EXCESS HEAT CADASTRE STYRIA

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1 SUMMARY

The Excess Heat Cadastre III Styria 2021 is part of the Climate and Energy Strategy Styria 2030 (KESS). The project consortium, consisting of the three partners AEE - Institute for Sustainable Technologies (consortium leader), the Chair of Energy Network Technologies of Montanuniversität Leoben and e-think energy research, was contracted to identify, collect and evaluate the excess heat potential of Styrian industries using both, Top Down and Bottom Up methods, as well as to integrate the data into the Geographical Information System (GIS) Styria and to develop a concept for an independent excess heat contact platform. The total technical excess heat potential in Styria amounts to 7.58 TWh/a. Out of this, 0.70 TWh/a is already utilized (9%) and 6.88 TWh/a (91%) is still unused. Overall, the cadastre proves the high technical potential of excess heat recovery, standing for 14% of the total final energy use in Styria (52.40 TWh) (Gössinger A. et al., 2020).

2 INTRODUCTION

The Climate and Energy Strategy Styria 2030 (KESS) forms the basis for the Styrian energy and climate policy. To achieve the set climate targets, energy efficiency is an important field of action and the use of excess heat is an essential component. The diverse and widespread use of technologies in various industrial sectors creates numerous opportunities to improve energy efficiency with potentially broad international impact (Berntsson & Asblad, 2019).

Due to the high number of industrial companies in Styria, the use of industrial excess heat represents a large potential. In 2012 an Excess Heat Cadastre was already accomplished with the focus on the five energy intensive sectors in Styria (Schnitzer et al., 2012). The Styrian action plan 2019-2021 (Gössinger-Wieser, A. & Thyr, D., 2019) includes the evaluation and further developments of the Styrian Excess Heat Cadastre. For this purpose, Bottom-Up methods (direct contact with companies with questionnaires as well as analyses of publicly available environmental reports and emission databases) as well as Top-Down analyses (statistical evaluation of different sectors of industry data) were used. Subsequently, the data were transferred into a database structure in order to its georeferenced representation in the GIS Styria. The last point was the conception of a platform for the use of excess heat and a basic specification for the implementation of the platform was developed.

3 MATERIALS AND METHODS

To define the theoretical and technical potential different literature such as reports were searched, for instance:

- Industrial waste heat potential in Germany (Brückner, et al., 2017)
- Preliminary assessment of waste heat potential in major European industries (Panayiotou, et al., 2017)
- Konzeptstudie zur wiederkehrenden Quantifizierung bestehender Abwärmepotentiale in Niedersachsen (Reckzügel, et al., 2017)
- Industrial_Excess_heat_for_DH (Gustafsson, 2013)
- How well can the potential of industrial excess heat be estimated (Cornelis, et al., 2016)

Out of these reports and studies, a final definition was established in a method workshop based on literature and experience, which is described below in Figure 1. The theoretical potential considers only physical constraints: The heat must be above 0°C (= reference temperature) and bound to a heat transfer medium (liquid, gas, solid). The technical possibility of extracting or using the heat is not taken into account here. Based on the theoretical potential, the technical potential considers limitations such as heat extraction possibilities, which depends on the technical possibilities and the state of the art. Technical limitations are the minimum temperature difference in the heat exchanger, strong pollutions of the heat transfer medium, biological boundary conditions with sewage or operational safety. It is not considered whether there is a possibility of direct use (industrial operation with heat demand, existing heat network) or whether the use is economical. The technical potential includes both the used and the unused potential.

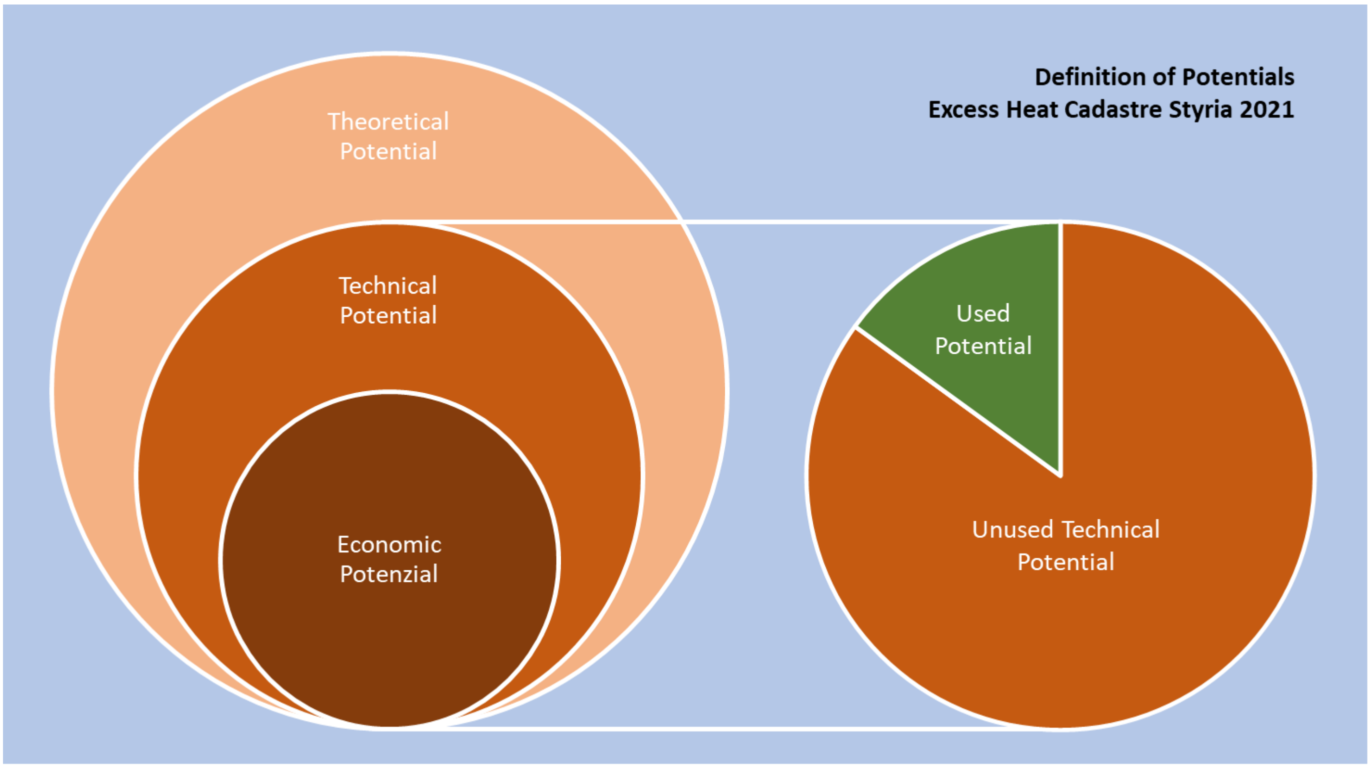

Figure 1: Definition of the excess heat potentials for the Excess Head Cadastre III Styria (own illustration)

Data collection methods

In order to carry out a detailed investigation of the waste heat potentials of Styrian industries, 3 different methods were applied to obtain an accurate and complete inventory. Two different Bottom-Up and one Top-Down analysis were used. The data of different industries were collected and the potentials of individual companies were defined:

(1) Publication-based Bottom-Up Analysis: As a first method, a publication-based Bottom-Up analysis was carried out for the energy-intensive industry. Since the largest excess heat potentials are also to be found in these industries. Therefore, such a more elaborate analysis was justified. Theoretical and technical potential was determined here. This method was carried out only for larger Styrian sites of the energy-intensive industry on the basis of publicly available environmental reports and Eco Management and Audit Scheme, shortly EMAS, environmental statements.

(2) Questionnaire based Bottom-Up Analysis: The second method chosen was a Bottom-Up method based on a questionnaire. The results can be attributed to technical potential. Considering questionnaires used in the past, a new questionnaire was created and lessons-learned from previous projects were integrated, with topics relevant to data protection clarified with the data protection officer of the province of Styria. The questionnaire for the excess heat potential survey was sent out to all manufacturing companies in Styria with more than 25 employees. Further analyses of the number of employees (at least 25) were used to define 460 focus businesses. A total of 94 companies submitted a questionnaire.

(3) Statistics-based Top-Down Analysis: The third method is a Top-Down analysis and was based on statistically available data in combination with industry or energy use indicators. In this case the energy quantities of the Bottom-Up method was added up for the individual sites and compared with the energy consumption statistics of Statistics Austria (Statistik Austria, 2022). The difference between these two energy amounts was allocated to the remaining sites and weighted according to the number of employees. In order to estimate the excess heat potential as a share of the final energy consumption of these locations, either industry-typical key figures from the literature or from observations of representative locations were used. In some cases, typical industry values were used to estimate the temperature levels.

The obtained information on theoretic and technical excess heat potentials were combined in an overall analysis and categorized in the following terms:

Classification of excess heat according to the temperature ranges

The fine classification in the lower temperature range compared to other studies is intended to consider the increasing importance of low-temperature sources and their use in low-temperature or anergy networks in combination with heat pumps. These applications can be fed with temperatures below 50°C. The range between 50 and 100°C is aimed at smaller networks, optimized or modern district heating networks with reduced flow temperatures, while the range above 100°C can supply classic district heating networks.

Classification according to time availability

In classifying the companies, an attempt was made to record the temporal distribution of excess heat. This was possible in an exact way via the evaluation of the questionnaires, with the Bottom-Up method via the analysis of the processes as well as with Top Down calculations one had to rely on information from the website of the company or further information from the web. Thereby the temporal availability was divided into seasonal and operational weekly effects.

Classification of excess heat according to carrier media or origin from the production process

After intensive considerations, the experience from the calculations and discussions, the classification by carrier media was carried out in this study with the aim of universal applicability across all occurring industries. This made detailed analyses possible in the overall evaluation. The excess heat categories are: Flue gas, condensation, sewage and cooling water, product heat and hall excess heat, exhaust air machine cooling.

Lastly, technologies for the use of excess heat were enumerated. Common technologies are direct use, use of heat exchangers or heat pumps, or multi-stage processes. As utilization paths, the internal options are direct utilization or with heat pump. As external use, there are the following options: Direct use in other industry, direct use for district heating and low temperature network with decentralized heat pump.

4 RESULTS

The total technical excess heat potential in Styria amounts to 7.58 TWh/a. Of this, 0.70 TWh/a are already used and 6.88 TWh/a are still unused. The sector breakdown shows a strong focus on energy-intensive industry. In total, 213 unused excess heat sources from 120 companies were surveyed. Of 39 companies, 58 utilized excess heat sources were identified. The unused and used technical potentials are shown in Figure 2 with a subdivision by sector. The industry breakdown was standardized with the ÖNACE industries. The paper, metal, glass and cement industries are the most energy-intensive sectors and also generate the most excess heat. For clarity, the non-energy-intensive industries are summarized as "other industries" in the figure below.

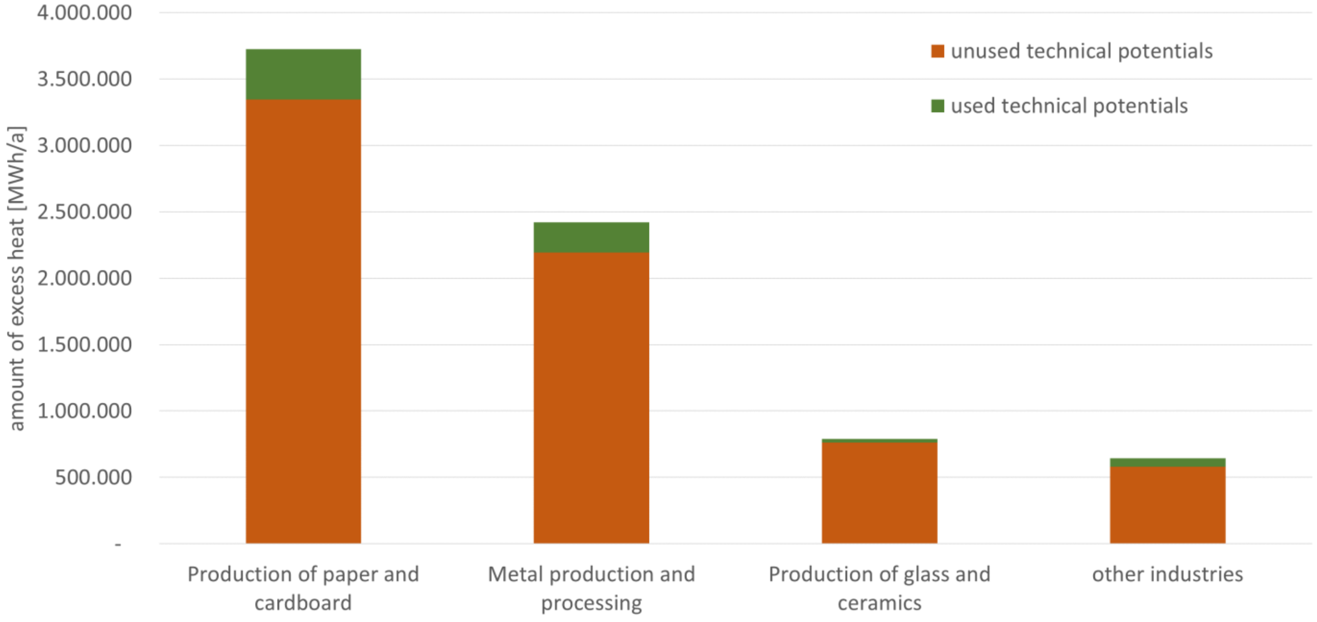

Figure 2: Industry overview of unused and used technical potentials in MWh/a (own illustration)

The 3 survey methods (questionnaire, publication-based, statistic-based Top-Down) were merged, cleaned up and standardized. The results of the public-based Bottom-Up analysis showed that the most excess heat is from the paper and metal sector with an amount of 3.34 TWh/a and 2.20 TWh/a. Based on a theoretical potential, the technical potential was determined. Therefore, the number of excess heat sources was identical for the theoretical and technical potentials of the publication-based survey. From 27 companies, 85 excess heat sources were taken over for the overall evaluation above. The detailed evaluation for the method of the questionnaires showed the focus on the non-energy intensive industries. Both in terms of the number of used and unused excess heat sources, the non-energy-intensive industries have been identified most frequently. A clear documentation showed the following results: 94 companies submitted a questionnaire and defined excess heat potentials. 24 stated that they already use excess heat, but were not willing to indicate this potential via questionnaire, because the own benefit was not obvious. 185 companies indicated that they do not have any excess heat. 80 companies could not be convinced to fill out a questionnaire because they were not interested or did not have enough time.
Using the Top-Down analysis, a further 42 companies were included in the overall evaluation. No theoretical excess heat potential was determined for this, as the values were derived directly from the publication-based technical excess heat potentials. In this method the focus was again on the energy intensive industries, especially on the paper and metal sector, which have an enormous amount of excess heat in Styria.

As shortly mentioned above, three temperature ranges were defined for the excess heat sources: < 50°C; 50 - 100°C; > 100°C. An excess heat source can pass through all three temperature categories if the excess heat is present at over 100°C and can be cooled down to the reference temperature. A clear correlation between low temperature heat can be seen for the categories of waste or cooling water, condensation and excess heat from cooling utilities. High temperature excess heat has been identified for flue gas as well as partially for product heat. At this point it should be said that the potential of a flue gas condensation was assigned to the excess heat category condensation and not to the excess heat category flue gas.
Although, the excess heat potential surveys were conducted with great care, uncertainties have to be addressed: (i) For the publication-based analysis, missing information on the operating site had to be supplemented with leads to uncertainties. (ii) The method of Top-Down analysis requires generalizations across the industry, which leads to inaccuracies for the individual companies. Therefore, a company-specific plausibility check (employees, site size, purpose of operation) was performed. (iii) The data from the questionnaires contain uncertainties since not all data can be verified; here, too, comprehensive plausibility checks and callbacks were carried out. Nevertheless, because of the different methods and the resulting mutual comparison of the surveys, a high degree of data quality and data quantity has been achieved because of the different methods used and the resulting mutual comparison of the surveys. For companies with multiple surveys, a validation could be carried out.

Another task of the project was to visualize the data in the Digital Atlas of Styria, offering an available and established platform to provide the collected data on excess heat potentials in a targeted and geo-referenced way according to the requirements of different user groups. In this context, the Excess Heat Cadastre Styria, in combination with the already available maps and especially in connection with the future heat atlas Styria, represents an essential information layer for spatial energy planning in cities and municipalities.
For visualization in the Digital Atlas Styria, the excess heat potentials were assigned to a possible use. The maximum distance of an excess heat utilization was determined depending on temperature, excess heat power and load profile. Linear distances of max. 3.5-14 km (depending on the utilization possibility) as well as max. 10% heat distribution losses were defined as limited values. As an example, Figure 3 shows the representation of the excess heat potentials in the Digital Atlas of Styria for the area Leoben. The areas marked in red are settlement areas (defined in the CORINE Land Cover 2018 dataset) that can be reached by the excess heat sources (>100°C) at the limits (max. 14 km and heat distribution losses ≤10%).

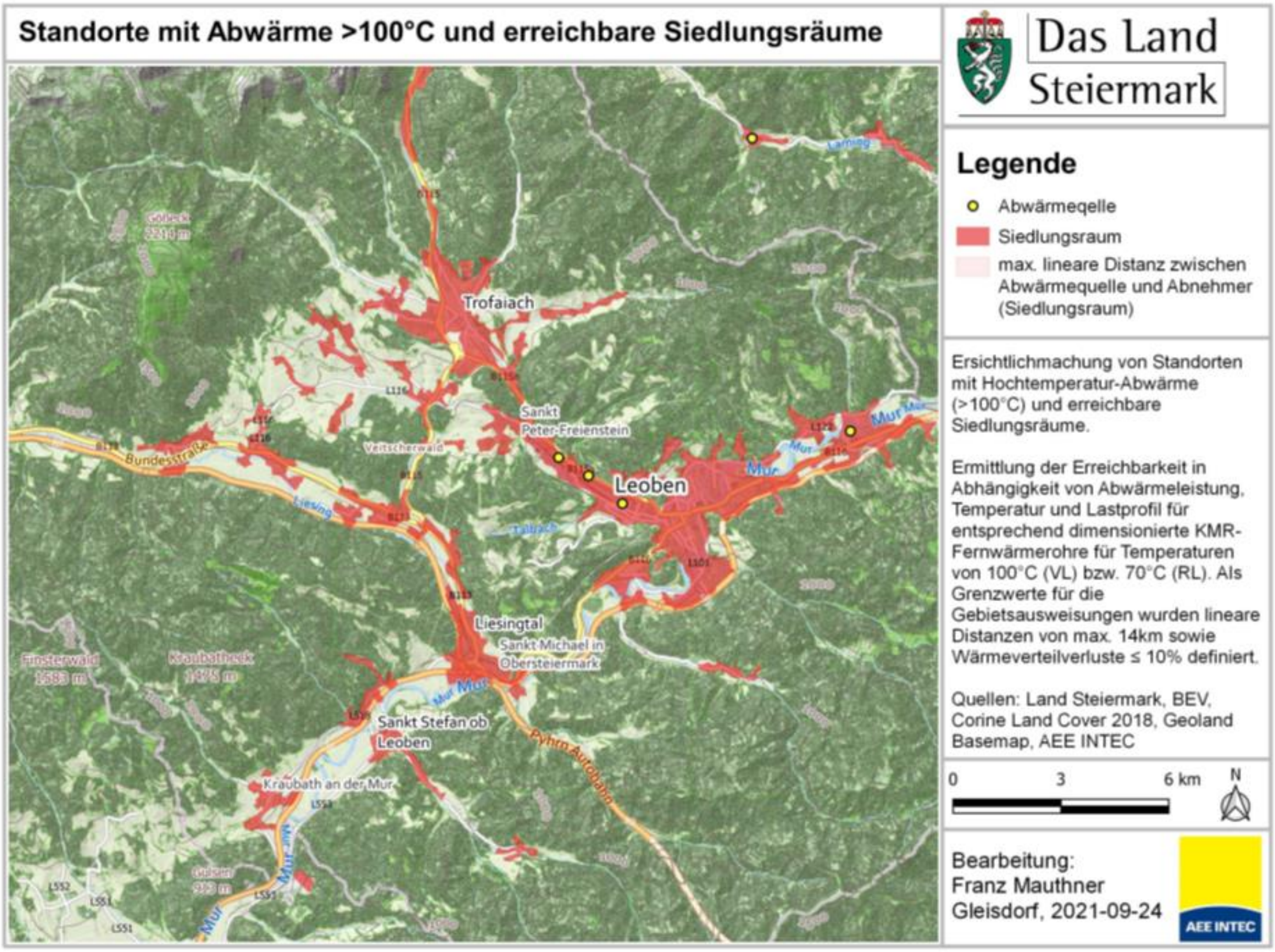

Figure 3: Locations with excess heat >100 °C and accessible settlement areas (own illustration).

Subsequently, the excess heat cadastre layer can be intersected with other data layers. The intersection of the information on the technically and economically possible route length for excess heat recovery and distribution with information on the adjacent settlement area (heat demand density, existing district heating) enables the assessment of whether detailed planning for the implementation of an excess heat recovery should be further pursued.

In addition to the geo-referenced representation of excess heat in the Digital Atlas Styria, the concept of an excess-heat-contact-platform was established. The reason why a platform of this kind would be useful is that potential excess heat providers, excess heat consumers as well as planners and project developers can get in contact with each other, they are able to initiate and implement concrete projects more quickly. In order to better understand the requirements of potential users of the excess heat contact platform for Styria, a survey was conducted among the target group. Questions were formulated on the central areas of the platform (data and information, functionalities, limited user area), iterated in the project team and with the client and transferred to an online survey. During the survey period, a total of 222 completed forms were submitted. The majority of these, with 150 responses, came from the target group of industrial and commercial enterprises, followed by 59 responses from the target group of network operators, as well as 8 from planners and 5 from public bodies. The outcome of the work is a basic specification sheet for an excess-heat-contact-platform for Styria. It contains a concept of the platform, the description of the user groups and the user modes, a concept of the restricted user area, a detailed description of the data and functionalities and additionally interfaces to be provided and further requirements.

5 DISCUSSION

The results show that excess heat recovery already plays an important role in Styria, but also the large unused potential. Compared to the heating sector 29% of the required final heat energy demand of 25.78 TWh could be covered and be an essential component of the future heat supply. The total technical excess heat potential in Styria amounts to 7.58 TWh/a. Of this, 0.70 TWh/a are already utilized (9%) and 6.88 TWh/a (91%) are still unused.

The largest unused technical excess heat potentials in the energy-intensive industries are:

- paper industry with 3.34 TWh/a
- metal production with 2.20 TWh/a
- glass and ceramics industry with 0.76 TWh/a
- remaining industries together 0.58 TWh/a

The consistent of smaller sources of excess heat should not be underestimated, because more immediate solutions are possible in regional proximity. Energy planning approaches must be driven further to continuously improve the data basis for planners and implementers.

It was identified that the largest potentials with 5.63 TWh can be found in the area of low-temperature heat below 50°C. An additional amount of 0.51 TWh/a is available in waste water treatment plants. In order to use this low-temperature potential for heat supply, an increased focus on low-temperature and anergy networks as well as the use of centralized and decentralized heat pumps is needed so that target temperatures can be reached at heat consumers. Seasonal storage in underground reservoirs, geothermal fields, or earth basin storage will also become increasingly important.

6 CONCLUSION

The consortium, consisting of the three partners AEE - Institute for Sustainable Technologies (consortium leader), the Chair of Energy Network Technologies of Montanuniversität Leoben and e-think energy research, surveyed the excess heat potential of Styrian industries to an unprecedented extent and accuracy. The methodology followed the scientifically proven and clearly comprehensible methods of Bottom-Up and Top-Down analysis by questionnaires, calculations from public environmental reports and CO_2 databases, and statistical data. These scientific methods will be applied in further projects on the excess heat survey in Austria.

Starting from a theoretically possible excess heat potential, a technical potential was determined, which considers the technological state of the art of heat exchangers (minimum temperature difference in the heat exchanger, strong pollutions in the medium of the heat transfer, biological boundaries for sewage or operational safety).

The total technical excess heat potential in Styria amounts to 7.58 TWh/a. Of this, 0.70 TWh/a are already utilized (9%) and 6.88 TWh/a (91%) are still unused. It was identified that the largest potentials with 5.63 TWh/a can be found in the area of low-temperature heat below 50°C.

The results of the excess heat potential survey will be integrated as technical excess heat potentials into the Digital Atlas Styria (Digitaler Atlas Steiermark, 2022). All companies with an excess heat potential are geo-referenced on a separate map layer. For each industry used and unused excess heat sources can be assigned and displayed. Based on this, an area designation was made for possible excess heat utilizations in settlement areas. With the spatial representation of excess heat potentials, the data from the Excess Heat Cadastre III are made available and prepared in a way that is suitable for the target group. Through the linking with heat density maps and heat network areas from the heat atlas of the Digital Atlas of Styria, detailed spatial analyses can be carried out.

As an additional and independent measure, it is recommended to implement the concept of an excess heat contact platform developed in this project. As a central product function, the excess heat contact platform would store data, providers and potential users, and would enable users an intensified exchange between the actors.

The intensive utilization of the technical excess heat potential identified in the Excess Heat Cadastre III is an important part of the decarbonization of the Styrian energy supply. The availability of the collected data enables project developers, planners, companies with excess heat, district heating operators, energy region managers and public institutions the consequent implementation of excess heat utilization projects as a contribution to achieve the goals of the Climate and Energy Strategy Styria 2030.

7 REFERENCES

Berntsson, T. & Asblad, A., (2019), Annex XV: Industrial Excess Heat Recovery – Technologies and Applications; final report of Task 2.

Brückner, S., Arbter, R., & Pehnt, M., (2017), Industrial waste heat potential in Germany - a bottom-up analysis, Energy Efficiency 10, Deutschland.

Cornelis, E. & Van Bael, J., (2016), How well can the potential of industrial, Genk, Belgium.

Digitaler Atlas Steiermark, (2022), retrived on: 21.2.2022, Digitaler Atlas Steiermark: KartenPortal (stmk.gv.at).

Gössinger-Wieser, A., Stejskal, H. & Loseries, W., (2020), Klimabericht 2019, Zahlen, Daten und Fakten der Treibhausgasemissionen und des Klimastatus in der Steiermark, Amt der Steiermärkischen Landesregierung, Abteilung 15 – Energie, Wohnbau, Technik, Graz, Austria.

Gössinger-Wieser, A. & Thyr, D., (2019), Klima- und Energiestrategie Steiermark 2030, Aktionsplan 2019-2020, Amt der Steiermärkischen Landesregierung, Abteilung 15 – Energie, Wohnbau, Technik, Graz, Austria.

Gustafsson, M., (2013), Industrial excess heat for district heating, Chalmers University of Technology, Göteborg, Sweden.

Panayiotou, G., Bianchi, G. & Georgiou, G., (2017), Preliminary assessment of waste heat potential in major European industries. Energy Procedia, International Conference on Sustainable Energy and Resource Use in Food Chains, S. 335 - 345.

Reckzügel, M., Meyer, M., & Waldhoff, C., (2017), Abwärme aus Niedersachsen – Konzeptstudie zur wiederkehrenden Quantifizierung bestehender Abwärmepotentiale in Niedersachsen, Hochschule Osnabrück: Kompetenzzentrum Energie, Deutschland.

Schnitzer, H., Schmied, J. & Titz, M., (2012), Abwärmekataster Steiermark Endbericht, Institut für Prozess- und Partikeltechnik, Technische Universität Graz, Austria.

Statistik Austria, (2022), Gütereinsatzdaten, retrived on: 23.3.2021, https://www.statistik.at/web_de/statistiken/wirtschaft/produktion_und_bauwesen/guetereinsatzdaten/index.html

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