IEA DHC | CHP

DHC Annex TS2

Implementation of Low Temperature District Heating Systems

Annex Text

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Operating Agent (suggested)

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Contents

1 Purpose of the TS2 Annex

1.1 Task Sharing

Annex TS2 is a task-shared annex. Task Sharing (TS) means that there is not one single source of financing for the project. The idea is that participants bring own funding to a shared project. The funding comes from national authorities of each country or from other organizations interested in the implementation of Fourth Generation District Heating (4GDH). There will be no individual, separate research projects started within the Annex. Instead, knowledge from multiple projects within the member countries of the IEA-DHC Technology Collaboration will be shared.

Each financing organization will request deliverables that are relevant to them. Therefore, the TS2 Annex does not outline any other deliverable than a 4GDH handbook. The handbook will contain the aggregated knowledge generated from the different projects included in the TS2 Annex.

1.2 Background

Third Generation District Heating (3GDH) technology is the current norm. It was implemented when fossil fuels were is use and when buildings had high heat demands. We are now experiencing a development transforming the preconditions for district heating. Renewable energy sources and near zero energy buildings are becoming the new norm. In addition to conventional renewable energy flows such as solar and wind energy, there are also low temperature heat sources readily available in cities (in metro systems, ventilation systems, from chilling processes, sewage water and other). The ambition of the 4GDH technology is to reuse such, low-temperature, heat sources. Doing so enables cities to meet their heat and hot water demands with the heat generated by their citizens.

There is one definition that provides insight on what 4GDH is. In Lund et al. (2014), the concept is outlined with its five abilities as follows: *"The 4GDH concept, which by means of smart thermal grids assists the appropriate development of sustainable energy systems. 4GDH systems provide the heat supply of low-energy buildings with low grid losses in a way in which the use of low-temperature heat sources is integrated with the operation of smart energy systems. The concept involves the development of an institutional and organisational framework to facilitate suitable cost and motivation structures".*

To date, information has been collected on what 4GDH is, demonstrations have been made (see for example the TS1 Annex) and there is interest amongst both academics and practitioners to implement it. The pace at which implementation is undertaken is, however, low. More information on what drivers of 4GDH implementation success are is needed to speed up the implementation process.

1.3 Purpose and TS2 Outline

The purpose of Annex TS2 is to facilitate the implementation of 4GDH. Doing so will support the attainment of the EU directive of energy performance of buildings (near to zero buildings; 2019 for the public sector and 2021 for the private sector) and provide input to the construction of future, smart cities

In TS2, five areas that are important for increased 4GDH implementation will be explored. The five areas allow for the identification of critical hurdles to overcome for efficient 4GDH implementation and to test and evaluate data from physical cases. A systems approach will be taken with focus on the following areas (1) the indoor heating systems of buildings, (2) the district heating systems, (3) new demonstrations, (4) the competitiveness of the 4GDH business and (5) bringing 4GDH to market (handbook).

The four first areas have been identified as important to successful 4GDH implementation based on a review on existing work on 4GDH (see section 3). The fifth area, addressing how to get 4GDH to market, has been identified jointly with representatives from the Swedish and Danish organizations working with export of current 3GDH technology. From this dialogue it is identified that there is a need to bring the knowledge of academia to market. Unless this is done fast, alternatives for heating near zero buildings will be developed and there is a risk that the district heating sector is locked into the 3GDH technology.

The knowledge and information generated by considering the four areas will be summarized and disseminated in the form of a 4GDH handbook. The handbook will be built on the results from TS2 and on discussions and feedback from technical component consultants, practitioners and municipal planning units. The handbook will be complemented by training workshops for academics, users, district heating industry and policy makers. The handbook will unlock the 4GDH market.

Existing know-how for developing new District Heating concepts was compiled in TS1. The activities undertaken in TS2 will resort to existing knowledge and, in conjunction to both evaluation of previous demonstrators and new demonstrators, will generate new knowledge of value for 4GDH implementation. TS2 will build on the experience of previous research on 4GDH. To increase the impact of IEA-DHC Annex TS2, a close collaboration with other IEA Annexes and related activities is to be established to introduce a bi-directional exchange of information.

1.4 Benefits to stakeholder groups of TS2

More knowledge on how to implement 4GDH is beneficial to different stakeholders such as cities, people and companies.

CITIES- main stakes

- Usage of waste heat that is currently wasted
- Increased resilience from lower dependence on primary energy sources
- Environmental gains
- Efficient municipal planning of new construction areas and energy

PEOPLE (owners of buildings, owners of waste heat and end users)- main stakes

- Energy efficient behaviour is incentivized and facilitated
- Remuneration for resources that are currently wasted
- Active engagement in the own energy consumption

COMPANIES (DH companies, component manufacturers)-main stakes

- Lower heat losses in the district heating networks
- Flexible plastic piping
- Integration of additional heat sources into the district heating scheme
- Higher electricity generation in cogeneration
- Removal of known system inefficiencies resulting in optimized system operation
- Known standards permit efficient 4GDH systems
- Large scale implementation and commercialization of new technology

The main stakes of stakeholders to the TS2 Annex is illustrated in figure 1.3.

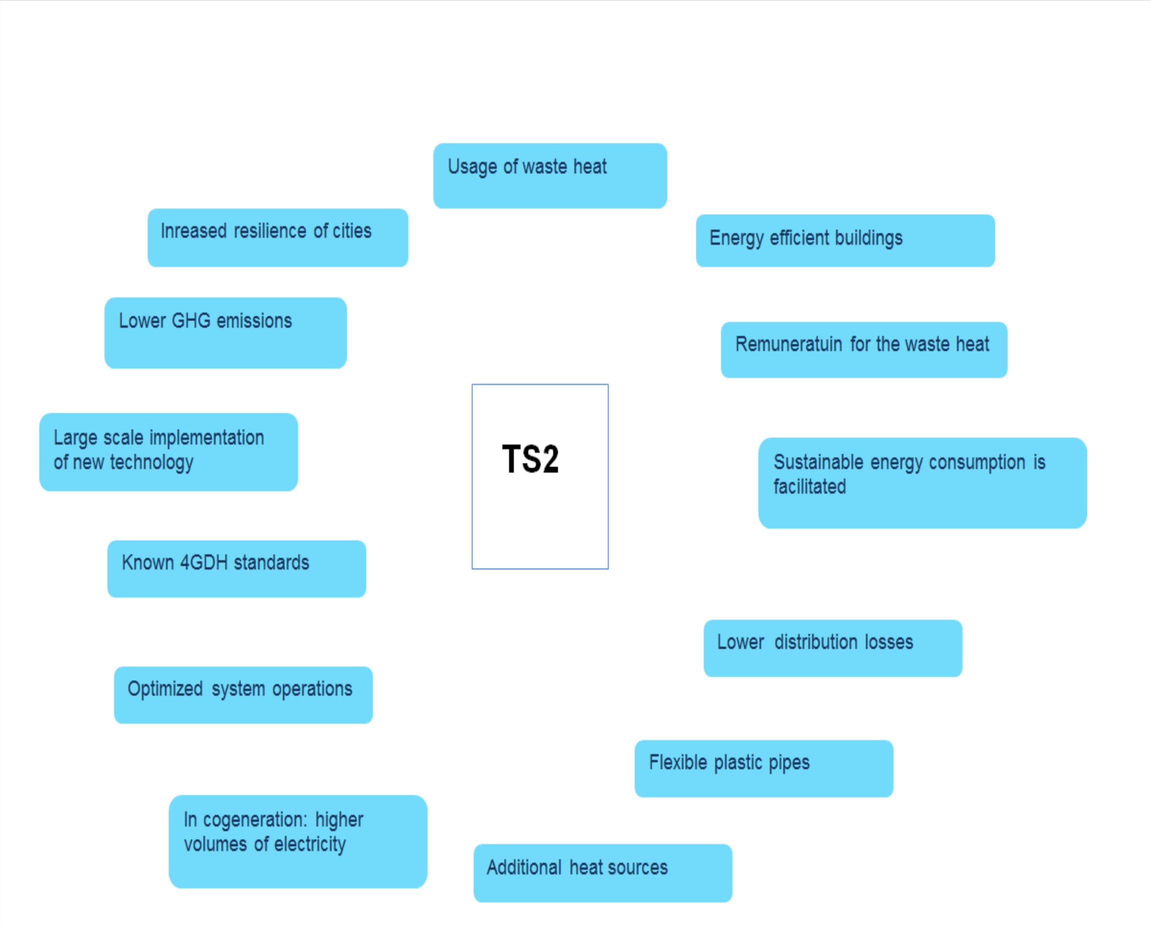

Figure 1. Main stakes of stakeholders to TS2

2 Previous work on 4GDH

International information on 4GDH is recent and stems from a few, concentrated sources. These are DHC+ (European network for district heating research; 2.1), the 4DH research centre with three international conferences on the theme of Smart Energy Systems and 4GDH (2015-2017; 2.2) and the IEA Technology Collaborations (2.3).

2.1 DHC+

In 2012, DHC+ presented a strategic research agenda where a vision towards 2020, -2050 was outlined. The goals of the EU on almost zero carbon energy solutions by 2050 are shared by the DHC+ and 4GDH is addressed and described as a solution allowing for lower and more flexible distribution temperatures, assembly oriented components and flexible materials.

2.2 4DH

The 4GDH Research Centre is a cooperation between industry, universities and the public sector to investigate the potential for and develop 4th Generation District Heating. It is located at Aalborg University in Denmark. 4DH has created focus on and knowledge about the future 4GDH potential within the industry. 4GDH systems and technologies will play an important role in future cost-effective sustainable energy system. It is likely that 4GDH will replace the import of fossil fuels and create jobs and economic growth throughout Europe. Reviewing the publication of the research centre publications on the theme of low temperature district heating are found, see for example (Skaarup-Oostergard & Svendsen: Energy, 2016), (Skaarup-Oostergard & Svendsen: Energy and Buildings, 2016), (Yang et al. Energy conversion and management, 2016), (Yang & Svendsen: Energy, 2016), (Dalla Rosa: Energy, 2011). Smart energy systems are also addressed in the context of 4GDH, see for example (Lund et al, Journal of sustainable energy planning and management, 2016).

Three international conferences have been held on the theme 4GDH (2015, 2016 and 2017). Going through the contents of the conferences different areas are discernable. One area is low temperature district heating systems. A second area is renewable energy integration A third area is regulation issues and barriers. A fourth area is prosumers. A fifth area is decentralized heat generation in district heating systems and a sixth area is system adjustments From the content of the conferences it can be concluded that there is much knowledge on temperature levels and on how to use renewable energy sources in 4GDH. Less is known about non-technical aspects such as barriers, consumer demands and new forms of heat generation in existing district heating systems.

2.3 IEA-DHC-Program

In the cost-shared annex of the IEA district heating technology collaboration, Annex X (2011-2014), the focus was to conduct research which will enable an optimal contribution of district heating and combined heat and power towards a sustainable energy future. In Annex XI, experiences from generational shifts (first, second, and third generation district heating: 3GDH) are generated in the Transformation Roadmap project. Additionally, information on what preconditions need to be met for concurrent 3GDH and 4GDH was generated. Annexes X and XI provide the most relevant basis for TS2.

Other relevant IEA projects are IEA ECBCS Annex 51 and 49. In Annex 51, (Energy efficient communities: case studies and strategic guidance for urban decision makers) where case studies in 11 participating countries was made is of relevance to understand non-technical barriers. Annex 51 has a broader context than 4GDH. IEA ECBCS Annex 49 (Low Exergy Systems for High-Performance Buildings and Communities) includes the analysis and optimization 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. The Low-Exergy approach of Appendix 49 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. The main focus of IEA ECBCS Annex 49 is the demand side.

2.4 Conclusions from previous research

The literature on 4GDH is technically oriented and the information comes from few, distinct sources. There appears to be sufficient technological information for taking the next step and scaling up the implementation of 4GDH. However, for full scale it is important to identify what 4GDH success factors are.

3 The TS2 Annex content

The content of this TS2 Annex has been developed during 2017, within a pre-study. The pre-study was financed by the Swedish Energy Agency. The progress of the pre-study is outlined first (3.1). The contents of the TS2 Annex are provided next (3.2).

3.1 Pre-study

The content of the TS2 Annex has been developed within a pre-study. The study has been financed by the Swedish Energy Agency and executed by Halmstad University during 2016-2017.

The first step of the pre-study was to review current information on 4GDH (presented in section 2). The second step was to draft preliminary areas of interest for 4GDH based on the existing knowledge of 4GDH at Halmstad University. The third step was to obtain input on the identified areas of interest from the wider 4GDH community. The participants of the TS1 Annex and other stakeholders of relevance were invited to attend a preparatory workshop in Halmstad 2017-03-22. More than 30 people attended the workshop and the following countries were represented: Sweden, Denmark, Norway, Finland, Germany, Austria, Belgium, the UK and China. Based on the information collected at the workshop a draft of the TS2 Annex was made and distributed to the people who had attended the workshop.

The draft TS2 annex text was presented to the IEA DHC Executive Committee meeting held in Hamburg on May 10. At the meeting, the TS2 Annex content was presented and the project proposal gained a go ahead to continue the work of presenting a final project proposal that the Executive Committee would make a decision on in November 2017. After the input from the Committee, the partners of the proposal presented their interest to work with different areas. An updated draft was made and sent to the proposal participants in August 2017.

The participants met for a second, preparatory work shop in Copenhagen in September 2017. There the final TS2 Annex content was agreed upon and the proposal text was updated to its current format after the workshop.

3.2 TS2 Annex content

In TS2, four areas that are important for increased 4GDH implementation will be explored. The four areas are: (i) Indoor heating system of buildings, (ii) District Heating system, (iii) Demonstrators and (iv) Competitiveness.

As a result of national funding and of new projects starting up after the start of the TS Annex the TS2 Annex content will be dynamic. Below, the foreseen contents of the four areas are listed but the content might change depending on the financing obtained.

3.2.1 Indoor heating system of buildings

The objective is to identify how return temperatures can be lowered. This is done by identifying which technical innovations are needed to implement 4GDH, from the point of view of buildings.

The heating system of buildings encompasses:

-systems for heating rooms

-systems for heating and distribution of domestic hot water (DHW)

-the substations of the building (connecting the district heating pipes entering the building and the indoor heating system of the building)

-control and metering systems in the buildings

The objective of the area of indoor heating system of buildings will be met by exploring 4 tasks that have been identified as relevant for increased 4GDH implementation. The first addresses errors in the heating system of buildings (including physical faults). The second task is focused on optimizing the indoor heating system. The third task is on renovation of buildings and the fourth task addresses national specifications.

Task 3.2.1 (1) Errors and faults in the heating system of buildings

There is information about errors in the heating systems of buildings. Examples of known errors are missing radiators, few or undersized radiators, inefficient heat surfaces, unnecessary short circuits and bypasses in distribution. The most important errors and faults impeding 4GDH implementation will be identified. Methods for error and fault identification and removal will be developed.

Task 3.2.1 (2) Optimization of indoor heating system

Efficient control reduces the supply and return temperature to expected levels for efficient functioning of 4GDH systems. Examples of known factors impacting the control are how efficient electronic thermostatic radiator valves can be managed, how the flow in the heat exchanger can be reduced and how DHW and space heating can be jointly provided through one heat exchanger. The most important control functions for 4GDH implementation will be determined. Methods for identifying these controls and to make them work efficiently will be developed.

Task 3.2.1 (3) Renovation of existing buildings

What the necessary preconditions for allowing 4GDH after the renovation of buildings are is examined. The most important factors for allowing 4GDH implementation in buildings will be identified. Examples of known factors of importance to consider when renovating buildings are radiators, floor heating, fan coils and the capacity of buildings to serve as storages of heat. The most efficient retrofitting actions of buildings for 4GDH implementation will be singled out. What retrofitting combinations are most efficient will be decided.

Information on the cost of reducing the heating load allowing the existing heating system to supply heat by using low temperature district heating will be collected. This information will be contrasted with the cost of replacing the heating system with new low temperature district heating radiators.

Task 3.2.1 (4) National specifications

It is of relevance to examine if the identification and management of errors, controls of systems and renovations of existing buildings have national traits. Information on how errors are identified, how control of systems is effectuated and how renovations of existing buildings are made will be collected for countries partaking in the annex. The question of Legionella and efficient domestic hot water management will be included in this task.

Interest in this area is expressed by several partners:

Area leader is Svend Svendsen at the Danish Technical university (DTU). The interest of other parties is:

- Citizen engagement and optimization of indoor heating system – pilot project is ongoing (UK: Nottingham Trent University)
- Citizen engagement (UK: University of Leeds)
- Optimization of indoor heating system, monitoring data, simulations- 2 pilot projects are ongoing (GER: University of Stuttgart)
- Renovation of buildings (GER: Fraunhofer)
- Error and fault detection and optimization of indoor heating systems– 2 pilot projects ongoing (AUT: Austrian Institute of Technology)
- All areas are of interest- 2 pilot projects ongoing (NED: Thermaflex and AUT: Institute for sustainable technologies)
- Domestic hot water management – 1 pilot project ongoing (UK: Loughborough University)

- Renovation of substations, control of system (lab studies on heat pumps, radiators, valves, fan coils), tap water use and losses (hotels, hospitals and building blocks (NO: Norwegian University of Science and Technology)

3.2.2 District heating system

The objective is to identify the opportunities and barriers for allowing an efficient 4GDH implementation on a systemic level. In close cooperation with subtask 1, 3 and 4 concrete recommendations and transformation strategies for 4GDH implementation will be developed.

<u>The district heating system encompasses:</u>

-the district heating network

-heat sources

-substations of the system

-distribution system

-heat storages (both long and short term storage)

The objective of the area of the district heating system will be met by exploring 4 tasks. In the first one, aggregation of information of key components for implementing 4GDH systems is collected. The second is focused on system assessments. The third considers the transformation to 4GDH. The last task considers tools and methodologies.

<u>Task 3.2.2 (1) The supply and value of low temperature heat sources</u>

The existing supply of low temperature heat sources must be known for efficient 4GDH implementation. The sources will be identified and quantified: allowing for an understanding of the potential of renewable low temperature heat sources. Low temperature heat sources are mapped and categorized according to their origin, degree of “renewability” and temperature levels. Their potential is quantified for each of the countries partaking in the TS2 Annex.

4GDH solutions are positioned in relation to conventional supply of heat. The advantages and disadvantages of 4GDH are identified compared to the existing heating alternatives (3GDH alternatives). In this context, different temperature regimes and modes (e.g. optimum supply temperatures in winter and summer, “anergy” networks) will be analysed according to the local/ national requirements (e.g. domestic hot water preparation).

The 4GDH solutions position and the value of the low temperature waste heat are identified for each of the countries partaking in the TS2 Annex. This way the 4GDH implementation potential is assessed. The specific cost gradient for lowered temperatures (cost per degree) will be estimated.

<u>Task 3.2.2 (2) System optimization</u>

4GDH implementation necessitates changes in the system compared to system setup for conventional heat sources. The most important challenge to manage to ensure

4GDH implementation is lower return temperature all the way from the buildings to the production of district heating (e.g. the distribution must be efficient).

Examples of known factors impacting 4GDH system optimization are heat storages, optimized system design (efficient pressure, temperature level, low distribution losses, correct dimensions), usage of alternative materials, alternative installation techniques, alternative pipe concepts and bypasses (e.g. inefficient distribution).It is also of relevance to understand how prosumers impact the system (they can induce pressure cones and heat losses in the grid). Factors of importance for efficient system operation with 4GDH are identified and methods for optimizing the system accounting for these factors are developed. As far as possible, cooling solutions will be included.

Options for operational optimization such as solutions for system controls, identification of errors and monitoring will be examined for the factors identified. The purpose is to match supply and demand, to reduce peak loads in the system and to manage multiple incoming heat sources.

Task 3.2.2 (3) Transformation towards 4GDH

In this task, transformation strategies from 3GDH networks to 4GDH networks will be developed. This includes mixed solutions, where networks of different generations are integrated with each other (e.g. by (bi-) directional energy transfer). Suitable urban planning processes enabling the transformation will be assessed.

Tools and methodologies for supporting the planning, design and operation phases of low temperature district heating networks will be aggregated.

Interest in this area is expressed by several partners:

Area leader is Ralf-Roman Schmidt at the Austrian Institute of Technology (AIT). The interest of other parties is:

- Optimization of district heating system, particularly peak load management (NO: Norwegian University of Science and Technology)
- Optimization of district heating system: storage (NED: Thermaflex and AUT: Institute for sustainable technologies)
- Impact on temperatures when heat pumps are used (UK: Loughborough University)
- Thermal storage, reduction of temperatures in existing networks, peak load, combination with CHP and waste incineration (GER: Technical University of Darmstadt)
- GIS tools, usage of heat pumps (GER: Fraunhofer)
- Transformation from 3rd to 4th generation –pilot project (GER: University of Stuttgart)
- Thermal storage, heat pump usage – pilot project exists (UK: University of Nottingham Trent)

- Peak load and lower return temperatures to the production unit (DK: Danish Technical University)

3.2.3 Demonstrators

The objective is twofold. On the one hand, knowledge will be validated and new knowledge will be generated. On the other hand, to ensure implementation, the new knowledge must reach market.

Already realised low temperature community energy system concepts as well as planned or designed systems shall be identified, collected and visualised. Furthermore, projects showing an innovative use or operation of buildings are included. The different projects are going to be assessed on identified key performance measures and compared. Measured data, if available, will be collected.

The demonstrators will be set up in such a way that knowledge is generated about the indoor heating system, the district heating system and of the competitiveness of 4GDH. In regards to the indoor heating system it is important to test elements such as radiators (how can radiators be adjusted to work in a 4GDH context and what can newly constructed 4GDH radiator solutions be) and the heat storage capacity of buildings. Concerning the district heating system it is imperative to test how to build and maintain storages in the network, how to build 4GDH networks, how to integrate the 3GDH and the 4GDH networks, how to include multiple heat sources into the network. For both the indoor heating system and the district heating system efficient control solutions need to be identified.

The demonstrators included in the TS2 Annex will be analysed in regards to which elements of new knowledge they can generate. For each demonstrator there will be a specific innovation in focus. The innovation will be validated from a technical point of view. The business model applied in each project will be documented.

The main work items are to (i) identify case studies, (ii) set the KPIs for the studies and (iii) collect data, evaluate it and assess the potential of 4GDH compared to conventional solutions. Several ongoing projects that are suitable for 4GDH testing have stated that they are interested to be included in the TS2 Annex. Which the final projects will be is not yet decided and the number of pilots is not known.

3.2.4 Competitiveness

The objective is to identify how competitive 4GDH is compared to other heating alternatives. To do so, 2 tasks are addressed. The first one aims understanding how 4GDH business models differ from 3GDH business models. The second one is focused on identifying the technical viability of 4GDH investments.

Task 3.2.4 (1) Business
From the definition workshop it has been identified that the decision making process of investing in 4GDH is a barrier to 4GDH implementation. To facilitate the decision making process it is important to know how 4GDH business models are different from 3GDH business models.

In TS2 there are 4GDH pilot projects. Information on the 4GDH business model will be collected from these pilots.

To understand the 4GDH business models, information will be collected on the heat source, the investment decision and customer value. Depending on the maturity of the different pilots of TS2 the available information on business model will differ. The available information will be collected and is foreseen to provide answers on heat source, investment decision and value. Examples of questions that will be asked are provided for these three areas in turn:

Heat source

- -what is/are the source/es?
- -what is the temperature of the source/es?
- -how large is the annual heat delivery (volume)?
- -how was its/their value (price) determined? ¨
- -was price settlement complex?
- -what kind of contract is drawn up between heat provider and heat distributor?
- -is the heat provider a prosumer?
- -who owns the substation?

investment decision

- -what is the payoff period?
- -how many parties invest (the owner of the heat; the heat distributor; other)?
- -are there any alternatives to the 4GDH investment (other heating solutions)?
- -what is the size of the investments (monetary)?
- -was the local authority/city involved in the investment decision?
- -is there any regulation/policy that impacted the investment decision?

value

- -how did the heat provider find the 4GDH investment valuable compared to a 3GDH solution?
- -what value is perceived by the building owner?
- -what value is perceived by the end user?

The business model canvas is a framework for outlining and analysing business models. It will be used to examine how 4GDH business models differ from 3GDH business models. The framework is composed of nine building blocks. These address (1) the customer segment, (2) the value of the product/service to customers, (3) the relationship with the customer, (4) the channels used to reach customers, (5) key activities undertaken to deliver the product/service, (6) key resources needed to deliver the product/service, (7) key relationships with partners and (8-9) the resulting revenue and cost streams.

The number of pilots of TS2 is not known. The work to be performed by this task 3.2.4 (1) is assumed to cover 10-15 projects.

Task 3.2.4 (2) The early 4GDH heat distribution experiences

There are early 4GDH demonstrator experiences concerning the efficiency of heat distribution. Based on these early experiences, conclusions can be drawn on what has worked well/ less well over time with respect to heat distribution of its competitiveness.

In the IEA-DHC Annex X report 'Toward 4GDH – Experience and potential of Low-Temperature District Heating', information was gathered and analysed for only seven heat distribution areas. These areas were considered to be early 4GDHsystems utilising low-temperature operation. The methodology consisted of nine input parameters that were utilised to generate eight main key performance indicators concerning the efficiency of heat distribution. These eight performance indicators were degree time integral, plot ratio, heat density, effective width, specific heat demand, relative heat distribution loss, and average heat transfer coefficient. This developed methodology will also be used in this TS2 annex. A ninth performance indicator (the exergy level of heat distribution) will be defined in order to express the energy quality level of heat distribution.

Since the Annex X report, we have continuously tracked early 4GDH systems. Currently, we have identified around 30 possible systems to be monitored. This database will also be harmonised with the identified demonstrators in the third area. Hopefully, we will be able fo finally analyse something between 30 and 50 early systems, including refurbished 3GDH systems that have successfully accomplished to lower their temperature levels.

Interest in this area is expressed by several partners:

Area leader will be Sven Werner, professor emeritus at Halmstad University

All other partners say that they are interested in the competitiveness of 4GDH. Input will be obtained from the demonstrators and from the knowledge that the TS2 project partners have on 4GDH business, from experiences beyond TS2.

4 Dissemination of results

4.1 Handbook

A 4GDH handbook is seen as a good way of condensing the knowledge of 4GDH and transferring it from academics to practitioners. The book should be built on the results of TS2, on discussions between technical component manufacturers, practitioners, municipal planners and 4GDH academia.

The leader of the task of building the handbook should be an actor who has access to a large number of technical component providers as well as to municipal planners. It is foreseen that technological component providers are actively involved in the development of the handbook. The handbook should be published in the format of an E-book. The handbook should be in focus at each TS2 meeting. The TS2 partners are foreseen to meet twice per year. The first part of the meeting, the results from the different areas (1-4) will be updated. The second part of the meeting, workshops should be held to discuss how the results obtained can be used and what additional information is needed. The outcomes of the workshops should be fed into the handbook. The handbook should be developed through an iterative process.

Interested parties in developing the handbook are:

The task leadership of the handbook is vacant.

The following parties have claimed an interest in the TS2 Annex:

- Grundfos
- Alfa Laval
- Danfoss
- Energiforsk
- CELCIUS project

4.2 Dissemination of results to the IEA and DHC+ communities

The results from TS2 will be presented at or in conjunction to the biannual, international symposiums of IEA (2018 and 2020).

The results will also be disseminated to the IEA and DHC+ communities through webinars. One webinar is foreseen per quarter.

A biannual newsletter on the TS2 progression will be shared with the IEA DHC Executive Committee and the DHC+ steering committee.

The three dissemination activities listed in 4.2 are the responsibility of the operating agent.

5 Expected results

The Annex will generate a number of results that have been requested by the national funding organizations. The results will be collected into a handbook on 4GDH implementation. Some key questions for the stakeholders will be answered:

- What technical innovations are needed for lowering the return temperatures from the building all the way to the production unit?
- How can a transition be made from 3GDH to 4GDH?
- How does the 4GDH business differ from the 3GDH business?

6 Annex TS2 Management

The management structure of the project is outlined. Last, the foreseen responsibilities are listed.

6.1 Management structure of the project

The TS2 Annex is a venue for project owners from different companies to cooperate. Each project owner has his/her deliverables and is responsible for his/her budget in relationship to the organization that has provided the funding to the project owner. In regards to the TS2 Annex, inclusion in the cooperation necessitates attendance at TS2 meetings and working according to the guidelines of the leaders of the five different areas (indoor heating system of buildings, district heating system, demonstrators, competitiveness and handbook). Partaking in the TS Annex also necessitates regular updates on the progression of work from project leaders to the operational agent (quarterly).

The TS2 Annex has a general assembly which is composed of the people responsible for the five areas and the operating agent. The general assembly has the right to settle disputes amongst the participants of the Annex. The IEA DHC Executive Committee supports the TS2 cooperation and has the final say in disputes that cannot be solved by the general assembly.

The management and decision making structure of TS2 is outlined in figure 5.1.

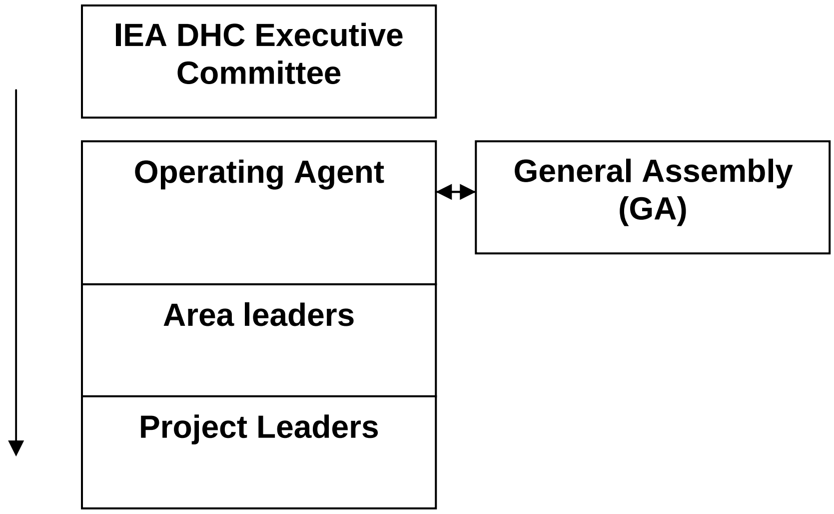

Figure 2 Management and decision making structure

6.2 Foreseen responsibilities

The partners of the project commit to delivering input that is in line with the deliverables due to the national authorities financing the TS2 Annex participation. The area leaders and the project partners jointly determine which deliverables should be entered in the different areas.

It is the responsibility of each partner to deliver what has been decided upon. The area leaders are responsible for coordinating the work of their area but not for any budget or deliverables from other parties.

The operating agent is responsible for:

-arranging TS2 meetings 2 times per year

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

-making sure that the project is represented at the biannual, international IEA conferences of 2018 and 2020

-arranging webinars on a quarterly basis: making sure that different partners of the TS2 Annex are given a possibility to expose the results that have been generated in the TS2 cooperation

-quarterly updates on the progression of work with the area leaders

-biannual newsletter on the progression of work to the IEA-DHC Executive Committee

Area 1: Indoor heating system	Denmark: Svend Svendsen from DTU
Area 2: District heating system	Austria:Ralf-Roman Schmidt from AIT
Area 3: Demonstration	Germany: Dietrich Schmidt from Fraunhofer
Area 4: Competitiveness	Sweden: Sven Werner from HU
Handbook	Vacant
Operating agent	Sweden: Kristina Lygnerud from HU

7 Time Schedule

Annex TS2 is expected to be initiated in Q2 of 2018 and will continue for a period of three (3) years. The Annex TS2 will be concluded by Q1, 2021. The following table represents the time schedule of each area.

Time schedule of the Annex TS2:

Area	2018	2019	2020	2021
1: Indoor heating system	x	x		
2: District heating system	x	x		
3: Demonstration	x	x	x	
4: Competitiveness	x	x	x	
Handbook			x	x

Participants The IEA-DHC member countries with current intentions to participate in Annex TS2 are:

- **Germany**
- Fraunhofer (Dietrich Schmidt)
- Technical University of Darmstadt (Frank Dammel)
- University of Stuttgart (Dirk Pietruscha)
- **Denmark**
- Danish Technical University (Svend Svendsen)
- **Sweden**
- Halmstad University (Sven Werner, Kristina Lygnerud, Mei Gong, and Helge Averfalk)
- IVL (Kristina Lygnerud)
- Energiforsk (Fredrik Martinsson)
- CELCIUS (Helena Nordström)
- **Austria**
- Austrian Institute of Technology (Ralf-Roman Schmidt)
- **Netherlands**
- Thermaflex (Christian Engel)
- **Norway**
- Norwegian Technical University (Natasha Nord)
- **United Kingdom**
- University of Loughborough (Michele Tunzi)
- University of Nottingham Trent (Anton Ianakiev)
- University of Leeds (Simon Rees)

Belgium is interested in partaking through VITO (Dirk Vanhoudt). China was represented at the first preparatory workshop. Korea was represented at the second preparatory workshop. A dialogue is held with Danfoss, Alfa Laval, Grundfos, Energiforsk and the CELSIUS project about taking lead on the handbook.

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