IEA DHC | CHP

DHC Annex TS1

Low Temperature District Heating for Future Energy Systems

Annex Text

Operating Agent

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1 Description of Technical Sector and Definition

The building sector is responsible for more than one third of the end energy consumption of societies and produces the largest amount of greenhouse gas emissions (GHG) of all sectors. This is due to the utilisation of combustion processes of mainly fossil fuels to satisfy the heating and cooling demand[1] of the building stock. District heating (DH) can contribute significantly to a more efficient use of energy resources as well as better integration of renewable energy into the heating sector (e.g. geothermal heat, solar heat and biomass from waste), and surplus heat (e.g. industrial waste heat). The more efficient use of all energy resources and the use of renewable energy are measures which lead to a reduced utilisation of fossil energy, and thereby a reduction of GHG emissions.

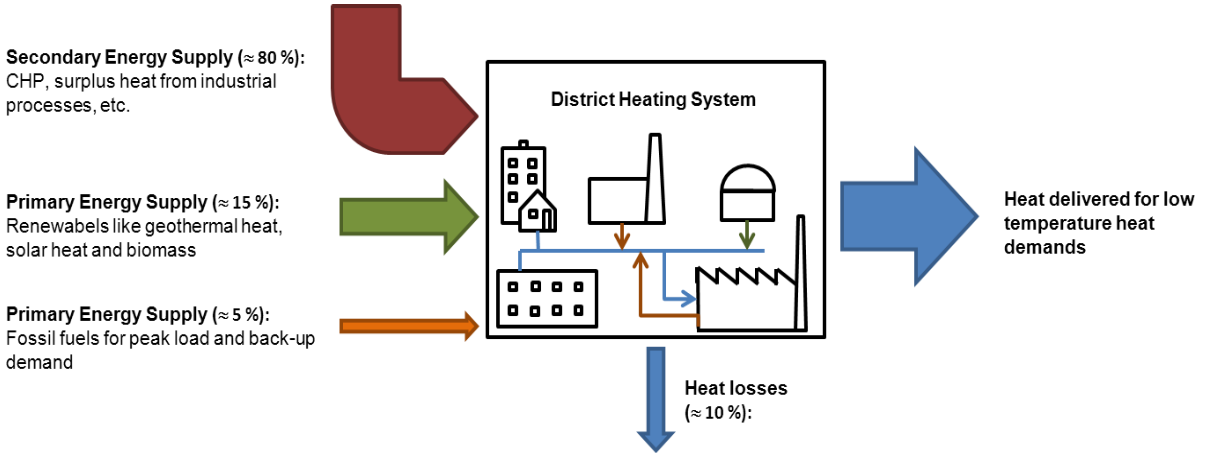

Figure 1: Example of a district heating system which incorporates inputs from fossil and renewable energy sources, and utilises surplus heat sources.[2]

Within this context, it is mandatory to consider the entire energy chain to achieve a good overall system performance. This means evaluating all energy flows, from the extraction of primary energy, to the utilisation of heat in buildings. This approach allows the prevention of sub-optimal solutions (e.g. supplying poorly insulated buildings by an efficient DH system, which, nonetheless, results in high energy consumption for heating). The components of the DH System, such as the pipelines, the operational structures, and the substations, are an integral part of the overall system optimisation. The building stock, the structure of the considered community and the heat generation facilities must also be taken into account for the assessment.

The IEA DHC Annex TS1 aims to identify holistic and innovative approaches to communal low temperature heat supply. It is a framework that promotes the discussion of future heating networks with an international group of experts. The goal is to obtain a common development direction for the wide application of low temperature district heat-

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[1] The cooling demand is usually satisfied by use of electricity form combustion processes.

[2] Fredriksen S, Werner S.; District heating and cooling, European DHC Textbook; English Edition 2012 6th draft

ing systems in the near future. District cooling can also be integrated into the programme but is not the focus. The gathered research which is to collected within this Annex should contribute to establishing DH as a significant factor for the development of 100% renewable energy based communal energy systems in international research communities and in practice. In connecting the demand side (community/building stock) and the generation side (different energy sources which are suitable to be fed in the DH grids), this technology provides benefits and challenges at various levels.

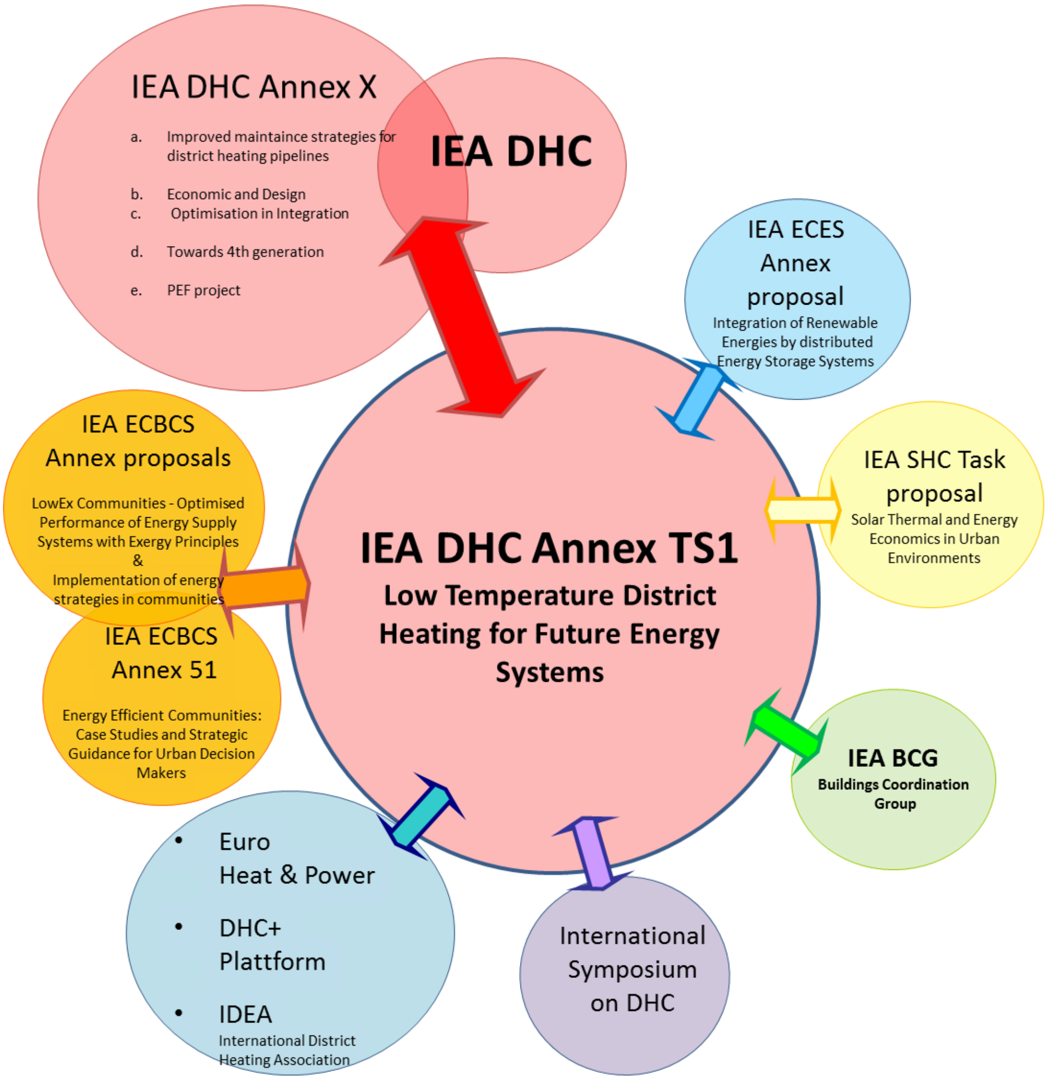

Figure 2: Connections from and to IEA DHC Annex TS1 to collect and assess information from other activities, as well as support these activities with information regarding issues within the field of low temperature district heating systems.

To increase the impact of IEA DHC Annex TS1, a close collaboration with other IEA Annexes and related activities is to be established to introduce a bi-directional exchange of information. On one hand, information about already existing activities shall be collected and assessed by the experts of Annex TS1. On the other hand, other activities shall be supported with information about low temperature district heating systems and the results from Annex TS1. An integrated cooperation with Annex X of the IEA DHC Implementing Agreement is presupposed. In addition, connections to the following activities (see Figure 2) and related experts are to be established by assigned contact persons from the experts group of Annex TS1.

A more detailed description of the related projects within the IEA context can be found in Chapter 5.

1.1 Performance of low temperature district heating on a community scale

Low temperature district heating for future energy systems offers prospects for both the demand side (community building structure) and the generation side (properties of the networks as well as energy sources). Especially in connection with buildings that require only low supply temperatures for space heating, low temperature district heating offers new possibilities for greater energy efficiency and lower fossil energy consumption.

On the demand side, low temperature heat is commonly available as a basis for energy efficient space heating and domestic hot water (DHW) preparation. Low temperature heat can be integrated into district heating through e.g. the use of efficient large scale heat pumps, solar thermal collectors and biomass fired - combined heat and power plants. Generally, the utilisation of lower temperatures reduces transportation losses in pipelines and can increase the overall efficiency of the total energy chains used in district heating. To achieve maximum efficiencies, not only do the district heating and cooling networks and energy conversion need to be optimal, but also the demand side must be fitted to allow the use of low temperatures supplied by the network. For this reason, the implementation of solutions based on large shares of renewable energies requires an adaptation of the technical and building infrastructure. The temperature levels required to heat and cool most building types (residential and non-residential buildings) are generally low (slightly above ≈ 23°C). In the case of the provision of domestic hot water, temperatures in the range of 50°C should principally be sufficient to avoid the risk from the legionella bacteria. Both renewable and surplus energy sources, which can be harvested very efficiently at low temperature levels, can fulfil this energy demand. On the community scale, synergies are maximised when buildings and building supply systems are regarded as integrated components of an energy system. A number of issues need to be addressed in regards to matching the demand created by space heating (SH) and domestic hot water (DHW) on the building side with the available energy from the supply side in order to develop advanced low temperature heating and high temperature cooling networks.

1.2 Optimisation of exergy efficiency – "LowEx" Approach and Cascading

Basically, the physical property "exergy" can be described as a product of energy and "energy quality". *The higher the temperature of a heat flow is above reference temperature, the higher the energy quality*. As a part of the considerations of this project, the following simplifications will be used: *the lower the temperature of a thermal energy supply flow for heating, the lower its energy quality and, therefore, the associated exergy flow*[3]. This fact can be used to optimise the exergy efficiency of a community supply system and is known as the low exergy (LowEx) approach. The LowEx approach entails matching the quality levels of energy supply and demand in order to optimise the

[3] Assuming the amount of energy transferred remains constant.

utilisation of high-value energy resources, such as combustible fuels, and minimising energy losses and irreversible dissipation (internal losses).

On the community scale, different types of heating systems require different supply temperatures. To obtain the maximum output from a given primary energy flow, different temperature levels can be cascaded according to the requirements of the building typology and technology. This demands an intelligent arrangement and management of the temperature levels and flows within the system. Bi-directional concepts and short term storage can be elements of a system which is not only energy efficient, but also exergy efficient.

2 Scope and Objectives

2.1 Scope

The Annex TS1 is intended to provide solutions for both expanding and rebuilding existing networks and new DH networks. It is strongly targeted at DH technologies and the economic boundary conditions of this field of technology. The area of application under consideration is the usage of low temperature district heating technology on a community level. This requires a comprehensive view of all process steps: from heat generation over distribution to consumption within the built environment. The approach includes taking primary, secondary, end and useful energy and exergy into account. This allows an overall optimization of energy and exergy performance of new district heating systems and the assessment of conversion measures (from high temperature DH to low temperature DH) for existing DH systems.

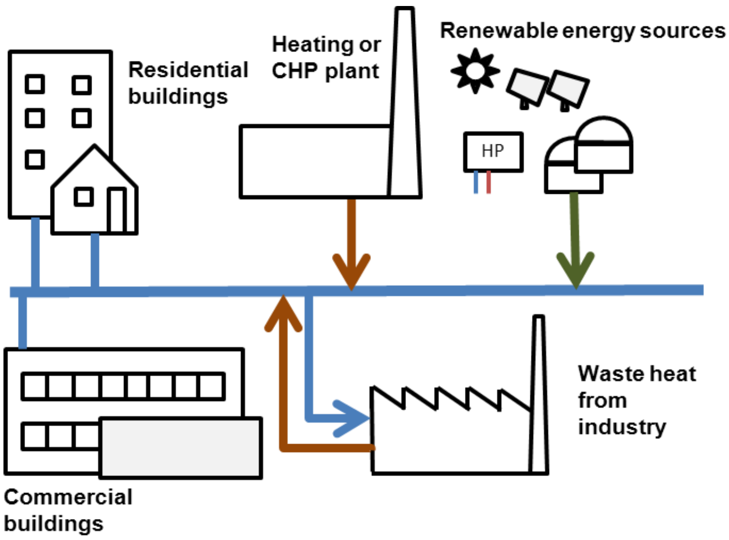

Figure 3: Schematic district heating community supply system with multiple supply options.

The main focus of DHC Annex TS1 is low temperature DH for the application in space and DHW heating. Cooling is only of minor importance, since it has been found that in most cases heating is by far more relevant for the building sector in areas where district energy is used. This also helps to keep a strong focus on the research initiative.

2.2 Objectives and Challenges

The main objective of the Annex TS1 is to demonstrate and validate the potential of low temperature district heating as one of the most cost efficient technology solution to achieve 100% renewable and GHG emission-free energy systems on a community level. The intention is to reach this goal by providing tools, guidelines, recommendations, best-practice examples and background material for designers and decision makers in the fields of building, energy production/supply and politics.

During the course of the planned activities, the aim is to develop and improve means for increasing the overall energy and exergy efficiency of communities through the use of low temperature district heating. Therefore, the compilation of existing know-how for developing new district heating concepts and for implementing the results in existing grids is necessary. In this way low temperature DH can become the least expensive way of effectuating the future use of fossil free energy systems in the heating sector. The new approach to DH is to support the setup of sustainable structures and safe energy systems for future building stock.

In order to achieve the described objectives challenges must be identified. The development of appropriate solutions can help to reduce fossil energy consumption and, thus, emissions. The improvement areas are new methodologies, concepts, and technologies in the field of DH. This includes an improved integration of renewable and surplus heat as well as the adaption of energy and exergy demand by taking interactions of buildings and supply systems into account.

Additionally, economic aspects must be taken into consideration. In this context, business cases and models must be developed for new and especially low temperature DH systems. Next to this technology, developments for reduced DHC network costs are necessary. It seems to be sensible to focus on the motivation for investments into new networks and the renovation of existing networks.

It can be said that the focus of Annex TS1 lies on reducing resource consumption (including primary energy) and GHG emissions through overall system optimization and developing new ways of bringing knowledge into practice.

A detailed statement of the planned research activities can be found in the IEA DHC Annex TS1 working program.

2.3 Benefits

The use of low temperature district heating networks offers various benefits.

C**ustomers** benefit in various ways. First of all, the use of district heating ensures a good comfort level and a secure supply. Customers do not have to worry about maintenance, fuel supply and optimal operation of heating systems. In the case of low-temperature DHW supply, the use of systems without DHW storage and pipes with small volume from heat exchanger to taps could allow the safe use of DHW at supply temperatures in the range of 50ºC. In this way, the risk of legionella growth may be minimised without having to resort to higher temperatures.

Utility companies benefit from low temperature district heating by having lower heat losses in the DH networks. Also, they can use flexible plastic piping, which can be more cost effective than conventional DH nets based on metal tubing. The use of low temperature heat allows for the integration of additional heat sources into the DH scheme, such as solar thermal collectors, deep geothermal wells and low temperature waste heat. If heat is generated by advanced CHP plants, such as combined-cycle plants, the low temperature of the used heat can lead to a higher electricity generation and therefore improved revenues from energy sales.

From an **economical** point of view, relatively high price stability can be expected due to the use of locally available, renewable, or surplus heat energy sources. An additional advantage of this is a lower dependency on foreign fuel supplies. The high overall system performance that can be achieved by using low temperature DH would lead to reduced resource consumption and therefore lower costs for fuels. This would also increase price stability and could potentially provide heat at very competitive prices.

2.4 Research Issues

The following research questions should be answered during the realisation of the IEA-DHC Annex TS1:

- What are the general conditions for a secure supply in connection with decentralised heat production?
- How much decentralisation is acceptable in existing DH networks (e.g. size, quantity and type of decentralised supply system) in terms of capacity and regulation?
- Which consequences result from the different dynamic characteristics of heat sources?
- How can operational schemes of DH networks be optimised?
- Which principles (of management and strategy) are to be considered in line with the development of future DH networks in low temperature energy systems?
- How can cascading strategies be integrated?
- How can the fluctuation of some renewable energy sources, such as solar thermal supply systems, be dealt with in the most sensible way?
- What opportunities arise from the use of constantly available renewable energy sources such as deep geothermal heat or industrial waste heat?
- How much variation in the temperature of the user's heat supply (space heating, tap water etc.) is acceptable and what degree of variation can simplify the decentralised feed-in of renewable energy?
- How can legionella-free domestic hot water preparation in low temperature supply installations be ensured?
- How can DH pipes be optimised to minimise heat losses and costs considering low temperature heat characteristics?
- What business models show promise in being successful for the refurbishment of existing DH nets and the construction of new low temperature DH systems?
- What are important conditions to consider when implementing low temperature DH systems?

3 Means

As Annex TS1 is a task-shared annex, there will be no individual, separate research projects started within the Annex. The Annex TS1 provides a framework for the exchange of research results from international initiatives and national research projects and allows, in a novel way, the gathering, compiling and presenting of information concerning low temperature district heating. The Annex TS1 aims at comprehensively covering the field of low temperature district heating.

To meet the objectives and overcome the challenges described in the previous chapters, all research activities presented by participants within Annex TS1 are structured, as follows, into subtasks (see Figure 2).

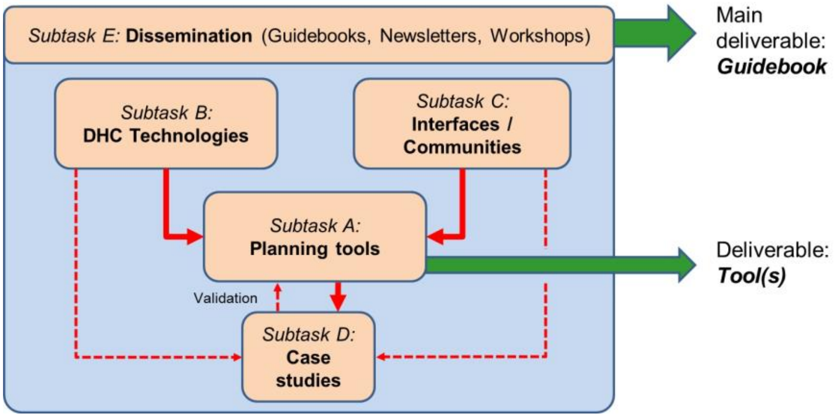

Figure 4: Structure of the IEA-DHC Annex TS1, connection of the subtasks and expected output

3.1 Subtask A*: Methodologies and Planning Tools.*

Objective

The objective of Subtask A is the identification and adaptation of a methodology for assessing and analysing procedures in order to optimise local energy systems. Furthermore, the aim is to develop simplified and advanced tools for design and performance analysis of energy systems within communities, which are based on district heating.

Main work items:

- Procedures, models and software tools for design and performance analysis.
  - Development of simplified and easy to understand assessment tools for local energy systems based on low temperature district heating technologies.
  - Development of advanced and dynamic assessment tools for local energy systems based on low temperature district heating technologies.
- System optimisation strategies based on energy, exergy, emission and cost indicators.
- Based on the developments, promising and innovative research areas may be identified, e.g. within low temperature production of domestic hot water,

Subtask A provides the necessary framework for more detailed analyses of district heating networks in combination with the different heat production facilities and with the heat supply at a community or neighbourhood level. Based on the conducted analyses, generalised guidelines for future design or retrofit of DHC grids, for example, can be derived, thus making clear under which conditions low temperature district heating can become a low-exergy supply system.

3.2 Subtask B: *District Heating and Cooling Technologies.*

Objective

Collection and identification of promising technologies to meet the goals of future renewable based community energy systems. The question on how and with which kind of components these systems can be realised shall be answered. The projects will take into consideration the framework derived from Subtask A and provide concepts for distribution, generation and storage of thermal energy that meet the demands of community members with a minimum input of primary energy.

Main work items:

- Innovative technologies for energy supply structures at low temperature levels.
- Innovative technologies for the local utilisation of renewable and ambient resources, e.g. heat pumps.
- Advanced system concepts and solutions for the distribution, local generation and storage of thermal energy at a low temperature.
- Improved integration of all subsystems and optimised operation.

Energy systems consist of a number of components and subsystems. These are to be identified and analysed within Subtask B. The focus here is on innovative solutions to meet the goals of a future renewable based energy supply for communities. At the component level, some topics are to be addressed, such as low temperature DH-substations, installation of domestic hot water preparation using low temperature heat supply, piping and transport concepts, heat generation facilities, such as advanced combined heat and power systems.

3.3 Subtask C: *Interfaces and Communities.*

Objective

This subtask is focused on the interfaces between an advanced generation and supply of thermal energy on one hand, and, on the other hand, the optimised demand management within the community. The holistic systematic approach is the key issue within the subtask to prevent the introduction sub-optimal systems.

Main work items:

- Identification of the relations between DHC and generation on one hand, and, on the other hand, between DHC and demand.
- Innovative control concepts and strategies for a demand controlled supply.
- System concepts and solutions, including storage systems for low temperature.
- Development of possible business cases and models for communities and utility companies based on the low temperature concept.

The core issues in Subtask C are the identification of interfaces and dependencies between the different subsystems and actors along the energy supply and use chain. The management of energy use, in particular, might offer new system layout and operational strategies. This may lead to innovative and more cost efficient designs and to a higher potential for integrating fluctuating renewable energies. A closer look at economical boundaries of the projects and new possibilities for new business opportunities is to round up the activities of this subtask.

3.4 Subtask D: *Case Studies.*

Objective

Within this subtask, already realised low temperature community energy, as well as planned or designed systems, shall be identified, collected and visualised. Based on these experiences, design guidelines are to be set and a basis is to be formed for validating the models and tools identified within subtask A with measured data from these community projects.

Main work items:

- Application of advanced system concepts and solution for the distribution, local generation and storage of low temperature heat.
- Usage of innovative control concepts and strategies for demand controlled supply.
- Collection of already existing community projects.
- Validation procedure of community design and planning tools.

The core issues in Subtask D are the identification, demonstration and collection of innovative low temperature district heating systems. Advanced technologies and the interaction between system components are to be demonstrated here. Based on the evaluation of the collected examples of low temperature DH systems, the tools and methods identified in Subtask A, and the implementation of combined dynamic analyses in Subtasks B and C, the case studies can be integrated into a larger picture of low temperature district heating.

3.5 Subtask E: *Knowledge Transfer, Dissemination*

Objective

The focus of this subtask is to collect and distribute information on on-going and finished work. This includes the set-up of an information platform and the organisation of seminars and workshops.

Main work items:

- Initiation of demonstration projects and development of new activity formats between research and business.
- Documentation of best practice examples.
- Newsletters, website and seminars/workshops.
- Design guide.

The results of Subtasks A, B, C and D are to be provided as input to the joint activity in Subtask E. All collected information and task-related results will be published via the different channels named in Chapter 3.6. A web-based information platform, open seminars and widespread scientific publications will provide sources of disseminating information. Also, new target groups are to be identified and new means of spreading information will be implemented, where it appears to be sensible. The plan is to condense the findings of Annex TS1 activities in order to simplify public access and use of the results.

3.6 Expected Results

The primary deliverable of the annex is an easy to understand and practical, applicable ***future low temperature district heating design guidebook*** for key people in communities. It is to contain an executive summary for decision makers. Some key questions for the targeted group of people are:

- What are arguments for taking action in regards to a possible change of the energy system within the community?
- What shall be done with regard to the community's energy system?
- And, what should not be done?
- Does our community fulfil the conditions for the implementation of low temperature district heating and, if not, what could we improve to allow for this in the future?

These questions will be answered in the guidebook, which is to be focussed at low temperature district heating from a communal, decision makers' point of view. This will cover issues on how to implement advanced low temperature district heating technology at a community level and how to optimise supply structures to ensure reduced costs for the system solution, while providing a high standard of comfort to the occupants of the buildings.

This brochure will be published preferably both as a book via a publisher, and as an electronic publication.

More detailed results, which will be published as appendices or separate reports via the project homepage are intended to cover topics such as:

- Analysis concept and design guidelines with regard to the overall performance. This could include a possible classification of technologies in terms of performance, improvement potential and innovation prospects.
- Analysis framework and open-platform software and tools for community energy system design and performance assessment.
- A collection of best-practice examples and technologies.
- Dissemination of information on demonstration projects.
- Guidelines on how to achieve innovative low temperature systems design, based on analysis and optimisation methods, and derived from scientific studies.

The dissemination of documents and other information is to be focussed at transferring the research results to practitioners. Methods of information dissemination include conventional means such as presentations at workshops and practice articles. The project homepage will be used extensively to spread information. Publications may be written in English and in the languages of the participants' countries. However, the translation of the key findings into English will allow for a broader distribution of knowledge. A communication platform will be developed using local networks and energy related associations. Regular workshops will be organised in all participating countries to show the latest project results and to provide an exchange platform for the target audience. Some of the workshops might be organised within the framework of national or international conferences or symposia of the district heating community/industry. It would be beneficial to track the number of downloads from the project website in order to measure the success of the developed tools and guidelines.

3.7 Annex TS1 Management

Annex TS1is on daily basis operated by an Operating Agent under supervisory control of the Executive Committee (ExCo) of IEA DHC. The Operating Agent reports twice a year to the ExCo in their meetings. The Subtasks A to D are managed by subtask leaders. Subtask E is managed by the Operating Agent of TS1.

4 Operating Agent of TS1 and Subtask Leaders

The Operating Agent for Annex TS1 is Dietrich Schmidt, Fraunhofer Institute for Building Physics. The work is on the daily basis monitored and supported by the Operating Agent of IEA DHC, Annex X Andrej Jentsch in agreement with Heiko Huther, German Heat & Power Association – AGFW e.V., which is acting on behalf of the ExCo of IEA DHC.

The subtask leaders are expected to be from different countries.

Subtask A: Possible leadership: n.n.

Subtask B: Denmark: represented by Svend Svendsen from DTU

Subtask C: Sweden: represented by Bo Johansson, Karlshamn Energi AB

Subtask D: Finland: represented by Kari Sipilä from VTT

Subtask E: Germany: to be managed by the Operating Agent Dietrich Schmidt from Fraunhofer IBP, which will be supported on daily basis by Andrej Jentsch, as well as Heiko Huther from AGFW.

5 Co-ordinated IEA Activities

5.1 IEA DHC Annex X:

The current cost-shared annex of the IEA DHC Implementing Agreement is Annex X. It officially started May 1st, 2011 and will be finished on April 30th, 2014. This is the current basis of the IEA DHC Implementing Agreement, while Annex TS1 is a new additional programme within the IEA DHC framework. The focus of IEA DHC, Annex X is to conduct research which will enable an optimal contribution of DHC and CHP towards a sustainable energy future. Four projects have currently been contracted under Annex X. The projects deal with the following topics: improving maintenance of DH systems, integrating renewable energy sources into heating grids, investigating fourth generation district heating, and developing a universal tool for a calculating individual primary energy factors and CO_2-emission coefficients for DH systems. Since the research topics covered in Annex X partially overlap with the focus of Annex TS1, it is presupposed that a vivid exchange between the two annexes will take place and that this is essential for the success of both programmes.

Annex TS1 can also build on the results from IEA DHC Annex IX and Annex VIII, where some projects covered research areas strongly related to “Low Temperature District Heating for Future Energy Systems”.

5.2 IEA ECBCS Annex 51: Energy Efficient Communities: Case Studies and Strategic Guidance for Urban Decision Makers

The objective of this annex is to evaluate case studies in 11 participating countries and to develop a Strategic Guidance for Urban Decision Makers. The main focus of this programme is to develop tools and instruments as well as strategies and institutional frameworks. Furthermore, gaps between technology, methods and models are to be identified.

The output and results of this programme are focused more on economic solutions than technical innovations. The distinction between Annex 51 and IEA DHC Annex TS1 is that ECBCS Annex 51 generally has a broader context. In contrast, the specific focus of Annex TS1 is on developing technical solutions of low temperature district heating networks (demand and supply side).

5.3 IEA ECBCS Annex 49: Low Exergy Systems for High-Performance Buildings and Communities

IEA ECBCS Annex 49 is based on an integral approach which includes the analysis and optimisation of the exergy consumption caused by heating and cooling systems, as well as in other processes where energy/exergy is used within the building stock. The low-exergy approach aims at satisfying the remaining thermal energy demand using only low quality energy.

For the realisation of the IEA DHC Annex TS1, the results of the finished IEA ECBCS Annex 49 offer an exergy calculation method (LowEx approach) as input. This approach was developed for the calculation of different energy qualities occurring in the built environment. The LowExergy approach offers the means to consistently specify energy sources (supply side) which fulfil the demand caused by buildings (demand side. Results from this project could help in the improvement of district heating supply networks. In contrast to Annex TS1, the main focus of IEA ECBCS Annex 49 is the demand side.

5.4 IEA ECBCS Annex Proposal on LowEx Communities - Optimised Performance of Energy Supply Systems with Exergy Principles

The proposed annex is primarily focussed on technologies and innovative concepts using low valued energy sources (LowEx) and a high share of renewable energies for the heating and cooling of neighbourhoods or, even, entire cities. This annex could be seen as the successor of the finished IEA ECBCS Annex 49, expanded to the community scale.

In contrast to IEA DHC Annex TS1 activities, the proposed "IEA ECBCS Annex LowEx Communities" is to look into a broader span of alternatives for the realisation of a good match of energy quality between demand side (buildings) and supply side. In contrast, DHC Annex TS1 deals with the context of low temperature DH as a possible link between the latter ones.

6 Time Schedule

The DHC Annex TS1 is expected to be initiated in November 2012, after a preparation phase of one year, and will continue for a period of three (3) years. The DHC Annex TS1 will be concluded by the end of December 2015.

The following table represents the time schedule of each subtask process.

Subtask progress	Prep. Phase	Working phase			
	2012	2013	2014	2015	2016
A: Methods & tools					
B: DHC technologies					
C: Communities					
D: Case studies					
E: Dissemination					
Annex Meetings					

Source Zimmermann

Figure 5: Time schedule of the DHC Annex TS1

7 Funding

Participation in this IEA DHC task shared annex requires a minimum effort of 12 person-months per country. Each participant's country is required to take part in at least one of the subtasks and it is recommended that all participants take part in Subtask E. Participation may partly involve funding allocated to a national activity, which falls substantially within the scope of work to be performed under this annex. Aside from providing the resources required for performing the work of the subtasks in which they are involved, all participants are required to provide the resources necessary for activities that are specifically collaborative in nature and are not meant to be part of a national program; for example, establishing common monitoring procedures, preparation for and participation in annex meetings, co-ordination with subtask participants, and contribution to documentation and information dissemination.

The meetings shall be hosted in turn by the various participants. The costs of organising and hosting meetings shall be borne by the host participant. Each participant will bear his/her own travel costs to the expert meetings.

The cost of publishing the reports and summary assessments shall be borne by the Operating Agent.

8 Participants

The DHC member countries currently participating in Annex TS1 are:

- Denmark, Finland, Germany, South Korea, Sweden and the United Kingdom.

Representatives from the following non-DHC member countries have indicated interest in participating:

- China and the Netherlands.

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