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Abstract

This report analyses the current status of district heating infrastructure in Mecklenburg-Western- Pomerania (MV) within the framework of the Interreg project "Baltic EnerShift" (BES). The study aims to identify the gap between current maintenance practices of local heat suppliers and international standards for data-driven Predictive Maintenance as outlined in the SAM-FW guideline by the AGFW [2].

Through a statewide survey of heat suppliers, data on network structure, operating parameters, and damage history were collected. The results reveal a heterogeneous network landscape with significant modernization needs for systems installed in the 1990s. While digital damage recording is largely established, model-based methods for predicting remaining service life are lacking across the board. The report concludes with recommendations for developing digital decision-support systems to ensure long-term, cost-efficient supply security in MV.

1 *Introduction*

District heating plays a pivotal role in the energy infrastructure of the Baltic Sea region. In certain areas, its market share reaches up to 60%, and in some cities, it accounts for nearly 100% of the heating supply. However, in light of the energy transition, utility companies are facing massive challenges. One of the most critical hurdles is managing aging pipeline networks, where renewal rates are lagging far behind original reinvestment plans.

Current studies highlight the magnitude of this issue. At the present rate of replacement, it would mathematically take over 400 years to fully renew the existing network [4, 5]. Furthermore, investment costs are immense. For a city of 100,000 residents, the cost of network renewal is estimated at over 1 billion euros [5, 6, 7]. In light of these circumstances, strategies that emphasise the prolongation of existing pipe lifespans beyond their anticipated limits, extending them to over 100 years, and prioritise targeted repairs over complete replacement, are gaining significance.

1.1 Interreg South Baltic Project: Baltic EnerShift (BES)

To address these challenges, the EU Interreg South Baltic project Baltic EnerShift (BES) was established. The project aims to increase energy efficiency in district heating systems through the development and implementation of digital services. A core aspect is the transformation from a reactive to a predictive maintenance strategy.

The project focuses on developing a digital prototype designed to assist municipal utilities with condition assessment and the estimation of remaining service life. By gaining a better understanding of the actual condition of steel pipes, corrosion processes, and the aging of PUR foam and PE casing pipes, investment decisions can be placed on a data-driven foundation.

1.2 Purpose and Content Structure

A reliable prototype requires a thorough understanding of real-world conditions. The purpose of this survey was, therefore, to create a representative profile of district heating structures in Mecklenburg-Western Pomerania. As part of a statewide structural and condition analysis, 26 municipal utilities and heat suppliers were contacted to collect data on the following key areas:

- Company and Network Structure: Collection of physical baseline data.
- Operating Parameters: Analysis of thermal and hydraulic loads.
- Damage and Maintenance Statistics: Documentation of previous experiences and vulnerabilities.
- Monitoring and Digital Requirements: Identification of gaps between the current state of the art and the requirements for sustainable asset management.

The following report evaluates these results and places them in the context of the current state of technology as well as the objectives of the Baltic EnerShift project.

2 State of the Art

The economics of heat supply, particularly district heating, is undergoing a profound transformation that goes far beyond simply replacing fossil fuels. Digitalisation and the maintenance of network infrastructure are not merely ends in themselves, but rather constitute a significant economic necessity. In the context of maintenance, the prevailing state of the art is undergoing a transition from a reactive (event-oriented) management paradigm to a data-driven strategy (time- and/or condition-oriented), which is also referred to as predictive maintenance or damage prevention. The integration of event-oriented maintenance with time- and condition-oriented approaches gives rise to risk-oriented maintenance, thereby unifying the benefits of all three core strategies [1].

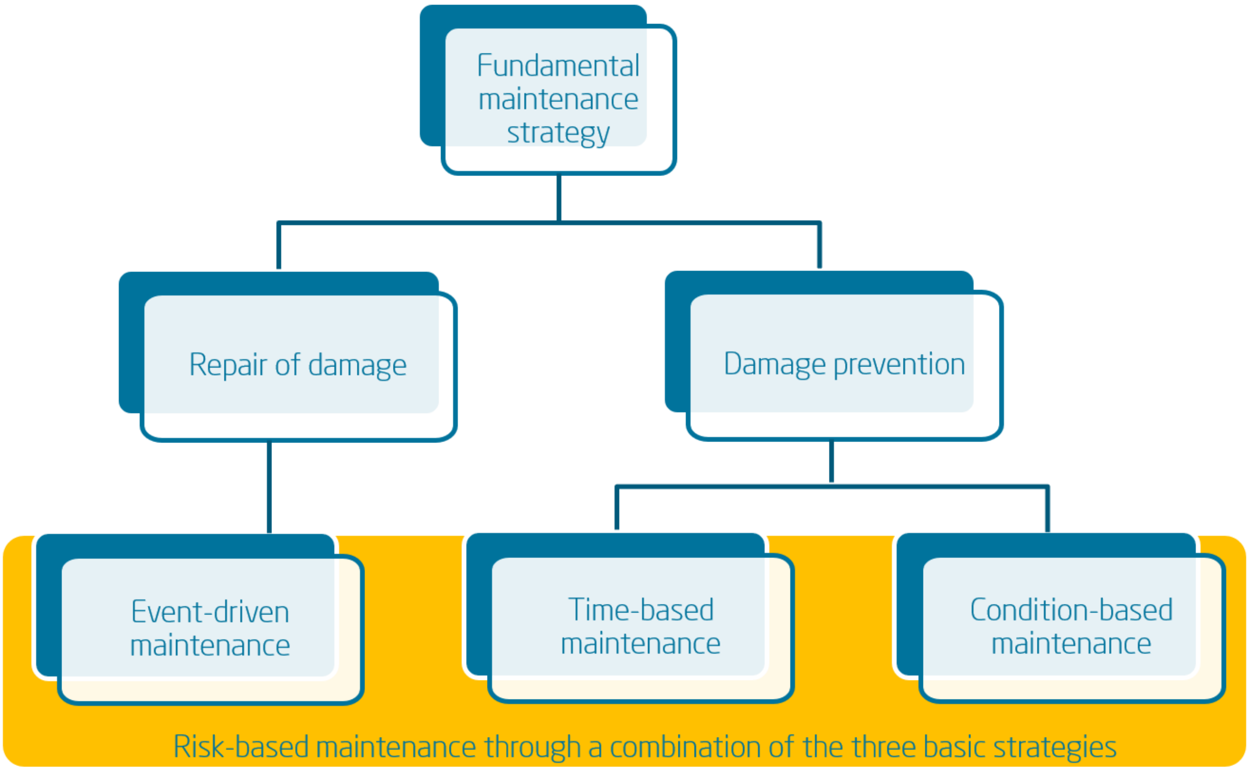


Figure 1: Hierarchy of maintenance strategies based on I. Krupp 3SConsult [1]

Local heat suppliers, especially in the newly formed German federal states, face the dilemma of aging networks paired with simultaneous cost pressure. According to analyses by 3SConsult, AGFW, and Öresundskraft, the strategy of waiting, also known as "run-to-failure", leads to incalculable risks [1, 3, 4]. These risks include immense maintenance costs, supply insecurity, and investment backlogs.

Statistically, emergency repairs are significantly more expensive than planned rehabilitations. Unplanned outages for critical consumers such as hospitals or industrial facilities can lead to high compensation claims in addition to the lack of heat supply.

Furthermore, such failures can damage customer trust. Rehabilitation based on predictive data identifies critical weak points in the network early on, allowing for the prioritization of section renewals based on actual remaining service life forecasts. Combining inventory data, operational data, and ultimately condition data enables this prioritization and the introduction of digital twins. These can predict damage events in GIS systems (Geographic Information Systems) using pressure and temperature curves [3, 4]. GIS systems link digital data with a map, creating a digital geographic representation including technical specifications.

The focus areas chosen for the survey are based on the technological standards presented in the AGFW practical guide "Sustainable Asset Management District Heating" (SAM-FW), which are used for comparison [2]. Querying the network structure and construction years serves the time-oriented identification of potential risks. These are complemented by the collection of operational data and reports on damage frequency from heat suppliers. Particular attention is paid to digital requirements. International pioneers, such as Öresundskraft, already rely extensively on "Smart Active Boxes" (SAB) and AI-supported moisture measurements to detect leaks before water even escapes [4].

Intelligent maintenance allows limited budgets to be deployed where they achieve the maximum effect for extending the network's service life. For suppliers in Mecklenburg-Western Pomerania, this is especially vital, as a digitally monitored and stabilized network is a prerequisite for the energy transition. Only when the condition of the infrastructure is known and controllable can fluctuating renewable energies be safely integrated and networks be operated more efficiently.

3 Methodology

To translate the theoretical requirements of modern asset management into the practical context of Mecklenburg-Western Pomerania, a methodical investigation was designed using the AGFW SAM-FW [2] practical guide as its strategic foundation. The goal was not to create an isolated theoretical model, but to generate a database reflecting the real uncertainties and needs of local suppliers.

3.1 Conceptual Framework

The conceptual framework of the survey is based on the three pillars of predictive maintenance as described in chapter 2. The first pillar comprises structural and asset data, which serve to determine the current network condition. In this context, the master data required by the guidelines, such as network length, year of construction, and pipe types, were surveyed. These data form the foundation for condition-based maintenance planning.

The second pillar reflects the operational history and load profiles. Based on the insight that thermal loads are the primary driver of aging in district heating pipes, supply temperatures and typical network pressures were determined in the survey. These data enable the implementation of time-oriented maintenance measures.

Damage and condition data constitute the third pillar of predictive maintenance. Utilizing this information bridges the gap between theory and practice, ultimately enabling a risk-oriented management approach.

3.2 Data Collection

The study was designed as a statewide survey among district heating suppliers in Mecklenburg-Western Pomerania, identifying and contacting a total of 26 heat supply companies operating within the state. To emphasize the relevance of the topic and obtain technically sound feedback, the technical directors of major municipal utilities including those in Schwerin, Wismar, Neubrandenburg, and Greifswald were informed of the project's objectives by telephone in advance.

The final response rate of the survey was approximately 20%. Although this quantitatively represents only a portion of the supply landscape, the participation of companies with highly diverse network structures and supply areas provides a qualitative initial insight into the district heating infrastructure of Mecklenburg-Western Pomerania. The results thus form a heterogeneous representation of the current local situation, serving as a guide for identifying local needs and technical challenges.

4 Implementation and Execution

The questionnaire was provided digitally via Microsoft Forms. A particular focus was placed on practical validity. Since it is known that historical data is often incomplete, participants were explicitly given the opportunity to provide informed estimates. This was intended to prevent excessive hurdles during archival research.

To maintain the confidentiality of sensitive infrastructure data, the survey was conducted completely anonymously, so that results are only evaluated in aggregate as SW1 to SW5. The objective of this survey is to collect a fact-based data foundation of district heating supply in the state of Mecklenburg-Western Pomerania and to identify the needs of local heat suppliers in the areas of Asset Management and digital services. In addition to identifying needs, the survey serves to identify potential partners for planned test measurements to be carried out as part of the Interreg project (BES).

4.1 Timeline and Process

Initial contact for the majority of the surveyed heat suppliers in MV took place at the end of February 2026 (26.02.2026). To underscore the relevance of the topic and increase the response rate, the major district heating suppliers in the state, such as Neubrandenburg, Wismar, and Schwerin, were informed in advance by telephone about the project and the survey. Initially, 24 heat suppliers were considered during the first contact.

To further encourage participation, a reminder was sent three weeks after the initial contact. In this context, two additional companies providing district heating in Mecklenburg-Vorpommern were contacted. The response deadline ended on 10.04.2026, which simultaneously marked the starting point for the statistical evaluation of the survey. In total, 26 heat suppliers in the state were contacted, with a response rate of approximately 20 percent.

4.2 Structure of the Questionnaire

The questionnaire for the statewide structural and condition analysis of district heating networks is divided into six thematic areas:

1. Company Structure: Initially, the structure of the surveyed company is recorded, focusing particularly on existing network lengths, the number of households supplied, and the maximum connected load.

2. Network Structure: A detailed analysis of the network structure follows, querying both technical aspects and physical properties such as age structure, installation type, and pipe types used.

3. Operating Parameters: Average flow temperatures for summer and winter operation, as well as typical operating pressure and historical operating data, are documented.

4. Damage and Maintenance Data: This section focuses on capturing annual damage and renovation rates, the most common causes of failure, and the status of digital damage recording.

5. Monitoring and Condition Assessment: This part deals with the monitoring and assessment of the networks, shedding light on the evaluation methods used and the criteria for investment decisions, as well as analysing models for estimating the remaining service life.

6. Digital Service Requirements: Finally, the sixth section identifies the greatest uncertainties of operators in the district heating sector and queries the willingness to participate in pilot measurements and in-depth professional exchange.

The survey was completed anonymously to ensure objective data collection and to achieve a higher willingness to provide sensitive infrastructure data

5 Results and Evaluation

The evaluation of the five participating municipal utilities (SW1 to SW5) provides a detailed picture of the current district heating situation in Mecklenburg-Western Pomerania.

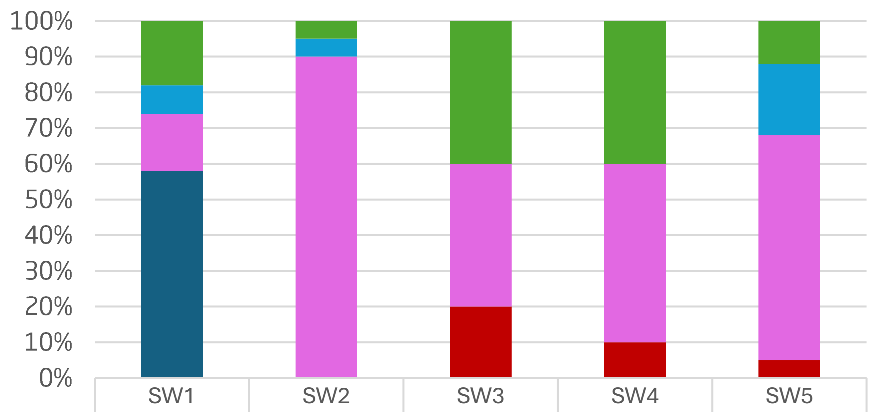
The analysis follows the three pillars defined in the methodology (Section 3.1) as the foundation for modern maintenance.

5.1 Company and Network Structure – Technical Analysis

The investigated networks in Mecklenburg-Western Pomerania differ significantly in their technical design and size, confirming the previously mentioned heterogeneity of the region. According to AGFW categorization, the participants range from medium-sized to large-scale networks, with maximum connected loads ranging from 13 MW to 152 MW. These differences are directly attributable to local conditions. While some suppliers serve compact urban areas, others must bridge long transit distances.

These differences in network structure are also reflected in historical development. In particular, the timing of expansion and the chosen installation systems are decisive for today's maintenance strategy. The following graphic illustrates the age structure of the networks of the surveyed companies.

A look at the construction years (see the following figure) highlights a central challenge for MV: a large majority of the pipelines were installed between 1990 and 2000.



	SW1	SW2	SW3	SW4	SW5
after 2010	18%	5%	40%	40%	12%
2000 - 2010	8%	5%			20%
1990 - 2000	16%	90%	40%	50%	63%
1980 - 1990			20%	10%	5%
without specific year of construction	58%				

Figure 2: Timeline for the construction of district heating pipes

This "expansion wave" following German reunification means that many networks are now reaching the end of their first theoretical service life of approximately 30 years nearly simultaneously. Since the pre-insulated bonded pipe (KMR) system dominates, the question of remaining service life has become urgent. As described in Chapter 2.1, age does not always correlate with condition. Without more precise data, municipal utilities risk either investing too early or endangering supply security due to undetected damage.

Regarding the installation method, the participants indicated that the largest share of district heating pipelines is directly buried. The percentages shown in Figure 3 should be considered rough estimates. In addition to directly buried lines, there are shares of overhead lines, duct lines, building lines, and baseboard lines.

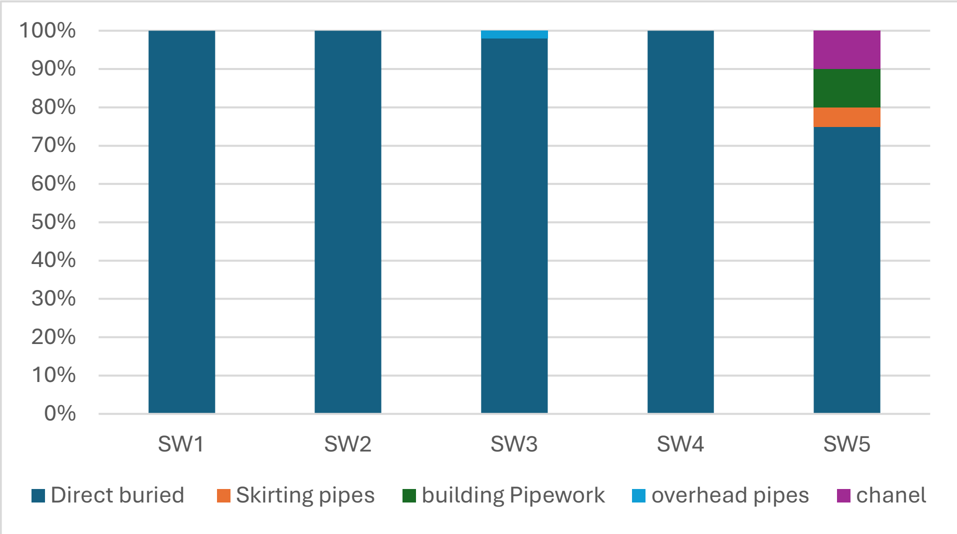


Figure 3: Installation type of district heating pipelines

5.2 Damage Analysis

Regarding the types of pipelines installed, pre-insulated bonded pipes (KMR) are predominantly used. These consist of a steel service pipe, polyurethane (PUR) insulation, and a polyethylene (PE) plastic casing. While a majority of the networks use pre-insulated pipe systems that already feature integrated condition monitoring, one surveyed company stated that it uses a substantial portion of its lines without such monitoring. Besides pre-insulated pipe, participants also utilize installation types such as steel-jacketed pipes or simple service pipes installed in ducts. The existing pipe systems and die possibility of monitoring from the participants is wrapped up in Figure 4.

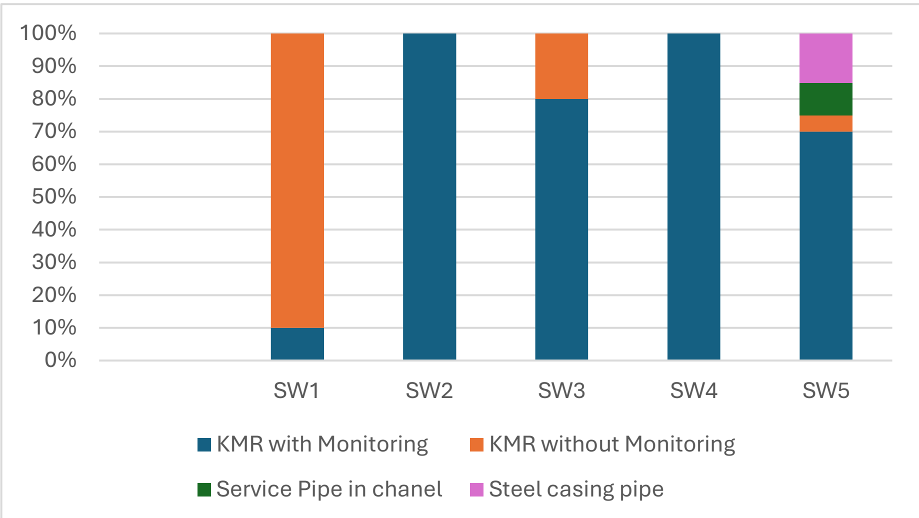


Figure 4: Existing pipe systems and Monitoring of each heat supplier

When examining the most frequent cause of damage in district heating networks, it is notable that corrosion of the steel service pipe due to damage to the outer plastic casing (PE) is primarily cited. In addition to corrosion, joint (muff) defects are among the frequent causes of damage.

Figure 5 shows the basis for investment decisions upon which network expansion or new construction is based. It can be seen that damage frequency and empirical data are often included in the decision-making process regarding when a line must be replaced or where new buildings can be connected to the network.

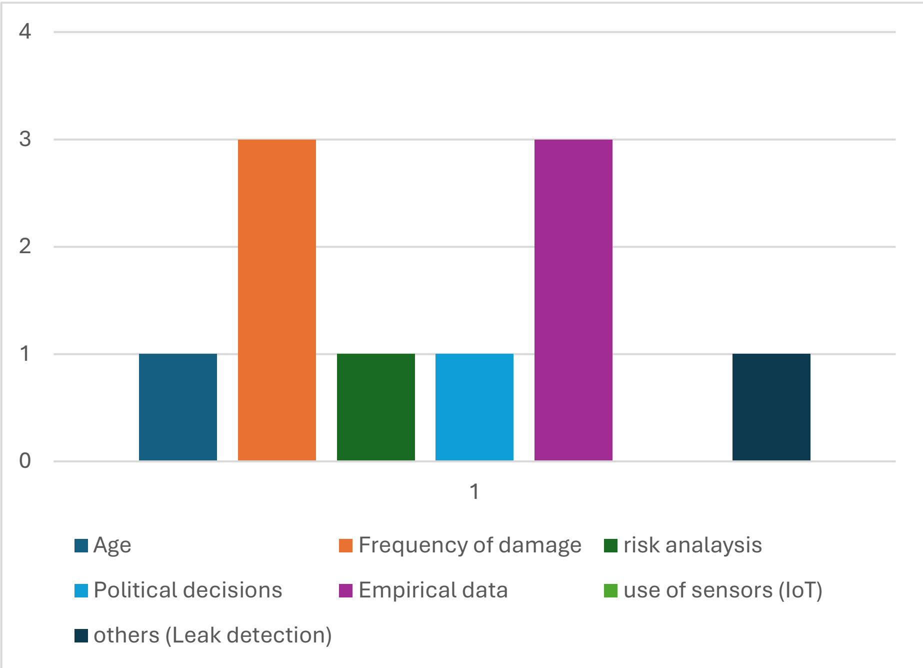


Figure 5: Basis for investment decisions in district heating network infrastructure

5.3 Status Quo of Condition Assessment

Regarding condition assessment, all participants stated that a detailed condition assessment of the networks has not yet taken place. Estimates of remaining service life are also not common in the state. This highlights the need for action on the priority topics of the BES project. Figure 6 shows which additional information, from the perspective of the surveyed municipal utilities, could contribute to a better condition assessment.

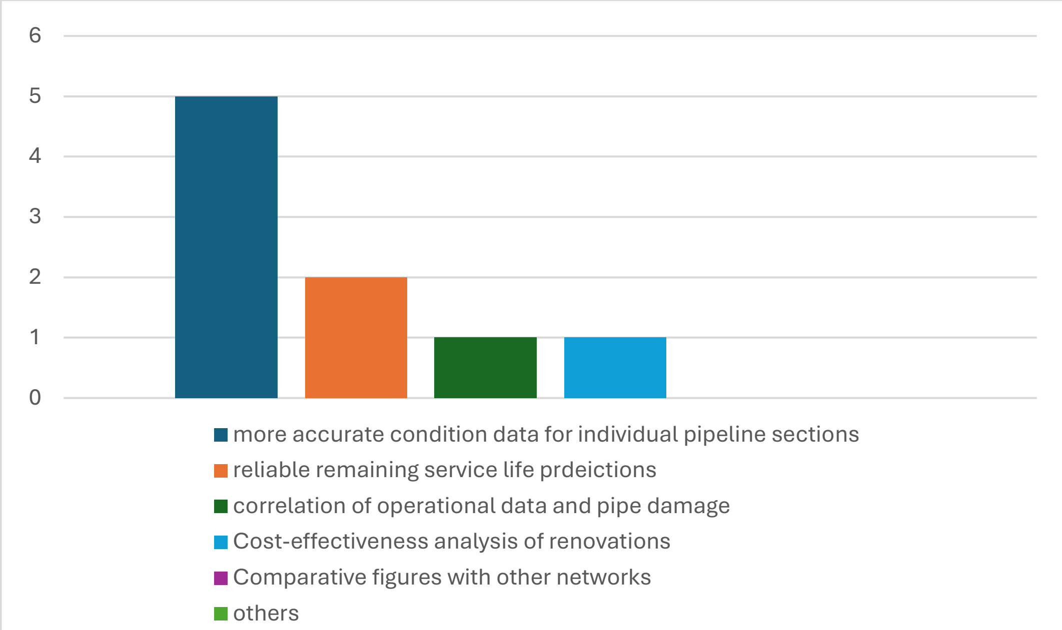


Figure 6: Overview of additional information that can contribute to a better assessment of the network condition

The evaluation of figure 6 clearly shows that more precise condition data for individual line segments would lead to a better condition assessment for all respondents. This is exactly the theme addressed in the Baltic EnerShift project, which aims to test methods that provide precisely such condition analyses.

6 Comparison and Outlook

In this chapter, the local results from Mecklenburg-Western Pomerania are compared with data from the AGFW practical guide "Sustainable Asset Management" (SAM-FW) [2]. This is followed by a summary and an outlook.

6.1 Comparison with AGFW

The AGFW practical guide provides a clear picture of installed district heating pipelines. Comparing this with the survey in MV, it is evident that the proportion of pre-insulated bonded pipes in Mecklenburg-Western Pomerania is above the national average for older existing networks due to massive renewals after 1990. Nevertheless, the susceptibility to damage in the remaining duct installations in MV correlates strongly with the national trends of the SAM-FW guideline, according to which these legacy systems in particular cause the highest maintenance costs per kilometre of trench. To illustrate this, the results of the SAM-FW regarding the percentage distribution of different pipe systems are visualized in the following representation.

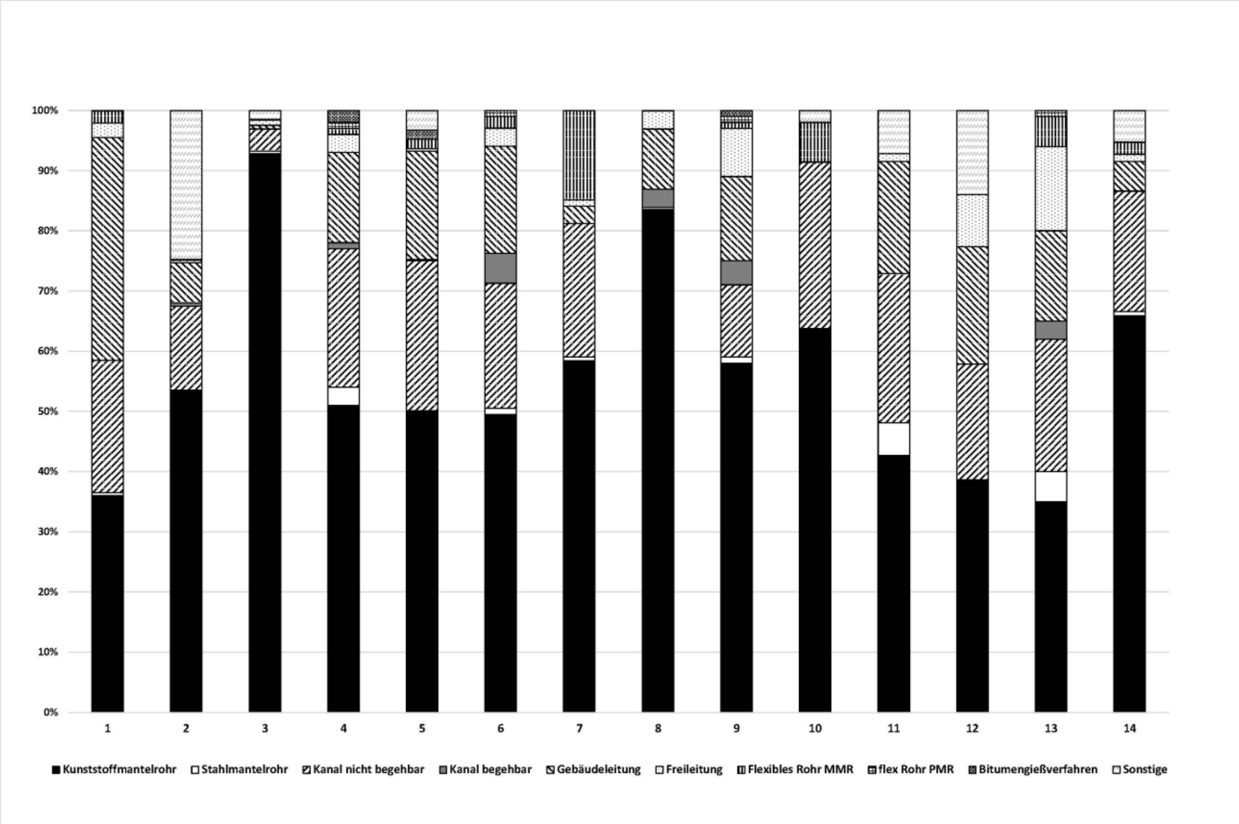


Figure 7: Percentage share of different pipe systems in 14 heating networks in Germany, analysed by AGFW in Sustainable Asset Management in District heating (SAM-FW) [2]

It can be seen that in this study, as well, the largest share of installed pipe systems is covered by pre-insulated pipes. Furthermore, among the surveyed participants, a large proportion of the installed pipes exist as non-accessible ducts or building lines. Above all, the distribution of pre-insulated bonded pipes, but also the share of non-accessible duct lines and building lines, can likewise be seen in the evaluation of the questionnaire from the municipal utilities in Mecklenburg-Western Pomerania.

A further key aspect of the SAM-FW framework is the representation of the average technical service life for individual pipe categories. This service life is outlined in detail within the AGFW code of practice FW-114 [8]. While a theoretical service life of between 35 and 70 years is predicted for pre-insulated bonded pipe systems (KMR) under standard operating conditions, alternative installation methods, such as steel-cased pipes or overhead lines, exhibit a maximum theoretical service life of up to 80 years. According to code of practice FW-114, the mean service life is 52.5 years for pre-insulated bonded pipes, 64 years for concrete ducts, 55 years for steel-cased pipes, and 65 years for overhead lines. Building connection lines possess the longest technical service life, with a mean durability of 75 years.

A cross-reference with the survey data from Mecklenburg-Western Pomerania (MV) reveals that the vast majority of the networks in the state were installed between 1990 and 2000. Consequently, these pipes are currently approximately 25 to 35 years old, thereby reaching the lower threshold of their theoretical service life. In the coming years, this development could trigger an investment gap, as numerous pipe sections will simultaneously approach the limits of their technical longevity. According to lifetime expectancy analyses conducted by the AGFW, as well as findings from the RISE Research Institutes of Sweden, material-induced degradation phenomena, such as corrosion, occur with increasing frequency once a system exceeds 30 years of age. Mechanical stress represents an additional contributing factor. These mechanical loads are primarily induced by high thermal stress. In Mecklenburg-Western Pomerania, this effect is further aggravated by high flow temperatures of up to 130 °C, which could significantly shorten the remaining service life calculated under SAM-FW compared to the theoretical maximum. This underscores the critical demand for predictive tools to manage rehabilitation cycles with greater precision than can be achieved through purely statistical service life estimations.

6.2 Summary

This report analyzes the status quo of district heating infrastructure in Mecklenburg-Western Pomerania within the framework of the "Baltic EnerShift" project. The statewide survey among heat suppliers has shown that the network landscape is characterized by high technical heterogeneity and a specific age structure. A majority of the pipelines were installed in the 1990s and will reach the end of their first theoretical usage phase in the coming years.

The comparison with the AGFW practical guide clarifies that while Mecklenburg-Western Pomerania has a higher pre-insulated bonded pipes rate than the national average, it faces a massive renovation wave due to high thermal loads and simultaneously aging infrastructure. Since investment decisions are currently still predominantly made reactively based on damage events, there is a significant need for action in introducing digital condition assessments. The results form the basis for the further development of recommendations for action to support the transition from an event-oriented to a risk-oriented and predictive maintenance strategy in the state.

6.3 Outlook

The results of this structural analysis form the basis for the next phase of the Baltic EnerShift (BES) project. To actively address the identified challenges, particularly the looming renovation wave of 1990s infrastructure, a deepening at the operational level is planned for the further course of the project.

To this end, targeted expert discussions are planned with those municipal utilities that have already expressed interest in deeper cooperation within the scope of the survey. The goal of these discussions is to identify specific problem areas in the networks and to directly incorporate the requirements of local practitioners into the development of solutions.

A particular focus lies on the preparation of pilot measurements. Since the purely statistical service life (according to SAM-FW) often does not reflect the real condition, innovative measurement methods are to be used to determine the actual degree of material degradation and thus the realistic age of the pipes. These pilot projects serve as validation for predictive maintenance models, with which suppliers in Mecklenburg-Western Pomerania can make objective and data-based repair decisions in the future. The focus thus shifts away from pure inventory-taking toward the practical field-testing of new technologies.

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