**Work plan - IEA DHC Annex TS 6**
**Status assessment, ageing, lifetime prediction and asset management of District Heating Pipes**
Details for Subtask A – Status assessment

Leader 1: Andreas Leuteritz (IPF) / Heiko Below (IMA Dresden)
Leader 2: Jan Henrik Sällström (RISE)

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| **Overall objectives of ST A** | Improve the knowledge concerning<br>• the status of district heating (DH) networks in participating countries<br>• status assessment methods<br>• failure modes of DH networks<br>Create reliable methods for status assessment as a key element of lifetime prediction of DH Pipes |
| **Work Item (WI)** | A.1: Give a survey of types of DH networks and their share |
| **Objectives** | • Identify of types of DH networks and the shares of different types<br>• Identify and explain status assessment method that are independent of type DH-network |
| **Activity** | |
| **Deliverables / Milestones** | Overview on DH pipes used in participating countries |
| **Target group** | |
| **Work item** | A.2: Pre-insulated bonded pipes |
| **Objectives** | • Identify and explain failure modes<br>• Assess if the failure modes depend on installation or time in service<br>• Quantify the end-of-life criteria<br>• For each type of failure mode identify existing status assessment methods<br>• Assess the need for new or developed status assessment methods<br>• Develop or refine the status assessment methods needed<br>• Assess if the status assessment methods give useful data for estimating the remaining lifetime<br>• Testing Methods (destructive and non-destructive, in the laboratory and in the field) |

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| | • Status assessment of DH Pipes as a corner stone of the transformation of DH<br>• Different Testing Methods and different values / results for material properties: Which ones are the most promising for reliable lifetime prediction based?<br>• How can they be measured? |
| **Activity** | To be done based on the contribution of participants |
| **Deliverables / Milestones** | Status assessment methods for preinsulated bonded pipes (guideline?) / test & evaluation in the field / suggestions for improved methods & possible results, values for material properties |
| **Target group** | DH companies, DH operators, consultants, DH Pipe manufacturers |
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| **Work item** | A.3: Flexible district heating pipes |
| **Objectives** | • Identify and explain failure modes<br>• Assess if the failure modes depend on installation or time in service<br>• Quantify the end-of-life criteria<br>• For each type of failure mode identify existing status assessment methods<br>• Assess the need for new or developed status assessment methods<br>• Develop or refine the status assessment methods needed<br>• Assess if the status assessment methods give useful data for estimating the remaining lifetime<br>• Testing Methods (destructive and non-distructive, in the laboratory and in the field)<br>• Status assessment of DH Pipes as a corner stone of the transformation of DH<br>• When are pipes obsolete and how can this be measured?<br>• Different Testing Methods and different values / results for material properties: Which ones are the most promising for reliable lifetime prediction based? |
| **Activity** | To be done based on the contribution of participants |
| **Deliverables / Milestones** | Status assessment methods for flexible pipes (guideline?) / test & evaluation in the field / |

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| | suggestions for improved methods & possible results, values for material properties |
| **Target group** | DH companies, DH operators, consultants, DH Pipe manufacturers |
| **Work item** | A.4: Concrete ducts for district heating |
| **Objectives** | • Identify and explain failure modes<br>• Assess if the failure modes depend on installation or time in service<br>• Quantify the end-of-life criteria<br>• For each type of failure mode identify existing status assessment methods<br>• Assess the need for new or developed status assessment methods<br>• Develop or refine the status assessment methods needed<br>• Assess if the status assessment methods give useful data for estimating the remaining lifetime<br>• Status assessment of ducts<br>• Status assessment of pipes and pipe components (bearings etc.)<br>Methods for measuring the operating conditions (f. e. air humidity in ducts) |
| **Activity** | To be done based on the contribution of participants |
| **Deliverables / Milestones** | Status assessment methods for flexible pipes (guideline?) / test & evaluation in the field / suggestions for improved methods & possible results, values for material properties |
| **Target group** | DH companies, DH operators, consultants, DH Pipe manufacturers |
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| **Work item** | A.5: Quantify the status of district heating (DH) networks in participating countries |
| **Objectives** | • Improve the knowledge about the status of district heating (DH) networks by use of testing and analysing available data from pervious testing<br>• Demonstration cases, examples of status assessment of DH pipes |
| **Activity** | |
| **Deliverables / Milestones** | |
| **Target group** | |

Summary of deliverables (D) and Milestones (M) for STA

| No. | Description | ref. to WI |
|---|---|---|
| **D.A.1** | Collection of methods for status assessment of different DH Pipes (A1, A2, A3) including value/characteristic of the materials; possible usage for lifetime predictions; reliability of the approach/method; possible improvements of test methods increase the reliability of the results | A.2, A.3, A.4 |
| **D.A.2** | Demo case: report on testings in the field for different types of pipes | A.2, A.3, A.4 |
| **D.A.3** | Approach for the evaluation of the status of DH pipes in DH grids (f. e. priorisation of pipes based on the security of supply, age of pipes, damage statistics of DH companies…) | A.2, A.3, A.4 |
| **M.A.1** | ZZZZZ | ZZZZ |

## National contributions

| Country | Organisation | ref. to WI | Description of contribution (describe contribution, ref. to a national project, when possible quantify available effort, period of participation) | estimated effort [PM] |
|---|---|---|---|---|
| **Sweden** | Öresundskraft AB | **A** | **Showing result and graphic of Delta-thickness** We use Arc Gis to show delta-thickness. The program needs to be more developed but is shows the result in a good way. → Steel service pipe, concrete ducts? | |
| **Sweden** | Öresundskraft AB | **A** | **Showing result and graphic of Smart Aktive Box** We use Power BI to show seven parameters (four temperatures, O2, CO and moisture). The program needs to be more developed but is shows the result in a good way. → Concrete ducts | |
| **Sweden** | RISE | **A.1** | **Give a survey of types of DH networks and their share:** Compilation of information and write parts of report | |
| **Sweden** | **Halmstad University** | **A.2** | **Pre-insulated DH Pipes:** Methods to identify status of pipes based on measuring data & different approaches for status assessment; share experience from national projects | |
| **Germany** | AGFW | **A.2** | **Pre-insulated DH pipes:** Demo cases for testing status of DH Pipes, cooperation with DH companies in different | **6** |

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| | | | cities in Germany | |
| **Germany** | HafenCity University | **A.2** | **identification of failure modes** | |
| **Sweden** | RISE | **A.2** | **Preinsulated bonded pipes:** Contribute actively to discussions on explaining failure modes and end-of-life criteria. Compilation of status assessment methods, discussions on developement needs and assessment of usefulness of experimental data. Especially knowledge about PipeOpsy and RISE Plug method. Take part in writing report. | |
| **Sweden** | RISE | **A.3** | **Flexible district heating pipes:** Take part in discussions and assess contributions from other partners concerning failure modes, end-of-life criteria, development needs, etc. | |
| **Germany** | HafenCity University | **A.3** | **identification of failure modes** | |
| **Austira** | Austroflex Rohr-Isoliersysteme GmbH | **A.3** | Sharing 40 years of practical experience with flexible DH piping systems with plastic medium pipes; in biomass DH systems, secondary DH networks, | |
| **Germany** | **AGFW** | **A.4** | **Concrete ducts:** Demo cases for testing status of DH Pipes, cooperation with DH companies in different cities in Germany | **3** |
| **Sweden** | **Halmstad University** | **A.4** | **Concrete ducts:** Methods to identify status of pipes based on measuring data & different approaches for | |

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| | | | status assessment; share experience from national projects | |
| **Sweden** | RISE | **A.4** | **Concrete ducts for district heating:** Take part in discussions and assess contributions from other partners concerning failure modes, end-of-life criteria, development needs, etc. | |
| **Sweden** | RISE | **A.5** | **Quantify the status of district heating (DH) networks in participating countries:** Participate in planning and evaluation of testing results concerning PipeOpsy and RISE Plug method. | |
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**Work plan - IEA DHC Annex TS 6**
**Status assessment, ageing, lifetime prediction and asset management of District Heating Pipes**
Details for Subtask B– Ageing of DH-pipes

Leader 1: Associate Professor Nazdaneh Yarahmadi
Leader 2: Dr. Andreas Leuteritz

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| **Overall objectives of ST B** | Ageing and crucial ageing mechanism specially for each material in pipe construction and generally for status assessment and life-time prediction of DH-pipe.<br>When are Pipes obsolete? |
| **Work Item (WI)** | **B.1: Pre-insulated DH pipe**- Develop and get acceptance for a relevant accelerated ageing test method based on combination of thermal and mechanical ageing |
| **Objectives** | • Identify need of combination of thermal and mechanical acceleration aging test method<br>• Determination of a relevant temperature for accelerated thermal ageing test method<br>• Determination of a relevant load for accelerated mechanical ageing test method<br>• Acceptance of relevant load for accelerated mechanical ageing test method as a ground for European and international standardization work<br>• Bondage between PUR and steel service pipe<br>• Properties of materials (in operation) → $\tau_{ax,measured}$ / $\tau_{ax,calculated}$ |
| **Activity** | Laboratory testings, Workshop |
| **Deliverables / Milestones** | • Advantage of laboratory tests<br>• Acceptance of need for combination of thermal and mechanical acceleration aging test method<br>• Decision on temperature and time for accelerated thermal ageing<br>• Decision on relevant load for accelerated mechanical ageing |

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| **Target group** | International and European experts in the field and standardisation group |
| **Work Item (WI)** | **B.2: Concrete and metal pipe**- Understand relevant accelerated ageing test method |
| **Objectives** | • Identify need of acceleration aging test method for this type of DH-pipe<br>• Determination of a relevant condition for accelerated ageing<br>• Determination of dominant degradation mechanism for failure |
| **Activity** | Workshop |
| **Deliverables / Milestones** | To be done based on the contribution of participants |
| **Target group** | DH companies |
| **Work item** | **B.3: New material for each component in DH pipe**- Investigate the ageing mechanism for new marketed material for DH-pipe |
| **Objectives** | • Identification of new material for service pipe as well as insulation and mantel pipe<br>• Identify ageing mechanism for new material for service pipe<br>• Identify ageing mechanism for new material for insulation<br>• Identify ageing mechanism for new material for mantel<br>• Identification the crucial failure mechanism and its relationship with degradation of the components in DH-pipe construction |
| **Activity** | Workshop |
| **Deliverables / Milestones** | To be done based on the contribution of participants |
| **Target group** | DH Pipe manufacturers, DH companies |
| **Work item** | **B.4**: **Effects of ageing tests on status assessment for each kind of DH-pipe material** |
| **Objectives** | • Analyse and collect data from the aged pipes<br>o For pre-insulated pipe i.e.by Pipeopsy<br>o For concrete and metal<br>o For new material |
| **Activity** | Workshop |
| **Deliverables / Milestones** | Correlation between natural ageing behaviour and accelerated ageing method |
| **Target group** | Energy companies |

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| **Work item** | **B.5: Relevance of ageing tests on the other subtask** |
| **Objectives** | • Analysis and identification of ageing mechanism related to the relevant ageing test in collaboration for Life-time prediction with subtask C<br>• Identification of interaction between this subtask with the others, how the information from this subtask could contribute to the others. |
| **Activity** | |
| **Deliverables / Milestones** | |
| **Target group** | TS members, Energy company, pipe manufactures |
| **Work item** | **B.6: Effect of new energy sources on ageing of DH-pipe**- Influence of new energy sources on ageing mechanism |
| **Objectives** | • Determination of relevant new energy sources<br>• Effect of type of energy source on condition and crucial parameters for ageing of each type of DH-pipe |
| **Activity** | |
| **Deliverables / Milestones** | |
| **Target group** | |

Summary of deliverables (D) and Milestones (M) for STB

| **No.** | **Description** | **ref. to WI** |
|---|---|---|
| **M.B.1** | • Decision on temperature and time for accelerated thermal ageing<br>• Decision on relevant load for accelerated mechanical ageing | B.1; |
| **D.B.1** | • Acceptance of need for combination of thermal and mechanical acceleration aging test method<br>• Acceptance of relevant load for accelerated mechanical ageing test method as a ground for European and international standardization work | B.1 |
| **D.B.2**<br><br>**M.B.1** | ZZZZZ | B.2 |

## National contributions

| Country | Organisation | ref. to WI | Description of contribution (describe contribution, ref. to a national project, when possible quantify available effort, period of participation) | estimated effort [PM] |
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| **Sweden** | RISE | **B** | RISE has three ongoing projects about, status assessment, lifetime prediction, next generation DH-pipes (future material and resource efficiency, renewable energy sources and its effect on low temperature and on pipe construction), Development of two sensors, Smart maintenance (AI/ML, DTL) and pipes for district cooling. | |
| **Germany** | AGFW | **B.1**<br>**B.4** | AGFW will deliver samples of preinsulated DH pipes aged in the field in Chemnitz (research section). Origin material properties and operational conditions (temperatur) / loads are recorded and can be used for investigations. | |
| **Germany** | HafenCity University | **B.1** | participation on workshops and laboratory testing | |
| **Sweden** | RISE | **B.1** | Take part in discussion and contribute with expert knowledge on pre-insulated pipe, polymer tecknology and material degradation mechanism and root cause for ageing in various conditiones for district heating and cooling. Participate in the design of accelerated aging tests for pre-insulated DH pipes and evaluation methods. Participate in workshops and standardization work. | |

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| **South Korea** | KDHC | **B.1** | Comparative thermal-mechanical ageing test between KDHC's (DN125 only) and RISE's tester for increasing the reliability of the decision on temperature and time for accelerated thermal ageing and on relevant load for accerated mechanical ageing.<br><br>(2) If in-kind contributions are also needed or planded, KDHC can contribute the operating temperature data and several test machines such as the thermal-mechanical accelerated ageing machine, axial shear strength machine, bend saw, as well as naturally aged DH pipe samples.<br><br>(3) For your reference, the thermal-mechanical accelerated ageing machine of KDHC is currently under trial testing and will be available to use from September this year. | |
| **Sweden** | RISE | **B.2** | Take part in discussion and assessment. | |
| **Austria** | Austroflex Rohr-Isoliersysteme GmbH | **B.3** | From my work in CEN standardization I'll involve experts from other main manunfacturer of plastic medium pipes with their experience. | |
| **Germany** | HafenCity University | **B.3** | new materials for insulation | |
| **Sweden** | RISE | **B.3** | **New material for each component in DH pipe:** participate in selection of new materials for low temperature DH and evaluation of their long term properties.Take part in discussions and assess | |

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| | | | contributions for using new polymeric material for each component in DH pipe - Investigate the ageing mechanism for new marketed materials for DH-pipe. Participate in workshops. | |
| **Sweden** | RISE | **B.4** | Take part in discussions for choice of new plastic materials, their durability and sustinability which could impact assets and be crucial for the management | |
| **Austria** | Austroflex Rohr-Isoliersysteme GmbH | **B.4** | As expert in CEN TC 107 / WG10 flexible DH piping we have made Life-time calculations, test methods as basis for life-time predictions. Analysis of break downs in existing networks. | |
| **Austria** | Austroflex Rohr-Isoliersysteme GmbH | **B.5** | We have analysed life-time and failure modes with raw material suppliers and operators of DH networks. | |
| **Sweden** | RISE | **B.5** | Contribute to analysis and identification of ageing mechanism related to the relevant ageing test in collaboration for Life-time prediction with subtask C | |
| **Sweden** | RISE | **B.6** | Contribute with knowledge about methodology for estimation of lifetime of plastic (polymeric) material in preinsulated pipes for both high and low temperature pipe construction. | |

**Work plan - IEA DHC Annex TS 6**
**Status assessment, ageing, lifetime prediction and asset management of District Heating Pipes**

Details for Subtask C– Lifetime prediction

Leader 1: Assoc. Prof. Ignacy Jakubowicz
Leader 2: Pakdad Pourbozorgi Langroudi

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| **Overall objectives of ST C** | Prediction of service life of a district heating system is a challenge due to a wide range of degradation mechanisms in polymer-based materials, metals and concrete including thermal, chemical and mechanical degradation and also combined effects. The overall goal of ST C is to elaborate appropriate mathematical models that can allow extrapolation of short-time data to predict long-term performance of DHPs. |
| **Work Item (WI C1)** | Lifetime prediction of pre-insulated bonded DH pipes |
| **Objectives** | • Collection of existing prediction models based on accelerated thermal ageing<br>• Collection of existing prediction models based on accelerated ageing using simultaneously applied thermal and mechanical loads<br>• Compilation of results from evaluation of naturally aged pipes and comparison with laboratory aged pipes<br>• Analysis of the most relevant life-determining properties<br>• Proposal for calculation of service life<br>• Relation between operational conditions and dominating aging mechanisms taking place |
| **Activity** | Workshop<br>Discussions on an ad hoc basis<br><br>Use mathematical models for lifetime prediction → Status Assessment in Subtask A → Evaluation / Validation of mathematical models |
| **Deliverables / Milestones** | Synthesis report<br>Description of knowledge gaps and needs for research efforts<br>Proposal for standardisation |
| **Target group** | Researchers in DHP<br>District heating industry<br>Laboratory staff working with testing of DHP<br>Experts in standardization |
| **Work item (WI C2)** | Lifetime prediction of new polymer-based media pipes and insulation materials |

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| **Objectives** | • Collection of existing prediction models for the current materials based on accelerated ageing<br>• Analysis and selection of the most relevant life-determining properties in relation to the area of use<br>• Identification of knowledge gaps and needs for research efforts |
| **Activity** | Workshop<br>Discussions on an ad hoc basis |
| **Deliverables / Milestones** | Report on the "state-of-the-art" for relevant materials<br>Description of knowledge gaps and needs for research efforts |
| **Target group** | Researchers in DHP<br>District heating industry<br>Plastic manufacturing industry<br>Laboratory staff working with testing of DHP<br>Experts in standardization |
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| **Work item (WI C3)** | Lifetime prediction of metal and concrete pipes |
| **Objectives** | • Determination of the ageing mechanism in metal pipes<br>• Determination of the fatigue type (low-cycle, high-cycle)<br>• Comparison of the fatigue models to the Palmgren-Miner<br>• Investigation of the availability of the steel grades parameters for the fatigue analysis |
| **Activity** | Workshop<br>(Expert interview) |
| **Deliverables / Milestones** | The methods currently are used<br>Necessity of developing a new model<br>Requirements to build a new model |
| **Target group** | Older DHC grid infrastructure operators<br>Steel pipe manufacturing industry<br>Fatigue in Pre-insulated |

Summary of deliverables (D) and Milestones (M) for STC

| **No.** | **Description** | **ref. to WI** |
|---|---|---|
| **D.C.1** | A collection of the state of the art of lifetime prediction methods and models for concrete ducts, pre-insulated, and 4th Gen. DH pipes<br>• Approach, methodology and life time prediction models used in different participating countries<br>• Collection of examples, practical experience based on predictive maintenance work done by the participants | |

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| | • The relevant descriptive aging phenomena and mechanisms that could be correlated to each models | |
| **D.C.2** | Collection of research results<br><br>• Identify knowledge gaps → where do national research results create an agreed way for lifetime prediction, where do participants disagree?<br>• Effects of combined aging mechanisms taking place during the operational lifespan of DH pipes. Is it possible to focus on the most dominant mechanism or should have a look on different aging phenomena separately → how is the deviation in prediction and real events?<br>• Available data and suggestions for additional information / data that leads to more reliable / imporved lifetime prediction models | |
| **D.C.3** | Define border values for lifetime of several DH pipes<br><br>• How obsolete pipes could be defined? | |
| **D.C.4** | Improved calculation models for lifetime predictions<br><br>• Based on the results of subtask B improved calculation models will be elaborated<br><br>• The methods for status assessment subtask A and testing in the laboratory and the filed will be used to validate the improved calculation models<br><br>• A certain look will be on the results of accelerated aging → is it possible to use an accelerated aging test to gain reliable results compared to DH pipes natural aging processes in operation?<br><br>• How would existing lifetime prediction models benefits from a more digitalised DH system? ☐ How do temperature and heat losses impact on aging and how can these measured data in the future effect on predictive maintenance (limit values → when do you have to replace a pipe)? | |
| **D.C.5** | Data framework for predictive maintenance<br><br>• The minimum required data for predictive maintenance<br>• Classification of required and optional data for prediction model<br>• Collection of the state of the art models being used in DH system for predictive maintenance | |

## National contributions

| Country | Organisation | ref. to WI | Description of contribution (describe contribution, ref. to a national project, when possible quantify available effort, period of participation) | estimated effort [PM] |
|---|---|---|---|---|
| **Sweden** | Öresundskraft AB | **C** | Scanning of concrete duct with radar to assess concrete and rebar<br><br>Is included in project below. In week 10 the scanning will take place and the result will be investigated after that. | |
| **Germany** | AGFW | **C1** | Conrtibution with the research sections of Chemnitz (operational data, static calculations, measuring data) | **3** |
| **South Korea** | KDHC | **C.1** | Collecting of naturally aged DH pipes under various service years and operating temperature conditions, and providing DH pipe specimens to KDHC and/or other participants to test the axial shear strength. | |
| **Sweden** | RISE | **C.1** | "Compilation of existing methods for lifetime prediction of DH pipes. Evaluation of the degree of agreement between laboratory methods and experience from the field. Compose a proposal for a calculation model to estimate service life of pre-insulated DH pipes. Prepare a synthesis report and a description of knowledge gaps and needs for research efforts.<br><br>Prepare a proposal for standardisation. Participation in | |

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| | | | discussions and workshops.". | |
| **Sweden** | RISE | **C.2** | Compilation of existing methods for lifetime prediction of new polymer-based materials with potential for use in low temperature DH. Description of knowledge gaps and needs for additional research efforts in the field. Prepare a report on the “state-of-the-art”. Participate in discussions and workshops. | |
| **Germany** | HafenCity University | **C.3** | Contribution through the ongoing research of the nationally funded “Instandhaltung-FW” | |
| **Germany** | AGFW | **C.3** | Contribution with the results of investigation and test on concrete ducts (demo case for a German DH company) | |
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**Work plan - IEA DHC Annex TS 6**
**Status assessment, ageing, lifetime prediction and asset management of District Heating Pipes**
Details for Subtask D – Asset Management

Leader 1: Ingo Kropp, 3S Consult GmbH, Germany
Leader 2: Andreas Büchau, Vattenfall Wärme Berlin AG, Germany

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| **Overall objectives of ST D** | Establish an AM framework for the other 4 sub tasks in this annex: A: Status assessment, B: Aging of DH pipes, C: Lifetime prediction, E: Future perspectives.<br>Thus, enabling effective and sustainable AM decisions in short- and long-term. |
| **Work Item (WI)** | D.1: Define AM processes within an AM framework for DH pipes and their relationship/interfaces; Describe data requirements, technologies/tools, inputs and outputs; show examples from other sectors and/or countries |
| **Objectives** | Provide a “manual” for Asset Management of DH pipes |
| **Activity** | • Describe relevant AM processes for DH pipes<br>• Describe data requirements<br>• Describe relationships and interfaces<br>• Describe inputs/outputs<br>• Describe technologies and tools |
| **Deliverables / Milestones** | Report on AM system for DH pipes |
| **Target group** | Network operators, engineering service provider and consultants |
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| **Work item** | D.2: Develop a KPI system for DH pipes |
| **Objectives** | Establishment of a KPI system for DH pipes to enable the assessment/evaluation of DH pipe systems related to technical, economic and ecological aspects |
| **Activity** | • Literature review of KPI systems in other sectors<br>• Transfer of findings to DH pipes |
| **Deliverables / Milestones** | Report on KPI system for DH pipes |
| **Target group** | Network operators, engineering service provider and consultants |
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| **Work item** | D.3: Assessment of carbon footprint for DH pipes over lifetime |
| **Objectives** | Enabling an ecological evaluation of AM decisions for DH pipes over lifetime |
| **Activity** | • Investigation about determination/calculation of carbon footprint<br>• Collection of relevant AM processes/activities<br>• Development of methodology to assess carbon footprint for DH pipes over lifetime |
| **Deliverables / Milestones** | Methodology to assess carbon footprint for DH pipes over lifetime |
| **Target group** | Network operators, engineering service provider and consultants |
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| **Work item** | D.4: Improve asset simulations by incorporating results from status assessment, aging, lifetime prediction and future perspectives, demonstration for one example tool |
| **Objectives** | Show practical application of asset simulations |
| **Activity** | Incorporate findings from Subtasks A, B, C and E<br>Implement findings in one example AM software<br>Demonstration for 1+ DH pipe network |
| **Deliverables / Milestones** | Example AM simulations |
| **Target group** | Network operators, engineering service provider and consultants |
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| **Work item** | D.5: Further develop the IKOS concept by considering supply reliability in AM simulations and the influence of decentralized renewable energy sources |
| **Objectives** | Combine AM simulations based on status assessment, aging and lifetime prediction with hydraulic simulations to assess supply reliability |
| **Activity** | • Connect example AM simulation tool with hydraulic simulation tool<br>• Assess supply reliability for various scenarios<br>• Draw conclusions for supply reliability related to further development of DH pipe systems |
| **Deliverables / Milestones** | Example IKOS simulation |
| **Target group** | Network operators, engineering service provider and consultants |

Summary of deliverables (D) and Milestones (M) for STD

| No. | Description | ref. to WI |
|---|---|---|
| **D.D.1** | Report on AM system for DH pipes | D.1 |
| **D.D.2** | Report on KPI system for DH pipes | D.2 |
| **D.D.3** | Methodology to assess carbon footprint for DH pipes over lifetime | D.3 |
| **D.D.4** | Example AM simulation | D.4 |
| **D.D.5** | Example IKOS simulation | D.5 |
| **M.D.1** | | |
| **M.D.2** | | |
| **M.D.3** | | |
| **M.D.4** | | |
| **M.D.5** | | |

## National contributions

| Country | Organisation | ref. to WI | Description of contribution (describe contribution, ref. to a national project, when possible quantify available effort, period of participation) | estimated effort [PM] |
|---|---|---|---|---|
| **Sweden** | Halmstad University | **D**<br>**D.1?**<br>**D.4?**<br>**D.5?** | Smart Asset Management: Share experience with SAM in DH in Sweden,<br>Contribution of Hakan Knutsson is more detailed; needs to be clarified during the Kick-off meeting | |
| **Germany** | 3S Consult | **D.1** | Describe relevant AM processes for DH pipes<br>Describe data requirements<br>Describe relationships and interfaces<br>Describe inputs/outputs<br>Describe technologies and tools<br>2022-2026; project start will depend on positive grant decision | **3** |
| **Germany** | 3S Consult | **D.2** | • Literature review of KPI systems in other sectors<br>• Transfer of findings to DH pipes<br><br>2022-2026; project start will depend on positive grant decision | **3** |
| **Sweden** | RISE | **D.2** | Assessment of environmental indicators to identify the best transformation path | |
| **Germany** | 3S Consult | **D.3** | • Investigation about determination/calculation of carbon footprint<br>• Collection of relevant AM processes/activities | **6** |

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| | | | • Development of methodology to assess carbon footprint for DH pipes over lifetime<br><br>2022-2026; project start will depend on positive grant decision | |
| **Germany** | HCU | **D.3** | methodology for carbon footprint assessment (+other environmental impacts?) | |
| **Germany** | 3S Consult | **D.4** | Include results from German national R&D project "Instandhaltung-FW" as initial starting point in TS6<br>Incorporate findings from Subtasks A, B, C and E<br>Implement findings in one example AM software<br>Demonstration for 1+ DH pipe network<br><br>2022-2026; project start will depend on positive grant decision | **12** |
| **Germany** | 3S Consult | **D.5** | • Connect example AM simulation tool with hydraulic simulation tool<br>• Assess supply reliability for various scenarios<br>• Draw conclusions for supply reliability related to further development of DH pipe systems<br><br>2022-2026; project start will depend on positive grant decision | **12** |
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**Work plan - IEA DHC Annex TS 6**
**Status assessment, ageing, lifetime prediction and asset management of District Heating Pipes**
Details for Subtask E – Future Perspectives

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Leader 2: Alberto Vega; RISE, SE

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| **Overall objectives of ST E** | **Transformation, development, optimisation, predictive maintenance, life-time prediction, ageing, influence of pipe materials on performance** |
| **Work Item (WI)** | E.1: Effect on future operation mode to life-time of DH-System in general |
| **Objectives** | • Reduction of DH network temperatures<br>• Transformation of DH (RES, new technologies [5G/machine learning])<br>• Hybridization of DH, e.g. storage-effect of the pipes (lifetime-prediction)<br>• Identification of key advantages, especially for plastic systems (future pipe systems)<br>• Regarding a more energy efficient system, which insulation series are required in future<br>• Identification of interaction between pipes an soil when feed-in fluctuating energy<br>• Combination of heating and cooling in the same DH network (5GDHC) |
| **Activity** | • Evaluation of state-of-the-art operation options for comparison to future requirements on operation modes to life-time of DH-System/ Piping<br>• Identification and definition of future requirements resp. approaches for futures piping-systems (transformation, hybridisation and digitalisation)<br>• Collection of case studies, research projects and results and Best-Practice Examples in this context<br>• Relation with IEA-DHC TS 4 “Digitalisation” (cooperation & using the results of TS 4 if possible!) |
| **Deliverables / Milestones** | • M.E.1: Fact sheets as overview technical options and ongoing research with regard to future operation mode |

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| | • D.E.1: Documentation of on technical options future operation mode |
| **Target group** | • Energy suppliers, DHC operators and technology providers<br>• Planners, Pipeline manufacturer<br>• R&D |
| **Work item** | E.2: Effects of digitalisation on district heating systems |
| **Objectives** | • Identify and collect data from the DHS and hardware (sensors) to equip the pipes (e.g. fibre cables) for sustainable heat supply<br>• Usage of data for improvement of models, e.g. optimisation models (predictive maintenance, lifetime-prediction)<br>• Identification of suitable knowledge, models/ approaches, balance boarders for optimisation as part of AI/ML.<br>• Identification of an approach to retrofit an existing district heating system<br>• Prediction of loads that effect the interaction between pipes an soil<br>• Relation with IEA-DHC TS 4 “Digitalisation” (cooperation & using the results of TS 4 if possible!) |
| **Activity** | • Evaluation digitalisation approaches taking into account DH-System/ Piping-System (e.g. predictive maintenance of leakage)<br>• Collection and comparison of AI/ML - and prediction Methods (e.g. ioT application “LoRaWAN”)<br>• Collection of case studies, research projects and results and Best-Practice Examples in this context |
| **Deliverables / Milestones** | • M.E.2: Fact sheets as overview technical options and ongoing research with regard to digitalisation<br>• D.E.2: Documentation of on technical options with regard to digitalisation |
| **Target group** | • Energy suppliers, DHC operators and technology providers<br>• Planners, Pipeline manufacturer, decision makers<br>• R&D |
| **Work item** | E.3: Assessment of environmental indicators to identify the best transformation path |
| **Objectives** | • Aspects of circular economy |

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| | • New materials causing lower pollution, higher share of recycled materials for new pipes.<br>• Influence of the pipe materials used on the operation and sustainability of the thermal network<br>• Influence of climate changes on heating and cooling demand<br>• Relation with IEA-DHC TS 5 “RES in DHC” (cooperation & using the results of TS 5 if possible?) |
| **Activity** | • Identification of environmental indicators to identify the best transformation path<br>• Collection of case studies, research projects and results and Best-Practice Examples in this context |
| **Deliverables / Milestones** | • M.E.3: Fact sheets as overview technical options and ongoing research with regard to environmental indicators<br>• D.E.3: Documentation of results with regard to environmental indicators |
| **Target group** | • Energy suppliers, DHC operators and technology providers<br>• Planners, Pipeline manufacturer, decision makers<br>• R&D |

Summary of deliverables (D) and Milestones (M) for ST E

| **No.** | **Description** | **ref. to WI** |
|---|---|---|
| **D.E.1** | Documentation of on technical options with regard to future operation mode | E.1 |
| **M.E.1** | Fact sheets as overview technical options and ongoing research with regard to future operation mode | E.1 |
| **D.E.2** | Documentation of on technical options with regard to digitalisation | E.2 |
| **M.E.2** | Fact sheets as overview technical options and ongoing research with regard to digitalisation | E.2 |
| **D.E.3** | Fact sheets as overview technical options and ongoing research with regard to environmental indicators | E.3 |
| **M.E.3** | Documentation of results with regard to environmental indicators | E.3 |

## National contributions

| Country | Organisation | ref. to WI | Description of contribution (describe contribution, ref. to a national project, when possible, quantify available effort, period of participation) | estimated effort [PM] |
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| **Sweden** | Öresundskraft AB | **E** | Repair of a concrete duct in a new way<br>This project will start week 9 and are finished in May. We will compare the cost and climate impact between new pipes and repair the concrete. The cathodic protection that will be used in order to protect the bars will also be investigated. | |
| **Germany** | AGFW | **E.1** | Impact of lowering the supply temperatures on the loads in existing research section Chemintz | |
| **Austria** | Austroflex Rohr-Isoliersysteme GmbH | **E.1** | We have experience with DH operators and the influences of operation mode on life-time | |
| **Sweden** | RISE | **E.1** | Choice of material, their durability and sustainability which could impact future usage of DHC | |
| **Sweden** | RISE | **E.1** | Identification and definition of future requirements resp. approaches for futures piping-systems (transformation, hybridisation and digitalisation) | |
| **Sweden** | RISE | **E.2** | Evaluation digitalization approaches taking into account DH-System/ Piping-System (e.g., predictive maintenance | |

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| | | | of leakage) | |