

International Energy Agency

IEA District Heating

Programme of research, Development and
Demonstration on District Heating and Cooling

DISTRICT HEATING & COOLING R&D PROJECT REVIEW

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acting as operating agent for
the IEA District Heating and Cooling project

INTERNATIONAL ENERGY AGENCY

Programme of Research, Development
and Demonstration on
District Heating and Cooling

DISTRICT HEATING & COOLING R&D PROJECT REVIEW

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PREFACE

The International Energy Agency (IEA) was established in 1974 within the framework of the OECD to implement an International Energy Programme. A basic aim of the IEA is to foster cooperation among the participating countries to increase energy security through energy conservation, development of alternative energy sources and energy research, development and demonstration (RD&D).

As an element of the International Energy Program, the participating countries undertake cooperative activities in energy RD&D.

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

IEA's Program of Research, Development and Demonstration on District Heating was established in 1983 at a meeting in Stockholm. In the first phase, ten countries took part in the program; Belgium, Canada, Denmark, Federal Republic of Germany, Finland, Italy, The Netherlands, Norway, Sweden and the 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 in the first phase during the period November 1983 - December 1987 was published in 1988 by the National Energy Administration, Sweden, (report Statens Energiverk 1988: R16).

In 1987 a second phase, including the following technical areas, was begun:

- 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 the second phase. Nine countries have participated in the second phase, i.e. all countries of the first phase except Belgium.

VIII.

In May 1990 decisions were taken concerning a third phase, in which all participants of the second phase will continue their participation for another three-year period during which the United Kingdom joined the program. Items of the third phase are:

- District Heating and the Environment
- Supervision of District Heating Networks
- Advanced Transmission Fluids
- Piping
- District Energy Promotion Manual
- Consumer Heating System Simulation

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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 in 1989 based on contributions from the member countries.

This 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 RD&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 the R&D review are

- to inform about R&D activities in the member countries
- to inspire to contact between researchers working within 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
U.S.A.	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 the review published in 1989 are available on 3½" (1.44 MB) diskette in ASCII format. The diskette can be ordered by mailing a cashier's check for USD 50.- to:

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CANADA

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 12mm and 100mm.

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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DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Low-temperature friction reducing additives for district cooling and building cooling systems.

Key Words: Advanced fluids. District Cooling.

Key Activity: District heating and cooling. Development.

Objective: To develop additives which are suitable for use in low-temperature cooling systems including those containing corrosion inhibitors and freeze point depressants such as ethylene glycol.

Technical Approach: Through analysis of existing friction reducing additives, develop a better scientific basis for the behaviour of effective friction reducing additives and the factors that affect solubility at low-temperatures. Select or "design" new additives which might be successful and conduct screening tests of the developed additives alone and in combination with other additives such as corrosion inhibitors. At the completion of screening tests, subject the new chemicals to testing using the same procedure as for other chemicals used in the IEA advanced fluids program.

Program Implications: Additives developed specifically for cooling systems (including temperatures down to about -5°C) will lead to expanded cooling system capacity or the reduction in pipe sizes and costs for new district cooling systems.

Current Status: Several chemicals have been identified, some of which are covered by existing patents. Some new chemicals have been developed which exhibit superior performance to existing chemicals. These are currently being tested for compatibility with other additives before large scale tests are conducted.

Future Activities: Finalize chemical selection testing and then conduct full scale tests and economic feasibility evaluations.

Research Product: Reports, possible description of the methodology for chemical formulation and related patents if applicable.

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DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Experiments with ice slurry produced from a generator based on the principles of supercooling.

Key Words: District Cooling, Ice Slurry

Key Activity: District cooling. Ice slurry transport. Ice slurry generation.

Objective: To build a commercial scale experimental loop for pure ice slurry. This experimental set-up will demonstrate the feasibility of ice slurry transport in different industrial scale fittings, ice slurry storage in tanks, etc...

Technical Approach: To design and construct an industrial scale loop (100 mm nominal pipe diameter) with storage vessels, pumps, fittings, piping, etc, including the required sensors and controls. The ice slurry inventory is to built and maintained with a SUPERPAC prototype generator of 2 ton capacity. Flows with different ice fractions will be tested to determine the limits of secure operation under realistic conditions. Problems of storing and then fluidizing and pumping ice will be resolved.

Program Implications: These experiments will determine the safe limits of ice loading in a commercial district cooling system.

Current Status: The equipment has been built and the experiments have are underway.

Future Activities: When the present series of experiments have been successfully completed, it is planned to enlarge the facilities by including heat exchangers in the loop.

Research Product: Report(s) on the results of the experiment, guidelines on the maximum ice fractions in the different components of district cooling systems.

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DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Deep lake water cooling (DLWC) project.

Key Words: District Cooling. Low Temperature water. System Design.

Key Activity: District Cooling.

Objective: To establish the feasibility and environmental acceptability of a district cooling system for the downtown area of the city of Toronto, using cold (4°C) water drawn from Lake Ontario at a depth of 80 metres. The project will replace individual chillers with a combined electrical demand of 300 MW.

Technical Approach: At 80 metres below the surface, Lake Ontario water is 4°C year-round. A tunnel will be drilled from the lake shore to this depth and a suitable low-velocity water intake will be constructed.

Program Implications: The low temperature water from Lake Ontario can be used directly in A/C coils. There will be no further need for individual building chillers. A fraction of the displaced electrical energy must be used to power the pumps of the distribution system.

Current Status: The conceptual design is complete and evaluations of alternative cooling methods are nearly finished.

Future Activities: Select a proponent for commercial implementation; finalize the design and perform a detailed cost analysis, conduct detailed environmental assessment.

Research Product: Design Report.

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DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Multi-utility telemetry systems for remote meter reading, monitoring and load control.

Key Words: Heat Metering, Load Management, Performance Monitoring, Telemetry.

Key Activity: District heating and cooling.

Objective: Telemetry systems offer many benefits to district heating and cooling utilities but appear to be too expensive. However, such a capability could be very useful in improving customer services and system cost effectiveness. Other utilities are undertaking trials based on telephony, cable television, hard wired systems using twisted pairs or fibre optics, radio signals as well as power line carriers but also find them costly.

Four utilities in Toronto, Ontario have agreed to cooperate in a multi-utility trial to see if they can obtain services at a lower cost. The trial will include a user survey to define functional requirements, technology option review and equipment selection. If feasible, a full scale trial will be implemented.

Program Implications: Telemetry services for district energy systems might be made more cost effective by sharing telemetry system costs with other utilities.

Current Status: A report has been prepared on the outlining system options and potential barriers, including a survey of interest in potential field trials.

Future Activities: Finalize a system performance specification for participating utilities. Identify technical development needs if any. Call for proposals for a functional system. Implement and monitor performance.

Research Product: Full report on functional requirements, description of system and new technical developments, monitoring of performance, economics and customer satisfaction.

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DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Installation of novel design heat pump using low temperature mine water as heat source.

Key Words: Heat Pumps. Low-temperature Systems.

Key Activity: District Heating. Prototype.

Objective: To develop existing technology to extract energy out of low temperature water on a commercial scale.

Technical Approach: Design and construction of a novel evaporator at a commercial (300 Ton) scale. Installation of the equipment at a research mine, using water at 6-7°C from the mine as heat source. The resulting energy will be used to heat the ventilation mine air, the offices and workshops as well as provide hot domestic water for the shower house.

Program Implications: The design, construction and operation of this equipment will allow us to increase the scale of the equipment even further and permit the use of a vastly increased inventory of low temperature surface and sub-surface water for space heating.

Current Status: The equipment has been designed and specified. The host site has been identified.

Future Activities: Using the cold water directly for A/C purposes during the summer. Do load-following experiments. Installation of a water turbine-generator combination to capture the potential energy in the water returned to the mine.

Research Product: A report with the results and conclusions from this program.

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DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Development of an experimental ice slurry based district cooling system.

Key Words: Ice Slurry. District Cooling.

Key Activity: District Cooling. Development.

Objective: To replace existing individual building chillers by developing ice slurry based district cooling system including central storage and process controls.

Technical Approach: Design and build a glycol/water ice slurry system with central storage. Initially, two buildings will be connected to the system. It is anticipated that eventually all buildings on this site (= 10) will be hooked up. The ice slurry will be transported in 50mm diameter shallow buried, insulated pipes. The system will be monitored for performance.

Program Implications: This will be the first practical district cooling installation based on ice slurry. It will produce practical information on all phases of ice slurry based district cooling: ice slurry generation, distribution, storage, end use and the process control of each phase.

Current Status: The system has been conceptually designed. All components are sized. Final design in progress.

Future Activities: Future buildings may be hooked up using distributed storage and/or pulsating supply using a single pipeline.

Research Product: Design Report; Performance Reports. Additional information for the ice slurry design manual.

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DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Thermal interaction between underground pipelines of different temperature.

Key Words: Piping Technology. Heat Transfer. Pipelines. Thermal Interaction. Temperature Measurements.

Key Activity: District Heating and Cooling. Distribution.

Objective: To develop an understanding of the heat losses and heat gains of underground pipelines of different temperature buried in proximity of one another.

Technical Approach: Design and construction of a structure to contain a matrix of uninsulated horizontal pipes buried in a soil of known thermal conductivity. Determine heat transfer from the warmer pipe to the cooler pipe by measuring the heat gains and losses of each pipe separately.

Program Implications: This work will increase our understanding of heat losses from pipelines in an underground thermal field. Also, this work will determine maximum distances between district heating pipes and other pipes to prevent the latter from freezing. This will reduce or eliminate energy requirements for shallow buried pipes.

Current Status: The experimental equipment is being designed.

Future Activities: Perform experiments for a range of 2-pipe geometries. Do modelling studies.

Research Product: Report on the results of the experiments and publication of the models.

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DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Feasibility study of district heating system in the proposed community of Ouje Bougoumou.

Key Words: System Design. Piping Technology. Bio-fuels.

Key Activity: District heating. Hot water technology. Biomass. Plastic piping. Benefits.

Objective: To conduct an evaluation to establish the feasibility of a district heating system for a low density community, based on new plastic pipe technology.

Technical Approach: Retain a consultant familiar with the concepts of low density district heating and identify all technical and institutional aspects that will impact on the financial and environmental considerations of the project. Suitable technologies will be evaluated for using local sawmill wastes.

Program Implications: The results of the study will permit a decision on whether or not to proceed to final design and construction. The study will also establish the feasibility of new technology for other low density communities.

Current Status: Study complete and construction underway.

Future Activities: Disseminate findings to other similar communities who might potentially use district heating.

Research Product: Report with conclusions of the economic analysis. Videos to document construction.

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DENMARK

DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Influence on heat transmission of smooth water in plate heat exchangers.

Key Words: Advanced fluids, Friction reduction, Heat exchanging, Operation.

Objective: The purpose of this project is to document the heat transmission in plate heat exchangers (PHE), where drag reducing additives are used in one of its circuits.

Technical Approach: A small 1 MW PHE was installed parallel to the existing 10 MW PHE at the Lind station in Herning. The exchanger is designed in a way, which made it possible easily to build in, take out or exchange plates, increase the number of passes etc. It is equipped with measuring devices for flow and temperature on both sides.

The circuits of both sides were provided with means for controlling the flow and temperatures fairly independent of the actual operating conditions.

Independent of the operation in the main circuit, measurements took place in the test PHE. Tests were made at two different types of plates and at two different numbers of plates and values of heat transfer and heat transmission were found. These data will form the basis for the sizing of new PHE's for a new EC demonstration project in Herning. This will involve a one-pipe, pulsating heat transmission line to be operated with smooth water.

Program Implications: The results obtained can be used for sizing of PHE's for new schemes or in connection with the application of smooth water in existing systems.

Future Activities: No more activity in this project

Research Product: A project report is almost finished (May 92)

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DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Use of smooth water in the water circuit of CHP plants.
ENS-1323/92-0013.

Key Words: Advanced fluids, Combined heat and power, Friction reduction, Heat exchange, Modelling, Optimization, System design.

Objective: Use of smooth water reduces turbulence in a flow and therefore also the heat transmission in heat exchangers. To what extent this effect in the CHP-plants condenser will disturb the heat balance / efficiency of the plant is the object of this project.

Technical approach: A condenser of a CHP plant is an integrated part of the condensate/steam circuit of the power plant, and is thus designed and optimized according hereto. Whether it is possible to alter some of the parameters (the water side) without influencing others critically (the steam side) is an open question. This has to be investigated before full scale tests can be commissioned.

Laboratory tests of heat transmission with smooth water in a number of different heat exchanger types have been carried out at University of Dortmund, FRG. Operational tests with plate heat exchangers have been made at Herning Municipal Works. These results will be taken into account. The heat balance of a model CHP scheme will be defined and parameters as to heat transmission in the condenser will be changed. The effects will be investigated and measures for compensation will be introduced and analyzed.

Program Implications: Being the last technical question, which has not yet been dealt with in relation to application of smooth water in district heating, it is hoped that the problems envisaged are of minor importance. The aim is to qualify and quantify the "problem", making it possible to handle it in CHP plants to operate with smooth water.

Current Status: Work is going to commence (May 92)

Future Activities: Not yet known.

Research Product: A report will appear by 1.1.94.

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DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Consequences for water treatment plants by using "smooth water" in district heating systems.

EM-1323/90-0011. NEI-900120.

Key Words: Advanced fluids, Friction reduction, Operation, System design.

Objective: Purpose of the project is to investigate what happens to present mechanical and ion-exchange filters in district heating circuits if tensides are added to the water.

Technical Approach: The project is divided into two phases, a theoretical and a practical. The theoretical is based on an investigation of the present technology in DH transmission networks. The work will focus on the technology used in hydraulically closed heat transmission networks. In the practical part of the project, which is presently going on (May 92), tests of a candle filter is going on in the demonstration plant in Herning. Tests with ion exchangers (cation and anion) are at the same time going on in a laboratory.

Program Implications: It is the aim to reach a practical result. This means, that it is hoped to be able to put forward concrete recommendations as to how water cleaning shall be dealt with in existing district heating systems being operated with smooth water.

Future Activities: Further tests are going to be made.

Research Product: A project report will be issued by the end of 1992.

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DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Water hammers in district heating systems applying smooth water.
EM-1323/90-0010. NEI-900121.

Key Words: Advanced fluids, Friction reduction, Hydraulics, Operation, System design.

Objective: Purpose of the project is to investigate the consequences of the use of smooth water in relation to the risk of water hammering in DH transmission systems.

Technical Approach: The water of a district heating system was circulated at rather high velocities. The inertia was thus considerable and water hammers could occur at sudden changes in the load or at shut downs. If smooth water was applied, friction would have been reduced and the velocity of the water could be increased. A model network with a certain heat load was defined. By means of EDP programs the consequences of water hammers were analyzed and suggestions in order to eliminate water hammers were proposed for the following conditions: - Use of pure water (reference). - Maintaining the velocity of the water, whereby the reduced friction was expressed as reduced electricity consumption for pumping. - The velocity of the water was increased to a level corresponding to an unchanged pumping requirement compared to pure water. Hereby the heat load could be increased without changing the net configuration. - A network with reduced pipe dimension, which by means of smooth water and increased velocity of the water was able to meet the heat requirement was defined. Compared to the situation of reference the pumping requirement was unchanged.

Program Implications: It was found, that risk of water hammers in general is reduced, if smooth water is applied without any change of the operating parameters (same flow). If the output of the system (flow) is enhanced, however, the risk of water hammers is increased and have to be analyzed carefully.

Future Activities: No more activity.

Research Product: A project report has been issued.

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DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Optimization of straw fired plants, the firing technical qualities of straw and selection of demonstration plant.

ENS-1323/90-0018. NEI-9000098.

Key Words: Bio-fuels, Optimization, Production, Straw.

Key Activity: Documentation for the firing technical qualities of straw seen in relation to origin kind of straw etc.

Technical Approach: Working out documentation for the firing technical qualities of straw seen in relation to origin kind of straw etc. The project will try to describe and solve problems with poor firing- and combustion conditions with high concentrations of pollution. The most important laboratory analyses for straw are investigated more thoroughly. Selection of demonstration plant with measuring programme is carried out.

Current Status: The project was started in 1989 and finished late 1991 with a report of 300 pages incl. of annex.

Contact Point for Additional Information:

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The report can be ordered at the above address.

The price for the report is DKK 400,- plus DKK 25,- for delivery costs.

DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Optimization of combined heat and power (CHP) plants. EM-1323/91-0017.

Key Words: Bio-fuels, Combined heat and power, Optimization, Straw.

Key Activity: Optimization of control and combustion at straw fired boilers.

Objective: To describe and show problem solutions as well as to analyze the possibilities for optimization of the combustion process at operating and future straw based heating plants, i.a. by application of modern control systems.

Technical Approach: Based on measurements at straw boilers it has been registered that the combustion in all types of straw boilers for short or rather long periods does not run in an optimum way. In order to solve this the following suggestions have i.a. been made: Optimization of the combustion process by addition of secondary air at different places in the firebox and thus fulfilling the demand for temperature, time and turbulence. Combustion tests with masonry in the firebox in order to keep the firebox temperature up resulting in low flue gas emissions. Optimization of control systems through analysis of collected data by combustion tests.

Program Implications: Three firing systems will form part of the investigation: Whole-bale, cigar-burner, and chopped straw firing. The systems are very different from each other and therefore demand to be investigated separately.

Current Status: Three demonstration plants have been selected, and test firing will be started at the middle of 1992, with report from the first phase at the end of 1992. The final report for the whole project is expected at the middle of 1994.

Future Activities: The project aims at establishing a correct fire-box design with correctly placed secondary air inlets. The project will thus be of importance for boiler manufacturers, operational staff at plants and suppliers of straw. The boiler efficiency will be improved and the load on the environment will be lowered.

Research Product: The final report will include detailed recommendations for further design concepts for straw-fired boiler plants.

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**DISTRICT HEATING AND COOLING RESEARCH
PROJECT SUMMARY**

Project title: Surface combustion of straw. ENS-1323/90-0019

Key Words: Bio-fuels, Combustion, Straw, Combustion modelling, Laser Doppler Anemometry, Liquid acid/base modelling, Second air flow patterns.

Objective: Surface combustion of straw is an interesting alternative to the traditional combustion technique i.e. the use fixed bed combustion system (grate). By the surface combustion technique the need of a straw divider system is avoided. The main task of the project was to investigate two measuring techniques: The Laser Doppler Technique and the Liquid acid/base technique in order to explain the flow and the reaction patterns in the combustion chamber. Furthermore to make a survey of theoretical models for gasification and pyrolysis and flow patterns (FEM).

Technical Approach: The purpose of the project was to investigate the potential of the laser doppler measuring technique in order to explain the flow pattern particularly in the region close to the straw surface. Measuring was carried out on a 100 kW prototype furnace and the result was compared with cold air model measurement. Practical experiments have shown that the size and location of combustion air nozzles are very important to the performance.

Another aim of the project was to investigate the liquid acid/base technique in order to explain the reaction and flow patterns especially in the region close to the surface. Tests were carried out on a 1:2 model of the 100 kW prototype furnace.

Program Implications: The research activity is continued in a new research project with the same title, see project ENS-1323/92-0005 (page 19).

Current status: The project is finished by the end of 1991.

Future Activities: The project is continued in project ENS-1323/92-0005.

Research Product: Report: Clausen S.; Gundtoft, S.: Overfladeforbrænding af halm, DTI og Risø. DTI Forlag 1992.

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DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Surface Combustion of Straw. ENS-1323/92-0005.

Key Words: Bio-fuels, Surface straw combustion, Combustion model, Laser doppler anemometry, Cold-air-modelling, CDF-simulation.

Objective: Further development of the surface combustion system for straw by experimental, practical and theoretical activities. Establish a design concept for SCS-stokers.

Project: Surface combustion of straw is an interesting alternative to the traditional straw combustion systems because grating or shredding can be avoided. The existing straw bale stokers are primarily based on practical experience, and the used configurations are rarely technically or economically optimized. It is the intention that the emission of pollutants from SCS-stokers can meet the requirement of the future.

The main purpose is to establish a theoretical SCS-model (Surface Combustion of Straw) and create inputs through full-scale tests, air-/water-modelling and numerical simulation by CDF-software.

The inputs to the SCS-model will be generated by developing sub-models for the pyrolysis and gasification processes in the surface of the straw bale, flow and reaction conditions in the jet-zone, the general flow field in the combustion chamber and the drying rate in the bale.

Current Status: Cold-air-modelling of the flow conditions in the jet zone has been started. Further, preliminary simulations on the CDF-software PHOENICS have been initiated.

Future Activities: In July-August 1992 the results will be implemented and tested on a 100 kW prototype. Later full-scale tests will be carried out on commercial plants.

Research Product: A report (late 1994) containing the SCS-model and the experimental results. The report will in detail describe the optimized design of the jet configuration and the combustion chamber.

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DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Evaluation of LOCUS-plants. (LOcal Cogeneration Utility System).
ENS-UVE-90-0179. TR-89.0256. NEI-8900234.

Key Words: Cogeneration, Combined heat and power, Heat pumps, Heat storage, System design, Energy conservation, Tariffs.

Project: The LOCUS-principle is a system consisting of a gas engine, an electric generator/electric engine and a heat pump, and includes steering, regulation and heat storage systems. Continued experience from the management of LOCUS-plants in Denmark is not particularly positive. There have been many operational problems which have resulted in a poor economy for the projects in hand. At the same time the rules of settlement achieved have not encouraged three-component management as much as it had been expected. The aims of the evaluation are to gain, and revise, experience from the management of existing LOCUS-plants, to estimate future possibilities and perspectives open to the LOCUS principle in the light of improved energy and environmental planning, energy conservation efforts, present and future roles of agreements etc., to instigate a recommendation concerning developments and demonstration of LOCUS plants, and to point out demands for the development of other combined-energy plants.

The project has been carried out by a working group in cooperation with a special follow-up group and an external hearing committee.

Current Status: The project was started in september, 1989, and was finished in December, 1990.

Future Activities: There are no future activities.

Research Product: Report Phase A: Existing Plants, 261 p., August, 1990. Report Phase B: Possibilities and Perspectives, 202 p., December, 1990. Report Phase C: Measurements, 42 p., September, 1990. Report Phase D: Final Report, 104 p., December, 1990.

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All reports are only available in danish language.

DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Humidification of Combustion Air of CHP Gas Engines - Energy and Environmental Aspects. ENS-1323/92-0010.

Key Words: Cogeneration, Combustion, Components, Economy, Energy conservation, Heat exchanging, Humidification, Optimization, Pollution, Production, System design.

Project: The objective is to analyze and test technologies to obtain improved utilization of fuel in combined heat and power (CHP) plants based on gas engines. The basic idea is to humidify combustion air and to heat it up using heat extracted from the exhaust gas. The added humidity replaces part of the air excess in lean-burn operation and is found again in the exhaust gas, thereby enabling condensation of the exhaust gas at a higher temperature. Lower specific fuel consumption means lower CO₂-emission and furthermore the NO_x-emission will probably be reduced due to the technology.

Principles for humidification of the combustion air are analyzed theoretically with respect to thermodynamics, cost-benefit, and influence on engine operation. In laboratories, experiments with an engine operating under varying conditions are carried out. One concept is selected and implemented on a commercially operated CHP plant with a capacity of about 900 kW electricity. To verify the theory, this pilot plant is provided with measuring instruments and the results are examined. The results from the project will be described in a report and in papers. The results will help to achieve the objectives of the Danish energy policy and strengthen the competitiveness of Danish companies on the export market.

Current status: Project starts in July 1992. Project ends in December 1993.

Research Product: A report containing all results gained from the project. A demonstration power plant.

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DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Design and construction of standard cogeneration units.
TR-88.1103. NEI-8900214

Key Words: Cogeneration, Combined heat and power.

Key Activity: System design, development and demonstration.

Project: The purpose of the project was to design and build a constructional throughout prepared energy conversion unit to achieve efficient transformation of natural gas, biogas and the like for local heat supply and electricity production to the public grid.

The project was carried through by a thorough examination and collection of experiences from earlier constructed prototype and pilot plants, compared with a search of market demands in local district heating networks. The result was an adjustment of components, especially the exhaust gas heat exchanger, the engine control gear and the control and monitoring equipment (hardware and software).

The current status is that the prototype was build and installed in 1990, and has ben running for more than 5.000 hours in peak and high load periods on the public grid.

Since the project was carried through the design and construction scheme has been widened to standard units with capacities of 300 - 3.000 kWe and 500 - 3.800 kWth.

Research Product: A report containing the general considerations in the design and construction work (in danish) and a demonstration project.

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DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Repowering of power station Ujpest (Hungary).
IMØ-65. NEI-9100024.

Key Activity: Cogeneration, Combined heat and power, Land management, Economy.

Project: The report was prepared in order to demonstrate to the Hungarian power companies how Western methods of analysis can be applied in connection with major projects within the power sector. An actual evaluation of the profitability of the conversion of the Ujpest power plant was also carried out. This report will be used for obtaining financing of the project. The report describes the technical and financial consequences as well as the possibilities in connection with an extension of the district heating supply in Budapest. Valuable contacts between the Danish and Hungarian electricity sectors as well as between the district heating companies of both countries have also been created. We hope that these contacts can be used for future cooperation, technology transfer, etc.

Current Status: The project was completed in December 1990.

Research Product: A report has been prepared which comprises the technical and financial analysis of the study.

Contact point for additional information:

Project manager: Mr. S. Aaen

Project engineer: Mr. P. Weiss

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**DISTRICT HEATING AND COOLING RESEARCH
PROJECT SUMMARY**

Project Title: Tommerup St. Varmeforsyning - Natural gas powered - combined heat and power station.

TR-88.1066. NEI-9000035.

Key Words: Cogeneration, Heat storage, Production, Natural gas powered engines.

Project: The aim of the project is to examine the joint operation of the combined heat and power station, the heat accumulator tank and the boiler with condenser. The work was carried out November, 1989 to March, 1990 with operation from April, 1990.

Research product: A production and efficiency report for the station.

Contact Point for Additional Information:

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DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Noise from rather Large, Gasfired Boiler Plants.
EM-1323/88-04. NEI-8900042.

Key Words: Combustion, Noise pollution.

Technical Approach: An investigation has been carried out for the Ministry of Energy. The purpose of the investigation was to enlighten the size of external noise nuisances from rather large, gasfired boiler plants. The investigation only dealt with noise nuisances which can be related to the combustion of gas, being experienced as a low-frequency "rumbling" in the surroundings.

The investigation, carried out as visits to chosen plants, was furthermore to enlighten whether special constructional conditions might immediately point at an influence on the origin of the noise. In this connection the interest especially gathered around the used boiler/burner combinations and types of burners.

The investigation did not include actual measurements of noise or firing technical conditions, as there was no basis for experiments involving exchange or rebuilding of parts of the plant.

The investigations confirmed that all the plants visited, with different, typically present boiler/burner combinations, did send out low-frequent noise of a strength that might be perceived as uncomfortable in the surroundings.

The investigation suggests further investigations of the construction of the burner and the influence of gas/air inlet on the noise generation.

Current Status: The project was started and finished in 1989.

Research Product: A report has been worked out by dk-TEKNIK and published in February, 1990.

Contact Point for Additional Information:

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DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: The optimum directly connected district heating substation (consumer connection) for low-temperature. ENS-1323/92-0014.

Key Words: Components, Consumers installations, Domestic hot water, Low-temperature systems, Optimization.

Key Activity: Research, development and testing.

Objectivity: The purpose of the project is to contribute to the development, production, and use of directly connected substations for district heating which are characterized in efficient exploitation of energy - also at low-temperature operation. Primarily it is aimed at small substations, and the objective is stations operating at an optimum level - both at the time of installation and under operation, where the users can interfere in the operation.

Technical Approach: The central items of the work include:

- Directly connected substations including both heat and hot water for domestic use
- Components, automatics, and the system as a whole
- New substations and existing substations

The project is divided into the following 3 phases:

PHASE 1: "ADAPTION WITH EXISTING COMPONENTS"

- Elucidation and evaluation of present experiences at the area.
- Drawing up a draft for high efficient substation and for a conversion of existing substations.
- Testing in practice of converted substations.

PHASE 2: "THE DEVELOPMENT PHASE WITH NEW COMPONENTS"

- Development of components, automatics, and systems.
- Testing new substations in laboratory and in practical use.

PHASE 3: "DISSEMINATION"

- Evaluation of results.
- Reporting and other disseminations.

Current Status: Started June 1992.

Future Activities: To be determined 1994.

Research Product: A report including the collected data of experiences, theoretical fact-findings, laboratory tests, and examinations of measurement results.

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The project is carried out in co-operation between:

- Aarhus Kommunale Værker (A district heating company owned by the Municipality of Aarhus),
- Danfoss A/S (Manufacturer), Redan A/S (Manufacturer)
- Danish Technological Institute, Dept. of Energy Technology.

DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Energy-efficient heat exchangers for district heating systems.
EM-1323/90-0014. NEI-900154

Key Words: Consumers installations, Domestic hot water, Energy savings, Heat exchanging, Heating and cooling demands, Modelling, System design.

Key Activity: Design of consumers installations, plate heat exchanger design, systems for hot water production.

Objective: To improve design of consumers installations for radiator systems and hot water production by improving product documentation.

Technical Approach: Energy-efficiency of district heating systems depends in general of the system temperature. Design and choice of heat exchangers are therefore very important. The goal of the project is to improve design criteria and design of heat exchangers. It consists of four parts: - Test of heat exchangers for heating systems and for hot water systems (small and medium size) - Development of a computer program for heat exchangers and for storage type hot water tanks - Test of control equipment for heat exchangers - Test criteria for heat exchangers in district heating systems.

Program Implications: Better product documentation. Better design of hot water systems. Decreasing demand for high temperature in district heating networks.

Current Status: Six heat exchanger have been testes. A computer program for storage type hot water systems have been developed and verified by experiments.

Future Activities: Use of the computer program for practical design. Report of tests results and design criteria for heat exchangers in consumers installations.

Research Product: Internal reports on tests and description of the computer program.

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DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Optimization of larger consumer plants for district heating by operation tests. ENS-1323/91-0008. NEI-9100129.

Key Words: Consumers installations, Optimization, Calcification.

Objective: To optimize larger consumer plants to adjust to the cooling demand in new district heating systems and find a way to minimize the calcification problem in the heat exchanger for domestic hot water.

Technical Approach: Measurements will be made primarily on two specially constructed test consumer plants. The test plants are constructed in such a way that it is easy to switch over from one operation to an other. Based on the a/m measurements the optimization of the consumer plant/operation system will be elaborated to include the cooling of the district heating medium - both long and short term values - as a function of the plant and operation costs. Calcification problems, primarily in the heat exchanger for domestic hot water, will be investigated under different circumstances. The tests include magnetic treatment of the domestic water.

Program Implications: Important improvement of the current knowledge of the construction of larger consumer plants.

Current Status: The measurements are started ultimo 1991, and first phase report will be completed in June, 1992.

Future Activities: The measurement will be completed in March 1993.

Research Product: A detailed report can be expected in June 1993.

Contact Point for Additional Information:

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DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Central heating in old house stock.
ENS-151/90-0035. NEI-9100114

Key Words: Consumers installation, Domestic hot water, Metering

Project: There is a general agreement that the standard of the older housing stock in the central part of the Greater Copenhagen area should be raised to an acceptable level. Especially with regard to heating and bath facilities. The environmental impacts should be limited. This project was conceived before a proposal for a CO₂ tax was set out. The purpose of the project was to find a technical, organizational and financial model, which could expedite the conversion of kerosine/electric heating into central heating based on cogeneration supply. A proposal for a CO₂ tax is today under consideration, which implies the possibility for government subsidies for conversion, and the organizational and financial aspects recede into the background, while an analysis of the technical possibilities is still topical, as conversion of maybe 50.000 flats to central heating corresponding to an investment of 1.5 - 2.0 billions DKK excl. of VAT is to be expected. In this connection it can be pointed out that under various auspices steady research and development are in progress concerning: new and more flexible tube systems, new materials for tubes, radiators and converters, new systems which - used in the right way - can make the establishment of central heating in the older house stock more effective and less expensive. The project is carried out in cooperation with The Copenhagen Lighting Company.

Future Activities: A demonstration project is being considered.

Research Product: A report and a "information package" for house owners.

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DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project title: On site calibration of large energy meters using an isotope based flow measurement method. EM-1323/90-0015.

Key words: Control, heat transport, metering.

Key Activity: Methods development.

Objective: To further develop and extent isotope based flow measurement methods in order to establish an easy accessible and efficient method for on site control and calibration of large energy meters.

Technical approach: The use of radioisotope tracers permits accurate measurement of fluid flow on site according to various ISO standards with a minimum interference with the system under investigation. To cope with the demands for flow measurements of hot water in district heating systems in connection with on site control and calibration of large energy meters, the existing methods are modified. Sufficient equipment for practical measurements is constructed and the method is verified against conventional calibration units. Finally, the method and equipment are demonstrated on an actual district heating energy metering installation.

Project implications: The method is expected to be widely used and provide confidence in metering of large hot water flows, and thus indirectly promote the use of extended district heating systems partially using wasted energy from thermo-electrical power production.

Current status: Method developed. Equipment constructed.

Future activity: Verification and demonstration.

Research product: A documented measuring method.

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DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: A PVC-based flue gas heat exchanger. Energy savings and practical experience. ENS-1323/90-0004. NEI-9000146.

Key Words: Corrosion, Energy savings, Flue gas, Heat exchanging.

Objective: To examine the possibilities of using PVC-materials for flue gas cooling from the temperature-range up to 250°C (and thereby avoiding "cold corrosion").

These experiments are performed in connection with a straw-fired district-heating plant (large amount of chlorides and particles in the flue gas).

Technical Approach: A heating plant under erection will be prepared for testing the PVC-based heat exchangers.

Different heat exchangers will be designed and tested to gain knowledge about their thermal loading characteristics.

Program Implications: The possibility of obtaining an alternative to the rather expensive stainless steel heat exchangers for low temperature use.

Current Status: Testing has been carried out during the heating season 91/92, additionally testing will be necessary. The project is assumed completed in the summer of 1993.

Future Activities: Nothing planned - depends of a successfully outcome of the current project.

Research Product: A report containing the achieved results and the evaluation of them.

Contact Point for Additional Information:

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DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: SESAM - North Jutland. Sustainable Energy Systems Analysis Model for North Jutland, Denmark.

Key Words: Economy, modelling, Optimization, Renewable energy

Key Activity: Comprehensive analysis of energy systems in transition based on a detailed SESAM-computer model of the regional energy system.

Objective: To analyze alternative scenarios for the development of sustainable energy systems with respect to energy consumption, atmospheric emissions and economic implications and consequences.

Technical Approach: The analysis is based on a new, advanced system of computer programs - the SESAM model - for the detailed modelling of the present state and future development of comprehensive local, regional and national energy systems. A SESAM-model comprises the entire energy system consisting of the end-use system, the system of energy conversion and transmission and the system of non-renewable and renewable energy sources. Total cost analysis of alternative scenarios are carried out by means of an economic database with corresponding programs for the economic analysis of the result from the energy analysis model.

Program Implications: New general insight in the practical opportunities for the improvement of the overall efficiency of energy systems and the associated economic consequences will be obtained. In particular the project will contribute to the establishing of a basis for rational energy planning decisions in the region studied.

Research Product: A number of reports on the technological potentials for the development of sustainable energy systems and the economic and political problems concerning the realization of these potentials.

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DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Pressurized Pulverized Coal Combustion.
EM-1323/91-0018

Key Words: Combustion, Economy, Flue gas, Production

Key Activity: To describe the state-of-the-art and propose future research and development activities.

Objective: The purpose of this project is to analyze the energy and environmental benefits of a pressurized pulverized coal combustion system, to describe the state-of-the-art as well as to draw up a long-term programme for development of this combustion concept.

Technical Approach: At pressurized pulverized coal combustion (PPCC), the combustion is realized under such a high temperature that the ash in the combustion chamber melts. By means of special cleaning methods, which have not been completely developed, the flue gas must be cleaned for particulate matters and alkali metals, i.e. the gas turbine downstream the combustion chamber will "survive". The heat available from the gas turbine exhaust and potential cooling of the combustion chamber are utilized in a steam cycle. Corresponding to the basic law of thermodynamics (Carnot), PPCC-plants have a potential for development of a very energy efficient plant. Furthermore, it is expected that the existing desulphurization technology will be suitable for the environmentally related cleaning of the flue gas from a pressurized combustion.

The system efficiency is evaluated by defining 3 specific plant alternatives and the net electrical efficiency of the systems has been calculated. The system models, consisting of well-defined and comprehensive thermal models, have been set up by computer modelling. The calculations state that an efficiency of 52 - 55% may be realized. In addition to the efficiency calculations, comparative costs of the PPCC-plant and other future options are discussed and figure estimates are presented. The crucial technical fields: Gas turbine, combustion and hot gas cleaning, especially alkali reduction are dealt with in detail in the report.

Current Status: The final report dated March 1992 is completed.

Future Activities: A research programme concentrated on selected fields is under consideration.

Research Product: A report (130 pages plus appendices) and computer based system models.

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**DISTRICT HEATING AND COOLING RESEARCH
PROJECT SUMMARY**

Project Title: Time-varying processes.
ENS-1323/90-0005. NEI-9000126

Key Words: Energy systems. Process integration. System design.

Project: The aim of the project is the improvement of techniques used for optimization of complex energy systems, including heat-exchanger networks, heat storage and cogeneration using simulation and the Pinch method. The systems and processes analyzed by the Pinch method, as originally developed, are subjected to a number of limiting conditions. The three most important are simultaneity of operation of the various components, exclusion of active components such as heat pumps and cogeneration plants internally to the energy system, and exclusion of heat storage. Through studies of systems with which the institute has worked over a number of years, the aim is to find methods by which the above-mentioned three limiting conditions may be relaxed and introduced into energy systems analyses and syntheses.

Current Status: The project will be completed during 1992.

Future Activities: The methods that have been developed will be applied to various cases.

Research Product: A technical report outlining the methods that have been developed.

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DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Optimum operation of district heating systems.
ENS-1323/91-0010. NEI 9100176.

Key Words: Energy savings. Control. Load management. Modelling. Operation. Optimization.

Key Activity: Modelling and optimization research. Demonstration by implementation of research results in software for on-line application.

Objective: To develop methods for on-line optimization of combined heat and power plant systems with attached heat accumulator as well as district heating systems of different size and configuration in general.

Technical Approach: By using existing and further developed models for dynamic description of the components in a district heating system an overall model for the temperature distribution in the district heating system is obtained. Methods for prediction of heat load and outdoor temperature are further developed, and optimization methods, designed for the system description, are investigated and developed. This includes the on-line control of supply temperature. A menu-based computer program for testing and implementation of modelling, prediction, control and optimization methods is developed.

Program Implication: Important improvement in the dynamic modelling, and hereby understanding, of district heating systems. Improved methods for load forecasting, and dedicated methods for supply temperature control as well as unit commitment and production optimization in systems with attached heat accumulator. Software menu system for implementation of resulting methods.

Current Status: Project start in October 1991 and end in December 1993. Results exist in all areas of the project.

Research Product: Report describing models and methods. Software menu system for implementation of research results.

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DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Development of heating plants for combustion of wood chips with high moisture content.

EM-1323/90-0012. NEI-900163.

Key Words: Combustion, Flue gas, Heat supply, Operation, Renewable energy, System design.

Technical Approach: The second generation of fuel chip production system is being developed. With the new system, the costs of producing fuel chips in the forest will be significantly reduced, and a new quality of fuel chips is developed. The new fuel chips will have a considerably higher moisture content than was previously accepted. A higher moisture content does not necessarily mean an inferior fuel. By applying condensed flue gas cooling - which has already become introduced on several chip fueled heating plants - and by constructing the plant to accept very wet fuel, the energy output of the wet fuel will be equal to or even superior to the energy output yielded by conventional heating plants. Two or three of the present chip fueled district heating plants are selected to be hosts of the trials. The plants selected must be equipped with condensing flue gas coolers. Series of measurements will be carried out on wet fuel deliveries produced according to the new delivery technique. The moisture content of the fuel in question will be between 55 and 65% of total weight. The measurement results are to be used to establish the causes of the limitations of the plants as regards operation and yield. If necessary, minor modifications will be made and subsequently tested. A technical evaluation will be made for all plants studied, and the requirements to plants adapted to accept very wet forest chips will be established. For at least one plant equipped with condensed flue gas cooling, the financial consequences of converting the plant to combust the new fuel product will be calculated.

Research Product: The final report in Danish language will be published around the middle of 1992.

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DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Heating of greenhouses based on low-temperature heat from return pipes from combined heat and power plant. Construction project.
ENS-3621-349. NEI-8900128.

Key Activity: Greenhouses, Heat supply, Surplus heat, Low-temperature systems, Energy savings.

Objective: Exploitation of surplus heat based on heat from return pipes to displacing oil. Establishment of low-temperature system in greenhouses for the first time in Denmark. Economical optimization of energy supply.

Technical Approach: The average return temperature is 52 - 56°C. Main pipe from the heat and power plant is Dn 550 and service pipe for greenhouses is Dn 350. Establishment of heat exchanger corresponding to app. 60% of peak load and 82 - 84% of the total greenhouse requirement. Two fuel oil burners are peak and reserve. The quantity of water through the system is controlled by a frequency-controllable pump regulated by the temperature of the supply pipe after the exchanger. The supply system is optimized by SRO equipment.

Current Status: Establishment of 43.000 m² greenhouses and heating supply system are concluded.

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DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: District heating in Hungary.
IMØ-34. NEI-9100084.

Key Words: Heat transport, Heat demands, Consumer installations, Load management, Economy, Cogeneration, Combined heat and power.

Project: District heating in Hungary. vp. Using the district heating system of Budapest as a model, the report deals with the possibilities of making district heating more efficient by constructing transmission networks, improving the utilization of combined heat and power, introducing modern differential pressure regulation of pumps etc. Furthermore, the data of a number of major district heating systems have been collected. The report will be used by the district heating company of Budapest (FÖTAV) in connection with evaluation of possible new transmission pipelines for district heating. As Danish technology has been introduced to the district sector, the report can be used by Danish firms for evaluating the potential of the district heating market. The long-term intention of the report is to promote energy planning in Hungary, which would accelerate the use of energy- efficient technologies, such as those applied in Denmark.

Current Status: The project was completed in December 1990.

Research Product: A report has been prepared which comprises all results in connection with the project.

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DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Optimization of operation of small district heating plants by heat accumulation.
ENS-51191-91.0022. NEI-9100095.

Key Words: Heat Storage, Optimization, Operation

Key Activity: Investigation of the possibilities to reduce the price, planning, consequences, measuring programme.

Technical Approach: Data has been collected in order to evaluate the situations of the heat plant before and after the tank was established. Especially the rate of efficiency and the oil and power consumption have been estimated. Different alternatives with different suppliers and a tank with different connection systems was planned. The tank has not yet been established and therefore the measuring programme has not been carried through either.

Current Status: The Project was started in 1991 and will be finished in 1992.

Future Activities: Completion of the measuring programme and establishment of a tank at the reduced price

Research Product: Midway report with the estimated consequences.

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DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Establishment of a low-temperature district heating system for new buildings and shops. Construction project.
ENS-51121-0003. NEI-9100066.

Key Words: Heat supply, Low-temperature systems, Energy savings, Metering.

Objective: Establishment of low-temperature district heating system for new buildings and shops etc. based on utilization of heat from return pipes and supplemented by high temperature heat. All based on the conclusions from a previous pilot project.
Establishment of a one year monitory program to meter the consequences.

Technical Approach: Comparing effect, temperature, pressure, flow, dimension, economy, and type of design in low-temperature system with existing district heating plant based on different premises as design, temperature, type of houses, connection for system and effect.

Current Status: Establishment of the low-temperature system is concluded and the monitory program is running.

Future Activities: A report based on the results from the monitoring program.

Research Product: The monitoring report will be available in the end of 1992.

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DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Combining low-temperature system with existing district heating plant. Pilot project.

ENS-51121-9023. NEI-9000071.

Key Words: Heat supply, Low-temperature systems, Energy savings, Optimization.

Objective: Technical and economical consequences of combining low-temperature system supplying new houses and shops in Horsens City with existing district heating plant or from return pipes from combined heat and power plant.

Technical Approach: Comparing effect, temperature, pressure, flow, dimension, economy, and type of design in low-temperature system with existing district heating plant based on different premises as design, temperature, type of houses, connection for system and effect.

Current Status: The pilot project is concluded.

Future Activities: Establishment of a low-temperature system for new building based on the current pilot project.

Research Product: A report containing a comparative analysis and conclusion.

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DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Measuring programme in connection with operation of heat storage tanks at 4 existing straw fueled district heating plants. ENS-51121-0042. NEI-9100072.

Key Words: Heat storage, Straw

Key Activity: Measuring, registration and estimation of the consequences.

Objective: To compare the theoretic assumptions with the practical consequences of establishing a heat storage tank.

Technical Approach: Data from 4 existing straw fueled district heating plants with heat storage tanks have been collected, among other things loss of heat, efficiency, power consumption and economy. These data are compared with corresponding data from two heating plants without heat storage tanks with the purpose to describe advantages and disadvantages by establishing heat storage tanks. Alternative dimensions, the principles for connection and the consequences of these choices are also estimated.

Current Status: The project is finished

Future Activities: Investigation of the possibilities to reduce the price of heat storage tanks and the systems for connection.

Research Product: Final report "Måleprogram på akkumuleringstanke".

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DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Low temperature heating system based on return string district heating from CHP-system combined with glass covering. EC/00259/89/DK. NEI-9000080.

Key Words: Low-temperature systems, Energy savings, Energy conservation, Solar energy.

Objective: The overall scope of the project is to demonstrate "an ecological office building" with optimized environmental solutions, e.g. considering low water consumption, intensive use of plants, low energy consumption and healthy climate inside the building.

Technical Approach: A new 60,000 m² office building, "Fisketorvet", (the fish market) will be built, in which the demonstration project is to be situated.

The heating of the building will be based upon the use of the energy in the return conduit to the CHP plant (H.C. Ørstedsværket) nearby. The temperature of the return conduit is about 60 C, and the distribution of the heat will be made in plastic district heating pipes.

The glass coverings will be established between the blocks of buildings with single layer glass. The glass covered areas amount to 11,100 m². On some facades facing south, glass extensions will be constructed and cover 800 m² of facade area. On a small area of 200 m², a glass house will be constructed inside the glass covered outdoor space as a smaller experiment.

Programme Implications: Commercial development of a low temperature heating system based on return water from a CHP district heating system with glass covering as an integrated energy saving element.

Part of the project is to show the most effective low temperature heating system.

Current status: At present (April 1992), the project is in the first phase, draft project/projecting. The expected start of the establishment of the building is summer 1992 and the measurement phase will start autumn/winter 1993.

Future Activities: Undertaking of the detailed measurement as to the efficiency of the heating system will be made in a 3 years' measurement phase.

Research Product: A demonstration project and a final establishment/ measurement report.

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DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Development of test facilities for dynamic testing of heat meters for district heating. ENS-1323/90-0022.

Key Words: Metering, Consumers installations, Domestic hot water.

Key Activities: Research, development and testing.

Objectivity: The purpose is to ensure a better measurement of the district heating consumption at dynamic water flow and temperature variations, e.g. in connection with the application of domestic hot water heat exchangers without accumulators (heated instantaneously).

The project is carried out in connection with the project: "Examination of district heating measuring and meters under dynamic operation" (as the phases 1, 2, and 4 in the joint project), and it aims at elucidating the experiences with the existing operating conditions of the district heating substations, and in continuation of this determine supplementary test methods and facilities for district heating meters compared to the present type tests.

Technical Approach: The project includes:

- Phase 1: Collection and examination of existing experiences (measurement data) about dynamic operating conditions in the Danish district heating plants.
- Phase 2: Mapping and evaluation of previous Danish and international projects regarding dynamic operating conditions and the simulation of these.
- Phase 4: Development of dynamic testing methods and facilities so that it is ensured that the meters conform to the relevant demands on exactness under dynamic operating conditions.

The dynamic testing facilities are to be established as relatively simple tests of the individual parts of the meter combined with a total consequence calculation at simulated dynamic operating conditions.

Current Status: Examination of existing measurement data have resulted in grouping into different dynamic load patterns (more measuring data will be included later) just like some activities regarding dynamic operating conditions and dynamic testing methods have been carried out.

Future Activities: The joint project will be determined in 1993.

Research Product: A report including data of experiences, theoretical fact-findings, laboratory examinations, test methods, etc.

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The project is carried out in connection with the project "Examination of district heating measuring and meters under dynamic operation"; See the organization described in this project.

DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Examination of district heating metering at different friction reducing additives (phase 1). ENS-1323/92-0012.

Key Words: Metering, Advanced fluids, Friction reduction.

Key Activity: Research and testing.

Objectivity: The purpose of the project is through fact finding and some laboratory tests to investigate the influence of different additives on district heating so that knowledge is acquired whether the meters are affected differently and the heating bill thus becomes "erratic" by addition of additives.

Technical Approach: During recent years there has been an increasing attention to reducing the friction of the district heating water by means of adding various additives ("smooth water"). When we compare this with the demand for correct metering, it is important to find out

- whether addition of additives causes a demand for special correction factors for the different flow metering principles.
- whether the addition may influence the heat transfer at the temperature sensors.

On the basis of theoretical and empirical formulas the importance of various additives is explained and evaluated on various measuring principles and temperature sensors. Contact is made with various research centers working with these matters. Afterwards pilot testings of different measuring principles by addition of additives will be carried out.

Project Implications: The implementation of the project will strengthen the basis of evaluation whether "smooth water" results in an unfortunate effect on the district heating meters, i.e. whether additional expenses for meter replacements by addition of additives will be necessary.

Current Status: Started in June 1992.

Future Activities: The project will be carried out in the period June 1992 - August 1993.

Research Product: A report covering fact-finding and pilot tests.

Contact Point for Additional Information:

The project is carried out by Center of District Heating Technology which is a co-operation between the Laboratory for Heating and Climate Technology/The Technical University of Denmark, and the Dept. of Energy Technology/Danish Technological Institute.

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DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Examination of district heating measuring and meters under dynamic operation. ENS-1323/92-0017.

Key Words: Metering, Components, Consumers installations, Domestic hot water.

Key activity: Research and testing

Objectivity: The purpose is to ensure a better measurement of the district heating consumption at dynamic water flow and temperature variations, e.g. in connection with the application of domestic hot water heat exchangers without accumulators (heated instantaneously).

The project is carried out in connection with the project "Development of test facilities for dynamic test of heat meters for district heating", and it aims at examining uncertainties of existing meters under practice-close conditions and at realistic dynamic load situations, and also at evaluating the importance of these on the district heating measurement as a whole.

The joint project includes 4 phases, where the present project is phase 3, and the other project is phase 1, 2, and 4.

Technical Approach: The project is carried out by testing heat meters under practice-close conditions at the participating district heating plants.

The test will be carried out with different meter types at dynamic varying temperatures and flows (up to a flow of 3 m³/hour) on 11 test rigs established in the participating district heating plants.

Current Status: Started June 1992.

Future Activities: The joint project will be determined in 1993.

Research Product: A report including the test results.

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The joint project is managed by a management group consisting of the three participating parties:

- The district heating plants in Aalborg, Herning, Randers, Aarhus, Jelling, Esbjerg, Grindsted, Odense, Kalundborg, Taastrup and Copenhagen),
- The Ass. of Manufacturers of Energy and Flow Meters in Denmark
- Danish Technological Institute, Dept. of Energy Technology.

Carl Emil Hessel is the chairman of the group.

DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Numerical model for a central solar heating system involving seasonal heat storage.

Key Words: Modelling, Seasonal heat storage, Solar energy, Pond storage, Bore holes, SEASUN.

Key Activity: Development of computer models for investigation of thermal behavior of large solar plants with seasonal storage.

Objective: The aim of the program is to supply designers of large solar plants with a simulation tool, so preliminary investigations of the thermal dynamics and expected benefits of large solar plants with seasonal storage can be performed thorough and in a cost and time reducing way.

Technical Approach: The program is based on a great number well tested program routines of which many originally was developed by Peter Berg. The program has grown into large user friendly thermal simulation model called SEASUN, which in great degree of detail can calculate the thermal dynamics of large solar plants with either a pond storage or a bore hole storage. These storage types has been chosen as they at present looks the most feasible for Danish ground conditions. The program can be used to perform thermal optimization of solar collector field and storage design, degree of insulation and design of pump and heat exchanger sizes etc.

Program Implications: The program is a powerful tool for designers of large solar plants with seasonal storage. The program will hopefully help to promote the use of solar energy as a realistic alternative to the use of fossil energy.

Current Status: The program exist in Danish version 2.0 with manual in Danish.

Future Activities: Ultimo 92 a version 3.0 of SEASUN will be completed. This version will include a heat pump model and allow for extended specification of thermal ground parameters. Hopefully an English version can be produced.

Research Product: A user friendly computer program with manual.

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DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Damping of noise from medium size gas fired boilers. ENS 1323/91-0002

Key Words: Noise, Combustion, Production.

Key Activity: Research and development.

Objective: To widen the knowledge and basis for reducing the problems of low frequency noise in medium size boilers.

Technical Approach: The project is divided into three subtasks.

- 1) The source of noise. A theoretical and experimental investigation of the different components which cause or increase the pulsations in gas combustion systems. Laboratory tests are performed.
- 2) Active damping of noise. Preliminary experiments have shown that it is possible to reduce and to increase pulsations in gas combustion systems by influencing the pressure in the gas supply system of the burner. This technique will be used in experiments in the attempt to eliminate self-exciting pulsations.
- 3) Experiments and measurements on plants. The results of tasks 1) and 2) will be used in selected plants in the attempt to predict and reduce the problems of low frequency noise in these plants.

Current Status: The project has been commenced in the end of 1991. The expected closing of the project is in the end of 1993.

Research Product: Substantiated methods of predicting and reducing the problems of low frequency noise of gas fired plants will be the benefits of this project. These methods will be used in the construction of gas fired plants and in the conversion from oil to gas fired plants in Denmark.

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DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Design codes for preinsulated pipes.
ENS-1323/93-0016.

Key Words: Piping technology, Preinsulated Pipes, Code, Statics.

Project: The task of the Unichal Statics Committee is to prepare joint European calculation codes of strength design of preinsulated earth pipes for distribution of district heating. The Danish representative of the committee is, among others, Mr. Karl Erik Hansen, M.Sc.C.E. (RH&H Consult). The purpose of Mr. Karl Erik Hansen's participation is to transfer experience from the ongoing revision of the Danish district heating code of practice, the code of practice of distribution pipes for district heating, DS 448, to a Nordic and European level. The committee agrees to the fact that the Danish code of practice is a good basis for the joint work in the statics committee. From 1987 to 1991 Mr. Karl Erik Hansen has been the chairman of the working group which has prepared drafts of a revision of the Danish code of practice and is now the chairman of the representative working group. The members of the statics committee come from Sweden, Finland, Germany, the Netherlands and Denmark. Representation from France, England and East European countries is under consideration. The committee is chaired by professor Sture Andersson, Malmö. The committee was formed August, 1991. The Danish codes of practice forms the basis of the work. It is the objective of the Unichal Committee work to form the basis of coming EC drafts. The work is expected to last for three years.

Research Product: The project will be finished with a report. The results will also be presented in relevant Danish periodicals.

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**DISTRICT HEATING AND COOLING RESEARCH
PROJECT SUMMARY**

Project Title: Investigation of strength and duration of preinsulated district heating pipes of plastics.

ENS-1323/91-0009. NEI-9100142.

Key Words: Piping technology, Low-temperature systems. Heat transport.

Objectives: The project investigates the possibilities of producing reliable, low cost flexible preinsulated pipes for district heating. The research is mainly based on new materials for the carrier pipe.

Technical Approach: The main activity of the project is to carry out experiments with accelerated test of pipes made of a newly developed material. Several materials have been made and are in a long term test. One material will be chosen for the accelerated test.

FEM analysis will be done to study the stress distribution in a preinsulated plastic pipe.

In the project will intensively be discussed why and how a preinsulated plastic pipe will break down during time.

Program Implications: All tests and experiments are made on pipe produced by Statoil and Løgstør Rør A/S. The technical problems are primarily related to low temperature (max. 80°C) district heating system.

Current Status: Long term tests are still going on. Accelerated tests are going on at present. It is expected that a report will be available in spring 1993.

Future Activities: Carry out the remaining accelerated tests. Make the final report of the project.

Research Product: It is expected that the project will describe and document a concept idea for new type of preinsulated pipes. This will be done in the final project report.

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DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Mechanical properties of cellular polyurethane (PUR) plastic insulation in pre-insulated district heating pipes.

Key Words: Piping technology, Preinsulated pipes, Heat transport, Insulation.

Key activity: Research.

Objective: To obtain knowledge on the creep properties of new cellular PUR-plastic materials under radial strain at increased temperatures in pre-insulated district heating steel pipe systems in the ground. New thermo-mechanical properties of the foam insulation will appear when CFC-gases are substituted by new frothing agents for the PUR-foam and it is intended to focus on the life properties of the cellular plastic.

Project: Experimental investigations and measurements are made in a laboratory test set-up to develop and document the properties of new cellular PUR-plastics in pre-insulated district heating pipes. Furthermore the required properties of the cellular PUR-plastics will be described. It is intended to use the test set-up later on when a test method has been developed. The measurement result will be compared with results of parallel thermo-mechanical analyses (TMA) using the previous methods and the possible correlations will be evaluated to decide to which extent the methods might be applied. The test set-up includes a larger pipe section than applied in the previous TMA-analyses. A systematic examination of the PUR-systems available on the market will be made when the applicability of the test method has been verified by the first series of experiments.

Current Status: The project was started in 1992 and is intended to be finished at the end of 1993.

Research Product: The project is financially supported to 60% by the Danish Ministry of Energy and will be published within the ministerial framework of Energy Research Reports.

Contact Point for Additional Information:

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**DISTRICT HEATING AND COOLING RESEARCH
PROJECT SUMMARY**

Project Title: Oxygen in plastic pipe district heating systems.
ENS-1323/91-0019. NEI-9100153.

Key Words: Piping technology, Preinsulated pipes, Oxygen, Chemicals.

Objective: To measure oxygen in a district heating system where the pipe grid consists of both plastic and steel pipe sections.

Technical Approach: The measuring will be carried out in such a way that the aggregate chemical fluctuations in the grid and the influence of the surrounding soil on the system may be recorded.

The project concerns the following measuring of oxygen:

Sections of combined steel and plastic system under present operational conditions, i.e. in the summer and winter months.

Measuring of the house installations which have been connected either with or without exchanger on the radiator to the district heating system.

In connection with all measuring, water samples will be taken that will serve as chemical reference analyses, including oxygen content and TOC.

Program Implications: When these oxygen diffusion measuring have been carried out, one will be able to gain an overview of the oxygen uptake of the various systems and sections together with a knowledge of how pressure and temperature influence this oxygen uptake. Furthermore, one will be able to assess the need for selective treatment of the water used in district heating lines. This will also result in clarification of the questions of how and where chemicals (if any) must be added to the water.

Current Status: The district heating system has been selected and the first winter measuring of the district heating system has been carried out.

Further Activities: Measuring of both the district heating system during summer and the house installations which have directly or indirectly been connected to the system.

Research Product: A report specifying analyses of the measuring and conclusions will be finished by autumn 1993.

Contact Point for Additional Information:

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FEDERAL REPUBLIC OF GERMANY

**DISTRICT HEATING AND COOLING RESEARCH
PROJECT SUMMARY**

Project Title: Corrosion behaviour of materials in circulating waters containing surfactants of different quality (0328710H)

Key Words: Advanced hydraulics, heat transport.

Key Activity: Research and development

Project: Project period: 01.05.1989 - 31.12.1991

The friction-reducing additives developed for use in district heating networks are examined for potential corrosive or anticorrosive effects. New findings are expected concerning an optimum selection of materials, heating water and operating conditions.

Parameter studies are being carried out in the following fields using a model of a pilot-scale district heating pipeline system:

- heating water composition and operating conditions
- behaviour of pipeline materials
- behaviour of sealing materials
- type and concentration of surfactants

The test series for the parameter studies have begun. Initial results show a dependence of corrosion on the pH-value and/or oxygen content of heating water containing surfactants.

Research Product: Report

Contact Point for Additional Information:

DECHEMA - Deutsche Gesellschaft für chem. Apparatewesen e.V.
Prof. Dr. E. Heitz
Theodor-Heuss-Allee 25
6000 Frankfurt 97

DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Corporate project on friction reducers; development of treatment processes for solutions containing surfactants (0328710F)

Key Words: Advanced hydraulics, heat transport.

Key Activity: Research

Project: Project period: 01.08.1988 - 30.06.1993

For the use of surfactants as resistance-reducing additives in district heating networks, processes are to be developed for separating the surfactants again from the network water. This is of particular significance for the bypass conditioning of network water during operation (deterioration of the purification stages) and during the occurrence of leakages (toxicity of surfactants penetrating into the ground/surface water).

Characteristic solubility data have been determined for the surfactants in water (temperature, critical micelle concentration).

Ultrafiltration, adsorption on bentonite (clay mineral) and adsorption on lewatite (organic resin) have proved suitable in preliminary tests.

The required equilibrium data have been determined for these processes.

Research Product: Report

Contact Point for Additional Information:

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4600 Dortmund 50

**DISTRICT HEATING AND COOLING RESEARCH
PROJECT SUMMARY**

Project Title: Influence of surfactant solutions in district heating systems on the operating and control behaviour of centrifugal pumps (0328710G)

Key Words: Advanced hydraulics, heat transport.

Key Activity: System development

Project: Project period: 01.08.1988 - 31.12.1990

The project aim is the use of surfactants in district heating systems. It will be studied in which way the addition of friction-reducing surfactants changes the operating behaviour of centrifugal pumps. For this purpose, the influence of speed, full-speed rate and degree of throttling on the delivery and efficiency is measured. Furthermore, the influence of surfactants on cavitation erosion is studied for different pump materials.

Friction reduction due to the addition of surfactants leads to an improvement in pump efficiency, which is the greater, the higher the contribution of friction to total losses becomes, i.e. the lower the full-speed rate is at a given delivery flow. However, this improvement is only effective in connection with relatively low pump speeds, since the surfactant has no effect at high shear velocities. Cavitation erosion is also clearly reduced for both grey cast and stainless steel pump materials, as was observed in tests with high cavitation intensity.

The test results show that the use of surfactants in district heating systems has no adverse effects on the use of pumps. Minor improvements are measurable with respect to efficiency. It should be noted, however, that friction reduction in pipeline systems clearly shifts the operating point with existing pumps. The addition of surfactants has clear advantages with a view to material erosion in the event of cavitation.

Research Product: Report

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6710 Frankenthal

DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Dynamic flow processes in connection with friction reducers (0328710D)

Key Words: Advanced hydraulics, heat transport.

Key Activity: Research and testing

Project: Project period: 01.01.1988 - 31.12.1990

This research project serves to improve computational modelling of dynamic flow processes in a district heating network with the aid of experimental and theoretical studies. These investigations have become increasingly necessary due to the use of friction--reducing additives, since they increase the flow rates within the pipe network thus increasing the risk of pressure surges.

The investigations have deepened the knowledge of dynamic processes in pipe networks. In particular, the influence of consumer installations on these processes in the network was elucidated and an adequate model for simulating consumer behaviour was developed.

The model for consumer installations makes it possible to include dynamic influences of consumer installations in pipe network calculations. This improves the accuracy of these simulation calculations for district heating. The inclusion of every individual consumer installation involves an unreasonably high preparation expenditure with respect to input data and excessive computing times. This expenditure can be reduced by the model comprising a group of consumer installations while simultaneously including dynamic consumer effects.

Research Product: Report

Contact Point for Additional Information:

Universität Hannover
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3000 Hannover 1

**DISTRICT HEATING AND COOLING RESEARCH
PROJECT SUMMARY**

Project Title: Influence of friction-reducing additives on the behaviour of measuring and control elements in district heating networks (0328710E)

Key Words: Advanced hydraulics, heat transport.

Key Activity: Research

Project: Project period: 01.01.1988 - 31.12.1990

Cationic surfactant systems fulfil the requirements to be met by resistance reducers in district heating networks with respect to activity, stability and reversible suppression of the action in heat exchangers. These additives reduce the flow pressure loss in pipelines and thus increase the transport capacity of existing pipelines. Moreover, the behaviour of different measuring and control elements in district heating networks can also be influenced. Experimental investigations of the volume measuring components of heat meters and of different positioners are intended to indicate possible changes in the characteristic behaviour of these components.

The measuring accuracy of single- and multi-jet impeller-type flowmeters was studied. Indication errors of up to 80 % were found for these meters. This error is dependent on the surfactant system used, on the flow rate and on temperature, but it can be empirically described.

Research Product: Report

Contact Point for Additional Information:

Universität Dortmund
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DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Influence of friction-reducing additives in different heat-exchanger systems (0328710A)

Key Words: Advanced hydraulics, heat transport.

Key Activity: Research

Project: Project period: 01.07.1986 - 30.06.1990

The influence of cationic friction reducers on heat transfer in different heat exchangers is to be studied.

Calculation equations are available for the heat transfer of surfactant-containing solutions in pipes and pipe coils.

Research Product: Report

Contact Point for Additional Information:

Universität Dortmund
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DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Application and testing of micellar friction reducers in district heating systems (0328710B)

Key Words: Advanced hydraulics, heat transport.

Key Activity: Research and testing

Project: Project period: 01.07.1987 - 30.09.1992

The objective of this project is the application and testing of micellar friction reducers in district heat transport systems.

The work programme involves:

- Verification of friction coefficients determined in laboratory experiments in a real district heat transport system.
- Demonstration of the effective temperature range in connection with real flow velocities.
- Demonstration of the effect with different district heating components (heat exchangers, bends, fittings).
- Operational changes in control and measuring instruments.
- Development of disposal concepts for normal draining measures.

Stable efficiency has been reached in laboratory tests in the temperature range of 50 — 130°C required for district heating.

A test on the district heat transport pipeline in DN 450 did not show the desired temperature stability (efficiency losses between 70 — 80°C).

The optimum concentration ratio of DOBON—G and sodium salicylate was not adjustable due to unstable concentration ratios.

The disposal of the surfactant solution still causes problems; it has so far only been possible to deactivate the surfactant-water mixture by means of bentonite.

Research Product: Report

Contact Point for Additional Information:

Fernwärmeverbund Saar GmbH
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6620 Völklingen

DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Advanced heat pump technologies for district heating systems (0328970A)

Key Words: Cogeneration, combined heat and power, heat pumps

Key Activity: Study

Project: Project period: 01.01.1989 - 31.12.1990

The project aims at

- 1) investigating the possibilities of using advanced heat pumps in district heating systems,
- 2) designing solutions for specific requirements in the different supply areas investigated for the systems conceived.

Based on this study the planning of heat pump application in district heating networks can be prepared more efficiently. It will thus be possible in future to increasingly connect users of low- and medium-pressure steam to district heating networks. Heat pumps can be used to cover their steam and cooling requirements using district heat on site. This can lead to reduced pollutant emissions, decreased primary energy demand and improved utilization of district heating networks.

Research Product: Report

Contact Point for Additional Information:

EAB Energie-Anlagen Berlin GmbH
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**DISTRICT HEATING AND COOLING RESEARCH
PROJECT SUMMARY**

Project Title: Development of a small-power low-NO_x diesel engine involving measures on the primary side of CHP plants (0328863A)

Key Words: Cogeneration, combined heat and power, pollution

Key Activity: Research

Project: Project period: 01.11.1987 - 31.10.1991

The following values are aimed at for exhaust gas emissions:

- NO_x < 400 mg/m³
- CH 40 ... 60 mg/m³ relative to 5 % O₂
- CO 200 ... 250 mg/m³

These target values must be reached with components satisfying the requirement of series capability for use in heat pumps and small combined heat and power generation plants, i.e. ensuring a service life of 40,000 operating hours with minimum maintenance requirements.

The following target values have been demonstrated at model test stands for a diesel engine with enlarged displacement:

- NO_x ≤ 400 mg/m³ exhaust gas
- HC _ 400 mg/m³ exhaust gas for 5 % O₂
- CO _ 400 mg/m³ exhaust gas

In conjunction with very good conversion rates for HC and CO, however, the "SO₂/SO₃" problem became also apparent at the oxidizing catalyst.

Fuel suppliers are challenged to further minimize the sulphur content in fuel oil.

Research Product: Report

Contact Point for Additional Information:

Fichtel & Sachs AG
Dr.-Ing. Lück
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8720 Schweinfurt 1

DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Technical and economic investigation of the combined transport of district heat and waste by rail based on specific applications in Germany (0329054A)

Key Words: Cogeneration, combined heat and power.

Key Activity: Study

Project: Project period: 01.01.1990 - 31.03.1992

The aim of the project is to investigate the feasibility of a solution which appears economically meaningful and environmentally acceptable. Specific examples are used to ascertain whether economic efficiency can be achieved by a combination of waste incineration, transport by rail and district heating supply.

The situation requirements have been defined and a cadastral map was drawn up. Since it proved very difficult to find suitable applications, the study was extended beyond the state of North Rhine-Westphalia to cover the whole Federal Republic. In the meantime, a promising waste disposal situation has been found to serve as a basis for the actual study once the boundary conditions are known.

Research Product: Report

Contact Point for Additional Information:

GEF Ingenieurgesellschaft für
Energietechnik und Fernwärme
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6906 Leimen

**DISTRICT HEATING AND COOLING RESEARCH
PROJECT SUMMARY****DISTRICT HEATING AND COOLING RESEARCH
PROJECT SUMMARY**

Project Title: Field testing of flue gas purification equipment (0328515C)

Key Words: Cogeneration, combined heat and power, flue gas, pollution

Key Activity: Testing

Project: Project period: 01.09.1988 - 31.12.1992

Selected flue gas purification systems in block heating stations are to be field tested within the scope of a research project providing the operator of a total energy unit with suitable means for checking the efficiency of the plant's flue gas purification equipment. It is furthermore planned to examine conventional heat generation units for possible primary pollutant reduction using novel techniques.

The following status has been reached:

- Work was commenced on September 1, 1988.
- Test van equipment and plant selection are completed. External measuring devices were selected and are being tested.
- The first measuring phase was successfully completed.
- The second measuring phase was begun.
- Statistical evaluation is under way.

Research Product: Report

Contact Point for Additional Information:

Technischer Überwachungsverein Bayern e.V.
Dipl.-Ing. M. Engel
Westendstraße 199
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DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: 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 (30E20010)

Key Words: Cogeneration, combined heat and power

Key Activity: Study

Project: Project period: 01.09.1990 - 30.09.1991

Technological and engineering solutions are to be evolved for the installation of cogeneration equipment in typified heat plants built in the former GDR with 6.5 t/h, 10 t/h and 40 t/h steam generators (pressure 1.3 MPa and 2.6 MPa, 220°C superheater outlet temperature).

The following status has been reached:

- Work was commenced at the beginning of October 1990.
- The typified heat plants built in the former GDR with 6.5 t/h, 10 t/h and 40 t/h steam generators were evaluated and classified according to year of construction, fuel and heating power.
- A theoretical study was conducted concerning the use of single-stage back-pressure turbines at different live steam pressures, different temperatures and varied back pressure.
- Initial investigations were carried out for increasing the steam parameters at Vorwärmer— und Kesselbau Köthen GmbH and Dampferzeuger Berlin GmbH.

Research Product: Report

Contact Point for Additional Information:

EWU Engineering GmbH
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O-1055 Berlin

**DISTRICT HEATING AND COOLING RESEARCH
PROJECT SUMMARY**

Project Title: Energy concept of the Technical University of Zittau for the territory of the former GDR up to the year 2020 (Zittau Energy Concept 2020)
State of knowledge in 1990 (30E20170)

Key Words: Energy savings, energy conservation, modelling, pollution.

Key Activity: Study

Project: Project period: 01.09.1990 - 31.12.1990

A model system is to be created and applied to obtain initial balance statements on the development of the energy economy in the new federal states on the basis of existing particularities and making allowance for the prolonged transition phase to be expected. This includes the investigation of potential effective energy carrier and plant configurations up to the year 2020.

Basic principles for energy policy design in the new federal states have been derived. Suggestions and concrete decision proposals have been formulated for executive bodies and industrial associations with the aim of a consistent economically efficient and environmentally acceptable energy use. Main aspects concerning the efficient use of energy and the reduction of pollutants have been outlined for the new federal states.

Research Product: Report

Contact Point for Additional Information:

Technische Hochschule Zittau
Prof. Dr. Beckmann
Postfach 2 61
O-8800 Zittau

DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Complex energy supply systems for the town of Neustadt-Gleve (30E20070)

Key Words: Geothermal heat, cogeneration, combined heat and power.

Key Activity: Study

Project: Project period: 01.09.1990 - 31.03.1991

A complex heat supply concept is to be established for the town of Neustadt-Gleve considering the current situation and the prospective development of trade and industry as well as further building schemes. In view of the high environmental pollution due to the use of raw lignite and brown coal briquettes, technologies are to be derived for utilizing geothermal energy in combination with effective cogeneration.

The actual heat consumption structure for the housing area supplied with district heat as well as the space and industrial heat consumption at the Lederwerk site were analysed. Existing producers are evaluated and possibilities for further connection examined. Process engineering solutions for geothermal energy uses have been evolved describing the original situation with geological data, possibilities of geothermal energy input and initial economic calculations for geothermal energy use.

Research Product: Report

Contact Point for Additional Information:

Wärmeanlagenbau GmbH i.A.
Obering. G. Schindler
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**DISTRICT HEATING AND COOLING RESEARCH
PROJECT SUMMARY**

Project Title: Improved utilization of district heating systems, optimization of operation (B 01) (0326907A)

Key Words: Heat transport, modelling

Key Activity: Research

Project: Project period: 01.11.1990 - 31.10.1993

The Chair of Thermal Process Engineering at the University of Dortmund has been entrusted with a mathematical description of district heating systems including the most important elements and boundary conditions involved. Based on this modelling, concepts are to be developed permitting optimum operation of interconnected district heating networks.

The work programme involves

- the establishment of goals, capacities and limits of the system to be provided;
- the formulation of suitable modelling approaches to reproduce non-steady-state thermohydraulic processes in district heating networks;
- the modelling of operating costs for district heating systems;
- the establishment of concepts for operational optimization;
- translation of the correlations derived into a programme system.

Work was started on November 1, 1990 by defining the system requirements and modelling approaches.

Research Product: Report

Contact Point for Additional Information:

Universität Dortmund
Prof. Dr.-Ing. Weinspach
August-Schmidt-Str. 4
4600 Dortmund 50

DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Manufacture, laying and testing of a district heating system with vacuum superinsulation (VSI) (0328641B)

Key Words: Heat transport, insulation

Key Activity: Testing

Project: Project period: 01.01.1988 - 31.12.1992

District heat transport over long distances requires high expenditures on thermal expansion compensation and heat insulation. The novel pipe system with vacuum superinsulation and integrated thermal expansion compensation offers an interesting solution approach and is being tested for practical applicability and technical reliability.

The following status has been reached:

- Assembly of the test facility was completed in the second half of 1990.
- Official commissioning of the test facility.
- The test operation for determining the characteristics of the test facility was carried out according to schedule.
- Transition to regular practice-oriented test operation.

Research Product: Report

Contact Point for Additional Information:

BEWAG AG
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1000 Berlin 30

**DISTRICT HEATING AND COOLING RESEARCH
PROJECT SUMMARY**

Project Title: Project study on "Improved Utilization of District Heating Systems"
(0329053A)

Key Words: Heat transport, optimization, modelling.

Key Activity: Study

Project: Project period: 01.08.1989 - 31.01.1990

The project study has created the basis for implementing an interdisciplinary corporate project for a more efficient utilization of district heating systems. The improvement is achieved by EDP-supported optimization strategies.

The aim of the project study was to demonstrate the benefits of such a corporate project, describe the project organization and define the costs and deadlines.

The study will ensure smooth cooperation between the special disciplines involved by a unique definition of tasks and work flows.

It has been demonstrated that the software product to be generated as part of the corporate project enhances the economic efficiency and thus the competitiveness of district heating supply.

Research Product: Report

Contact Point for Additional Information:

GEF Ingenieurgesellschaft für
Energietechnik und Fernwärme
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DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: German participation in the IEA Implementing Agreement on District Heating Annex III
Cooperative projects in the field of district heating and cooling (03E8493B)

Key Words: Heat supply, heat transport, modelling.

Key Activity: Study

Project: Project period: 01.12.1990 - 31.12.1993

The various advantages of district heating are evaluated differently in view of the boundary conditions prevailing in the individual IEA countries so that different technological solution approaches are derived in the heat production and distribution sector. The aim of this project is therefore to analyse the different boundary conditions and arrive at new common approaches in this field.

The work programme of Annex III covers the following:

- district heating and the environment
- monitoring of district heating networks
- advanced transport media for heating and cooling
- plastic jacket pipes with new foams (CFC-free)
- exchange of information and promotion of the district heating concept.

The work programme was commenced early this year. Results are not yet available.

Research Product: Study

Contact Point for Additional Information:

Forschungszentrum Jülich GmbH
IR. J.C. Resing
Postfach 19 13
5170 Jülich

**DISTRICT HEATING AND COOLING RESEARCH
PROJECT SUMMARY**

Project Title: German participation in the IEA Implementing Agreement for Programme Research, Development and Demonstration on District Heating (03E8493A)

Key Words: Heat supply, heat transport.

Key Activity: Study

Project: Project period: 01.03.1984 - 30.06.1990

The various advantages of district heating are evaluated differently in view of the boundary conditions prevailing in the individual IEA countries so that different technological solution approaches are derived in the heat production and distribution sector. The aim of this project is therefore to analyse the different boundary conditions and arrive at new common approaches in this field.

The results obtained are available to national district heating utilities and to AGFW. They have improved international cooperation.

Research Product: Study

Contact Point for Additional Information:

Forschungszentrum Jülich GmbH
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DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: "First processing phase" for the energy concept Leipzig (30E20120)-/ISE2012A

Key Words: Heat supply, energy savings, energy conservation, pollution.

Key Activity: Study

Project: Project period: 01.09.1990 - 30.11.1991

An energy concept focusing on thermal energy supply is being developed for a selected territorial area in the town of Leipzig. The potential for savings and rationalization is analysed and suitable system solutions are proposed for covering the demand.

The primary energy input must be reduced by 20 % and air pollution by 25 %.

Work was begun on September 1, 1990 by analysing the energy supply situation. Direct surveys were conducted in selected industrial plants. The delivered energy consumption in the population sector was determined by a first data evaluation.

Research Product: Report

Contact Point for Additional Information:

EWU Engineering GmbH
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**DISTRICT HEATING AND COOLING RESEARCH
PROJECT SUMMARY**

Project Title: Manufacture, laying and testing of a district heating pipe system with vacuum superinsulation (VSI) (0328641C)

Key Words: Heat transport, insulation, piping technology.

Key Activity: Testing

Project: Project period: 01.12.1988 - 31.12.1992

District heat transport over long distances requires high expenditure on thermal expansion compensation and thermal insulation. The novel pipe system with vacuum superinsulation and integrated thermal expansion compensation offers an interesting alternative and is being tested with respect to practical applicability and technical reliability.

Test operation for determining the pilot plant characteristics was carried out on schedule.

Regular test operation has commenced.

Research Product: Report

Contact Point for Additional Information:

Technische Universität Berlin
Prof. Dr. G. Zöllner
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1000 Berlin

DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Novel heat distribution - new laying techniques for flexible district heating systems with plastic medium pipes (0328789F)

Key Words: Heat transport, piping technology, preinsulated pipes.

Key Activity: Research and development, testing

Project: Project period: 01.08.1988 - 31.12.1992

The project entitled "Novel heat distribution with plastic medium pipes" is part of the corporate project "Novel Heat Distribution".

The aim is to develop and test a flexible district heating system with pipes to be manufactured in great lengths and laid similarly to cables.

The investigation targets for the two plastic medium pipelines using "cross-linked" polyethylene and polybutane were defined and matched with already existing manufacturers' specifications.

The individual tasks have been discussed with the candidate institutes and contracts are being awarded.

A pilot laying procedure served to test the handling of the plastic medium pipe system under site conditions prior to the actual field test. The result comes up to expectations.

Research Product: Report

Contact Point for Additional Information:

Fernwärme Verbund Saar GmbH
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6620 Völklingen

**DISTRICT HEATING AND COOLING RESEARCH
PROJECT SUMMARY**

Project Title: Corporate project: Novel District Heat Distribution.

Subproject: New testing techniques and system components for plastic jacket pipes (0328789G)

Key Words: Heat transport, preinsulated pipes, piping technology.

Key Activity: Development and testing

Project: Project period: 01.08.1988 - 31.12.1992

The aim is to reduce the construction costs for laying plastic jacket tubes in the ground. Novel components such as pipe elbows with insulating foams of elevated compression strength will serve to reduce thermal expansion and stresses/deformation in the pipe through higher foundation forces. The welded sleeves of the jacket pipe must be improved to withstand higher loads. New techniques are to be developed for pressure and leak testing.

The three development goals require engineering work comprising the steps of theoretical preparation, design, laboratory test and field test. This applies both to the pipeline components to be developed with system producers and to the weld sleeves for which especially creep tests are important as well as to the test equipment and methods.

The following status has been reached:

- A) Pressure and leak tests of welds
- B) Welded sleeves for plastic jacket pipes: a large number of tensile creep tests were carried out in the laboratory on strip specimens and whole sleeves (at 4/3/2 N/m² and 95/80/60/50°C)
- C) Plastic jacket pipes with lateral load capacity: The compressive creep tests for radial pressure loads up to 2 N/mm² and 160°C medium temperature were repeated for a pipe with CFC foam and expanded glass reinforcement (collection of reference values). The creep tests at 140°C were begun.

Research Product: Report

Contact Point for Additional Information:

Gas-, Elektrizitäts- und Wasserwerke Köln AG
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5000 Köln 1

DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Development and construction of critical single components for the mobile district heat system. Testing using a model system - Phase A (03E8553A)

Key Words: Heat transport.

Key Activity: Research and development

Project: Project period: 01.06.1986 - 30.06.1991

The project aim is to develop a system for low-temperature heat transport by railway in order to utilize the heat in existing or new district heating networks. The application aims in particular towards extracting heat from nuclear power stations or other heat sources located far from high-demand areas.

Phase A of the project involves the definition and selection of transfer principles as well as the development and construction of a prototype tank wagon, a transfer station and an accumulator. Phase A is completed by testing the model system in Wolfsburg.

The loading station was completed. The functionality of the full hose union forming the link between station and heat wagon was attested by the Technical Control Board (TÜV).

The test programme was started. The final report will be presented in the third quarter of 1992.

Research Product: Report

Contact Point for Additional Information:

Forschungsgesellschaft Wolfsburg mbH
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3180 Wolfsburg 1

**DISTRICT HEATING AND COOLING RESEARCH
PROJECT SUMMARY**

Project Title: Research and development project on "operational self-prestressing" of district heating pipes (0328789H)

Key Words: Heat transport, piping technology.

Key Activity: Testing

Project: Project period: 01.01.1988 - 31.12.1993

The technology of "operational self-prestressing" for district heat transport pipes is currently being studied under project 0328599 A. Owing to the positive results from this project, the investigations will be extended to include the area of sub-distribution. The aim is to specifically examine the weak points of the plastic jacket pipe, such as tees, branches and bends in pilot-scale and field tests under the conditions of operational self-prestressing. Considerable cost reductions in district heating pipe laying are expected from a positive completion of the project.

The first results from investigations on the radial compressive strength of CFC-free foams (1st generation) at test temperatures of 160°C and 140°C are available. These foams did not withstand the loads applied. Conventional CFC foams were therefore additionally tested in order to obtain comparative measurement results.

The component test rig is under construction. Planning of the model networks was begun.

Product: Report

Contact Point for Additional Information:

Fernwärmeversorgung Niederrhein GmbH
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4220 Dinslaken

DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: "SF Generators" - generators with superconducting field coils (0328296B)

Key Words: Heat transport

Key Activity: Research and development

Project: Project period: 01.04.1989 - 31.12.1990

Continuation of work for the construction and testing of a synchronous generator with superconducting field winding to progressively demonstrate the functionality and commercial feasibility, reliability and control of the new technology, and the foreseeable reduction in generator losses.

The construction of a test generator has been largely completed, test results will be reported in due course. The work and findings will form the basis for the construction of superconducting generators for use in power stations. The power loss from superconducting generators is about half of that from conventional machines with otherwise identical or slightly better performance characteristics. Since their utilization rate is also doubled, the performance level for an economically efficient use of super-conducting generators is in the upper range of current conventional units despite the more sophisticated technology.

Results have been published in: D. Lambrecht, Panel Discussion on the Impact of Superconducting Technologies on Future Power Systems and Equipment - Superconducting Generators, CIGRE Session 1990, August 26th - September 1st.

Research Product: Report

Contact Point for Additional Information:

Siemens AG - E 482
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8520 Erlangen 2

**DISTRICT HEATING AND COOLING RESEARCH
PROJECT SUMMARY**

Project Title: "Operational self-prestressing of district heating pipelines"
(plastic composite jacket pipe system and vacuum steel jacket pipe system) (0328599A)

Key Words: Heat transport, piping technology, preinsulated pipes.

Key Activity: System development and testing

Project: Project period: 01.09.1986 - 31.08.1990

The aim of the project is the development of a new laying technique for vacuum steel jacket pipes and plastic jacket pipes. Costs of the order of 20 — 30 % are to be saved by "operational self-prestressing" as compared to current expansion compensation.

Cost savings up to 20 % are achieved with the new laying technique.

Fernwärmeversorgung Niederrhein GmbH as well as other utility companies have meanwhile also used this technique for new pipelines in the transport sector. The technique contributes significantly towards improving the competitiveness of district heating.

Research Product: Report

Contact Point for Additional Information:

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DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Corporate project: Novel district heat distribution
Subproject: Development of new components for plastic jacket pipes (0328789D)

Key Words: Heat transport, piping technology.

Key Activity: Research and development

Project: Project period: 01.04.1988 - 31.03.1991

Development of standardized connecting elements to combine flexible composite plastic jacket pipes with other freely sliding laying techniques.

Testing of different elements for expansion compensation under district heating network conditions in a test facility.

All candidate elements were tested under district heating network conditions.

A casing for the expansion elements was designed. Static proof was furnished for some materials. Other materials still require experimental proof for which simplified models were produced.

Research Product: Report

Contact Point for Additional Information:

ARGE Energieversorgung
Oberhausen/Deutsche Babcock
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**DISTRICT HEATING AND COOLING RESEARCH
PROJECT SUMMARY**

Project Title: Determination of frictional forces on soil-covered heat-conducting pipelines to ensure economical designs (0328789A)

Key Words: Heat transport, piping technology.

Key Activity: Research and testing

Project: Project period: 01.04.1987 - 31.03.1991

The movements and stresses of a heat-conducting pipeline should be calculable more precisely than before and the phenomena occurring in practice should be clarified; this requires research into and quantification of the parameter spectrum for soil-covered plastic jacket pipes in district heating systems with respect to mechanical and thermal loads.

The following status has been reached:

- initial measurements for low depth of coverage to define an experimental procedure varying only one state parameter
- investigation of all parameters influencing plastic jacket pipes DN 80/160 and DN 150/250 and DN 250/400 at a high degree of compression of the bedding material

Research Product: Report

Contact Point for Additional Information:

Fernwärme-Forschungsinstitut in Hannover e.V.
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Max-von-Laue-Str. 23
3005 Hemmingen 1

DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: New underground laying techniques for large district heat transport pipes in conurbations (03E8626A)

Key Words: Heat transport, piping technology.

Key Activity: Demonstration

Project: Project period: 01.06.1985 - 30.06.1991

The aim of this demonstration project is to test new techniques for laying large district heat transport pipes in densely populated areas and to indicate possibilities for reducing the high investment costs.

The work programme involves

- a) testing and further development of techniques for piercing through the soil for large cross-sections of pipe
- b) novel design of an elastic pipe support to reduce the forces to be transmitted to the ground
- c) extensive measuring programmes for the verification and documentation of results.

The anchor design was modified for the second measuring phase, replacing the rigid connection between the heating flow pipe and the anchor point by springs to obtain an elastic construction. The springs were pre-tensioned with 80 kN based on the results from the first measuring phase.

Research Product: Report

Contact Point for Additional Information:

BEWAG AG
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Postfach 30 40
1000 Berlin 30

DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Corporate project: Novel District Heat Distribution.
Subproject: New laying techniques for the plastic composite jacket pipe systems
(0328789E)

Key Words: Heat transport, preinsulated pipes, piping technology.

Key Activity: Development and testing

Project: Project period: 01.04.1988 - 31.12.1992

The aim of the subproject "New laying techniques for the plastic composite jacket pipe system" is to achieve considerable cost reductions in district heat distribution by the development and application of novel techniques and construction methods utilizing static thresholds and improved laying techniques. The work programme involves

- advanced design of system components for house service connections with a view to cost reduction, decreased laying depths, shorter assembly times
- new construction and laying techniques for plastic composite jacket pipes with a view to building mass reduction and smoother construction progress (a one-day building site)
- evaluation of laying techniques for district heat distribution pipes using the time recording and calculation system to compare and evaluate all relevant economic variables on the site (masses, times, costs)

The following status has been reached:

- development of the "lower extraction" technology to the point of application; this tap connection is superior to the former design with respect to pipe laying depth requirements, assembly friendliness and costs
- planning and implementation of the test section "Münchwälder straÙe" laying flow and return pipes on top of each other and including measuring equipment for expansions, subsidences and stresses
- completion of the structural development of the time recording and calculation system which is operative and tested on site; the associated data have been largely established.

Research Product: Report

Contact Point for Additional Information:

Stadtwerke Mannheim AG
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6800 Mannheim 1

DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: New laying techniques using heat-insulated compensating socket pipes of ductile cast iron as well as efficient methods for laying service pipelines (0328789C)

Key Words: Heat transport, piping technology.

Key Activity: Testing

Project: Project period: 01.04.1988 - 31.12.1992

The project goals are:

- I. Demonstration of system reliability with a view to ensuring permanent efficiency, developing a suitable welding technique for branch and circumferential seams under site conditions and developing system components for control of the shearing forces due to internal pressure.
- II. Applicability of the pull-in technique with ground penetration equipment and controllable lance drive for flexible district heating pipelines. Examination of the applicability of the Suction excavator technique to replace manual excavation.

The following status has been reached:

- I.
 - Calculation of a sealing ring of DN 150 nominal width in the socket using the finite-element method.
 - Accompanying measurements using different humidity penetration monitoring systems in soil covered test routes.
- II.
 - Applicability of techniques for laying the candidate elastic pipe systems directly in the ground using the pull-in technique, ground exploration by georadar as well as the suction excavator technique.
 - Verification of the branch and connection technology proposed by the manufacturer on corrugated pipes.
 - Time studies on suction excavator use and comparison with real manual excavation work.

Research Product: Report

Contact Point for Additional Information:

Technische Werke der Stadt Stuttgart AG (TWS)
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DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Manufacture, laying and testing of a district heating pipe system with vacuum superinsulation (VSI) (0328641D)

Key Words: Heat transport, insulation.

Key Activity: System development and testing

Project: Project period: 01.11.1988 - 31.12.1992

The aim of this research project is the practical testing of a novel district heating pipe system with vacuum superinsulation (VSI) for the transport of district heat with high power output over long distances. The prefabricated VSI pipe is characterized by good thermal insulation, low pressure losses and simple laying. Use in district heat engineering is planned as soon as possible.

The work programme involves

- the manufacture of prefabricated VSI pipes of DN 600 nominal width with associated filler material and simultaneous testing of the production technology covering all individual processes involved;
- the project planning, construction and commissioning of a VSI pilot plant on the site of the BEWAG power station "Reuter-West" with a pipe length of 2 x 96 m and a nominal width of DN 600;
- test operation and the evaluation of tests concerning the thermal, hydraulic and mechanical behaviour of VSI pipes.

The pilot plant was completed in the period from April to September 1990 and officially put into operation.

A programme for automated test operation was jointly set up by the Technical University of Berlin, BEWAG Berlin and Mannesmann Seiffert.

Research Product: Report

Contact Point for Additional Information:

Mannesmann-Seiffert GmbH
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Postfach 42 04 29
1000 Berlin 42

DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Corporate project: Novel Heat Distribution

Subproject: New techniques and construction methods for district heat distribution utilizing static thresholds, new materials and improved laying techniques (0328789B)

Key Words: Heat transport, piping technology.

Key Activity: Research and development

Project: Project period: 01.04.1988 - 31.12.1995

The R & D corporate project "Novel heat distribution" pursues the general aim of developing new laying techniques for expanded district heat supply and of putting these techniques into practice by improving the design, using new materials, new building machines and new construction methods.

The work programme involves

- state-of-the-art design and laying technique
- determination of future requirements
- analysis of parameters influencing costs and safety/design
- concepts for cost reduction using new design methods
- optimization in terms of minimizing the expenditure on the construction of subdistribution networks while simultaneously securing long-term pipe integrity.

This framework project belongs to a broad-based corporate research project currently involving 7 other operators.

The EDP model reproduces a concrete supply situation in a built-up suburban area with apartment houses and low heat density.

Research Product: Report

Contact Point for Additional Information:

AGFW

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**DISTRICT HEATING AND COOLING RESEARCH
PROJECT SUMMARY**

Project Title: Energy and environmental concept for the town of Meissen (30E20110)

Key Words: Heating demands, pollution.

Key Activity: Study

Project: Project period: 01.09.1990 - 31.10.1991

An energy and environmental concept has to be evolved for the town of Meissen, analysing the actual situation and conceiving a heat supply scheme for the old town centre (remediation area).

Work was begun in October 1990. Since the most important cooperation partner has dropped out, the costs for cooperation services did not become effective and additional own contributions had to be made.

The actual situation was analysed by computer-aided data processing including a calculation of heat requirements and pollutant emissions.

The variant calculations for the remediation area were completed.

Research Product: Report

Contact Point for Additional Information:

Verbundnetz AG im Aufbau
Dr. E. Gundermann
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O-1140 Berlin

DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Development and operation of an information system for municipal energy supply (KEV) (0339215A)

Key Words: Modelling

Key Activity: Study

Project: Project period: 01.11.1987 - 31.12.1991

The results from the work programme "Local and regional energy supply concepts" are to be processed for selective access in the "Information system for municipal energy supply" in order to fully utilize the large potential for municipal energy savings by demand-oriented information supply.

A documentation has been prepared completing the programming work carried out in 1989 for a data bank on municipal energy supply and serving as a basis for further activities. Preliminary work for the menu-controlled user surface generated in 1991 was carried out. External data sources, e.g. a total energy unit data bank, were linked to this data bank system. The overall data bank is accessible free of charge via the KEV information exchange.

Research Product: Report

Contact Point for Additional Information:

Fachinformationszentrum Karlsruhe GmbH
Prof. Dr.-Ing. J. Grewen
7514 Eggenstein-Leopoldshafen 2

DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Energy concept for Berlin (30E20020)/ISE202A

Key Words: Modelling, heat supply.

Key Activity: Study

Project: Project period: 01.09.1990 - 30.11.1991

A model energy concept for Berlin (region South/East) concentrating on heat supply is being evolved for a study area agreed upon with the Senate/Municipal Government and representatives of the municipalities of Berlin Köpenick/Treptow. The area was delimited as a complete remediation area with heavy industrial pollution and potential industrial settlements.

The following data are available for evaluation:

- producer file
- heat requirement data for Treptow/Köpenick (consumer side)
- district heating consumer file
- extracts from the "housing policy" data memory.

Furthermore, activities are under way to obtain necessary information and data from the Statistical Office, the Senate administrations for town development/environment as well as from the construction and housing sector.

Research Product: Report

Contact Point for Additional Information:

EWU Engineering GmbH
Dipl.-Ing. C. Bauer
Storkowerstraße 134
O-1055 Berlin

FINLAND

DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Planning System for Combined Heat and Power Supply

Key Words: Combined heat and power, Economy, Modelling, Operation, Optimization, Production,

Objective: To develop a computerized planning system to assist energy utilities in the short and medium term operation planning of large and comprehensive combined heat and power systems.

Technical Approach: The calculation is based on advanced calculation methods such as the linear programming decomposition method and the heuristic simulation method, which are alternatively available depending on the accuracy required and the calculation time allowed for the results. The user interface is based on DECwindows software and the database is realised on ORACLE basis.

Program Implication: The system optimizes the operation of complex CHP systems including several CHP plants, such as combined cycle, back pressure, condensing extraction, diesel plants and electric or fuel fired boilers and heat pumps. Energy reservoirs, such as hydro power and hot water tanks, are included as well. There may simultaneously be several district heating networks operated by steam or hot water. Trading of heat and power with neighbour utilities is optimized as well.

Current Status: Started in 1989, finished in 6/1992

Research Product: A practical planning system, reports

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DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Reduction of NO_x Emissions in Oil-fired Boilers by Using Selective Non-catalytic Reduction

Key Words: Combustion, Corrosion, Pollution, Production

Objective: To research in practice the effects and costs of NO_x-reduction in oil-fired boilers by using the selective non-catalytic reduction (SNCR) technology.

Technical Approach: Tests were made with a 40 MW oil-fired district heating boiler. The reactive substance was ammonia-water liquid, which was injected into the furnace at a temperature of about 1000°C, where there should be no undesired reactions after the furnace caused by the reaction between ammonia and sulphur trioxide. The results of this reaction are ammonium sulphates, which can be very corrosive.

Program Implication: The costs of ammonia with 50 per cent NO_x reduction were about 3000 FIM/tNO₂, with ammonia-water and about 600 FIM/tNO₂ with urea as reactive substance. The dependence of the reaction effectiveness on the furnace temperature and NH₃/NO mole ratio was also studied.

Current Status: Started in 1989, finished in 1991

Future Activities: The SNCR method will be applied in a coal-fired CHP plant

Research Product: A pilot plant, a report

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DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Analysing of the Couplings and Dimensioning Criteria of District Heating Subdistribution Systems

Key Words: Consumer installations, Domestic hot water, Economy, Optimization, Substations

Objective: To analyse the cost-effectiveness of different dimensioning criterias of district heating consumer appliances. Especially the effect of dimensioning temperatures on consumer costs was considered. Another aim was to analyse and get basic information about the thermohydraulic behavior and the controllability of district heating subdistribution systems.

Technical Approach: The research work was mainly done by computer simulations. In addition, simulation models for heat exchangers were verified with laboratory tests. The calculations were made for a multistorey residential building and an office building. It was assumed, that the rate of interest is 10 per cent and the repayment period of the heating system is 15 years.

Program Implication: The present dimensioning temperatures 115-45/40-70°C are not optimal from the consumer's point of view. It would be more economical for the consumer to raise the outlet temperature and increase the temperature difference on secondary side, and to decrease the temperature difference on primary side, respectively. If the dimensioning temperatures were, for instance, 115-55/50-90°C, the total annual costs would be 10 per cent lower. If, however, the primary supply temperature of 115°C and secondary supply temperature of 70°C are fixed, the present temperature differences both on primary side and secondary side are most economical from the consumer's point of view. According to the analyses the domestic hot water preheater is only reasonable in large residential buildings. If, for instance, the continuous domestic hot water flow in a multistorey residential building is 5 per cent of the dimensioning flow rate, the return water temperature is 5°C lower with preheater than without it. In an office building the 5°C extra cooling with preheater can only be obtained, if the continuous domestic hot water flow is 40 per cent of the dimensioning flow.

Current Status: Started in 1990, finished in 1991

Future Activities: Further analyses have been made in a continued project.

Research Product: A report

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DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Behavior of District Heating Consumer

Key Words: Consumer installations, Domestic hot water, Substations, Tariffs

Objective: To determine heat load variations of different types of consumers

Technical Approach: The heat loads were measured and analysed

Program Implication: 1. The load behavior of four different district heated areas was analysed. The areas included two small-house areas, an area of blocks of flats and an industrial area. It turned out, that the variations in the supply temperature did not affect the return temperature. After the variations the water flow moved gradually to the value corresponding the original heat load and the new temperature difference.
2. A regression model was developed for the heat load affected by domestic hot water. The relations of 1 min, 5 min, 1 h, 24 h, 1 week and 1 month domestic hot water peak loads were developed. For instance, the maximum heat load of 1 min is 35 times as high as the monthly average. It was found out, that the 1 min and 5 min peak loads are too short for the dimensioning of the heat exchanger. The heat load of domestic hot water was 30...50 per cent lower in summertime than during the heating season.

Current Status: Started in 1987, finished in 1989

Future Activities: The heat load measurement program has been continued, and the new phase will be finished in 1992.

Research Product: Measurement results in a database, a report

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DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Operation Experiences of a Low-temperature District Heating System in a Small-house Area

Key Words: Corrosion, Economy, Heat losses, Low-temperature systems, Metering, Piping technology

Objective: To explain the technical and economical factors concerning a low-temperature district heating system in a small-house area.

Technical Approach: The research was realised by constructing a low-temperature distribution system in a small-house area in the city of Kuopio, central Finland. The distribution system utilises plastic pipes. The maximum temperature is 70°C and the maximum pressure is 0,6 MPa.

Program Implication: The construction costs of the distribution system were around 25 per cent lower than those of a traditional system using steel pipes. Relatively the biggest savings were achieved in house branch pipes because of the flexible structure of the pipeline. The operation of the system was followed up during one year. Big operational problems did not occur. Some problems were, however affected by the circulation water quality. In the beginning there was corrosion in the system, which affected, that the corrosion products were collected in flow meters. The circulation water was later treated with an inhibitor, after which the problems diminished. The annual heat loss of the network is 12 per cent. The reason for the relatively small heat loss (compared to other small-house areas) is the careful dimensioning of the network.

Current Status: Started in 1985, finished in 1989

Future Activities: The long-time experiences of the system will be followed-up

Research Product: A practical installation, two reports

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DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: District Cooling, pilot study

Key Words: District cooling, Economy, Cooling Demands

Objective: To review the available techniques for district cooling as well as their economy in finnish conditions.

Technical Approach: The recent developments in the different strategies and techniques are reviewed and their advantages and disadvantages are described and compared. A case study is made of a growing commercial area located in southern Finland. The cooling load of the area is estimated to be 4 MW covering the demands of both existing and new buildings. The investment costs and the energy economy of the following cooling strategies were compared:

- individual cooling using compressor chillers in each building (reference case)
- district cooling using central compressor chillers in the district cooling plant and chilled water distribution network
- district cooling using central absorption liquid chillers in the district cooling plant and district heating as the heat source for the absorption chillers and a chilled water distribution network
- district cooling using sea water and a distribution network

The case study showed increases in the investment costs for all of the evaluated district cooling alternatives in comparison to the reference case. The increases were in the above order 14, 39 and 67 per cent. From the energy economy point of view the compressor based central chilling unit alternative did not differ from the reference case, while the central absorption unit as well as the sea water alternatives showed a shortening of about 1 MW in the electric power demand and about 500 MWh/a less electric energy requirement. However, the absorption chilling unit increased the summertime demand of district heating by 6 MW and the energy use by 3000 MWh.

Program Implication: An overview of the economy of district cooling in finnish conditions

Current Status: Started in 3/91, finished in 11/91.

Future Activities: Not planned

Research Product: A report

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DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Development Requirements of District Heating Company Organisations

Key Words: Economy, Maintenance, Operation

Objective: To study development requirements of district heating company organisations in view of business, services, outside services, operation and maintenance

Technical Approach: The study was carried out partly as a literature study, partly by discussing with representatives of district heating companies and other experts

Program Implication: The main development requirements are:

- * renewal of companies' ordinance
- * simplification of processes to acquire and connect new customers and to develop these processes to be more customer-friendly
- * development of services to customer-relation marketing
- * allocating of renovation work to the design and construction group
- * purchasing of maintenance services
- * development of control center operations
- * development of personnel's work contents, training and incentive systems

A tailor-made organisational development project would be useful in most district heating companies.

Current Status: Started in 1989, finished in 1990

Research Product: A report

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DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Electric Heating in District Heating Areas

Key Words: Economy, Energy conservation, Heat supply, Tariffs

Objective: To indicate the shares of direct electric space heating and district heating as modes of heating in new residential buildings during 1985-1987. To evaluate the economic consequences of electric heating compared to district heating. To illustrate the opinions of energy companies and building entrepreneurs towards electric heating and district heating.

Technical Approach: The shares of electric heating and district heating were investigated by using house building statistics and a number of selected new construction plans. The opinions of energy companies and building entrepreneurs were ascertained by interviews.

Program Implication: Statistics show that the share of direct electric space heating was in semi-detached houses about 60 per cent, in terrace houses about 45 per cent and in blocks of flats about 4 per cent. It was estimated that about 80 per cent of the electric-heated semi-detached houses and about 85 per cent of the electric-heated terrace houses and blocks of flats are located outside potential district heating areas. In the research period 15 per cent of the semi-detached houses, 6 per cent of the terrace houses and 0,5 per cent of the blocks of flats were equipped with electric heating in the potential district heating areas. The total costs of district heating are lower than the costs of electric heating in terrace houses and in blocks of flats. From the entrepreneur's point of view, direct electric heating is clearly cheaper than district heating in semi-detached houses. If electric heating will be used in district heating areas at the present rate, or even at a higher rate, this may, within ten years, lead to a potential loss of about 25 MW of back-pressure electric power in Finland.

Current Status: Started in 1989, finished in 1990

Research Product: A report

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**DISTRICT HEATING AND COOLING RESEARCH
PROJECT SUMMARY**

Project Title: An Experimental Study on Heat Losses of Different Types of District Heating Pipes

Key Words: Heat losses, Insulation, Piping technology, Temperature measurements

Objective: To measure in field conditions the total heat losses of six different types of district heating pipelines

Technical Approach: The measurement results were compared with theoretical figures. The results show, that the theoretical calculations are not, as such, suited for the determination of the thermal energy losses. The main reason is, that the earth surrounding the pipeline acts like a condensator, storing a part of the solar energy during the summer and releasing the stored energy during winter. For this reason, and depending on the installation depth of the pipeline, there is a delay of up to one month in the temperature changes between the thermal field around the pipe and ambient air. The temperature of ambient air or the temperature of the earth surface should therefore not be used when the heat losses of district heating pipes are calculated.

Program Implication: The method developed in the study makes it possible to determine the temperature of the outer surface of the pipeline construction. The heat loss of the pipeline is calculated on the basis of the temperature differences between flow pipe, return pipe, and outer surface of the pipeline. The measurements showed differences between the heat losses of different types of constructions, as well as different changes of heat conductivity during the test period. The test results can be used for the development of more optimal constructions.

Current Status: Started in 1984, finished in 1989

Research Product: A report

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DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Definition of District Heating Consumer Heat Load

Key Words: Heating demands, Tariffs

Objective: To develop a method for defining the maximum heat load of different kinds of district heating consumers

Technical Approach: The heat load of five apartment houses was measured and analysed. The analysis was carried out by calculating linear regression of daily maximum hour heat load as well as average daily and weekly heat loads as a function of outdoor temperature. Linear regression analyses were also made for monthly energy consumptions. A computer programme was developed for the regressions.

Program Implication: According to the analyses of five apartment houses the maximum heat load calculated on the basis of monthly energy use seems to be a good approximation of the real heat load. The regression line of daily maximum hour heat load is parallel to the average daily heat load line. It means that the mean value of daily maximum hour heat load variations is constant. The hourly heat load addition to average daily heat load caused by heat load changes varied between 1,5 to 4 W/cu.m. depending on the building.

Current Status: Started in 1991, finished in 1991

Future Activities: The research will be continued using more measurement results from different kinds of buildings.

Research Product: A report, a computer program for heat load analysis

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**DISTRICT HEATING AND COOLING RESEARCH
PROJECT SUMMARY**

Project Title: Thermal Stresses in District Heating Pipes

Key Words: Insulation, Piping technology

Objective: To analyse the temperature conditions in prefabricated district heating pipes

Technical Approach: The water temperature in a district heating network is varying due to control measures and possibly due to failures. The supply temperature is adjusted as a function of outdoor temperature, and charging and discharging of heat in the network also affect temperature variations. In failure situations the temperature can vary very quickly if e.g. return water flows directly to the supply pipe. Changes in water temperature cause tension in pipelines and tension has an effect on durability of the pipes. How large are the temperature transients in the pipelines, and what are their consequences, is considered in the study. The temperature variation in pipe wall and in insulation is studied with a simulation model. The temperature of the water is changed stepwise or gradually during a specified time. The change in water temperature causes a temperature transient in steel wall and in insulation.

Program Implication: The maximum temperature difference e.g. between inside and outside wall of the steel pipe is about one-tenth of the transient in the water temperature when the pipe size is DN 300 and velocity 1 m/s. The temperature difference is depending on both pipe size and velocity. Temperature in the pipe wall reaches a balance in about half a minute when the temperature in water is changed stepwise. In the insulation the temperature changes happen slowly. Water temperature transient of 50 degrees celsius causes on the outer surface of insulation a change of about 3 degrees and the time lag is 20 days. The greatest temperature transients in insulation occur close to the steel wall. The temperature transient can be higher than 50 degrees/cm if the temperature change occurs stepwise.

Current Status: Part one started in 1990, finished in 1991

Future Activities: Further analysis will be concentrated on the consequences of the tensions.

Research Product: A report, a simulation model

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DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Predictive Maintenance of District Heating Networks by Infrared Measurement

Key Words: Leak detection, Maintenance, Temperature measurements

Objective: To develop a measuring system so that potential leaks could be located as early as possible

Technical Approach: A method is developed for analysing the condition of underground district heating pipelines. The method is based on infrared measurement of the ground surface temperature. The measurement is made by using a mobile infrared scanner which is fixed to a car. The analysis is carried out by using the mobile equipment and a system for image processing. The reliability of the measurement system was evaluated by making a series of tests and comparative measurements in a test field in which all the most common types of damage were constructed and run for about two years. The test field was run in controlled conditions in order to find out how soon and how well different kinds of faults could be detected in the ground surface temperature.

Program Implication: The system is connected to the preventive maintenance data system and the network maps. The infrared video recording is processed to produce a longitudinal temperature distribution curve of the ground above the district heating pipeline. The temperature distribution is compared to the network map in order to distinguish the "normal" temperature peaks from the exceptional ones. The maintenance data system uses an image data base so that the temperature curves of previous measurements can be used for comparison.

Current Status: Started in 1989, phase one finished in 1992. A continuation project is started in 1992.

Research Product: A report, a computer program for analysing the thermography results

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**DISTRICT HEATING AND COOLING RESEARCH
PROJECT SUMMARY**

Project Title: The Possibilities of Energy Meter Remote Reading in District Heating

Key Words: Metering, Telemetry

Objective: To study the possibilities of energy meters remote reading in district heating.

Technical Approach: The research was carried out partly by literature study and partly by doing experiments. The research was concentrated mainly in the following:

- * the study on fundamentals of meter reading systems
- * market study of remote reading systems in Finland
- * user experiences concerning remote reading systems by telephone network or by electricity distribution network
- * the situation in standardization of heat meters
- * facts, which have to be taken into consideration when planning to invest in remote reading system.

Program Implication: A list of systems adaptable for remote reading as well as a list of the base features of some of the systems are presented. It was noticed, that while using telephone network the data communication was reliable. The system using electricity distribution network for data communication has fulfilled user needs. The main problems of this system have been the difficulty in using programs and also in the beginning the breakages of bidirectional units. The standardization of district heating meters and their data communication is still going on and the final results of standardization will be ready in 1993.

Current Status: Started in 1989, finished in 1990

Research Product: A report

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DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: No-compensation Pipeline System in District Heating

Key Words: Piping technology, Preinsulated pipes

Objective: To study the operation of a no-compensation (no-comp) system in actual field conditions using an accelerated test technique.

Technical Approach: The no-comp system refers to a pipeline installed in the ground without anchor points and expansion joints compensating the linear thermal expansion. The no-comp system makes use of the properties of prefabricated bonded elements; the friction between the jacket and the earth surrounding it as well as the polyurethane bonded to the jacket and to the flow pipe should prevent linear expansion of the flow pipe. A test system, consisting of 196 meters long DN 100 pipeline was constructed and equipped with strain gauges, displacement sensors and temperature sensors.

Program Implication: As a result, it turned out, that the actual displacements were considerably larger than those expected on the basis of theoretical calculations. The results also show an interesting difference between the values measured in winter and in summer. The displacements are in winter considerably larger than in summer. This may be due to the ground freezing. The frozen ground causes less pressure against the pipe.

Current Status: Started in 1986, finished in 1989

Research Product: A report

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NETHERLANDS

In The Netherlandse is no governmentally initiated ongoing research & development on District Heating. The government stimulates combined heat and power and in this way district heating is supported indirectly. It means that actual R&D efforts are ordered by the Dutch 'EnergieNed' Association (late VESTIN), with emphasis on the subjects and items that might reduce costs for connecting dwellings and other buildings, system operating costs, as well as costs of maintenance.

The efforts of the association are partly supported by Novem. The total sum to be spent on R&D amounts to some \$ 300,000 annually.

29 April 1992
92/E0563/221220/40

**DISTRICT HEATING AND COOLING RESEARCH
PROJECT SUMMARY**

Project Title: Adsorption system of cooling buildings by DH.

Key Words: District cooling.

Key Activity: A demonstration of a absorption cooling system driven by DH.

Objective: Summer usage of DH.

Technical Approach: By loading and unloading a salt mixture.

Current Stage: Will start in the spring of 1992 and will last throughout 1992.

Research Product: A rapport by De Beyer Engineers.

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**DISTRICT HEATING AND COOLING RESEARCH
PROJECT SUMMARY**

Project Title: Absorption cooling with DH water.

Key Words: District cooling

Key Activity: Field study.

Objective: To use normal (70°C) DH water to drive a absorption cooling system.

Current Stage: Completed.

Future Activities: A demonstration of a absorption cooling system.

Research Product: A rapport with possible locations of this system by Tebodin.

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**DISTRICT HEATING AND COOLING RESEARCH
PROJECT SUMMARY**

Project Title: Centralized production of domestic hot water for dwellings.

Key Words: Domestic hot water.

Key Activity: System study.

Objective: Research on the possibilities and feasibility of a centralized domestic hot water provision for groups of houses in DH areas.

Technical Approach: Research and study including the process requirements, design criteria.

Program Implications: Better knowledge of the specific properties of the two domestic water heating systems, i.e. centralized production versus individually produced hot water.

Current Stage: The study by KEMA, Arnhem, was finished in 1988.

Future Activities: At present no future activities are planned.

Research Product: A report with the results of the study.

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DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Value of DH in the heating of domestic dwellings.

Key Words: Economy

Key Activity: A study to investigate in the value of heat for domestic dwelling.

Objective: A survey to get a proper base for the pricing of heat in The Netherlands of DH.

Current Stage: Will soon be contracted.

Future Activities: Depending on the results.

Research Product: A rapport.

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**DISTRICT HEATING AND COOLING RESEARCH
PROJECT SUMMARY**

Project Title: Research and enquiry on slip-losses.

Key Words: Economy. Metering.

Key Activity: Applied research.

Objective: To collect information of the amount of heat which is not registered by the heating meter in dwellings during the year.

Program Implications: Better selection by DH company of the most appropriate heat meter.

Current Stage: The study, executed by KEMA and Hasko has been completed.

Future Activities: The development of rules for the proper use of heating meters in dwellings.

Research Product: A report with calculations and conclusions.

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DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Base load connected bulk consumers.

Key Words: Load Management.

Key Activity: System study.

Objective: To define design, operation and feasibility criteria to connect base load bulk consumers, i.e. consumers who provide the peak load demand by means of their own auxiliary boiler.

Technical Approach: The study will cover the technical and economic aspects of this system. Existing field experience will be incorporated.

Program Implications: A base load connection will diminish the investments for the DH company, by making use of the (mostly existing) heat boilers of bulk consumers. In case of an 'interruptible contract' these consumers might be disconnected from the grid in case this should be favorable for the DH company.

Current Stage: The study is finished.

Future Activities: To specify contracts regarding tariffs and supply conditions.

Research Product: A report describing the proper conditions.

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**DISTRICT HEATING AND COOLING RESEARCH
PROJECT SUMMARY**

Project Title: The behavior of electronic heat cost apportionment under different circumstances.

Key Words: Metering.

Key Activity: Study.

Objective: Establishing of the accuracy of the different kinds of electronic measurement system under extremely conditions.

Current Stage: The study has been finished in 1991.

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DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Advantages and disadvantages of heat expenses sharing systems.

Key Words: Metering.

Key Activity: Study, documentation.

Objective: To get a complete view of the advantages and disadvantages of the use of heat expenses sharing systems, compared with other heat metering devices.

Technical Approach: The activity consists of a literature survey and functional tests on available sharing systems. Limiting conditions for the use of these systems are traced.

Program Implications: By familiarizing the results of the study, a better selection as well as an improved use of the sharing systems in appropriate situations is expected.

Current Stage: Project finished (September 1987).

Future Activities: Extensive testing of the results of the sharing systems compared with the real individual heat consumption under various load conditions and external influences, to increase the knowledge of these systems.

Research Product: Report of the results of the study and tests by the Technological Institute TNO.

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**DISTRICT HEATING AND COOLING RESEARCH
PROJECT SUMMARY**

Project Title: Metering of heat flows in buildings with collective heating systems.

Key Words: Metering.

Key Activity: Study.

Objective: For the allocation of heating costs in buildings with collective heating installations different principles can be used. The effectiveness of three types of cost sharing systems are compared, i.e.

- metering of the heat input at the water side of the installation;
- metering of the heat input at the air side of the installation;
- metering of the inside room air temperature (comfort metering).

This comparison is made for different types of buildings, for different orientations of dwellings in a collective building and for different ways of life of the inhabitants.

Technical Approach: A dynamic calculation model is used for the evaluation of the effects of changing parameters on the accuracy of a heat sharing system. For a great number of situations the results are presented graphically, which gives the possibility to select easily the optimal system under given circumstances.

Program Implications: Better selection by DH company of the most appropriate heat sharing system.

Current Stage: The study, executed by the Technological Institute TNO, was made in 1988 and has been finished.

Future Activities: The development of rules for the proper use of heat expenses sharing systems.

Research Product: A report with the calculations and conclusions.

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DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Evaluation of 'electronic' heat expenses sharing systems.

Key Words: Metering.

Key Activity: Laboratory testing.

Objective: For different makes of electronic heat sharing systems the influence of changing operational conditions on the accuracy of the registrations is to be tested.

Technical Approach: In a laboratory test rig 7 makes of electronic heat sharing systems will be installed on 5 different shaped heat radiators. With infra-red thermography surface temperatures on several spots of the radiators can be registered and compared with the indications of the electronic devices. Temperature levels of the circulating water in the radiators and water flows will be varied similar to temperature variations under normal operational conditions. Also other practice conditions will be simulated like: curtains over the radiators, sunshine on the radiators, hot connection pipes in the surroundings of the radiators.

Program Implications: By comparing the results of this study with the knowledge of other sharing systems, optimal decisions can be made concerning the most suitable system in a given situation.

Current Stage: The project executed by the Technological Institute TNO is finished.

Research Product: A report with test results.

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**DISTRICT HEATING AND COOLING RESEARCH
PROJECT SUMMARY**

Project Title: Evaluation of four different makes of direct heat meters.

Key Words: Metering.

Key Activity: Laboratory testing.

Objective: To collect impartial performance figures regarding the behaviour of four makes of direct heat meters, based on different measuring principles.

Technical Approach: Determination of:

1. the accuracy of energy metering;
2. the electric behaviour;
3. the effects on functions and accuracy of environmental influences.

Program Implications: Familiarizing of the functional behaviour of the direct meters, as a result of which the selection by the DH companies is made easier and will be more unanimous.

Current Stage: Project finished (December 1987).

Future Activities: Stimulating this kind of research as a base to select equipment.

Research Product: A report by the National Engineering Laboratory, Glasgow, Scotland.

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DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Development of a control and optimization strategy for the operation of District Heating networks.

Key Words: Optimization.

Key Activity: System Development.

Objective: For cost optimization of the total DH system temperature levels, water flow and heat storage are main parameters. By changing these parameters in order to reach lowest operation costs, the continuity of heat supply to the consumers could be influenced. A software program will be developed, which covers both the aims of cost optimization and continuity of supply to all the consumers.

Technical Approach: General study of the dynamic behaviour of heat distribution networks in relation to normal variations in demand. Determination of the effects of changing production patterns on the supply conditions at the borders of the network, at a given heat load. Within the limits of system parameters daily optimization of the flow conditions in the network. The software will be tested on an existing district heating system.

Program Implications: With the optimization program daily system control in advance is possible, based on expected load curves and scheduled production plans.

Current Stage: The project is finished.

Future Activities: The results of this project will be integrated, with other partial studies, into a total optimization program for the optimal design and operation of the production, distribution and consumption in district heating systems.

Research Product: A general report and initial software (Research Institute: KEMA, Arnhem).

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DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Optimization of heat supply to small individual dwellings.

Key Words: Optimization. Heat supply.

Key Activity: Applied research. Field study.

Objective: To develop a control strategy for heat supply to dwellings. A prototype of a supply station that meets this control strategy will be developed.

Technical Approach: A control strategy is to be defined considering both consumption and comfort of the consumer on the one side and the running costs of the DH company on the other side.

Program Implications: The results of the investigations can be used for the development of new regulations devices and for remote control and monitoring of the heat demand. Load management will result in lower peak loads and cheaper design of distribution systems.

Current Stage: A number of long-term field measurements have been done to get a clear view on the effects of variations in heat supply on indoor temperature levels and comfort. Based on this experience, a model is developed for a new approach of heat supply control, which will fulfill optimally the interests of both consumers and heat supplier. The field test and the development of a control strategy have been finished in 1986. Integrated regulation and measuring device is constructed but will be not available commercially.

Future Activities: Further activities are stopped for economical reasons at the moment.

Research Product: A report including a prototype for a supply station that meets all of the above requirements (Technical University of Twente).

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DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Optimization of the heat load curves in substations.

Key Words: Optimization. Heat supply.

Key Activity: Research. Development.

Objective: To decrease the momentary heat load fluctuations in substations. A control system to meet optimum heat loads should be designed and tested.

Technical Approach: A control strategy is developed, by which short-time load fluctuations can be suppressed, without interference into the contractual rights of the consumers. This strategy is tested in field tests with a non-commercial prototype control device.

Program Implications: A more constant heat load will result in a better load pattern for the heat production installations, lower peak loads and better use of the distribution system.

Current Stage: The above-mentioned control strategy has been tested in a substation. In addition computer simulations have been carried out in order to develop the proper operational control strategy. Some commercial prototypes will be installed in 1990 for field test of the control devices.

Future Activities: Integration of these control strategy in the total optimization concept of the DH-system in 1992.

Research Product: A report including the control strategy and market ready control components.

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**DISTRICT HEATING AND COOLING RESEARCH
PROJECT SUMMARY**

Project Title: Research on the ageing of polyurethane foam in district heating networks.

Key Words: Piping technology.

Key Activity: Research.

Objective: To build up knowledge of the long-term behavior of polyurethane foam, used in district heating systems. Apart from the insulation properties, the adhesion between polyurethane and heat carrying pipes and the axial shear strength of the foam are important features. Methods must be developed to predict the lifetime of a foam under given operational conditions.

Technical Approach: From a preliminary study, temperature level appeared to be the only parameter causing the ageing of polyurethane. So thermic extrapolation offers a possibility to predict lifetime of a system. From testing the physical properties at different temperatures during a given time in a laboratory, information is collected about the declining as a function of temperature and time. As a further step, in a research program over 5 years more security must be obtained about the first theoretical conclusions.

Program Implications: The knowledge of physical properties will enable to make optimal decisions about system layout for new district heating schemes.

Current Stage: The project was started in 1981 by KEMA, Arnhem with the preliminary study. The long-term research program started in 1986 and will go on until 1991.

Research Product: Status reports and final report in 1992.

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DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Study of compact house substations.

Key Words: Substations.

Key Activity: Study.

Objective: A global survey and a technical and economic comparison, based on a program of requirements, of a compact station with heat exchanger and an indirect central system.

Technical Approach: First a theoretical study will be executed. Later on tests on standard compact stations will be conducted, considering the results of the theoretical study.

Program Implications: These compact stations might be a good alternative for the indirect central system with a collective heat exchanger for 100-200 dwellings, particularly in bungalow-type houses.

Current Stage: This study is carried out at the Fernwärmeforschungsinstitut in Hannover and will be finished in 1989.

Future Activities: At present, no future activities are planned.

Research Product: A report including a comparison between the compact station (indirect decentral) and an indirect central system.

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DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Use of boilers for domestic hot water in compact house substations.

Key Words: Substations.

Key Activity: Development.

Objective: The goal is to develop an integrated house substation for heating and domestic hot water, equipped with commercial available appliances, in which the domestic hot water is provided by a boiler. In this substation a double separation between DH water and domestic hot water will be realized.

Technical Approach: By the construction of an integrated compact station on a test rig all related aspects will be tested. Three different arrangements of the components will be compared in the tests.

Program Implications: A compact station for each dwelling directly connected to the primary mains of the district heating system eliminates the need for secondary mains. This compact station is expected to be used primarily to connect detached houses.

Current Stage: The development and the tests by Jos Claessen BV were finished in 1986.

Future Activities: No future activities in this field are planned.

Research Product: A report with the results of the tests with price calculations of such a substation.

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NORWAY

**DISTRICT HEATING AND COOLING RESEARCH
PROJECT SUMMARY**

Project Title: Analysis of energy- and load-demand in district cooling-systems

Key words: Cooling demands

Key Activity: Measurement and registration of cooling load

Objective: To establish reliable data for dimensioning heat-exchangers and related installations in each building, and for dimensioning new district-cooling systems. Cooling-load as a function of ambient temperature, season and technical installations will be presented, together with maximum acceptable outgoing temperature in the district cooling system

Technical Approach: Measurements from the district heating- and cooling system in Sandvika, Norway, will be used together with information from buildings (located in different parts of Norway) with local cooling systems

Program Implications: Will improve quality and feasibility of district cooling systems

Current Status: The project started in June 1992, and the report will be completed in December 1992

Future Activities: No definite plans

Research Product: Report to "The Federation of Norwegian Energy Utilities"

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DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Optimization of hot service water production in consumer substations

Key words: Domestic hot water, heating demands

Key Activity: District heating, hot service water, load and energy metering

Objective: Establish connection between hot service water load and energy usage in various building categories

Technical Approach: By using a ultrasonic "clamp on" flow meter and thermo couples the hot service water load is sampled with a frequency of 1/15 sec. through a 14 days period

Program Implications: Develop basic material for evaluation and dimensioning of hot service water systems in consumer substations

Current Status: Data from 7 office buildings are processed, and currently measurements are made on hotels and hospitals

Future Activities: Continue measurements in hotels and hospitals

Research Product: A report to "The Federation of Norwegian Energy Utilities" containing load and energy analysis of hot service water production in consumer substations

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**DISTRICT HEATING AND COOLING RESEARCH
PROJECT SUMMARY**

Project Title: Thermal Power and Energy for Heating Systems

Key words: Heating demands

Key Activity: Continuous registration of thermal power and energy in DH-system for verification of parameters in a simple model for estimating thermal power and energy demands in buildings

Objective: To develop a simple model to estimate thermal power and energy demands in buildings for heat planning and for use in an early stage in building planning

Technical Approach: The effect of all the main parameters affecting the thermal power and energy demands in buildings are systematically analyzed and organized into a simple and practical model

Program Implications: The model is expected to improve the quality of heat planning and decrease the tendency to overestimate the thermal power and energy demands in DH-systems and in buildings in general. Increased feasibility of DH-systems is expected to be one of the important results of the project

Current Status: A preliminary model is developed. The model will be calibrated against measured values of thermal power and energy in actual buildings by the end of 1992

Future Activities: Continuous registration of thermal power and energy demands for buildings connected to a couple of DH-systems in Norway that have a complete "telemetering" system will be continued to improve the statistical quality of the gathered data

Research Product: Report to "The Federation of Norwegian Energy Utilities". Papers to seminars etc and articles in engineering periodicals

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SWEDEN

**DISTRICT HEATING AND COOLING RESEARCH
PROJECT SUMMARY**

Project title: Advanced heat transfer fluids

Key words: Advanced hydraulics, heat transfer fluids

Key activity: Basic and applied research

Objective: The research programme considers basic knowledge of materials and properties which are of significance for improvements of the energy transmitting capacity in DH-systems

Technical approach: An introductory survey of suitable materials and a following experimental investigation of the material qualities. The heat exchange process is studied in a laboratory model of a DH-system

Program implications: The project comprises experimental investigations of thermophysical properties such as transition energy, supercooling, transition kinetics and heat conduction

Current stage: Running

Research product: (656 112) Report

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DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: New technique for central control unit

Key Words: Control

Objective: To connect a small housing area to the main district heating network with new control technique.

Technical Approach: Residential control units are replaced by an advanced central unit.

Program Implication: Demonstration of new and more efficient central control technique.

Current Status: Running

Research Product: (654 017) Report

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**DISTRICT HEATING AND COOLING RESEARCH
PROJECT SUMMARY**

Project Title: Planning of production of heat in district heating systems by heat load estimation

Key Words: Energy savings, optimization, modelling

Objective: To apply a computer model for practical use in a district heating system.

Technical Approach: A computer system for modeling is installed in a district heating system. The computer model will estimate the heat load on basis of data from the process system.

Program Implication: A model for estimating heat load has been developed at the university of Umeå. The model will be useful in planning an economically and environmentally efficient production of heat in a district heating system.

Current Status: Running

Research Product: (654 018) Report

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DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Impurities on heat exchangers

Key Words: Heat exchanging

Objective: To increase the understanding of the mechanisms behind impurities on heat exchangers.

Technical Approach: Studies on impurities on heat exchangers in district heating control units. Development of new cleaning methods. Tests will be made in laboratories and in real systems. Both organic and inorganic impurities will be studied

Program Implication: The consequences of impurities on heat exchangers are extensive. It causes decreasing of heat transfer, fall of pressure, problems with erosion and corrosion and increased health risks. It is of great importance to study the mechanisms behind this problem and to give recommendations how impurities should be avoided.

Current Status: Running

Research Product: (654 027) Report

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**DISTRICT HEATING AND COOLING RESEARCH
PROJECT SUMMARY**

Project Title: On Ultrasonic Flow Meters. Investigations and improvements of the sing around flow meter.

Key Words: Leak detection, metering

Objective: Develop a method for measuring flow to control the DH-production system and to divide the cost among the end-users.

Technical Approach: Modeling work has been performed on fluid and sound interaction in the U-type flow meter geometry. Mathematical corrections for errors due to speed-of-sound changes and errors due to incorrect detection of sound waves have been theoretically derived and experimentally verified.

Program Implication: The dissertation consist of a general introduction covering the topics of flow measurement using ultrasound methods. Further the following reports are included:

1. Viscosity Effects in Sing-around Type Flow Meter.
2. Ultrasonic Gas Flow Meter with Corrections for Large Dynamic Metering Range.
3. A New Type of Ultrasonic Densitometer.
4. A New Velocity Algorithm for Sing-around Type Flow Meters
5. A New Ultrasonic Flow Meter - Modification of the Sing-around Method for Use in Heat Meter.

Current Status: Project finished

Research Product: (656 086) Dissertation

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DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project title: Research programme, LTH

Key words: Metering, substations, piping technology

Key activity: Research. Field studies. Laboratory tests

Objective: Long term research activities concerning DH-systems. Accumulate knowledge from DH-system researching

Technical approach: Long term basic research and documentation activities. University educational activities

Program implications: The research work comprises activities concerning:

- customer control techniques
- DH-measurement device techniques
- DH-pipe net techniques
- Composing of DH-testbook for university educational purposes

Current stage: Running

Research product: (656 054) Reports and a DH-textbook

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**DISTRICT HEATING AND COOLING RESEARCH
PROJECT SUMMARY**

Project title: Research programme, UMEÅ TH

Key words: Optimization, operation

Key activity: Research. Field studies. Laboratory tests

Objective: Long term research activities concerning DH-systems. Accumulate knowledge from DH-system researching

Technical approach: Long term basic research and documentation activities. University educational activities

Program implications: The research work comprises activities concerning optimization of heat production plant operation, distribution techniques, heat accumulation and measuring technique facilities

Current stage: Running

Research product: (656 061) Reports and articles

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DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project title: Specifications and requirements of PUR- foam manufactured without freon for joints

Key words: Piping technology, Insulation

Key activity: Basic research, Technical device

Objective: To investigate and develop a new PUR-foam with another blowing agent than freon applicable for joints in DH-networks

Technical approach: To investigate the influence of climate and pipe temperature to the quality of the in situ manufactured PUR-insulation the temperature of the surrounding air and the temperature of the service pipe are varied between -5°C and $+60^{\circ}\text{C}$

Program implications: The quality of the foam is tested in accordance with European standard EN 253. The following test are performed:

- Density
- Water absorption
- Compressive strength
- Cell structure
- Ageing

Current stage: Running. A report has been completed

Research product: (656 101) Report

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**DISTRICT HEATING AND COOLING RESEARCH
PROJECT SUMMARY**

Project Title: Studies on ductile iron pipe systems for district heating purposes

Key Words: Piping technology

Objective: To investigate properties of prefabricated ductile iron pipe systems for district heating purposes.

Technical Approach: The work program includes studies of:

- system performance under imposed settlements
- movements under temperature and pressure cycling
- studies of long time thermal stability of joint material exposed to district heating water
- heatlosses and the application of methods for leakage detection on systems in operation.

Investigation of possible development of methods for tightness tests of pipe joints and pipe systems.

Program Implication: The result of the study will be of importance for the potential use of prefabricated ductile iron pipe systems for expansion and renewal of district heating systems in Sweden.

Current Status: Running

Research Product: (656 080) Report

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DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Direct laying technique for district heating pipes

Key Words: Piping technology

Objective: To find out what material properties of the heating pipes that govern or influence the ploughing and to elucidate the technical requirements for ploughing equipment and project planning methods.

Technical Approach: The work has comprised of:

- Collection of data about different material
- Clarifying of the technical conditions with respect to equipment and methods
- Market analysis
- Design of pipebed and drainagesystem - appropriate techniques.
- Practical tests - ploughing

Program Implication: When expanding district heating network in areas with low heat usage the cost for the distribution network takes a major part of the cost of the heat production which makes it important to reduce the laying cost of district heating pipes.

Current Status: Project finished

Future Activities: The continued work should concentrate on developing the ploughing equipment in order to find an optimum solution for direct laying of steel pipe systems.

Research Product: (654 016) Report

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DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Research program on distribution techniques

Key Words: Renovation

Objective: To determine the applicability of the described methods in the renovation of the Swedish district heating systems.

Technical Approach: The program is divided into three projects:

- Relining of district heating pipes - evaluation of the in-situ and the cone-pipe methods.
- Detection of leakage - evaluation of the method "LOKAL"
- Condition of insulation - evaluation of two methods, one concerning heat conductivity, and one concerning measuring of moist.

Program Implication: The projects described are intended to be part of a future research program on district heating aiming at improving efficiency and quality.

Current Status: Running

Future Activities: A continuing program is under discussion

Research Product: (654 028) Report

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U.S.A.

**DISTRICT HEATING AND COOLING RESEARCH
PROJECT SUMMARY**

Project Title: Friction Reducing Additives for DHC

Key Words: Advanced fluids

Key Activity: Development. Testing

Project: The use of friction reducing additives in DHC systems can significantly reduce pipe, heat exchanger and pump sizes. This, in turn, can reduce upfront capital and operating costs. These potential improvements are significant and hold promise of further enhancing the viability of DHC systems. The objectives of the research are to identify and develop additives that can be utilized to reduce frictional losses in district heating and cooling (DHC) distribution systems, and to characterize their influence on pressure drop and heat transfer. Additives have been screened and promising additives for DHC applications have been identified on the basis of tests in laboratory-scale loops. Scale-up tests including heat transfer performance testing with commercial heat exchangers have been conducted in the Argonne Pilot-scale DHC System Simulator.

Research Product: Reports, papers, and the Argonne Pilot-scale DHC System Simulator

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DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Ice Slurry District Cooling Development and Field Testing

Key Words: District cooling, ice slurry, storage, load management

Objective: This collaborative four-year program with 50% private sector funding involving Argonne National Laboratory, Northern States Power, and the Electric Power Research Institute will conduct field tests of the ice slurry district cooling concept involving pumping slurry to distributed loads at a Northern States Power utility center. The field tests will further develop and prove the technology and promote transfer to the private sector. The program will further develop key components of hardware and an engineering data base through laboratory research at Argonne.

Technical Approach: In the first year of this program, a suitable ice maker will be identified, modified, and tested at Argonne and detailed design of the field installation will be completed. In the second year, the system will be installed and testing started with slurry distributed only within the utility center. In the third year piping will be installed for slurry delivery to satellite users and tested. Testing will continue in the fourth year to explore system control philosophy and to further improve performance.

Program Implications: Demonstrated workability of ice slurry generation, transport, and storage in a field environment involving multiple loads and storage tanks; Developed control and operation philosophy; Accelerated technology transfer to private sector and developed design information.

Current Status: A program plan mutually developed and private sector funding secured. Detail design completed and ice maker selected in 1992.

Future Activities: Perform supporting development at Argonne and installation of field system in 1993.

Research Product: Successful demonstration of technology and engineering data base for future application of technology.

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**DISTRICT HEATING AND COOLING RESEARCH
PROJECT SUMMARY**

Project Title: Fundamentals of Ice Slurries

Key Words: District cooling, ice slurry

Key Activity: Development. Testing

Project: Current district cooling systems require large capital and pumping costs because of the small temperature difference between chilled water supply and return lines. The use of ice slurries in district cooling systems can significantly reduce pipe, heat exchanger and pump sizes. This, in turn, can reduce upfront capital and operating costs. Also, the ice slurry concept may be applicable to cool storage, and thus to load leveling. These potential improvements are significant and hold promise of further enhancing the viability of district cooling systems. The purpose of the research is to develop design correlations for heat transfer and pressure drop with ice-slurry flows. Such information is essential to the successful design and adaptation of district cooling systems that can use ice slurries. Heat transfer and pressure drop experiments with ice slurry flows have been performed in the Argonne Ice Slurry Heat Transfer Test Facility. Ice velocity will be measured with the laser-Doppler velocimeter to verify the flow rate under homogeneous slurry flow conditions.

Research Product: Reports, papers, and the Argonne Ice Slurry Heat Transfer Test Facility.

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DISTRICT HEATING AND COOLING RESEARCH PROJECT SUMMARY

Project Title: Leak Detection and Location Using In-Stream Acoustic Sensors.

Key Words: Leak detection, steam, piping technology, microphone, acoustic, underground, in-stream

Key Activity: District heating and cooling and leak detection and location.

Objective: To develop, evaluate, and implement an advanced in-stream acoustic leak detection sensor and system applicable to steam, water, and gas-filled buried pipe.

Technical Approach: The proposed effort is a cost-shared program among DOE, Consolidated Edison of New York, and NRG Thermal (subsidiary of Northern States Power). Tests for the development of an in-stream monitor are being carried out at ANL with existing steam facilities. The program will progress from sensor development and testing, to system development, to field testing, to transfer of technology to users.

Program Implications: Implementation of this technology is expected to increase leak location accuracy, minimize unnecessary excavation, and reduce the general cost of operating a DHC system. The acoustic leak location system is also expected to save energy and replace current leak location methods that may be limited or imprecise. Whereas the current system is directed toward leak location in steam systems, the probe and associated electronics will be applicable to water systems and gas lines.

Current Status: We have carried out an evaluation of in-stream monitoring to illustrate the potential for improvements in location capability. A survey was completed, and report published, of existing leak detection systems and experiences of utilities in using them. A two-sensor system has been assembled to detect and locate existing leaks with advanced signal processing and in-stream monitors. This system is being tested and will be implemented on a steam line of the Consolidated Edison district heating system.

Future Activities: The acoustic leak detection system will be demonstrated, and transfer of technology implemented.

Research Product: Field implementable acoustic leak location system.

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**DISTRICT HEATING AND COOLING RESEARCH
PROJECT SUMMARY**

Project Title: Development of Three-Pipe DHC System with Once-Through Domestic Hot Water Supply

Key Words: Three pipe system, once-through system, district heating and cooling.

Objective: To perform a preliminary investigation of the three-pipe transmission and distribution system with once through hot water supply for district heating and cooling applications.

Technical Approach: An assessment of the three-pipe concept in district heating and cooling applications is performed to determine the economic benefits. The elimination of the fourth pipe in conjunction with the implementation of a once through hot water system produces significant capital and operating cost savings. This assessment includes the following tasks:

- * Technical and economic analysis of the applicability of the three-pipe system in the different climatic zones in the United States.
- * Assessment of corrosion control methods and treatment in DHC systems.
- * Assessment of the existing code requirements as applied to the three-pipe system with once-through hot water supply.
- * Corrosion and water quality field tests in the Jamestown District Heating System as applicable to the once-through water supply.

Program Implications: The implementation of a three-pipe transmission and distribution system district heating and cooling systems may produce substantial capital and operating savings, especially when combined with a once-through hot water supply. One pipe supplies hot water for comfort heating and domestic hot water applications, the second pipe provides chilled water for cooling, and the third pipe serves as a common return. The elimination of the fourth pipe reduces the transmission and distribution system cost producing viable economies, particularly for low/medium load density areas. Further reduction in equipment and operating costs may be realized by eliminating the user heat exchangers and supplying domestic hot water in an open cycle or once through system. This system presents its maximum economic benefit in regions where the cooling load is substantially higher than the heating load.

Current Status: The study was completed in March of 1991 and a report was issued.

Future Activities: Proposed to perform an engineering analysis of a three-pipe system application in an existing site in a southern U.S. Region.

Research Product: A final report was issued to the U.S. Department of Energy (Contract No. DE-EG01-89CE26595) on March, 1991.

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