



Training module guidelines

to smart maintenance of district heating networks



LINNAEUS UNIVERSITY
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BSAM-Baltic Smart Asset Management

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<https://lnu.se/en/bsam>

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1 Background and introduction

What is a training module? A training module is a segment of an overall e-learning course that focuses on a specific topic or objective. Each training module acts as a step in a learner's journey, each time edging closer to completing the overall course. Similar features have been facing during preparation of the BSAM training module.

It is important to have a basic platform of knowledge among all stakeholders to ensure the same level to understand the communication through networks using Triple Helix model⁷.

The basic platform of knowledge allows all stakeholders to develop and improve their knowledge and present their needs and viewpoints. Creating own training course may face the difficulties and challenges of its developing. An important residual education gap remains can be covered by university in order to strengthen the stakeholders training course. The main objective of the course will promote cooperation between the academia, industry and public sector based on the Triple Helix concept.

A graduate course in collaboration with the prominent and knowledgeable energy companies can be organized. Also, a master's degree project at an advanced level could be provided and then a doctoral student position can be applied.

In the Figure 1, we show a schematic picture of central heat supply system and specify where the BSAM section is included and how it works within our project to better understanding the BSAM part for any enrolled students in the course.

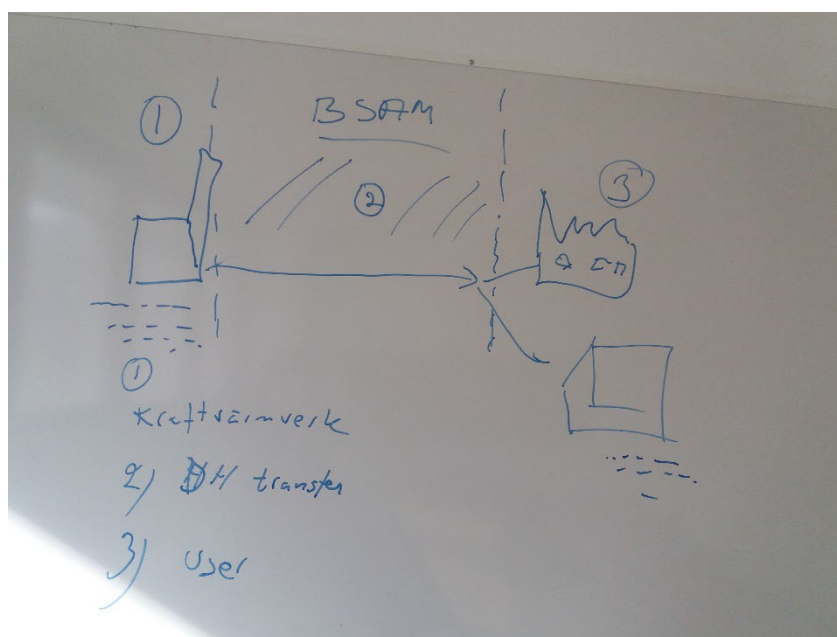


Figure 1. BSAM part (draft by William Hogland).

⁷ The Triple Helix model of university-industry-government relations was introduced in 1995 by Etzkowitz and Leydesdorff (Etzkowitz & Leydesdorff, 1995, 2000; Leydesdorff & Etzkowitz, 1996, 1998), <https://doi.org/10.1002/asi.22931>

Entitlement

Baltic Smart Asset Management – on-line training module

Learning Outcomes

No.	Learning Outcomes	Teaching / Learning Methods	Assessment Methods
1	Knowledge and understanding of district heating systems, exploitation problems and dedicated smart asset management solutions	Interactive lectures, Chat with top-industry experts, Scientific and technical material's analysis	Test, questionnaire
2	To be able to find and evaluate the current situation and data required for a technological action, critically evaluate and present conclusions based on analysis of available information	Case analysis (Pilot cases)	Test, questionnaire
3	To be able to select a technical SAM solution including economical and feasibility study	Case analysis (Pilot cases)	Test, project
4	To be able to work effectively independently and in a team	Case analysis (Pilot cases)	Test, questionnaire

Main aim

The main objective of the study course is to provide knowledge and understanding of using smart asset management solutions for district heating systems in order to monitor and prevent damages/[destruction](#) and increase the reliability and longevity of the system

Summary

In order to boost district heating efficiency and reduce capital need, one of the most needed processes to be implemented are Smart Asset Management (SAM) solutions. This course gives an overview of durability problems in district heating systems together with most popular conventional solutions to solve these problems. In contrary to these traditional solutions, novel SAM solutions are presented and described. The course considers application of different SAM solutions with a

special focus on modern ICT-tools for Data Driven Predictive Maintenance of DH networks. Finally, possibility to take in touch with pilot-cases design, data monitoring and analysis are given.

Level of the course/ The final grade

Evaluation procedure of knowledge and abilities:

The final grade is given based on the BSAM project evaluation test

To understand the strategically political approach to installing pilot cases focusing on phytoremediation solutions and methods, Linnaeus University, Gdansk University of Technology and Klaipeda University are responsible to set the structure of the training programs and coordinate the information for the cross-border distribution. The training program will aim at inviting external stakeholders as well, such as technology providers for BSAM solutions and energy companies in the region. The training module includes both educational elements with the industry's top experts, as well as online tool for further increase of knowledge capacity. The module will be promoted through the website, as well as partners' marketing channel. The module is based on the prior experiences in the WPs (work packages) as well as activities 3.1, 3.2 and 3.3. in work package 3, BSAM Development and Pilot Case Analysis.

Level of the training module: basic, bachelor or MSc, or practical/industrial stakeholders

Target groups: operators of DH networks, DHC engineers and heating planners, pipeline construction specialists, civil engineers involved in heating system construction, energy institute scientist, energy supplier employees and civil engineering students.

Platform: Gdansk Tech e-Learning platform

Access to on-line BSAM Training module: The access to the on-line BSAM training module is open for everyone interested in this sustainable method of environmental and waste management. The access requires logging in the Gdansk University of Technology (Gdansk Tech) IT system, which is possible upon contacting Gdansk Tech representatives or Linnaeus University as Lead Partner of the BSAM.

Link to on-line BSAM Training module:

<https://enauczanie.pg.edu.pl/moodle/course/view.php?id=20455&lang=en>

2 Training module structure

The training module as an e-learning platform is developed at Gdansk University of Technology. It is a modern tool for on-line learning, popular and useful during the pandemic situation. The general a plug-in module configuration webpage is shown in Fig. 2.1. The toolbar clickable icons enable to use various functions, including presentation of graphical materials, organizing on-line meetings/lectures, posting vides form YouTube, organize test or quizzes and manage a training module/course. The overview and general structure of the training module given in Figs. 2.2 and 2.3 and in Table 2.1

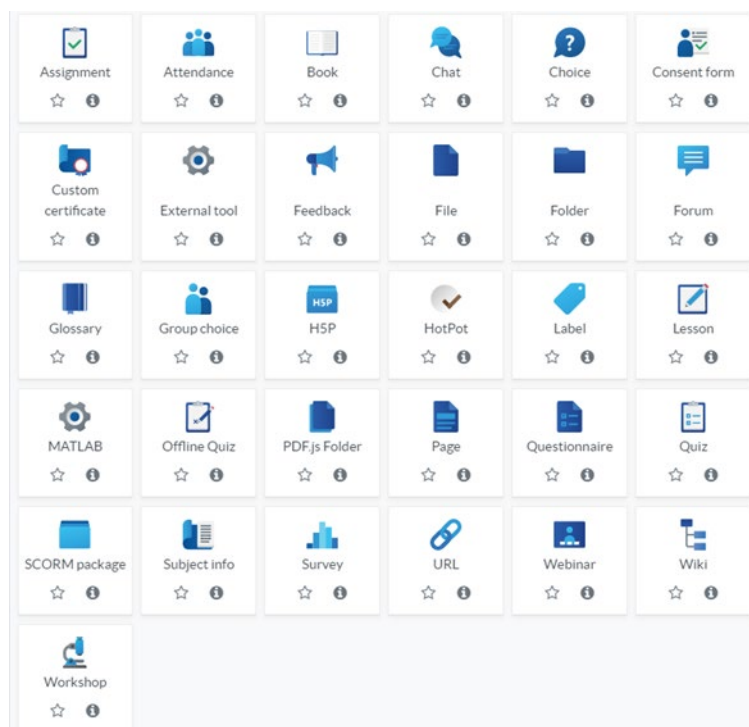


Figure 2.1. A plug-in module configuration webpage.

The screenshot shows a web browser window displaying a Moodle course page. The URL is <https://enauczanie.pg.edu.pl/moodle/course/view.php?id=20455>. The page title is "Baltic Smart Asset Management - Training Module". The left sidebar contains a menu with "General" selected, showing "Announcements" and "Chat for workshops 8-4-2022". The main content area shows the "General" section with an "Announcements" icon and a text box stating: "Important pieces of information on the training module are displayed here. In case of any questions and problems, please send an e-mail to Piotr Rybarczyk." The bottom of the browser window shows the Windows taskbar with various application icons and the system clock indicating 10:41 on 2022-12-27.

Figure 2.2. Overview of the module content (selected fragment).

This screenshot provides a more detailed view of the Moodle course page. The left sidebar menu includes "BSAM Training", "Participants", "Badges", "Competencies", "Grades", "My courses", "Site home", "Calendar", "Content bank", and "All courses". The main content area is titled "Baltic Smart Asset Management - Training Module" and includes a "Turn editing on" button. Below this, there is an "Announcements" section with the same text as in the previous screenshot. The "BSAM TRAINING MODULE PROGRAMME" section lists three items: "Training module programme", "BSAM Training module structure and content description", and "Training module : ideas for discussion among Project Partners". The "About BSAM Project" section includes a "BSAM Project Poster". The "Part 1: District Heating in Lithuania, Poland and Sweden" section includes an "Overview of District Heating in Lithuania". The bottom of the browser window shows the Windows taskbar with the system clock indicating 14:18 on 07.03.2022.



Figure 2.3. General structure of BSAM Training module

Table 2.1 General content of BSAM training module sections (proposal - under development)

No.	Section	Content
1	Introduction (background and aim)	<ul style="list-style-type: none"> About BSAM project Background of the training module (to whom is addressed, what can expect, and what be a result) Aim of the training DH and SAM - general information (short notes or presentation in pdf)
2	Instruction	<ul style="list-style-type: none"> How to go through the training module? Instruction of use, short description of each section – what will be presented in each section
3	Current state of DH in Poland, Lithuania, Sweden	<ul style="list-style-type: none"> General information about status of DH networks in Poland, Lithuania and Sweden (progress from last years, novel solutions, main problems, what have to be done)
4	DH networks – technical aspects	<ul style="list-style-type: none"> Here recorded lectures/presentations with written material will be presented; we may use the material we already have from the previous project seminars/workshops (these were recorded). Exemplary topics could be as follows: <ul style="list-style-type: none"> ✓ Technical details of district heating networks ✓ Novel solutions on repair methods ✓ New construction materials and management approaches Each lecture should be for about 15 minutes, it should be about different 8-10 lectures, written material (pdf of presentation) should also be available.
5	SAM for district heating	<ul style="list-style-type: none"> Commercially-available solutions for SAM in DH systems Identification of barriers and success factors for SAM implementation Here Pilot cases, success stories and real applications of SAM will be presented. Interviews with experts, study tours in BSAM will be presented (movies, written material)
6	Training courses	<ul style="list-style-type: none"> Agendas for previous and future training courses (e.g. on-day training course) and workshops, organized within the scope of BSAM project, will be available here An offer for organizing future training courses on request of interested audience

7	Forum	<ul style="list-style-type: none"> Under this section, participants of training will have an opportunity to contact responsible persons as well as experts in DH sector or SAM for additional questions and discussions A forum for exchanging knowledge, news and ideas will be created
8	Supplementary materials	<ul style="list-style-type: none"> Various materials related DH and SAM will be available here Scientific papers, also published as a results of BSAM project, will be available
9	Knowledge evaluation	<ul style="list-style-type: none"> A test/quiz will be available for the training participants – test will be based on materials presented in sections 2,4 and 5 Participants who obtain more than 75% (or 60%) from the test will obtain a certificate of completion of a course under BSAM Training module

Specific topics included in the module (Power Point presentations are being prepared for each of the topic):

1. Introduction to DH
2. DH Generations
3. Heat Supply Systems
4. Connection Heat Supply and Heat Distribution
5. Heat distribution
6. Heat transfer
7. Challenges in Operating of Heating Systems (describe general info and problems: technical, social, economic, environmental, health care)
8. Preventive Policy for the DH Network
9. Preventive measures for the longevity of the heating system
10. Smart DH strategy (demand/load forecasting, storage of the thermal energy, CHP, RES, digitalization, active box)
11. EU District Heating Systems examples
12. Economic Assessment of DH system
13. Environmental indicators of DH green evaluation
14. DH social issues
15. DH sustainable management under geopolitical pressure

Additional materials will be available on:

Examples of the prevention means:

1. Ensure high water quality to prevent internal corrosion
2. Use pre-insulated pipes with welded muffers and bonded system
3. Ensure outside and inside draining and ventilation of underground constructions
4. Ensure pressure and temperature levels are within parameters
5. Avoid thermal strain on pipes from too fast supply temperature changes

6. Inspect periodically and exchange critical components before they fail
7. Monitor for unwanted behavior, such as pressure and temperature oscillations

Early detection

8. Leakage detection wires in pipe insulation
9. Periodic visual inspections of accessible equipment
10. Thermographic inspection
11. Continuous parameter analysis on available data
12. Regular testing of critical components, e.g. shut off valves and back up units

3 Materials for training module

3.1 Training programme

Teaching in all levels is an important way to increase the interest on SAM methods for District Heating. The training course can be organized physically or in the online mode. The aim of the training programme is a strategic approach with structured dialogues targeting business, public, society, academy and authorities to increase knowledge implementing Data Driven Proactive Maintenance solutions based on the project pilot cases.

Inviting speakers and experts from industry, company and business sector is a teaching strategy to demonstrate a learning collaborative way. Companies' experts should convincingly share innovative ways to increase the efficiency of the heat transfer process, the pipelines lifetime, water preparation, leak detection technologies, accident prevention, DH digitization and neutral climate issues.

With the speakers' permission, the recorded presentations might be available to the training module audience as well as Power Point presentations. Above mentioned, the additional materials as the electronic copies of any scientific papers, handbooks and guidelines can benefit the students from these contributions.

A template schedule given below as example was for a two days' workshop.

BSAM PROJECT TRAINING COURSE'S PROGRAM

“DH: toward efficient heat distribution networks”

DAY 1

25th of March, 2021

Meeting link:

8.55	<p>Welcome</p> <p>prof. dr. William Hogland, prof. dr. Olga Anne - Linnaeus University and Klaipeda University</p>
	<p>Introduction</p> <p>DH from production to customer</p>
9.00	<p>Anna Karlsson, Kalmar Energy (Sweden)</p>
	<p>Pipelines</p>
9.30	<p>The main factors affecting different DH pipelines lifetime</p> <p>Failures and degradation mechanisms</p> <p>Vytautas Džiuvė - “Vilniaus silumos tinklai” CHP</p> <p>Ingas Mikalauskas, AB “Klaipėdos energija” (Lithuania)</p>
10.00	<p>Thermal ageing and mechanical loads. Effects of mechanical loads on the thermal ageing of district heating pipes.</p> <p>Alberto Vega, RISE (Sweden)</p>
10.30	<p>Statistics on the real lifetime of DH tubes. Investigation of pipelines' material mechanical properties degradation depending on operation time</p> <p>Jolanta Januteniene – Klaipeda University (Lithuania), Kamil Roszkowski – OPEC (Poland)</p>
11.30	<p>Relining of DH pipes, avoiding excavation.</p> <p>Andreas Martsman, PPR AB (Sweden)</p>
12.00	<p>Predictive maintenance and sensor boxes.</p> <p>Paavo Persaud, Arne Jensen AB (Sweden)</p>
12.30	<p>Lunch</p>
13.00	<p>Experience of usage of plastic tubes in DH networks</p> <p>Christian Engel, Austroflex (Austria)</p>
	<p>Water preparation</p>
13.30	<p>Requirements (self-regulation) for make-up water and net water quality</p> <p>Water treatments technologies and deaeration methods applied for make-up water in DH systems</p> <p>Richard Bremer, QTF (Sweden)</p>
	<p>Leakage detection</p>
14.00	<p>Tracing of leakage and repair</p> <p>Magnus Ohlsson, Öresundskraft (Sweden)</p>
14.30	<p>Aerial thermography application in DH</p> <p>Patrik Stensbo, Termisk Systemteknik (Sweden)</p>
15.00	<p>Vexve's smart leakage detection system</p> <p>Maria Kalli, Vexve Oy (Finland)</p>
	<p>Conclusions</p>
15.30	<p>The main outputs of the 1st day training course</p> <p>Håkan Knutsson - SweHeat & Cooling (Sweden)</p>

DAY 2

26th of March, 2021

Meeting link:

DH digitalization

- 9.00** **Digital solutions for economic optimization of energy production and the forward temperature in heat networks**
Moa Dahlman - CFO Energy Opticon AB (Sweden)
- 9.30** **Data Analytics**
Christian Johansson – NODA (Sweden)
- 10.00** **Metering and Digitalization in DHC**
Steen Schelle Jensen - Kamstrup A/S (Denmark)
- 10.30** **Smart solution for DH**
Patrick Isacson, Cetetherm AB (Sweden)
Real-time underground network data – a game changer in optimization
- 11.00** **Maria Kalli, Vexve Oy (Finland)**
- Discussion and conclusions**
- 11.30** **Final outputs from the training course**
Håkan Knutsson - SweHeat & Cooling (Sweden)
- 12.00** **The official closure**
Prof. dr. William Hogland - Linnaeus University (Sweden)

3.2 Sample annotated agenda

General objects of the BSAM project are to provide the tools and knowledge to educate potential employees for decreasing the capital need and inefficient operation (losses) of District Heating Grids as seen by the low return on capital and a massive replacement need.

How to find the leaks with aerial thermography? How to get installation/proposal for relining of district heating pipes? Can a cyclic mechanical load affect the properties of DH pipes? These and many other questions are important topics for discussion through attending seminars and workshops. The experts in district heating and cooling could possibly take part in the virtual or onsite workshops to have a possibility to dive deeper into the topics. Listening to other experts, an inspiration for new ideas and solutions may come up.

The training workshop can be combined of two parts: one of the information to the subject and the second part for follow-up actions and results.

The structure of the training programs could be based on following goals:

- to increase the knowledge around the different parameters that can affect the lifetime of district heating pipes during service time
- to better understanding of preventive and predictive maintenance as well as the strategically political approach to installing pilot cases focusing on data driven proactive and preventive maintenance methods in the South Baltic, and to co-ordinate the information transfer for the cross-border distribution.

The samples of the announcement shown below in Fig. 3.2.1.

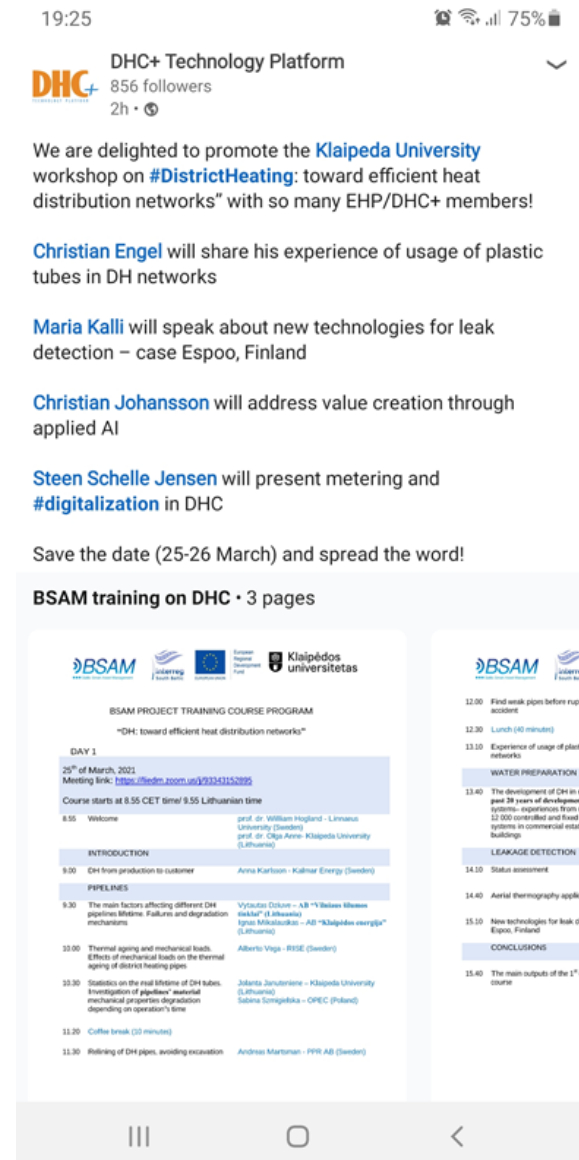


Fig. 3.2.1. Samples of BSAM training workshop invitation.

4 Cross-border collaboration

5 Conclusions

Both theoretical and practical knowledge should be included in the course. The educational elements with the industry's top experts, as well as online tools for further increase of knowledge capacity are included. The module may be promoted through the website, as well as partners' marketing channels. The practical and learning collaborative strategy is conducted to revolve developing

teaching, by formulating and answering questions. In addition, the possibility to take in touch with pilot-cases design, data monitoring and analysis given.

Training module can vary in format, from interactive videos and quizzes to text rich modules or demonstrations. Ideally, it's best to incorporate a blend of different training module types to ensure you're catering for different learning styles and promoting stakeholders engagement.

The important points of BSAM project countries to reach more than 50% for DH market share, future proofing aging DH systems that enable its conversion – decarbonization. The priorities as renewable energy expansion, energy efficiency and digitalization might be taking into account to nearest future, to the next course.

5. Extra resources

1. Czaplicka, N., Grzegórska, A., Wajs, J., Sobczak, J., Rogala, A. “Promising Nanoparticle-Based Heat Transfer Fluids—Environmental and Techno-Economic Analysis Compared to Conventional Fluids”, Int. J. Mol. Sci. 2021, 22(17), 9201; <https://doi.org/10.3390/ijms22179201>
2. Embedding a Module into an Article (Joomla 2.5) <https://www.cloudaccess.net/joomla-knowledgebase/77-joomla-2-5/article-manager/113-embedding-a-module-into-an-article-joomla-2-5.html>
3. [Euroheat & Power](#)
4. Grzegórska, A., Rybarczyk, P., Lukoševičius, V., Sobczak, J., Rogala, A. “Smart Asset Management for District Heating Systems in the Baltic Sea Region”, Energies 2021, 14(2), 314; <https://doi.org/10.3390/en14020314>
5. <https://chem.pg.edu.pl/en/bsam/bsam-training-module>

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