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| **Descriptive form** | |
| **Program name** | The Clean Energy Transition Partnership (CETPartnership) |
| **Call module** | TRI 4: Efficient Zero-Emission Heating and Cooling Solutions |
| **Website of program** | https://cetpartnership.eu/ |
| **Project name** | **H**eat **E**nergy **R**ec**O**very from **WASTE**water: **HERO-WASTE** |
| **Project duration** | Max 36 months |
| **Aim of project** | The main purpose of this project is to determine the heat energy recovery potential of wastewater at different points of a municipal wastewater treatment plant (WWTP) with a pilot-scale heat energy recovery system that involves a heat pump and a heat exchanger, and to propound the optimum point for heat energy recovery as well as evaluating possible usage area of the recovered heat energy within the WWTP. |
| **List of partners and a brief explanation of their role in the project** | 1. Istanbul Technical University (ITU) 2. Istanbul Water and Sewerage Administration (ISKI) 3. Potential Partner-1 4. Potential Partner-2   In HERO-WASTE Project, ITU will take part in the scientific research part, and will be responsible to conduct research studies and evaluate the results of the study. ISKI will provide support to the project in terms of providing the required space for research activities at the selected WWTP. A pilot-scale heat energy recovery system that involves a heat pump and heat exchanger, will be established by the Potential Partner-1 to be located at different points in WWTP. A mathematical model will be developed by Potential Partner-2 for a full-scale heat energy recovery system using experimental data obtained from the pilot scale system. With this collaboration, a sustainable solution for the problems concerning energy demand and carbon footprint with the implementation of a heat energy recovery system will be proposed. During and/or after the completion of the project, project results will be shared with academia and industry. Publications related to heat recovery from wastewater are expected. |
| **The expected role from the Potential Partner-1** | The potential partner will be responsible to install and turnkey a pilot-scale heat energy recovery system that involves a heat pump and heat exchanger for different points of the WWTP. The system to be installed should be suitable for different flowrates and temperatures of wastewater since the wastewater flow and temperature would be different at different locations in WWTP. |
| **The expected role from the Potential Partner-2** | Potential Partner-2 will be responsible for developing a mathematical model for a full-scale heat energy recovery system. |
| **Brief Information About the Project** | Space heating, cooling, and domestic hot water supply account for the majority of energy used in buildings. Hot water in buildings is used for a variety of purposes including showers, sinks, dishwashers, washing machines, and more. On the other hand, wastewater, dissipated from these, retains a significant portion of its initial energy, which can be recovered. By recovering waste heat, the use of fossil fuels in order to heat domestic hot water can be reduced, thereby reducing greenhouse gas emissions into the atmosphere. According to the World Green Building Council, around 28% of global carbon dioxide (CO2) emissions come from building operations, due to the energy used for heating and cooling. Moreover, the European Council published “The 2030 Climate and Energy Framework”, aiming at reducing greenhouse gas emissions by 40% by 2030, and by 80-95% by 2050, relative to the 1990 levels. A renewable energy share target of at least 27% was defined as well. China, the world's biggest emitter of CO2, is aiming to be carbon neutral before 2060 and achieve 60–65% carbon intensity reductions by 2030. Similarly, Europe's ambition is to become the world's first net-zero emissions continent by 2050, compared to1990 levels. Besides, in the United States (US) a target of net-zero emissions by 2050 was announced based on Paris Agreement.  Conventional heating and cooling systems are not suitable for reaching net-zero emission target since they have high CO2 emissions. Thus, the use of technologies, that has low carbon footprint for heating and cooling in residential, commercial, and industrial settings in the world, is needed. Heat pumps, one of the most important environmentally friendly technologies, have been used for a long time in developed countries due to their high energy efficiency. Heat energy recovery systems including a heat pump and heat exchanger can radically reduce the carbon footprint of buildings compared to fossil fueled boiler systems. In wastewater heat pump system, heat exchanger systems are used to provide the energy required for both heating and cooling. However, wastewater may contain various solid particles. For these systems, specific heat exchangers that do not fall under conventional classifications of the heat exchangers should be designed and used. On the other hand, wastewater was officially recognized by the European Union as a renewable source of energy, with the EU Directive 2018/2001. Hence, this source of energy may become a new constituent of sustainable energy supplies, contributing to more efficient resource use, and reducing pressure from other renewable energy sources that are needed to achieve energy transition. Converting wastewater into a valuable resource with heat energy recovery technology has become increasingly popular due to the advantages of relatively higher energy utilization efficiency and environmental protection. Using a heat energy recovery system for municipal wastewater has lots of advantages including a higher energy efficiency when compared to other heaters (electric boiler, gas boiler, oil and coal boiler), a higher coefficient of performance than the other source heat pumps (air and ground source heat pump), high potential due to high flowrates and an environmental-friendly technology that emits no air pollutants. Moreover, municipal wastewater can be considered as a reliable energy source for heat energy recovery system as the temperature of wastewater is stable throughout the year. There are various applications of heat energy recovery systems from wastewater at different scales in the world. Heat energy is recovered from wastewater by heat energy recovery technology with a capacity of 18.4 MW in Oslo (Norway), and it has a significant contribution to the air conditioning of more than 9000 buildings and provides an annual fuel saving of 6000 tons. WWTPs in Austria contribute 40% of the installed heat power in district heating grids. Besides, in Finland in the Turku region, a new facility, including two 21 MW heat pumps to recover heat energy from wastewater, was built. The facility produces 302 GWh of heat annually, which corresponds to 8% of its district heating. The heat has mainly replaced burning oil and coal, which is estimated to have replaced 5.7 TWh of fossil heat production and reduced emissions by 1.7 MtCO2. Denmark is a well-known country for smart sustainable energy solutions in cities, and it has a unique energy plant, including heat pumps and a chilled water tank that combines smart use of electricity, district heating, and district cooling. Produced heat from wastewater in Taarnby covered around 60% of the total heat demand for large buildings in the municipality, including Copenhagen Airport.  In this project, energy recovery potential from wastewater at different points of a WWTP in Istanbul will be examined. To reveal the current energy recovery potential of wastewater with a heat pump system, the pilot scale heat energy recovery system, that consists heat pump and heat exchanger, will be located at different points in WWTP. The heat energy recovery potential of municipal wastewater per m3 wastewater treated will be determined for each point. Besides, in the project, possible usage areas of the recovered energy will also be investigated within WWTP. The heat energy recovered from wastewater has a great potential for energy-neutral or positive WWTPs. There is a significant amount of energy consumption in WWTPs: Energy consumption for advanced biological WWTPs in Istanbul ranged between 19 and 31 kWh/PE.year. Anaerobic digester (AD) is one of the treatment units with the highest energy consumption in WWTPs. Generally, the ADs are operated at either mesophilic (35 °C) or thermophilic (55 °C); therefore, high heat energy is needed to keep it constant at the desired temperature. In addition, heat energy is also needed for sludge drying units and air conditioning at WWTPs. To provide a better understanding of environmental impacts and the economic performance of each point, a Life Cycle Assessment (LCA) and a comprehensive economic evaluation will be conducted.  In 2021, leaders from 200 countries attended to the United Nations (UN) Climate Change Conference (COP26) to review and update their Nationally Determined Contributions regarding climate change. Turkey has set the target of achieving net zero emissions by 2053 and should reduce its emissions by 35% until 2030. Renewable energy sources can decrease carbon emissions and efficiently meet energy demand worldwide. Wastewater has been approved as a renewable heat source. This project is supposed to provide valuable technical insights to reveal current heat energy recovery from wastewater in Istanbul with a heat energy recovery system, and the applicability of this system in a full-scale WWTP. Considering that the amount of wastewater treated at WWTPs in Istanbul is around 4,100,000 m3/day for 2021, it can be stated that there is a significant and continuous energy recovery potential from wastewater with the use of heat energy recovery systems. Accordingly, the project is fully compatible with the Sustainable Development Goal 7 (SDG7), as it contributes to energy recovery and a low carbon footprint with a circular economy concept. Residential buildings should be close to the source of this heat for district heating. This project is of utmost importance as it will ensure a sustainable solution for the problems concerning energy demand and carbon footprint with the implementation of heat energy recovery system. |
| **Profiles of partners for carrying out the proposed activities** | **Istanbul Technical University (ITU)**  ***Assoc. Prof. Hale Ozgun***  Assoc. Prof. Hale Ozgun graduated as an environmental engineer from Istanbul Technical University (ITU) in 2004 holding the first rank both in the department and faculty. In 2005, she graduated as an industrial engineer from ITU. She received her MSc degree from ITU, Department of Environmental Engineering. She holds a joint doctoral degree in Environmental/Sanitary Engineering from Delft University of Technology (the Netherlands) and ITU (Turkey). Her doctoral dissertation focuses on the treatment of municipal wastewater by Anaerobic Membrane Bioreactors (AnMBRs). She got the PhD fellowship award provided by Turkish Academy of Sciences (TUBA), German Water Partnership-Award Turkey 2015 and ITU-2015 The Most Successful Thesis Award from her PhD topic. She is currently working in ITU as an associate professor at Environmental Engineering Department. Her main research areas include wastewater and water treatment technologies, membrane processes and environmental economics. Moreover, she received 2021 TUBITAK Incentive Award.  ***Assoc. Prof. Mustafa Evren Ersahin***  Assoc. Prof. Mustafa Evren Ersahin received his MSc degree from Department of Environmental Engineering at Istanbul Technical University (ITU). In 2010, he has joined the Sanitary Engineering Section of the Watermanagement Department at TU Delft as a PhD researcher. He obtained two PhD degree from both ITU and Delft University of Technology in 2015. His PhD study focused on dynamic membrane technology in anaerobic membrane bioreactors. He was involved in many research and development projects in the field of membrane processes, membrane bioreactors, dynamic membrane technology, energy efficient wastewater treatment processes, anaerobic biotechnology, and biosystem modelling. He got the HUYGENS PhD fellowship award (2011), which is one of the most prestigious awards given by the Dutch Government, German Water Partnership GWP Award (2016), Waternet Watercycle Innovation Award (2017) and 2020 TUBITAK Incentive Award.  ***Asst. Prof. Huseyin Guven***  Asst. Prof. Huseyin Güven received his MSc and PhD degree from ITU, Department of Environmental Engineering. His doctoral dissertation focuses on the energy efficient municipal wastewater treatment at high-rate activated sludge (HRAS) systems and co-treatment of municipal wastewater and food waste. He investigated the treatment performance of HRAS systems and digestibility of produced excess sludge as well as the environmental impacts of HRAS systems from a life cycle perspective. He is currently working at ITU as an assistant professor at Environmental Engineering Department. His main research areas include wastewater and water treatment technologies, renewable energy resources, waste management and life cycle assessment.  ***Prof. Bayram Sahin***  Prof. Bayram Sahin graduated as a mechanical engineer from Atatürk University. He received his MSc and PhD degree from Atatürk University, Department of Mechanical Engineering. His doctoral dissertation focuses the investigation of heat and flow characteristics for heat exchangers having enlarged and contsracted oriented rectangular fins. He is a professor in Mechanical Engineering Department at ITU. He had administrative duties involving head of the department of Mechanical Engineering, Secretary General of Erzurum Technical University, and vice rector of Erzurum Technical University. His main research areas include conventional energy systems and technologies, thermodynamics and heat transfer.  ***Asst. Prof. Abdussamet Subasi***  Abdussamet Subasi is an assistant professor in Department of Mechanical Engineering at Istanbul Technical University (ITU). He received his BSc degree in Mechanical Engineering and Electrical and Electronics Engineering Department from Atatürk University in 2008 and 2009, respectively. He got his MSc and Ph.D. degrees in Mechanical Engineering of Atatürk University and Istanbul Technical University, respectively. He studied for one year on laminar-to-turbulent transition and stability analysis in Institute of Aerodynamic and Gas Dynamics (IAG) at University of Stuttgart during his Ph.D. He worked six months on nanofluids in the Laboratoire de Génie Civil et Génie Mécanique (LGCGM) at University of Rennes1. His research interests include Computational Fluid Dynamics, nanofluids, minichannels, heat transfer enhancement, optimization, and laminar-to-turbulent transition.  ***Res. Assist. Busra Cicekalan***  Res. Assist. Busra Cicekalan received her BSc degree in Environmental Engineering and Management Engineering (double major program) from ITU. She also holds an MSc degree in Environmental Engineering at ITU. She is a PhD candidate and currently working as a research assistant in Environmental Engineering Department at ITU. Her PhD thesis is about the energy recovery in sewage sludge management. Her main research areas include benchmarking the efficiency of water and wastewater administrations, energy efficient wastewater treatment processes, anaerobic biotechnology, membrane technology and environmental economics.  **Istanbul Water and Sewerage Administration (ISKI)**  Founded in 1981 with the launch of ISK Law No. 2560, ISKI is a public utility of Istanbul Metropolitan Municipality with an independent budget. The managerial board of the administration, where the Mayor of Istanbul is the Board Chairman, is the Metropolitan Municipality Council. The General Director of ISKI is elected upon the proposal of the Metropolitan Municipality Mayor and approved by the Minister of Interior Affairs. The General Director of ISKI also acts as the Vice Chair of the Management Board that also includes 4 members including a senior Deputy General Director. Two inspectors elected by the ISKI General Board (Municipal Assembly) conduct inspection services. The administration includes 5 Deputy General Director Offices, Department of Inspection Committee, Legal Advisor’s Office, Internal Auditing Unit, 20 Departments and 104 Directorates. A total of 9,905 staff includes 7,100 workers and 2,805 officers with a majority of technical background. To receive ISKI’s services, water and wastewater subscription is required through a contract with İSKİ. Water consumption is identified and measured via mechanical or smart meters. Contracts are classified according to the consumer groups of households, businesses, public institutions, industrial locations, village settlements and offices as well as municipal buildings. |
| **List of publications related to the energy recovery and heat pump** | Guven, H., Ersahin, M. E., & Ozgun, H. (2022). Energy self-sufficiency in wastewater treatment plants: perspectives, challenges, and opportunities. Clean Energy and Resource Recovery, 105-122.  Afshari, F., Sahin, B., Khanlari, A., & Manay, E. (2020). Experimental optimization and investigation of compressor cooling fan in an air-to-water heat pump. Heat Transfer Research, 51(4).  Khanlari, A., Sözen, A., Sahin, B., Di Nicola, G., & Afshari, F. (2020). Experimental investigation on using building shower drain water as a heat source for heat pump systems. Energy Sources, Part A: Recovery, Utilization, and Environmental Effects, 1-13.  Guven, H., Ersahin, M. E., Dereli, R. K., Ozgun, H., Isik, I., & Ozturk, I. (2019). Energy recovery potential of anaerobic digestion of excess sludge from high-rate activated sludge systems co-treating municipal wastewater and food waste. Energy, 172, 1027-1036.  Guven, H., Dereli, R. K., Ozgun, H., Ersahin, M. E., & Ozturk, I. (2019). Towards sustainable and energy efficient municipal wastewater treatment by up-concentration of organics. Progress in Energy and Combustion Science, 70, 145-168.  Guven, H., & Tanik, A. (2018). Water-energy nexus: Sustainable water management and energy recovery from wastewater in eco-cities. Smart and Sustainable Built Environment. |