Baltic Smart Asset Management – data driven predictive maintenance methods for future

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Abstract. This Interreg project Baltic Smart Asset Management focuses on District Heating (DH) studies in the three Baltic countries Lithuania, Poland and Sweden. Some part of the grids in the member countries start to be old and safe, secure and affordable energy supply must be delivered and reduction of CO₂ emission is obvious though boilers are fed by gas, oil, coals and solid wasted and renewable energy sources must be used instead. The paper gives some basic information about district heating system and how the countries through a cross-border strategy will create awareness of preventive data driven maintenance methods energy companies based on the educational purpose to decrease harmful emissions to environment. As technological methods has improved greatly in recent years these should be given more consideration as a possible treatment option of DH instead of chemicals which can have Environmental impact in the form of the influence of metals and degradation of habitat, species etc. Involvement of associated partners and stakeholder in the work is of high importance in the project.

1 Introduction

In order to create comfortable heating and cooling of homes, business and public buildings we need district heating systems. District heating has a long standing tradition in Sweden and today it is the most common way of producing and transporting heat [1]. The first district heating system in Sweden was constructed in the middle 20th century. It was considered environmentally friendly but it was also targeted to be flexible and adaptable for different town districts application but also with high security. First industrial plants, large enterprises, shops and housing associations was served first and later multiple story dwellings and private residences and much later one family houses. Earlier urban district heating plants where replaced by systems of district heating pipes. The systems where heated by boilers mainly fed by coal and peat. Some costumers needed steam which give higher supply temperature, which is needed within pharmaceuticals and food industry, as well as in some other industrial process need steam but it more common to use water as medium than steam, which give less energy losses. In some countries during the early stage of installation, it was easy to track the district heating pipe system due to the snow has melted on top but today the distribution pipelines are highly insulated. Swedish district heating has contributed to the entire Swedish
heat supply being largely fossil fuel free. Others being in the front is the Netherlands where 95% is natural gas heating.

The district heating (DH) system is commonly divided into four parts 1) the production facility 2) distribution network 3) second heat stations 4) the costumer network and facility. The heat produced in the facilities is distributed to the customers via a heat transfer medium, usually water (DH water), in piping networks that make up the DH network [2]. The heat is transferred to the customers via the heat exchanger at which point they can use it as heated tap water or for heating purposes. In some town districts DH are old and are leaking. As for the sanitary sewage nets there are a need for refurbishment to renew the grid. When talking about the sewage net with the speed of renewing as exist today the time 300-400 years has been mentioned to upgrade the entire net. The need of renewing of the DH is not fully understood today but it is clear the system become weaker and weaker and need strategical control and repair. The fluids in the heating and cooling system have a high potential of environmental impact. The DH networks are often constructed in steel as it is cheap and a relatively resistant material. However, it has the disadvantages of corrosion and expansions when it is exposed high temperatures which lead to damages in the DH network resulting in loss of the DH water, this is an unavoidable occurrence in any DH network. This results in addition of pollutants by leakages into the DH network or with the water that is used to compensate for the losses. When a breakage of the pipes system occurs and the hot water sprays out in the vicinity to a school day care centre or a city centre or heavy traffic road. It happens the concertation leaking water exceed the limit values which could have toxic / very toxic effects on aquatic animals and plants. High oxygen content, conductivity and chemical oxygen demand, gives a great risk of degradation and corrosion of the district heating system that also adds metals to the water. The pollutants cause further corrosion, leading to metal contamination, and more damages on the DH network meaning there is a continuous degradation [3]. Therefore, various treatments are used to clean and ascertain an acceptable chemical environment in the DH systems. These treatments are effective but not at a level which is required so many chemicals are used to enhance the treatment of the water. Some of these are known to be toxic to humans and water ecosystems. The cogeneration of fuel and renewable forms of energy sources makes the new technologies more environmentally friendly and the development goes fast. New systems for measurements of the corrosion and reduction need to be more sophisticated.

2 BSAM project

To achieve Europe 2020 objectives a major challenge including increase of energy efficiency and also reduce carbon dioxide emissions. The running Baltic Smart Asset Management has the target to create both environmental benefits for the Baltic Sea region and deliver cheaper heat for the customer by using our existing assets and resources longer and more efficiently including both fuel and energy savings. Methods will be developed and transnational cooperation in the Baltic Sea region will be carried out to improve the knowledge related to district heating processes. Obstacles are identified and removed for development and implementation of future district heating networks. Still the European Union is too dependent on import of coal and gas. Efforts must be done to modernize the existing grids and its infrastructure and promote energy efficiency and reduce heat loss as well target for green energy. The partners involved in this Interreg project is Linnaeus University, Swedish Council of District Heating and Cooling and Öresundskraft from Sweden; OPEC Gdynia Energy Company and Gdansk University from Poland; Lithuanian District Heating Association and Klaipeda University from Lithuania as well as 4 associated partners. There is a critical mass with expertise with knowledge on maintenance methodology to applied infrastructure for municipal as well as industrial district heating and sanitation. Öresundskraft
is developing methodologies for examination and prevention of damages and avoidance of open leakage in the city where streets are able to collapse and citizens facing huge physical risks to the body. In figure 1 a district heating pipe system is shown from inside the culvert and installation of sensors for tracing potential section for future leakage in the grid.

**Fig. 1.** District heating pipe system and installation of sensor system for measurement of the thickness of metal in the pipe.

**Fig. 2.** Sensor for measurements of thickness of pipe metal walls

It is very important to make future research in the district heating area. Economic, technical and maintenance benefits can be archived if cooperation with sanitary engineering research so modern repair and reinvestments strategies are developed in common. District heating might be combined with other environmental technologies and circular flow in society as phytoremediation. It is possible to burn biomass with high content of heavy metals in waste incineration plants with advanced ash and flue gas treatment. In Sweden research on Sustainable Cities has been to some extent been focused on organization of expansion and exchange of critical infrastructure across industry boundaries eg. drinking and sewage waters system, storm and drainage, electrical cables, optical fibers and other infrastructure facilities and technologies. In order to make it easier to detect leakage from district heating systems, the water is colored. In figure 3 such discharge to a pond can be seen and also here plants have function in the remediation process.
3 Pilot Cases

Within the project two pilot cases are going to be carried out based on a three step approach including a) Data Driven ICT-analysis of the District Heating-grids, b) Implementation of smart innovative maintenance methods and green solutions, c) Organizational enhancement of capacity through educational program. OPEC plan to install ultrasonic flowmeters on selected sections of the pipe network. This investment focuses on increase of the efficiency of the heating network, leak detection and optimization of heating management. Ultrasonic flowmeters are considered as one of the most efficient for district heating systems. They will search for cracks that may occur in the basic material of the pipe, in welds and in the heat-affected zone adjacent to welds. They will control older pipelines and detect stress cracking and other types of cracks. Öresundskraft is in the stage of formulate their case study in detail.

4 Water Quality Indicators DH systems

Leakage of district heating water is common, and this is expected to increase in the future as distribution networks become older. Chemicals are added to the networks to protect the pipe systems. It is known that some of the chemicals can be harmful in water ecosystems and that district heating water falls into wastewater treatment plants. Therefore, a respirometric analysis was carried out to assess how district heating water affects the active sludge process [4]. Water from two district heating networks, Kalmar and Växjö, was tested on active sludge from Tegelviken's sewage treatment plant in Kalmar. A metal analysis was performed to assess any possible toxicity of corrosion products in the water. The district heating water from Kalmar inhibited nitrification by about 20% for all concentrations tested, despite the large differences in concentration (6.25%, 25%, 50% and 100%) used in the test. The district heating water from Växjö showed a negative correlation between an increase in concentration and an increase in toxicity, 74% (6.25%) -11% (100%). Unlike Kalmar's district heating water, Växjö's water has a stronger inhibition at low concentrations than at high. Corrosion products were excluded as probable sources of toxicity as the metal analysis showed no significant concentration of ordinary metals. The decisive conclusion was thus that the chemicals are the probable cause of the inhibition.

Reduction of the use of chemicals for treatment and release of DH water to WWTPs should therefore be considered. As technological methods has improved greatly in recent years these should be given more consideration as a possible treatment option instead of chemicals.

In Lithuania water quality indicators have been studied, see Table 1.
| Nr. | Indicator | Unit                  | Network water | Topping up water |
|-----|-----------|-----------------------|---------------|------------------|
| 1   | pH        | 8.3 – 10              | 8.5 - 9.5     | 7 - 10           | 8.5 - 9.5        |
| 2   | Water hardness | μg-equiv/l | 20 – 500    | Not regulated   | 3 - 500          | Not regulated   |
| 3   | Calcium hardness | mg-equiv/l | 0.02 - 0.2 | Not regulated | 0.02 - 0.25     | Not regulated   |
| 4   | Alkalinity | mg-equiv/l | 0.3 – 8    | Not regulated   | 0.3 – 8          | Not regulated   |
| 5   | Iron compounds | mg/kg       | 0.02 - 0.98 | < 0.5          | 0.01 - 0.6       | < 0.5           |
| 6   | Suspended solids | mg/kg | 0 – 5     | < 5           | 0 - 5            | < 5             |
| 7   | Oil products | mg/kg       | 0 – 1      | < 1           | 0 - 1            | < 1             |
| 8   | Oxygen concentration | mg/kg | 5 - 20 | < 20       | 5 - 50           | < 20            |
| 9   | Carbonate index | (mg-equiv/kg)² | 0.1 - 3.2 | Depending on temperature | 0.02 - 3 | Depending on temperature |
| 10  | Carbonic acid | mg/kg       | 0          | 0             | 0                |
| 11  | Phosphate concentration | mg/kg | 0.2 - 3.5 | Not regulated | 0 - 3.5          | Not regulated   |
| 12  | Specific electrical conductivity | μS/cm | 725 – 950 | Not regulated | 380 - 820        | Not regulated   |
| 13  | Silicates | mg/kg SiO₂ | 0 – 15 | Not regulated | 0 - 15           | Not regulated   |
| 14  | Other water quality parameters? |          |            |                |                  |

If leakage happens and ends up in a waste water treatment plant which often gives disturbances in the biological treatment and have toxic effects on the activated sludge process.

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