wide use today. As such, their toxicological and ecological properties are similar:

- primary biodegradability > 80%
- ultimate biodegradability > 60%
- fish toxicity > 1 mg/l
- bacteria toxicity > 1 mg/l

Two important characteristics of cationic surfactants serve to reduce the exposure risk associated with their accidental release into the environment:

- they form neutral salts when in contact with anionic surfactants that are present in all waste waters and surface water.
- they adsorb on all solid surfaces.

To assess the potential for damage due to leakage in a district heating or cooling system employing cationic surfactants, adsorption testing was conducted using several common soil types. The results of these tests indicated that surfactants are irreversibly adsorbed, with the rate of adsorption by the amount of clay present in the soil.

Ice Slurry based District Cooling Systems
With the evolution of residential and commercial buildings into tighter, more energy efficient structures, and the greatly increased use of electrical equipment and appliances within them, the need for space cooling has increased significantly. District cooling systems provide an attractive means of cooling building, especially in higher density commercial areas. Accordingly, research is being conducted to improve the energy and operating performance of large chilled water systems. One particular technology, the use of ice-water slurries, provides an opportunity to greatly increase the cooling energy capacity of a given volume of cooling water, leading to reductions of capital costs for system construction, as well as reductions in pumping costs associated with system operation.

Under this IEA annex, Energy, Mines and Resources Canada developed a design manual for ice slurry based district heating and cooling systems. The manual summarizes several system design alternatives, which are each organized in accordance with the major elements comprising a typical district cooling system: ice slurry generation; distribution; storage; and utilization. These design alternatives illustrate the diversity that currently exists among the technologies that can be employed for ice slurry based district cooling. The design manual also identifies a number of areas where research, development, or testing is required to support the various system design alternatives.

The influence of Friction Reduction Additives on corrosion rates of District Heating System Materials.

The use of friction-reducing additives in district heating and cooling systems provides an opportunity to reduce system costs and improve operating performance. However, the potential exists for these additives to have deleterious effects on metal piping and other distribution system components. The IEA therefore conducted a preliminary study, in 1990, of the corrosion effect of cationic surfactants in solutions of tap water, deionized water, and tap water containing corrosion inhibitor. Subsequently, a more detailed study of the corrosion effects of friction reduction additives was determined to be required, and was under taken by the Ohio State University under this IEA annex.

Pitting corrosion rate susceptibility and corrosion rate tests were carried out on AISI type 304 stainless steel, SAE 1112 (API Grade B) carbon steel, copper 90/10 copper/nickel, and 60/40 copper/zinc samples. Corrosion environments included tap water, deionized water, deoxygenated water, deionized/deoxygenated water, and a 50% tap water- 50% deionized water mixture. Tests were carried out at temperatures between 60 °C and 110 °C, and also at 25 °C to approach district cooling system temperatures, with pH values varied between 7 and 10. The effects of several friction additives on pitting susceptibility and corrosion rates were assessed. Additional tests were conducted using corrosion inhibitors in combination with friction reduction additives.

The results of testing showed that, with the exception of pitting susceptibility in tap water, the addition of Habon-G or Ethoquad T/13-50 (plus NaSal) friction reduction additives either improves or has no negative effect on pitting susceptibility or corrosion rates of the iron-based or copper-based metals typically found in district heating and cooling systems at temperatures of 60 °C and 110 °C, and in some cases gave improved results. However, adverse corrosion effects were found when friction reduction additives containing chlorides were tested.

THE DESIGN AND OPERATION OF ICE-SLURRY BASED DISTRICT COOLING SYSTEMS (1993 P7.1)

Introduction

Since the oil crisis of the 1970's, interest in district heating and cooling has increased dramatically. The Scandinavian countries particularly, are continuously applying the latest improvements in district heating technology. There are a number of excellent reasons for this renewed interest. In addition to improved performance due to economy of scale, a wide range of heat sources can be applied to DHC systems including waste heat and combined heat and power (CHP).

Interest in DHC and community integrated energy systems (CIES) is now increasing markedly in North America as well. One important element of CIES is the summer air conditioning load.

Environmental concerns about the ozone depletion potential of some CFC's used today have prompted a search for alternative cooling technologies. With the recent improvements in low-temperature absorption chillers, waste heat from any process stream of CHP plan may be used to satisfy a chilling load, without the use of CFC's. This also improves the overall efficiency of the process of which the residual energy is derived.

In a typical air conditioning installation, cold water is supplied at about 7 °C and returned at about 13 °C. The small amount of sensible heat corresponding to this temperature difference of

6 °C means that a large volume of water has to be circulated in the DHC system. If the temperature of the supply water could be decreased, or if phase change materials were incorporated in the circulating heat transport liquid, the system mass flow and pipeline diameters could be reduced, thereby improving the economics of the system. Smaller pipes reduce the installation and capital costs, and the reduced surface area decreases heat gains and therefore operating expenses. Also, existing district cooling systems can be expanded using ice slurry without increasing pipeline capacity.

The advantages of low temperature air distribution (i.e. less than 10 °C) are now being recognized. Ice slurry based air conditioning is of course very suitable for low temperature air distribution. The advantages include less air transport, lower horsepower fan motors, less voluminous duct work (the height of buildings can thus be reduced) and extra comfort from lower relative humidity, without terminal reheat (Tamblyn, 1992).

This report describes the advantages and disadvantages of using ice slurry in district cooling systems. Some existing ice slurry air conditioning projects, and some that are under construction are described to demonstrate the feasibility of the concept and to highlight current practice. The more important physical properties and behaviour of ice slurries are presented in a form that will help the practising engineer or consultant to develop a DHC system design.

Summary

The district heating and cooling (DHC) industry is enjoying renewed interest in North America. The successful implementation and operation of district heating systems in Northern Europe proves that significant advances have been made in the areas of fuel efficiency and self-sufficiency. Impressive reductions of harmful emissions have been achieved at the same time.

With respect to district cooling, scientific breakthroughs have been made recently with friction reducing additives for cold liquids and phase change slurries.

Interest in district cooling is propelled by the increasing cooling load in commercial buildings due to factors such as the widespread use of personal computers, other electronic office equipment and by the need to phase out the use of CFC's in accordance with the Montreal Protocol.

Ice slurry has the potential to achieve considerable benefits for district cooling systems. The cooling capacity of ice slurries can be four to six times higher than that of conventional chilled water.

In this report, current practices and possibilities of ice slurry utilization are reviewed. The pressure drop properties of ice slurries are presented. Several commercially available ice slurry chillers are compared in terms of performance and costs.

The distribution network is one of the high cost items in DHC systems. The advantages of ice slurry with respect to cold water are presented. The effect of storage facilities on the capacity of the chillers is discussed. Possible consumer substation configurations are compared. The report concludes with a look at controls, energy metering possibilities and heat exchanger design for ice slurry use.

Ice slurry technology can significantly decrease the operating cost of a district cooling system. Although the capital cost of ice slurry chillers is at present higher than that of conventional chillers, significant progress is being made to reduce this cost.

APPENDIX I

Projects summarised in the R&D Review Report (Area 1)

1. **Canada**
   1.1. IEA advanced fluids project. Subcontract for ice slurry transport.
   1.2. Low-temperature friction reducing additives for district cooling and building cooling systems.
   1.3. Experiments with ice slurry produced from a generator based on the principles of supercooling.
   1.4. Deep lake water cooling (DLWC) project.
   1.5. Multi-utility telemetry systems for remote meter reading, monitoring and load control.
   1.6. Installation of novel design heat pump using low temperature mine water as heat source.
   1.7. Development of an experimental ice slurry based district cooling system.
   1.8. Thermal interaction between underground pipelines of different temperature.
   1.9. Feasibility study of district heating system in the proposed community of Ouje Bougoumou.

2. **Denmark**
   2.1. Influence on heat transmission of smooth water in plate heat exchangers.
   2.2. Use of smooth water in the water circuit of CHP plants.
   2.3. Consequences for water treatment plants by using 'smooth water' in district heating systems.
   2.4. Water hammers in district heating systems applying smooth water.
   2.5. Optimization of straw fired plants, the firing technical qualities of straw and selection of demonstration plant.
   2.6. Optimization of combined heat and power (CHP) plants.
   2.7. Surface combustion of straw.
   2.8. Surface Combustion of Straw.
   2.9. Evaluation of LOCUS-plants (LOcal Cogeneration Utility System).
   2.10. Humidification of Combustion Air of CHP Gas Engines Energy and Environmental Aspects.
   2.11. Design and construction of standard cogeneration units.
   2.12. Repowering of power station Ujpest (Hungary).
   2.13. Tommerup St. Varmeforsyning - Natural gas powered - combined heat and power station.
   2.14. Noise from rather Large, Gasfired Boiler Plants.
   2.15. The optimum directly connected district heating substation (consumer connection) for low-temperature.
   2.16. Energy-efficient heat exchangers for district heating systems.
   2.17. Optimization of larger consumer plants for district heating by operation tests.
   2.18. Central heating in old house stock.
   2.19. On site calibration of large energy meters using an isotope based flow measurement method.
   2.20. A PVC-based flue gas heat exchanger. Energy savings and practical experience.
   2.21. SESAM - North Jutland. Sustainable Energy Systems Analysis Model for North Jutland, Denmark.
   2.22. Pressurized Pulverized Coal Combustion.
   2.23. Time-varying processes.
   2.24. Optimum operation of district heating systems.
   2.25. Development of heating plants for combustion of wood chips with high moisture content.
   2.26. Heating of greenhouses based on low-temperature heat from return pipes from combined heat and power plant. Construction project.
   2.27. District heating in Hungary.
   2.28. Optimization of operation of small district heating plants by heat

accumulation.

2.29. Establishment of a low-temperature district heating system for new buildings and shops. Construction project.
2.30. Combining low-temperature system with existing district heating plant. Pilot project.
2.31. Measuring programme in connection with operation of heat storage tanks at 4 existing straw fuelled district heating plants.
2.32. Low temperature heating system based on return string district heating from CHP-system combined with glass covering.
2.33. Development of test facilities for dynamic testing of heat meters for district heating.
2.34. Examination of district heating metering at different friction reducing additives (phase 1).
2.35. Examination of district heating measuring and meters under dynamic operation.
2.36. Numerical model for a central solar heating system involving seasonal heat storage.
2.37. Damping of noise from medium size gas fired boilers.
2.38. Design codes for preinsulated pipes.
2.39. Investigation of strength and duration of preinsulated district heating pipes of plastics.
2.40. Mechanical properties of cellular polyurethane (PUR) plastic insulation in pre-insulated district heating pipes.
2.41. Oxygen in plastic pipe district heating systems.

3. Federal Republic of Germany

3.1. Corrosion behaviour of materials in circulating waters containing surfactants of different quality.
3.2. Corporate project on friction reducers; development of treatment processes for solutions containing surfactants.
3.3. Influence of surfactant solutions in district heating systems on the operating and control behaviour of centrifugal pumps.
3.4. Dynamic flow processes in connection with friction reducers.
3.5. Influence of friction-reducing additives on the behaviour of measuring and control elements in district heating networks.
3.6. Influence of friction-reducing additives in different heat-exchanger systems.
3.7. Application and testing of micellar friction reducers in district heating systems.
3.8. Advanced heat pump technologies for district heating systems.
3.9. Development of a small-power low-NOx diesel engine involving measures on the primary side of CHP plants.
3.10. Technical and economic investigation of the combined transport of district heat and waste by rail based on specific applications in Germany.
3.11. Field testing of flue gas purification equipment.
3.12. Reducing the primary energy consumption by new technological and engineering solutions for the installation of cogeneration equipment in existing heat plants with low thermal parameters.
3.13. Energy concept of the Technical University of Zittau for the territory of the former GDR up to the year 2020 (Zittau Energy Concept 2010). State of knowledge in 1990.
3.14. Complex energy supply systems for the town of Neustadt-Gleve.
3.15. Improved utilization of district heating systems, optimization of operation (B 01).
3.16. Manufacture, laying and testing of a district heating system with vacuum superinsulation (VSI).

3.17. Project study on ’Improved Utilization of District Heating Systems’.
3.18. German participation in the IEA Implementing Agreement on District Heating Annex III. Cooperative projects in the field of district heating and cooling.
3.19. German participation in the IEA Implementing Agreement for Programme Research, Development and Demonstration on District Heating.
3.20. ’First processing phase’ for the energy concept Leipzig.
3.21. Manufacture, laying and testing of a district heating pipe system with vacuum superinsulation (VSI).
3.22. Novel heat distribution - new laying techniques for flexible district heating systems with plastic medium pipes.
3.23. Corporate project: Novel District Heat Distribution.
Subproject: New testing techniques and system components for plastic jacket pipes.
3.24. Development and construction of critical single components for the mobile district heat system. Testing using a model system - Phase A.
3.25. Research and development project on ’operational selfprestressing’ of district heating pipes.
3.26. ’SF Generators’ - generators with superconducting field coils.
3.27. ’Operational self-prestressing of district heating pipelines’ (plastic composite jacket pipe system and vacuum steel jacket pipe system).
3.28. Corporate project: Novel district heat distribution.
Subproject: Development of new components for plastic jacket pipes.
3.29.Determination of frictional forces on soil-covered heat-conducting pipelines to ensure economical designs.
3.30. New underground laying techniques for large district heat transport pipes in conurbations.
3.31. Corporate project: Novel District Heat Distribution.
Subproject: New laying techniques for the plastic composite jacket pipe systems.
3.32. New laying techniques using heat-insulated compensating socket pipes of ductile cast iron as well as efficient methods for laying service pipelines.
3.33. Manufacture, laying and testing of a district heating pipe system with vacuum superinsulation (VSI).
3.34. Corporate project: Novel Heat Distribution.
Subproject: New techniques and construction methods for district heat distribution utilizing static thresholds, new materials and improved laying techniques.
3.35. Energy and environmental concept for the town of Meissen.
3.36. Development and operation of an information system for municipal energy supply (KEV).
3.37. Energy concept for Berlin.

4. Finland

4.1. Planning System for Combined Heat and Power Supply.
4.2. Reduction of NOx Emissions in Oil-fired Boilers by Using Selective Non-catalytic Reduction.
4.3. Analysing of the Couplings and Dimensioning Criteria of District Heating Subdistribution Systems.
4.4. Behaviour of District Heating Consumer.
4.5. Operation Experiences of a Low-temperature District Heating System in a Small-house Area.
4.6. District Cooling, pilot study.
4.7. Development Requirements of District Heating Company Organisations.
4.8. Electric Heating in District Heating Areas.

4.9. An Experimental Study on Heat Losses of Different Types of District Heating Pipes.
4.10. Definition of District Heating Consumer Heat Load.
4.11. Thermal Stresses in District Heating Pipes.
4.12. Predictive Maintenance of District Heating Networks by Infrared Measurement.
4.13. The Possibilities of Energy Meter Remote Reading in District Heating.
4.14. No-compensation Pipeline System in District Heating.

5. Netherlands

5.1. Adsorption system of cooling buildings by DH.
5.2. Absorption cooling with DH water.
5.3. Centralized production of domestic hot water for dwellings.
5.4. Value of DH in the heating of domestic dwellings.
5.5. Research and enquiry on sliplosses.
5.6. Base load connected bulk consumers.
5.7. The behaviour of electronic heat cost apportionment under different circumstances.
5.8. Advantages and disadvantages of heat expenses sharing systems.
5.9. Metering of heat flows in buildings with collective heating systems.
5.10. Evaluation of 'electronic' heat expenses sharing systems.
5.11. Evaluation of four different makes of direct heat meters.
5.12. Development of a control and optimization strategy for the operation of District Heating networks.
5.13. Optimization of heat supply to small individual dwellings.
5.14. Optimization of the heat load curves in substations.
5.15. Research on the ageing of polyurethane foam in district heating networks.
5.16. Study on compact house substations.
5.17. Use of boilers for domestic hot water in compact house substations.

6. Norway

6.1. Analysis of energy- and load-demand in district cooling-systems.
6.2. Optimization of hot service water production in consumer substations.
6.3. Thermal Power and Energy for Heating Systems.

7. Sweden

7.1. Advanced heat transfer fluids.
7.2. New technique for central control unit.
7.3. Planning of production of heat in district heating systems by heat load estimation.
7.4. Impurities on heat exchangers.
7.5. On Ultrasonic Flow Meters. Investigations and improvements of the sing around flow meter.
7.6. Research programme, LTH.
7.7. Research programme, UMEA TH.
7.8. Specifications and requirements of PUR-foam manufactured without freon for joints.
7.9. Studies on ductile iron pipe systems for district heating purposes.
7.10. Direct laying technique for district heating pipes.
7.11. Research program on distribution techniques.

8. USA

8.1. Friction Reducing Additives for DHC.
8.2. Ice Slurry District Cooling Development and Field Testing.
8.3. Fundamentals of Ice Slurries.
8.4. Leak Detection and Location Using In-Stream Acoustic Sensors.
8.5. Development of Three-Pipe DHC System with Once-Through Domestic Hot Water Supply.

APPENDIX II:
List of Publications

List of publications Annex I

1986:	R9	IEA District Heating Small-Scale Combined Heat and Power Plants
1986:	R10	IEA District Heating Cost Analysis of District Heating Networks
1987:	R4	IEA District Heating Temperature Levels in District and Local Heating Systems in Sweden
1987:	R6	IEA District Heating Technical and Economic Assessment of New Distribution Technology
1988:	R12	IEA District Heating Small Heat Meters
1988:	R13	IEA District Heating State-of-the-art Review of Coal Combustors for Small District Heating Plants
1988:	R16	IEA District Heating Summary of Research Activities 1983 - 1987

List of publications Annex II

Number	Title	ISBN-number
1989: R1	District Heating & Cooling R&D Project Review	90-72130-07-3
1989: R2	Advanced District Heating Production Technologies	90-9002876-5
1989: R3	Static problems in the laying of plastic jacket pipes	90-7213-09-X
1989: R4	Fittings in plastic jacket pipelines	90-72130-08-1
1990: R5	Welded Sleeves Technique for Plastic Jacket Pipes	90-72130-17-0
1990: R6	New Methods in Underground Engineering and Installing of District Heating Pipelines	90-72130-16-2
1990: R7	A technology assessment of potential telemetry technologies for district heating	90-72130-10-3
1990: R8	Guidelines for converting building heating systems for hot water district heating	90-72130-12-X

1990:	R9	Advanced Energy Transmission Fluids Final report of research	90-72130-11-1
1990:	R10	Heat Meters - Report of research activities - Annex II	90-72130-15-5
1990:	R11	Thermal Energy from Refuse Analysis Computer Program	90-72130-18-9
1990:	R12	Summary of research activities 1987 - 1990	90-72130-19-7

Publications Annex III

Reports:			ISBN-number
1992:	P1	The environmental benefits of District Heating and Cooling	90-72130-36-7
1992:	P1.1	DETECT Consequence model for Assessing the environmental benefits of District Heating and Cooling in a well defined area	
1992:	P2	CFC-Free Plastic Jacket Pipes	90-72130-28-6
1992:	P3	District Heating Piping with plastic medium pipes, status of the development and laying costs	90-72130-29-4
1992:	P4	Bends for Plastic Jacket Pipe Systems, able to withstand high transverse loadings	90-72130-30-8
1992:	P5	Consumer Heating System Simulation	90-72130-32-4
1992:	P6	R&D Project Review	90-72130-33-2
1993:	P7	Advanced Energy Transmission Fluids Final Report of Research, annex III	90-72130-34-0
1993:	P7.1	The design and Operation of Ice-Slurry Based District Cooling Systems	90-72130-50-2
1993:	P8	Supervision of District Heating Networks	90-72130-35-9
1993:	P9	Promotion Manual for District Energy Systems	90-72130-39-1

Brochure: A Clean Solution? It is also your responsibility.

APPENDIX III:

List of participating countries and their Ordinary Members of the Executive Committee

Canada
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