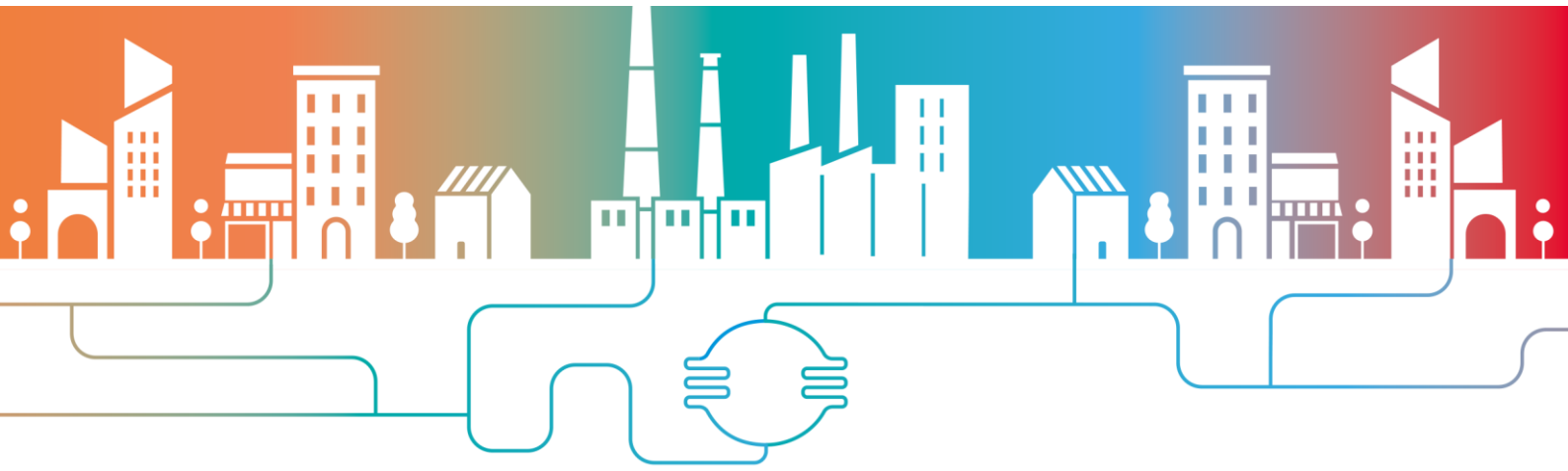
LIFE 4 HEAT RECOVERY

After-LIFE Plan– Action F.1



Low temperature, urban waste heat into district heating and cooling networks

as a clean source of thermal energy

LIFE4HeatRecovery

Project Title: Low temperature, urban waste heat into district heating and cooling networks as a clean source of thermal energy

Project Acronym: LIFE4HeatRecovery

Deliverable Title: After-LIFE Plan

Lead beneficiary: Eurac

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Date: 14/06/2024

This document has been produced in the context of the Life4HeatRecovery Project.

The project has received funding from the LIFE programme of the European Union under contract number LIFE17 CCM/IT/000085

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1 Introduction

This plan explains how the LIFE4HeatRecovery beneficiaries foresee to continue and expand their project related actions, with reference to both the demonstration sites and other project activities. Moreover, the report provides an overview of future dissemination and communication measures.

The continuous information of experts, investors and decision makers will remain an ordinary activity supporting the daily business of all project beneficiaries.

LIFE4HeatRecovery focused on low-temperature waste heat (WH) recovery into district heating and cooling (DHC) networks. The following three demonstration cases were implemented in the project:

- **Ospitaletto**, Italy: heat recovery from the cooling system of a **foundry** into a **cold network**, operated by Cogeme. The waste heat temperature is about 25 °C, while the network temperature is the same or lower (as it can be supplied also by aquifer wells at 15 °C). The installed substation (about 125 kW) can also deliver heat to the local heating system of the foundry (for space heating and sanitary hot water production), up to 60 °C using a heat pump (HP).
- **Heerlen**, the Netherlands: heat recovery from the cooling system of a **foundry** into a **cold network**. The network is a full neutral-temperature district heating and cooling network – often also defined as 5th generation DHC (5GDHC) – managed by Mijnwater, with supply temperatures of the order of 30 °C. The waste heat (about 700 kW) can be recovered up to a temperature of 42 °C, through a simple heat exchanger. The heat is then mainly reused at a nearby swimming pool, where a heat pump substation is installed.
- **Aalborg**, Denmark: heat recovery from 3 racks of a **data centre** of Aalborg University into a **medium-high temperature network**, operated by Aalborg Forsyning. The waste heat temperature can be in the range 40-60 °C (depending on the server operating conditions), thanks to a two-phase passive liquid cooling system developed by Heatflow. The network supply temperature is about 80 °C in winter and about 60 °C in summer. A heat-pump-based substation (with a configuration proposed by Eurac and a control implemented by Enisyst) is used to inject the recovered heat into the network, enabling direct heat exchange when the waste heat and the network temperatures match each other. The recovered heat is also used to heat the local building.

Complementary mapping and simulation activities, as well as financial and business model analysis, were carried out. Several stakeholders, early adopters and business partners were involved in order to foster replication.

- Project start date: 15/06/2018
- Project end date: 16/06/2024
- Duration: 72 months
- Project budget: € 5,804,127
- EU contribution: € 3,360,079
- Contact persons: Roberto Fedrizzi, roberto.fedrizzi@eurac.edu, Marco Cozzini marco.cozzini@eurac.edu

2 Planned actions

2.1 Website and social media

The project website https://www.life4heatrecovery.eu/ was realized and maintained by Eurac during the entire project activity. In order to keep a good visibility of the project and to give proper time to further spread its results, the website will be restyled and maintained by Eurac for at least 3 years after project end. Internal Eurac resources will be used.

The website is already available in all project languages. The restyled website will include easier access to downloadable material, like public deliverables.

LIFE4HeatRecovery also has the X/Twitter account "**@life4hr**". This is also expected to be maintained by Eurac during the same period.

2.2 Distribution of project information material

Within LIFE4HeatRecovery, a "Project booklet" and a "Guidebook for planners" have been developed. These documents contain a summary of the main technical information and results of the project.

- The "Project booklet" is a short summary of the main project achievements, written with technical language but with a limited level of detail. It will be made available for download on the project website (with versions in each project language) and distributed directly by project beneficiaries among their contacts. It is mainly intended for utilities or local authorities to provide an overview of low-temperature waste heat recovery solutions.
- The "Guidebook for planners" is instead a more detailed technical report including a list of specific plant configurations used in the project. It summarizes the main heat pump combinations identified for the demonstrations sites and it is closely connected with the "Database of heat recovery measures" developed for the project. Both will be made and kept available on the restyled website. The guidebook is also available both in English and in the local project languages. It is mainly addressed to an audience of engineers/designers at engineering offices, utilities, and academic entities.

For a more academic audience and with the specific target of university students, an "Educational kit" was also developed. This will be distributed among several universities. Feedback from university contacts will also be collected and the material will be maintained at Eurac also for internal training.

2.3 Future events

Conferences:

- ICSD 2024, "42th International Conference on System Dynamics", 4-8 August 2024, Bergen. Oral presentation "Measuring the Socio-Economic Impact of New-Generation District Heating Networks Utilizing Renewable Energies" by Eurac.
- SDEWES 2024, "19th Conference on Sustainable Development of Energy, Water and Environment Systems", 8-12 September 2024, Rome. Article "Coupling Energy Efficiency in Industry and District Heating: Modelling of Low-Temperature Waste Heat Recovery Substations and a Case Study Analysis" submitted by Eurac.

Workshops and webinars:

- HeatMineDH Knowledge Exchange Forum. A webinar summarizing the key findings of LIFE4HeatRecovery is expected to be organized within the project HeatMineDH, funded by the LIFE-CET programme and coordinated by Eurac. The webinar will be planned within 2024 involving stakeholders from other EU projects of the same call, to enhance diffusion and visibility. Contacts with the corresponding coordinators are already ongoing.

2.4 Partner plans

In this section, a summary of the expected future activities related to LIFE4HeatRecovery is reported for each project Beneficiary.

2.4.1 Eurac

Eurac was responsible for project coordination and took care of communication and dissemination activities as well. Moreover, it carried out several simulation activities (both on networks and substations) and developed dedicated simulation and waste heat mapping models. In this context, the following main actions related to LIFE4HeatRecovery are expected for the future (partly already started).

- Further improvement of substation configurations, focusing on heat pumps. Eurac directly contributed to the configuration design for the heat pumps system used in the Aalborg demo. In connection with the development strategy described in deliverable “Business plans for exploitation of heat recovery skid from wastewater” (Action C.5.4), Eurac will continue its configuration design and simulation work, also including more general combinations. In particular, the devised heat pump configurations are expected to be applied to larger and more complex storage solutions, possibly including seasonal storage. These developments are expected to take place in 1-2 years after project end, with applications both in consultancy activities and funded research projects.
- Further development of WH mapping activities. Within LIFE4HeatRecovery Eurac developed a QGIS plugin to realize semi-automated maps of waste heat resources. The plugin partly needs imported data (mainly the list of local industry, including NACE code, number of employees, and address) and partly automatically retrieves data from web services (in particular related to low-temperature urban waste heat sources like supermarkets, hospitals, ice rinks, etc.). Based on the available data and using conversion factors taken from literature, the plugin estimates the waste heat potential of each source and geo-references it. The plugin was successfully applied to the 3 demo cases of LIFE4HeatRecovery, but it is intention of Eurac to further develop its capabilities. First, an expansion and consolidation of the waste heat conversion factor database will be pursued, progressively validating literature data base on more real cases. Second, the improvement of the decision-making support tool embedded in the plugin will be continued, revising the current criteria thanks to stakeholder feedback. These improvements are expected to take place in 1-2 years after project end.
- Result exploitation in other EU projects and consultancy. During the development of LIFE4HeatRecovery and partly thanks to the challenges identified in the project, Eurac developed other project proposals. In particular, it successfully applied to the LIFE-2022-CET-DH call as coordinator, getting the HeatMineDH project approved. HeatMineDH started in September 2023 and will apply to 8 district heating case studies several of the ideas developed in LIFE4HeatRecovery, with a focus on waste heat recovery (both in terms of mapping and in terms of heat pump substation configurations). Eurac was also invited as a beneficiary to the LIFE-2023-CET-DHC call, participating to the project proposal DHC SwEEtch, which was also approved. DHC SwEEtch will start in October 2024, and again waste heat mapping solutions developed in LIFE4HeatRecovery will be applied there. Finally, Eurac was also successful in two other smaller project proposals related to district

heating: InteGradeDH (funded by IEA-DHC Annex XIV, started in April 2024, coordinated by Eurac and focused on waste heat and deep geothermal energy) and ALPHA (funded by Alpine Space, to be started in September 2024, where Eurac participates with supporting services related to 5th generation district heating and cooling). Other project proposal related to district heating and waste heat recovery are expected to be presented in a near future. Moreover, Eurac typically carries out 1-2 consultancy services per year for district heating companies, where the experience collected research projects can be transferred to companies and tailored to specific needs.

- Communication and dissemination. Beside the aforementioned information material, conferences, and presentation activities, Eurac plans to disseminate LIFE4HeatRecovery results through its future research and collaboration projects. Moreover, further publications related to LIFE4HeatRecovery are expected: an article for the sectorial magazine "Servizi a Rete" (in Italian) is expected to be submitted within 2024 and a more detailed peer-reviewed journal article on network simulations is planned for 2025.

2.4.2 Aalborg Forsyning

Within LIFE4HeatRecovery, AAFOR contributed to connect the Aalborg demonstration plant to its own district heating network. It also investigated the possibility to install a replication plant at one of its own data centers, planned in Action C.4.

The Aalborg district heating network is already expanded to cover the large majority of city buildings. Therefore, a significant expansion in terms of customers cannot be expected. On the other hand, the network still includes a non-negligible share of coal among its sources (to supply cogeneration plants). With the objective of a further decarbonization of the system, AAFOR is committed to search for sustainable solutions able to replace coal. The expansion of waste heat sources is one of the considered opportunities.

While within LIFE4HeatRecovery it was not feasible to apply waste heat recovery from the new data center being built by AAFOR, the project remains open for the future years. The plan of AAFOR is to combine the cooling system of the data center with other cooling needs of the area, building a small district cooling network to be interfaced with the district heating network through a heat pump. In this way, the waste heat collected by the cooling network could be transferred to the district heating network in large sizes (order of 1 MW). Hence, AAFOR is expected to apply the concept of the heat pump substations developed in LIFE4HeatRecovery in a very similar context in a near future (2-3 years).

2.4.3 Aalborg University

Within LIFE4HeatRecovery, Aalborg University hosted one of the demonstration cases, applying waste heat recovery from a few servers of its own data center. Moreover, it contributed to the project analyzing scenarios for the data center waste heat recovery potential at Danish and European level (two publications were achieved in the project context), as well as supporting general waste heat mapping activities.

As a University, the main interest of AAU is about academic developments and the work on waste heat mapping is expected to be continued, e.g., in the framework of IEA-DHC TS7, a Task Shared titled "Industry-DHC symbiosis". On the other hand, AAU will consider the possibility to replicate the demonstration prototype, with the heat recovery system by Heatflow, on other servers of its data center. No well-defined timeline can however be specified at the moment. This is also related to the fact that the Heatflow prototype is expected to provide the best performance for higher power fluxes, more common in new server generations. An extension of the Heatflow heat recovery solution to more servers

at AAU is hence more likely to take place in future data center refurbishments, where the economic advantage would be higher.

2.4.4 Alperia

Alperia contributed to LIFE4HeatRecovery mainly with the analysis of a potential "early adopter" case study in Bolzano. The feasibility study was focused on a shopping mall, connected to the district heating network and with large cooling needs. The specific context of Bolzano, where the district heating network is mostly supplied by a waste-to-energy plant with very low heat costs, was found not to be favourable to the immediate installation of a waste heat recovery solution in the shopping mall. On the other hand, during the project Alperia made progress in the development of a network expansion plan. The heat supplied by the network was about 150 GWh in 2023, while it is planned to increase to more than 250 GWh in 2030, almost doubling the demand. In this scenario, a strong need of new sustainable sources is expected, with heat cost values very different from the cheap ones obtained with the waste-to-energy plant. In such context, Alperia is collaborating with Eurac to identify other suitable waste heat recovery opportunities, where the project findings are expected to be reused.

2.4.5 Cogeme

Cogeme was responsible for one of the demonstration sites of LIFE4HeatRecovery. Here, Cogeme applied a two-component waste heat recovery system to the case of the ASO foundry in Ospitaletto. Waste heat is taken from the factory cooling towers and is then reused either locally or in the neutral-temperature network of the city. The two components of the system consist in separate containerized skids, one containing a hydraulic kit managing the actual heat recovery and the distribution of heat to the different circuits, the other containing the heat pump needed to raise the temperature to the level required by the factory space heating and sanitary hot water plants. The hydraulic kit includes a bi-directional interface with the district heating network, since heat can either be given to the network (in case of excess of waste heat with respect to the local need) or taken from the network (in case the available waste heat is less than the local need, as it happens when the melting process is still being started). The installed prototype was based on a "laboratory design", not optimized in terms of space occupation and modularity. Being the first installation of this kind realized by Cogeme, it was indeed considered necessary to have easy access to all system components for possible adjustments and control tuning. Based on this experience, in the final part of the project Cogeme carried out a design revision, in order to assess the potential improvements obtainable with an "industrialized" version. The focus was on the hydraulic kit, which contains the crucial bidirectional logic for the heat recovery. It was identified a potential for savings in the range of 20-35 %, thanks to a simplified control panel, a reduction of pipe lengths, optimization of pumps, and other similar improvements. The analysis was carried out for a modular size of 2 m x 1 m x 1.5 m, installed on a skid with dedicated casing (sandwich panels), less expensive than the fully containerized and climatized solution designed for the demo. Similar improvements might be applied to the system component including the heat pump: here, it was also identified the possible advantage of changing heat pump model, in particular to increase the limit on the maximum evaporator temperature. This might increase the system flexibility and allow the integration of a wider range of waste heat sources. In terms of modularity, Cogeme considers promising also for its own applications the solution developed by Mijnwater (multiple modules of heat pumps, in pairs). In spite of this revision work, Cogeme does not expect a realization of the industrialized skid version on a short time scale. This is because at the moment the main development plans of Cogeme are focused on the electric sector, with a strong engagement in PV systems (in line with the electrification trend determined by both heat pumps and electric vehicles). On the other hand, Cogeme expects to continue the operation of the Ospitaletto network and of the bidirectional heat recovery system at ASO for the entire lifetime of the system. Concerning the network, though an explicit

strategy has not yet been developed, Cogeme is also aware that the system would be able to include more customers, with a benefit for the entire economic balance. This is an opportunity which will be monitored in future years, compatibly with available resources.

2.4.6 Enisyst

Enisyts provided crucial contributions to LIFE4HeatRecovery, developing the entire control system of the Aalborg demonstration case. The realized prototype was successfully tested in terms of temperature levels and efficiency, though its scale remained very small compared to initial plans. Both for this reason and due to the need of further technical improvements, a significant development plan was foreseen by the involved partners. This was detailed in deliverable "Business plans for exploitation of heat recovery skid from data centers", for Action C.5.4. The document contains forecasts on the needed development budget and time, with the plan to search for additional funding schemes. The expectation is to reach a full market introduction in 2-3 years after project end.

Beside the direct development of the datacenter waste heat recovery solution in collaboration with Heatflow, Enisyst will continue to pursue the highest automation levels in all its control systems, with wide activities in the heat pump sector.

2.4.7 Heatflow

Heatflow was the key beneficiary for the development of the core compoenent of the datacenter waste heat recovery system, namely its thermosyphon circuit. Heatflow applied here its proprietary heat exchanger design, bringing into the project the benefits of this passive two-phase cooling solution.

While this component was able to achieve the expected temperature performances – yielding temperatures up to about 60 °C and thereby paving the way towards extremely high COP values in datacenter heat recovery solutions – a series of minor technical shortcomings were identified, including, e.g., circuit insulation, circuit filling, and pipe welding. All of these aspects exhibited room for optimization in the prototype. While Heatflow already identified simple technical solutions to improve these processes (a needed step to scale up production at competitive costs), their actual implementation needs of course time and effort. Therefore, as mentioned for Enisyst, a specific business plan was presented in deliverable "Business plans for exploitation of heat recovery skid from data centers", for Action C.5.4, including steps and thresholds to fully meet the final TRL 9 level. This objective is expected to be feasible in 2-3 years. At the same time, Heatflow will nevertheless be involved in commercial projects for datacenters. Indeed, thanks to the strong sector expansion there are already opportunities with the current level of product development, even in the absence of a 100 % optimized engineering. With these premises, Heatflow expects a significant market growth in the future years.

2.4.8 KWA/Eviva

Within LIFE4HeatRecovery, KWA followed three important activities: financing and risk analysis, an "early adopter" case, and a "partner city" case. These activities contributed to consolidate the experience of the company in the thermal sector. While this is expected to be reused in future project, on the short term KWA is focusing activities on electric-sector projects, for reasons similar to the ones explained for Cogeme. Therefore, no direct continuation of the LIFE4HeatRecovery activities is planned at the moment. On the other hand, the electric-thermal sector coupling introduced by heat pumps will anyway keep KWA interested in seeking future synergies with LIFE4HeatRecovery partners and results.

2.4.9 Mijnwater

Mijnwater was responsible for the realization of the demonstration case of Heerlen, where low-temperature waste heat was recovered from the VDL foundry and mostly delivered to a nearby swimming pool. Moreover, Mijnwater investigated the possibility to replicate its solution to other partner cities, in the Parkstad Limburg area (considering in particular Brunssum and Hoensbroek).

The installation of the demonstration plant was fully successful. Mijnwater is committed to provide energy to the swimming pool for the entire lifetime of the plant, with a well-defined contract. Unfortunately, on the waste heat source side, issues were communicated by the foundry during 2024, so that a dismissal of the plant can be expected in the coming months. This is due to global market strategies of the owner, which go beyond the negotiation power of Mijnwater. It is not clear at the moment whether the foundry site will be purchased by other companies or not and if production will continue in some form. Under this very uncertain scenario, Mijnwater is strongly committed to identify additional sustainable heat sources. In particular, the investigation carried out for Hoensbroek led to the selection of the local wastewater treatment plant as a promising source to balance the network (exploiting the clean effluent water through a heat pump). The concept is fully in line with the low-temperature waste heat recovery applications pursued in LIFE4HeatRecovery (originally considering heat recovery from sewages as well). At the moment, the feasibility of a 4 MW installation is being evaluated by Mijnwater. Since this would require some network extension, the new installation would not only give rise to a better network energy balance, but also to a potential customer increase (the network path would cross a nearby residential area). These developments are expected to occur in 3-5 years after project end and are of high interest for Mijnwater. Company shareholders already secured the needed level of internal funding for investments.

2.4.10 Søren Jensen

Søren Jensen was mainly responsible for the sizing and engineering of the hydraulic plant of the Aalborg demonstration site. In particular, Søren Jensen was responsible of the Electrical & Mechanical design. The company has a long history in data centre design and it considers of crucial interest to follow developments in the related cooling sector. As such, it expects to follow the development of the Heatflow system and to have similar collaborations in the future. This kind of application fits perfectly into the company values, i.e., Building for the Next Generation Today, Innovation and Responsibility.

2.4.11 Spinergy

Spinergy carried out the analysis on trading schemes and business models for the project. It reviewed the regulatory frameworks of the involved countries and included in the analysis long-term price projections, in order to assess economic feasibility of similar engineering projects.

The outcome exhibited a large rangeability of results, showing the possibility to achieve profitability in all the considered countries provided the available incentives are exploited. On the other hand, combining the observed limited margins with the identified risks, the need for a case-by-case detailed investigation of the local conditions emerged. With this perspective, Spinergy plans to exploit this experience in its consultancy projects, with special interest for the fast-expanding datacenter sector. Spinergy already includes similar customers in its portfolio and expects to remain active in the sector in future years.

3 Conclusions

As described in the previous summary for each partner, several of the project activities are expected to be continued, both with commercial (e.g., network expansion and installation of waste heat recovery solutions for some of the involved utilities) and research outcomes (e.g., further product development and new research projects). A mix of internal and external (mainly research grants) funding is expected. The new activities already started or planned by most of the project beneficiaries prove the large potential of this sector.