EUROPEAN DHC RESEARCH ISSUES

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ABSTRACT
Euroheat & Power is now working towards a European Technology Platform for District Heating and Cooling. In response to this important European DHC research initiative, a preliminary detailed list of research issues within 18 dimensions was elaborated and communicated to more than 100 people in February 2008. After additions and comments received, an updated list of research issues was again distributed in July 2008. This paper contains the current list of suggested research issues.

INTRODUCTION
District heating schemes comprise a network of pipes connecting the buildings in a neighbourhood, town centre or whole city, so that they can be served from centralised plant at one or more Energy Centres. This approach allows any available source of heat to be used, including combined heat and power (CHP), Waste-to-Energy, industrial heat surpluses, and renewables. It is also a versatile approach; any newly available energy source can be integrated rapidly.

By providing a way to aggregate a large number of small, inconsistent heating demands, district heating provides the key to wide scale primary energy saving and carbon emission reduction in whole communities.

In recent years, there has been a great deal of focus on the need to address climate change and in particular to curtail global warming. Although one of the most potent ways to do this, district heating does not receive the attention it deserves as an enabling technology for low and zero carbon technologies.

The district heating companies within the EU27, the three EFTA countries, and the three EU accession countries had an annual turnover (2005) of 19,5 billion Euro and annual heat sales of 1,7 EJ (about 10% of the total net heat demand in the area excluding the use of electricity for heating). However, the district heating market is growing only slowly. If district heating is to contribute more substantially to higher energy efficiency, greater security of supply, and lower carbon dioxide emissions in Europe, then there needs to be much more dynamic growth in the sector. This was one of the most important conclusions from the Ecoheatcool project (http://www.euroheat.org/ecoheatcool/) carried out by Euroheat & Power during 2005-2006.

There is a need to strengthen the competitiveness of district heating by wider dissemination of best practice, by transferring the knowledge of district heating to new generations of district heating professionals, and by communicating the advantages of district heating to the international community. This knowledge extends beyond purely technical issues to incorporate policy and regulatory issues, and organisational and financial models to deliver energy services at a localised level. It also includes the need to address how district heating itself might adapt to future circumstances including radical changes to the nature of future buildings, and what energy savings are made compared with other energy supply options.

This demand can be met by an all-European district heating and cooling research and development program called EDIHEAT, a suggestion put forward in a keynote paper by Sven Werner at the 9th DHC symposium in Helsinki in 2004. In that paper, 13 operating dimensions were suggested for the programme, but no detailed research issues were presented.

Euroheat & Power in Brussels is now working towards a European Technology Platform for District Heating and Cooling. In response to this important European initiative, detailed research issues within 18 operating dimensions have been set out.

RESEARCH ISSUES
The research issues can be divided into various subprograms according to the many dimensions of DHC. After the first draft of this paper, we have received additions of more research issues from:

- Daniela Popescu, Romania
- Michael King, UK
- Pär Dalin, Sweden
- Veli-Pekka Sirola, Finland
- Benny Bøhm, Denmark
- Marie Münster, Denmark
- Poul Erik Grohnheit, Denmark
- Arto Nourkivi, Finland
- Svend Frederiksen, Sweden
- Jerker Delsing, Sweden
- Wolfgang Streicher, Austria
- Michael Wiggin, Canada
- Astghine Pasoyan, Armenia

Without any prioritisation, the current research issues identified are:

1. The heat demand dimension

Issues concerning customer heat demands (for cooling demands, see the cooling dimension):

- What are the current indoor temperatures in various European countries? Need to define – is this domestic only or all buildings?
- How high should indoor temperatures be? Is 21OC really the minimum for health reasons? – Arto Nourkivi
- How much domestic hot water is consumed in various countries?
- What are the average heat demands in various countries?
- How large are the distribution of heat demands?
- What constitutes high- and low-consumers of heat?
- What are the heat demands for new buildings and future buildings, compared to existing buildings?
- Where space heating demands are virtually eliminated, as may be the case in certain types of new building in the future, can district heating be justified on the domestic hot water demand alone?
- For new buildings, very low heat demands are expected in the coming years. Is it possible to make an efficient DH supply for areas with such energy efficient buildings, including the integration of RES (solar and heat pumps) - centrally or on individual houses? – Benny Bøhm
- How to improve the operation of existing building installations in order to obtain energy savings in buildings and networks.- Benny Bøhm
- How will European heat demands be reduced due to future climatic change?
- What is the effect of changing weather patterns on heat demand likely to be?
- Will the reduced heat demand from higher outdoor temperatures mean DH is hard to justify?
- Are the existing example weather years used in models representative of future temperatures?
- How can the European heating index, introduced in the Ecoheatcool project, be further developed for a better understanding of the European heat demands?
- How big could the demand be for new uses of district heating (washing appliances, refrigeration etc)? – Marie Münster
- What is the impact of two-way heat pumps on DH demand? – Poul Erik Grohnheit
- Technology interaction with customers and its influence on reduced energy demand. – Jerker Delsing
- User behaviour adaptive energy control systems in houses and system wide. – Jerker Delsing

2. The social cost dimension

Issues concerning the social benefits and costs of DHC:

- What are the economic benefits of heating and cooling for customers/scheme operators (overall net present values) to achieve a given indoor temperature?
- How much higher are these benefit values compared to the heating costs?
- What are the social costs for heat and fuel poverty?
- What are the social cost benefits for using district heating in social housing?
- What extra skills are required in a non-DHC country that strategically decides to develop DHC?
- What effects on local employment does the development of DHC have?

3. The environmental dimension

Issues concerning environmental benefits and impact of DHC:

- What are the overall avoided carbon dioxide/ greenhouse gas –Marie Münster emissions from district heating and cooling?
- How effective are DHC systems as mitigation measures compared to other measures?
- How much can the urban air qualities improve from extensive district heating and cooling? – particularly with reference to NOx emissions and particles (due to individual burning of firewood) –Marie Münster.
  -particularly with reference to particulate matter? –Svend Frederiksen.
  -particularly with reference to NOx, HC, Particles (PM5, PM10 etc). – Wolfgang Streicher
- What is the potential for achieving zero carbon heating in existing housing with district heating? How does this compare (economically, logistically) with other zero carbon solutions?
- How is the benefit of district heating shared in carbon allocation methods when district heat is obtained in conjunction with combined heat and power?
- How can district heating contribute to future fossil free energy systems? –Marie Münster
- When conducting life cycle assessments of GHG emissions, how significant (compared to other options) or what are the emissions relating to embodied energy in manufacturing and construction of DHC networks? -Michael Wiggin
- What is the significance of DHC in facilitating the use of renewable energy (e.g. biomass, geothermal, solar, ocean cooling etc.)? - Michael Wiggin

4. The institutional dimension
Issues concerning legal, market, management and cultural conditions for DHC systems:

- What are the customer/govt policy maker/municipal level decision makers/ ESCO participants opinions about district heating in various countries?
- What is the current infrastructure for generating power and fuelling heating plant?
- What is the best option for DHC/CHP: large CHP stations or embedded generation?
- Where and when (instead of what) is the best option for DHC/CHP: large CHP stations or embedded generation? – Poul Erik Grohnheit
- What level of DHC infrastructure build-up is feasible?
- In a 'new' or 'small' district heating country what is the best approach to capacity building of the necessary skills base?
- In a 'new' or 'small' district heating country how can installation costs compete with the high volume conventional alternatives?
- Would the development of DHC lead to (gas infrastructure) stranded assets?
- With a large increase of DHC/CHP would cooking with gas still be a viable option?
- What are the possibilities and difficulties for DHC in the current legislative and regulatory frameworks?
- What planning methods such as zoning are used today?
- Where public price control is used?
- Where is the competition distorted with respect to low gas prices?
- What are the good and bad examples of international and national DHC policies?
- What are the conditions for using third party access in DHC systems?
- What are the major barriers for expanding the European DHC systems?
- How can the international energy statistics be improved in order to show the hidden benefits of DHC systems?
- Infrastructure build-up strategies – or infrastructure build up historic examples. – Poul Erik Grohnheit
- Interaction with the electricity market, e.g. CHP facing a day ahead spot market with hourly prices. – Poul Erik Grohnheit
- Operation strategies for CHP and heat storage in an electricity system dominated by wind power. – Poul Erik Grohnheit
- Shall one still rely on voluntary customer connections or is regulation needed to force economic connections to materialize –Arto Nourkivi
- How can the barriers of PPP be reduced to attract investment in DH with long pay back times? –Arto Nourkivi
- Communication to the policy makers; -Pär Dalin
    - o - to create a level playing field towards the alternative
    - o - to avoid regulations
- Does inclusion of DHC within a regulatory framework provide sufficient confidence for investors? –Michael King
- Can and should legal-regulatory tools be legitimately applied to maintain or recover district heating in areas with multi-apartment buildings with a growing number of individual gas heating systems? –Astghine Pasoyan
- Does community ownership address consumer protection concerns? –Michael King

5. The competition dimension
Issues concerning competition with other heating and cooling technologies:

- What are the competitor heating technologies to district heating in European countries? Now and in the future? –Marie Münster
- In countries with a highly developed gas infrastructure, if gas prices became too high to operate individual gas boilers in single dwellings, what alternative method of heat provision would occupants use? To what extent would this increase the market for district heating?
- How can consumer protection be delivered for DHC customers in the absence of competition? –Michael King
- Are consumers organised into consortia (coops, ESCo's, municipally owned co's) based on DH able to secure greater competitive advantage in the market than individual consumers based on decentralised heat? –Michael King
- Is there a need for the accreditation of DHC engineers and contractors? –Michael King

6. The organizational dimension
Issues concerning how DHC systems are owned and organized:

- Who are the DHC entrepreneurs in various countries?
- Who are the owners of the European district heating systems?
- Which ownership and co-ownership models exist?
- How is the benefit of district heating shared in cost allocation methods when district heat is obtained in conjunction with combined heat and power, waste incineration, and industrial surplus heat?
- What are the relative merits of local community based ESCOs and utilities for delivering DHC?
- How will Multi-Utility Service Companies (MUSCOs) influence the development of district heating?

7. The DHC resources dimension
All aspects concerning the strategic resources available:

- Combined heat and power (including waste heat from large Power Stations as well as small-scale CHP plant).
- Waste incineration (shouldn't this be extended to all EfW technologies?) – Michael King
- Industrial surplus heat recycled
- Geothermal heat
- Fuels difficult to handle individually, as biomass from wood waste etc
- Free cooling resources
- Solar heating – Marie Münster
- Ambient heat (ground, water, air) – Marie Münster

with the following research questions:

- What are the pros and cons of central CHP compared to decentralised CHP as micro-CHP?
- What are the pros and cons of central solar thermal collection compared with decentralised solar thermal collection? –Michael King
- To what extent can existing waste incineration plants be used for district heating networks?
- To which extent can existing industrial surplus heat in Europe be recycled into district heating networks?
- What is the net present value of a well diversified district heat supply, when having a volatile energy market?
- Where are the European heat demands and the European district heating systems located in comparison to the large identified basins of warm and hot geothermal water?
- What is the geographical distribution of heat currently being thrown away, and proximity of heat demand?
- What contribution can scale make towards addressing air quality issues associated with biomass? –Michael King
- What price should be paid for heat from large power stations and waste for incineration? – Poul Erik Grohnheit
- Statistics concerning and theory regarding urbanisation and housing – the geographical dimension. –Svend Frederiksen

8. The heat distribution dimension

Issues concerning the economy, reliability and efficiency of DHC distribution:

- What are the typical building densities and the corresponding linear heat densities in European cities and towns?
- What are the average costs and its variation among countries for putting district heating pipes into the ground?
- What are the conditions for existing pipes with respect to pipe damages in the three generations of district heating pipes: steam pipes, duct water pipes, and prefabricated water pipes?
- To what extent has local heat control with variable flow control replaced the traditional central heat control and constant flow in operation of CEE systems? (local heat control with variable flow has a better cash flow from perfect flow allocation and perfect heat generation merit order).
- Should steam-based urban systems be retrofitted to water-based systems? – Poul Erik Grohnheit
- Should partial instead of full local heat control be considered an efficient option for Eastern European countries? –Daniela Popescu
- What possibilities appear with lower return temperatures in order to get more efficient heat generation and lower heat losses?
- What types of pipes are used and why? –Veli-Pekka Sirola
- What types of joints are used and why? –Veli-Pekka Sirola
- What installation methods of pipelines are used and why? –Veli-Pekka Sirola
- How is building and construction of pipelines organised and implemented in different countries? –Veli-Pekka Sirola
- What are the average maintenance and repair costs and variation among countries? –Veli-Pekka Sirola
- How is maintenance organised and which kind of maintenance strategies exist? –Veli-Pekka Sirola
- Renovation (replacement of old pipe and component types) strategies in different countries. –Veli-Pekka Sirola
- What possibilities appear to improve the (work) quality of pipe installation and speed up the installation process? –Veli-Pekka Sirola
- What installation supervision and site inspection methods and practises are used? – Veli-Pekka Sirola
- Water treatment needs and methods –Veli-Pekka Sirola
- What status control and leak detection methods and practises are used? –Veli-Pekka Sirola

9. The best available technology dimension

Which are the best available technologies and methods today for

- combined heat and power from various fuels?
- waste incineration?
- industrial surplus heat?
- geothermal heat?
- fuels difficult to handle individually?
- solar heat to DHC systems?
- flue gas condensation when using moisture fuels
- optimization of heat generation?
- short term heat storage?
- long term heat storage? –Marie Münster
- large scale heat pumps or CHP plants – Poul Erik Grohnheit
- integration of renewable energy and efficient energy systems. – Poul Erik Grohnheit
- low cost heat distribution?
- extension of pipe lifetimes?

- distribution network rehabilitation?
- heat storage in distribution networks?
- sparse district heating?
- substations for connection of customer heating systems?
- local heat demand control?
- local heat demand control in Central and East European countries?
- a rational step by step plan for the conversion from traditional production driven to modern demand driven technologies in CEE? –Daniela Popescu
- low error rates in the information chain from heat meters to invoices?
- individual heat metering?
- customer interface?
- pricing models?
- what other complementary heat demands can DHC meet today (eg washing machines, ground heating etc)

10. The developed technology dimension

Issues concerning the development and exchange of new DHC technologies such as:

- Stack flue gases of 30ºC when using biomass
- Long term heat storage without heat losses
- Error-free heat deliveries with annual average return temperatures of 30ºC
- Plug-and –play intelligent substations
- The 2 pipe system, which is more and more used in Austria and Germany. It is also suitable for multifamily houses with district heat network as heat source as secondary network within the building or for small district heating networks directly. – Wolfgang Streicher
- Self adaptive control valves managing high differential pressures
- Water hammer free networks
- Dynamic design conditions for heat distribution networks
- Software for design and real-time optimization of DHS –Daniela Popescu
- District heat-driven washing machines
- District heat-driven dishing machines
- District heat-driven refrigerators
- Single dwelling district heat driven absorption chillers
- Trigeneration –Svend Frederiksen
- 50% reduction of installation costs – possible and if so, how? –Svend Frederiksen
- Lowered heat conductivity of piping insulation – Svend Frederiksen
- Super-insulation of pipes –Svend Frederiksen
- Advanced fluids –Svend Frederiksen
- Phase-change fluids –Svend Frederiksen
- Friction Reducing Additives –Svend Frederiksen
- Energy transportation by truck, train or boat (TTB) –Viktoria Martin

11. The demonstration dimension

Demonstration of DH BAT and developed technology used in other countries, but not used in the target countries:

- Waste incineration in CEE countries.
- Local heat control with perfect flow allocation and merit order in CEE countries.
- Biomass in CEE countries.
- Biomass CHP in Brussels, Scotland and Tallinn –Arto Nourkivi
- Industrial waste heat
- Gasification of wood chips.

12. The knowledge exchange dimension

An extensive research dissemination network with

- A European scientific DHC journal
- Annual DHC conferences
- A European website about DHC
- A European textbook about DHC
- A European Encyclopaedia of DHC
- DHC training workshops
- Exchange of students and young professionals
- Upgrading the academic programs in universities preparing DHC professional to cover contemporary technical solutions. – Astghine Pasoyan

13. The Eastern dimension

Cooperation with Belarus, Russia, Ukraine, Romania and Moldova, and the Balkan countries–Arto Nourkivi, especially concerning

- The social cost dimension
- The demonstration dimension
- The knowledge exchange dimension
- The heating system optimization dimension – Arto Nourkivi
- Involvement of “eastern” research institutes to EDIHEAT –Arto Nourkivi
- Can EE projects in DHC systems be made eligible for CDM financing (in non-Annex B countries under UNFCCC) that would be just great!y notes from the meeting. d a conference call with USAID. , rs and ESCO project Hungary, Bulgaria, Balallowing utilization of carbon financing in this area? –Astghine Pasoyan
- How will future closure of old DH systems (unable to achieve reduction in emissions required by the Kyoto Protocol) affect the use of this technology in CEE? –Daniela Popescu

14. The cooling dimension

District cooling issues in all dimensions:

- What are the cooling demands in Europe?
- What is the impact of the heat island effect in cities? How much will cooling loads increase?
- Which free cooling resources are available for district cooling?
- To which extent can low cost or free summer heat from district heating systems be used in absorption chillers for feeding district cooling systems?

- To realize a program where the alternatives seasonal performance are measured. –Pär Dalin
- To implement a quality-DC labeling –Pär Dalin
- Ice-slurries –Svend Frederiksen

15. The global dimension
What are the overall benefits of DHC systems with respect to:

- Lower carbon dioxide emissions
- Higher security of supply
- Higher energy efficiency
- Economics
- DHC in global long-term optimisation models, e.g. IEA/ETSAP TIAM. – Poul Erik Grohnheit
- What is the contribution of DHC to energy security and can a value be ascribed to it that could be included in a low carbon heat incentive? –Michael King
- What is the contribution of DHC to future proofing and can a value be ascribed to it that could be included in a low carbon heat incentive? –Michael King

16. The future dimensions dimension
What are the possible scenarios for future energy sources for society and how will that affect DHC and CHP? -Michael Wiggin

- Will net zero buildings eliminate the need for DHC? -Michael Wiggin
- Will DHC be a means of moving locally produced energy between buildings? -Michael Wiggin
- Will DHC become the prime means of utilizing renewable energy like biomass, concentrating solar, geothermal etc.)? -Michael Wiggin
- Will gas be available for decentralized CHP? -Michael Wiggin
- How could DHC systems change to accommodate future energy supplies and demands? -Michael Wiggin
- How can DHC contribute to assisting society with changes? -Michael Wiggin
- On-going research focus on the development of DH systems for buildings with heat demands of < 2 kW. It appears to be realistic to obtain an efficiency of 80% or more by the use of buffer tanks and good network design. –Benny Boehm

17. The economic dimension

- How to overcome the upfront capital investment barrier where DHC is economically justified but required multi-million dollar investments? –Astghine Pasoyan
- What finance models and mechanisms work best for extending existing networks, refurbishing old networks, and establishing new networks?
- The best environmental solution for existing networks is to expand the network without increasing the heat sales. How can this be managed economically?
- What is the contribution of DHC to energy security and can a value be ascribed to it that could be included in a low carbon heat incentive? –Michael King
- What is the contribution of DHC to future proofing and can a value be ascribed to it that could be included in a low carbon heat incentive? –Michael King

18. The program quality assurance dimension
An internal quality assurance group within the research program for supervision of and securing input to, quality, relevance and output from the DHC research program. This group should be composed by 5-10 skilled DHC professionals from companies and universities having knowledge and experience from many of the 18 dimensions.

THE NEXT STEP
This extensive list of research issues should be apprehended as a full menu for choosing highly prioritised projects within a future European DHC research program. Prioritisations will be made from the number of interested parties and their collective willingness to finance a project.

After prioritisation, the following question will appear: **What are the current knowledge and experiences and the future possibilities within the prioritised research issues?**

REFERENCES
Werner S, Proposal for a District Heating and Cooling Research and Development Programme in an Extended EU. 9th International DHC Symposium, Helsinki 2004.