LATVIJAS UNIVERSITĀTE ANNO 1919
NACIONĀLAIS ATTĪSTĪBAS PLĀNS 2020
EIROPAS SAVIENĪBA
Eiropas Reģionālās attīstības fonds
IEGULDĪJUMS TAVĀ NĀKOTNĒ

Decision Support Tool for Decarbonisation Assessment of District Heating Systems

Annual report on dissemination, communication, mobility and training activities, and progress and risk monitoring: 2022 (*Deliverable D4.3.)*

START

Prepared within the project "Decision Support Tool for Decarbonisation Assessment of DistRicT Heating Systems (START), Nr. 1.1.1.2/VIAA/4/20/604

Postdoctoral researcher: Jelena Ziemele
30.11.2022.

CONTENT

General information about the postdoc project

The scientific aim of START project is to develop a decision support tool for identifying the decarbonisation level for scenarios in the transition towards the 4th generation district heating (4GDH) system. The 4GDH includes the sectors coupling or cross-sectoral interconnection (SC/CSI), transition to low-temperature system and 100% RES. Thus, this tool will present various development scenarios for decarbonisation and select the most sustainable option for the development of the studied systems under various conditions. **The novelty of this project** is to connect Life Cycle Carbon Assessment with the System Dynamics model of the district heating system that provides the transition from the existing system towards 4GDH.

Results of the project: Four activities are planned in the project:

1. Definition and validation of the SD model for the reference DHS,
2. Scenario development and conceptualisation of their comparative assessment,
3. Development and application of the hybrid SD-LCCA-MCA model for ranking of scenarios,
4. Knowledge transfer, mobility, and training.

At least two peer-reviewed papers in scientific journals indexed in international scientific databases will be published during this project. International cooperation with European universities in the field of energy planning and smart energy systems will be developed.

As a result of the project, the postdoctoral researcher will significantly improve her scientific, managerial and communication skills, which will help her achieve the status of an independent, mature researcher.

The proposed study is directly related to the two areas of the Latvian Smart Specialization No. 3 "Smart Materials, Technologies and Engineering Systems" and No. 4 "Smart Energy". The planned result of the research will impact the innovation capacity of Latvia, mitigate climate change, promote business competitiveness and ensure the resilience of the local energy system.

Project period: 01.015.2021. – 30.06.2023. (30 months)
Project costs: 111 504.90 (94 779.16 EUR from EU as ERDF funding; 5 575.25 EUR – the share of the University of Latvia)

Source of funding: European Regional Development Fund Specific Objective 1.1.1 “Improve research and innovation capacity and the ability of Latvian research institutions to attract external funding, by investing in human capital and infrastructure” 1.1.1.2. measure “Post-doctoral Research Aid”. Project application selection round No.4.

Project Leader: Researcher, Dr.sc.ing. Jelena Ziemele, jelena.ziemele@lu.lv

1. DISSEMINATION, EXPLOITATION AND COMMUNICATION ACTIVITIES

Three scientific articles have been envisaged to report the results of the project. In the second year of the project, one article Janis Edmunds Daugavietis, Raimonda Soloha, Elina Dace, Jelena Ziemele “Comparison of Multi-Criteria Decision Analysis Methods for Sustainability Assessment of District Heating Systems” has been published in the journal Energies (MDPI, ISSN: 1996-1073, Impact Factor 1.104, CiteScore 5.0, https://doi.org/ 10.3390/en15072411). The article can be found in the SCOPUS database https://www.scopus.com/record/display.uri?eid=2-s2.0-85127424064&origin=resultslist&sort=plf-f

The article presented a comparison of different multi-criteria decision analysis (MCDA) methods. The sustainability of energy systems is increasingly assessed for development of more resilient, greener district heating (DH) systems. That requires compiling technological, environmental, economic indicators in a social, political, and institutional context. This work investigates DH system sustainability analysis by five frequently applied MCDA methods – WSM, TOPSIS, PROMETHEE, ELECTRE and DEA. To compare the sustainability assessment results, a selection of 8 criteria describing 12 DH companies (DHC) was examined. Sensitivity analysis was performed to determine the most credible MCDA method. Criteria weights were changed: (1) individually for evaluation of the range of stability for alternatives (score of DHC performance); (2) individually by a fixed value to compare how each criterion weight change affects the average score of a result; (3) to compare the AHP weighting method to an equal weight scenario. The results of sensitivity analysis along literature investigation shows that all methods are suitable for sustainability analysis of DH systems while also having differences in calculation process and result interpretation. The generalized algorithm for sustainability analysis in the energy sector outlined in this study along with the documented features of main MCDA methods can be used as a guide for future assessment of energy systems by researchers and industry professionals.
Second scientific article J.Ziemele, E.Dace "An analytical framework for assessing the integration of the waste heat into a district heating system: Case of the city of Riga" was published in the International Journal Energy (Elsevier, ISSN: 0360-5442, Impact Factor 7.147, CiteScore 11.5, https://doi.org/10.1016/j.energy.2022.124285). The article can be found in the SCOPUS database https://www.scopus.com/record/display.uri?eid=2-s2.0-85131574864&origin=resultslist&sort=plf-f. The article is dedicated to research of waste heat integration into the DH system. Waste heat diffused in the urban environment gives floor for considering this heat for integration into the DH systems. This article presents an analytical framework for assessing the integration of waste heat (WH) into a DH system. The framework is used to estimate whether a selected case study area (city of Riga) can achieve carbon neutrality by implementing three different pathway scenarios of an efficient DH system. The system dynamics modelling approach is used to operationalize the framework and identify the drivers of waste heat integration. Energy, economy, environmental and social indicators are selected and assessed. In case of waste heat integration, the primary energy factor is reduced 2.6 times and 86% of CO2 emissions are avoided. That moves the selected DH system closer to the carbon neutrality target yet does not allow to achieve it completely. The results show that a positive contribution is made to consumer welfare as the result of avoided heat expenditure. Thus, providing a DH system's services that utilise waste heat is justified not only from an environmental, but also from an economic and a social perspective.

The project envisages three presentations at International scientific conferences on their results. During the second postdoc project year one of the research topics was dedicated to development of a methodology to support decision-making for decarbonization scenarios of cities. Scenarios study transition towards a sustainable 4th generation district heating (4GDH) system combined with renovation of existing building stock and development of newly built areas in the long-term perspective (till 2050). Several scenarios are proposed where a multi-generative DH system is assessed by implementation of industrial heat pumps, solar systems, and low-temperature regime into an existing DH system that currently is based on biomass and natural gas combustion technologies. Changes in the heating load of a DH system due to improvement of building energy efficiency are studied in combination with three weather scenarios – low RCP2.6 (Representative Concentration Pathway); medium – RCP4.5, and high – RCP8.5. Heat balance model of buildings combined with system dynamics model estimates the potential of climate change impacts on the DH system of the Riga city.

The obtained calculation and modeling results were presented at the 8th International Conference on Smart Energy Systems in September 13-14, Aalborg by presentation "Impacts of global warming and building renovation on the heating energy demand and district heating capacity: Case of the city of Riga".

I virtually participated in the 17th Conference on Sustainable Development of Energy, Water and Environment Systems (SDEWES), which was held November 06 – 10, 2022 in Paphos, Cyprus. The presentation title is "Comparative assessment of heat recovery from treated wastewater in the district heating systems of the three capitals of the Baltic countries", Jelena Ziemele, Anna Volkova, Eduard Latõšov, Lina Murauskaite, Vytautas Džiuvė.
The aim of this study was to evaluate the integration of waste heat (WH) into a district heating (DH) system via absorption heat pumps. While all cities have great potential for sewage wastewater (WW) and treated WW, they are still an underutilized heat resource in many European cities, including the three Baltic capitals of Tallinn, Riga, and Vilnius. The study presents a three-step methodology that develops an innovative multi-dimensional approach to energy poverty analysis and includes the three main drivers of energy poverty: fuel prices, household income, and energy efficiency. The study shows that the integration of the WH is economically feasible from the consumer's point of view and reduces energy poverty.

At the national level, the project results were to be disseminated in three events for a professional audience. One of these events took place on September 6, 2022, where the impact of global warming and building renovation on thermal energy demand and district heating capacity was discussed with the representative of the Sustainable Energy Policy Department of the Ministry of Economy and Riga City Council.

The second and third events took place on September 7 and December 6, 2022, where a relevant topic that related to waste heat recovery from treated wastewater was discussed with the representatives of Riga Municipal Agency "Riga Energy Agency".

The presented results of the study could be exploited for the development of sustainable energy action plans of Riga city.

The communication activities of the project include (chronologically):
1) Participation in the Vidzeme Innovation Week's event "Kas vienam lieks, otram – prieks! Bet ko darīt ar ražošanas blakus produktiem un bioatkritumiem?" with presentation "Wastewater treatment process heat as a valuable by-product" on February 23, 2022; 2) presentation to and discussion with researchers from Tallinn Technology University, School of Engineering, Department of Energy Technology about future district heating and cooling system development as a part of an integrated energy supply system that is based on smart and sustainable low or zero-emission technologies; 3) discussions with representatives of the Energy Technology Department of Tallinn University of Technology Anna Volkova, Andres Siirde, Igor Krupenski, Eduard Latõšov, Kerta Lepiksaar, Siim Poom during the short-term visit on April 11, 2022 about integrated energy system development in Baltics states; 4) presentation of the postdoc project results for the representative of the Sustainable Energy Policy Department of the Ministry of Economy and Riga City Council on September 6, 2022; 5) presentation about possible development project of waste heat recovery from treated wastewater for the representatives of Riga Municipal Agency "Riga Energy Agency" on September 7, 2022; 6) participation in the 8th International Conference on Smart Energy Systems in September 13-14 in Aalborg with presentation "Impacts of global warming and building renovation on the heating energy demand and district heating capacity: Case of the city of Riga"; 7) postdoc project results presentation and discussion in Vilnius on September 15 for representatives of district heating companies and national district heating associations of Sweden, Lithuania, Latvia, and Estonia by the presentation "Impacts of global warming and building renovation on the heating energy demand and district heating capacity: Case of the

city of Riga"; 8) presentation to and discussion with researchers from the University of Parma (UNIPR), Department of Engineering and Architecture about the transition of the district heating system towards 4th generation, Power-to-X technologies implementation as part of the smart energy system during the mobility visit from September 18 until September 30, 2022; 9) virtually participation in the 17th Conference on Sustainable Development of Energy, Water and Environment Systems (SDEWES), which was held November 06 – 10, 2022 in Paphos, Cyprus, with the presentation "Comparative assessment of heat recovery from treated wastewater in the district heating systems of the three capitals of the Baltic countries"; 10) meeting with students of Riga Hansa Secondary School November 24, 2022 with a presentation and the following discussion and workshop on the topic "Sustainable development of energy supply"; 11) discussed with the representatives of Riga Municipal Agency "Riga Energy Agency" about possible project of heat recovery from treated waste water from waste water treatment plant "Daugavgrīva" in Rīga.

A dedicated section has been developed at the website of the University of Latvia (https://www.lu.lv/zinatne/programmas-un-projekti/es-strukturfondi/1112-pasakums-pecdoktoranturas-petniecibas-atbalsts-4-karta/lemumu-pienemsanas-atbalsta-riks-centralizeto-siltumapgades-sistemu-dekarbonizacijas-novertesanai/), that informs visitors about the project's aims, tasks, and progress, while also providing links to all results published as an outcome of the project (information is provided in Latvian). Also, the website of the Computational Systems Biology Group (https://www.biosystems.lv/start) holds a section dedicated to the project (information is provided in English). In addition, a project has been developed at ResearchGate (https://www.researchgate.net/ profile/Jelena_Ziemele) where periodic updates of the project's progress are published. Information about the START project and its results was posted on the professional web sites of the postdoctoral researcher LinkedIn (https://lv.linkedin.com/in/jelena-ziemele-77835b5b/).

At the beginning of the project, an information plate (A3 size) about the project and funding provider was placed in the premises of the University of Latvia – the House of Nature. The plate will be maintained for the whole project, thus informing employees and visitors of the House of Nature and acknowledging the financial supporter of the research project.

2. MOBILITY AND TRAINING ACTIVITIES

A virtual mobility visit to Tallinn University of Technology (TalTech), School of Engineering, Department of Energy Technology was implemented from February 28 until March 22, 2022. Topical issues in the field of district heating system transition towards 4th and 5th generation, innovative technologies implementation, and the district heating sector impacts to city decarbonization policy (in accordance with a previously agreed program), as well as possibility for cooperation in applying for European-funded projects. Additionally, the scientific article with a title "Comparative assessment of treated wastewater heat recovery into district heating systems of the three Baltic capital cities" was created. The topics discussed during the mobility are set out in more detail in the report. The previously approved virtual mobility visit program was completed, and it is confirmed by senior researcher Anna Volkova (Head of research group "Smart District Heating Systems and Integrated Assessment Analysis of Greenhouse Gasses Emissions").

A mobility visit to the University of Parma (UNIPR), Department of Engineering and Architecture from September 18 until September 30, 2022. Topical issues in the field of district heating system transition towards 4th and 5th generation and Power-to-X technologies implementation as part of the smart energy system were discussed during the mobility visit. A potential future collaboration and partnership in a European project open-call "CETPartnership.

Clean Energy Transition Partnership. CETPartnership Joint Call 2022" was also discussed. During the mobility, the district heating source of the campus of the University of Parma was visited. Perspectives, advantages, and disadvantages of gasification technology development were debated. During the mobility visit, the possibility of creating a joint conference paper with the title (draft version) "Evaluation of the validity of the integration of power-to-x technology in the centralized heat supply system: the case of the city of Riga" was discussed.

Several national and international level webinars and conferences have been attended to learn about a range of topics, including scientific, motivational, managerial, and personal development topics. No certificates of attendance have been received, yet the post-doctoral researcher has used the vast opportunities provided by organizers of virtual events available during the pandemics.

The planned milestones and deliverables of the project were achieved on time.