Co-funded by the Intelligent Energy Europe Programme of the European Union

RES H/C SPREAD
RES Heating and Cooling Strategic Actions Development

Project title: RES Heating and Cooling – Strategic Actions Development
Acronym: RES H/C SPREAD
Project No. IEE/13/599/SI2.675533

Methodology for Preparing Regional Maps of Industrial Excess Heat

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Version: **June 2016**

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1 Step wise development of maps

In Austria, the region under study includes two “regional associations” of the federal province of Salzburg, which both consist of different municipalities (21 in total). For the City of Salzburg and its surroundings, a heat map covering heating as well as warm water demand for residential and non-residential buildings, has already been developed by the company “iSPACE” on behalf of the Province of Salzburg. The map is GIS-based, has a resolution of 100x100 meters and will be expanded step-by-step to the whole province of Salzburg. This will not be done within the project RES H/C SPREAD.

Within the project, the work in Austria is therefore focused on a contribution to this already existing map and planning activities. In close coordination with the country-governance-committee (CGC), methodologies for mapping the cooling-demand / industrial excess-heat have been developed. The methodologies combine the top-down approach of the IEE-project “Stratego” (first identification of relevant facilities) with a bottom-up approach for the concrete assessment of excess heat potentials of different facilities in the 21 municipalities.

The excess-heat potential is analyzed using the following seven-step-methodology:

1) Literature research on benchmarks for different industries
2) Matching of literature data with measured data (if available)
3) Discussion of “relevant” categories with stakeholders; first assessment of potentials
4) Identification of facilities (concrete addresses)
5) Visualization on maps with different icons
6) Contact the facilities; questionnaire on concrete excess-heat potential; calculation of actual excess heat potentials
7) Definition of next steps (Country-Governance-Committee, CGC)

Step 1: Literature research on benchmarks for different industries:

Several sources have been analyzed and reviewed. As a result, data of the IEE-project “Stratego” have been used in order to generate a first overview on industries, which are of possible interest regarding excess heat. According to “Stratego”, the following categories of industries have been selected by taking their “default recovery efficiency” into account:

- “high potential”: thermal power (main activity; auto producers, waste-to-energy); fuel supply and refineries

- "medium potential": chemical and petrochemical, iron and steel, non-ferrous minerals, paper-pulp and printing, non-metallic minerals
- "low potential": food and beverage industry

"Stratego" uses the publicly available carbon dioxide emission data from the European Pollutant Release and Transfer Register as well as energy statistics to perform a reverse calculation to quantify the potential of excess-heat available for district heating. This approach is very useful for a first overview on the excess-heat potentials in the Salzburg region.

The results of the literature analysis reveal that these industries tend to be important also in other studies. In Bavaria, Germany, guidelines for heat maps have been defined (see *www.energieatlas.bayern.de*). The types of industries with excess heat potential mostly align with those of the project "Stratego".

Furthermore, the results of the IEE-project "iSERV – Inspection of Building Services through Continuous Monitoring and Benchmarking" (Intelligent Energy Europe Project IEE/10/272; 07.05.2011 - 06.05.2014) have been studied. These analyses are described in the following section.

Step 2: Matching of literature data with measured data (if available)

In addition to the type of industries taken from "Stratego", several other industries like big office buildings etc. can be of great relevance. Within the EU-project iSERV about 1600 HVAC systems in 20 EU countries were monitored for several months or even years. Electricity consumptions of components and/or the whole system were measured. The HVAC systems were analysed in detail (down to 15 min interval) taking into account the usage type (opening hours etc.). Building owners were supplied with advice for enhancement of their HVAC system(s) and comparisons of their consumption with other similar buildings. For building types with a certain number of participating objects (e.g. offices, hospitals) benchmarks for the cooling demand per m² could be built. Those benchmarks are also used for RES H/C. AEA was partner in this project. For further information see *www.iservcmb.info*. For Austria, the average annual cooling demands (based on "iSERV") are the following:

- Office buildings: 55 kWh/m²a; In detail: compression refrigeration systems 9 kWh/m²a [non-glazed facade] – 45 kWh/m²a [glazed facade]; absorption refrigeration systems 5 kWh/m²a; "split-systems" 190 kWh/m²a.
- Restaurants: 109 kWh/m²a
- Hotels: 51 kWh/m²a
- Hospitals: 40 kWh/m²a

- Event venues: 15 kWh/m²a
- Shopping venues/centers: 4,2 kWh/m²a

Within the IEE-project "Stratego", the specific cooling demands for "the service sector" amounts to 83 kWh/m², whereas the specific amount of the residential sector is much lower (38 kWh/m²). The average specific cooling demand of Austrian buildings is 49 kWh/m²a.

The comparative analysis has demonstrated that "Stratego" defines interesting types of industries, but other branches also have to be considered. The selection of "relevant" branches should be done in accordance with regional stakeholders, like described in the following section.

Step 3: Discussion of "relevant" categories with stakeholders; first assessment of potentials

In order to consider the know-how of local stakeholders, the relevance of the categories of industries has been discussed in the Salzburg planning region. As a result of the discussion with the Country Governance Committee, the following categories have additionally been selected:

- Hospitals
- Large offices (server rooms, etc.)
- Laundries

Their potential was assessed using data for the average cooling demand from "iSERV" (except the one for laundries). Although the cooling demand is high, hospitals, large offices and laundries have been categorized as "low potential" according to expert decision.

Step 4: Identification of facilities (concrete addresses)

In a next step, all of the facilities have been identified by using the "WKO"-database, a company directory for all businesses in Austria compiled by the WKO (Austrian Chamber of Commerce). The addresses have been assembled in an Excel®-Sheet and have been categorized according to the discussed methodology (see above; "high – medium – low" potential). This Excel®-Sheet has then been circulated to the CGC in order to assure the quality of the data. Comments and feedback received have then been incorporated subsequently. Furthermore, the list has been discussed on a municipal level with representatives of Grödig and within the "e5"-Network.

Step 5: Visualization on maps with different icons

All of the identified facilities have then been located on different maps using the open source online application "SAGISonline"(*http://www.salzburg.gv.at/themen/salzburg/sagis/sagisonline_themeneinstiege.htm*). This application is open-source and frequently used by planning authorities and CGC stakeholders. Different icons have been used in order to distinguish between the different categories (high-medium-low potential). In a further stage, these facilities will also be included into the existing GIS-based heat map of the federal province of Salzburg.

Step 6: Contact the facilities; questionnaire on concrete excess-heat potential; calculation of actual excess heat potentials

In accordance with the CGC, selected facilities have been contacted in order to match the theoretical potential (result of step 3, see above) with the real situation. As a consequence, the selection of relevant industries can easily be adopted, e.g. if "high-potentials" turn out to be of low interest and vice versa. In this context, a meeting with representatives of the municipality of Grödig was held in October 2015. The involvement of regional/local stakeholders and exploiting their local know-how can be seen as a success factor for the mapping and planning activities, especially for the communication with local industries etc.

In order to contact the facilities in a standardized procedure, a questionnaire has been developed. According to this document, the actual heat demand, type of potential excess-heat supply (presence of HVAC systems, air compressors, flue gas temperature, waste water temperature, other wastes etc.) as well as on the personal opinion on the possibility to become an (excess-) heat supplier can be analyzed:

In detail 10 groups of energy source types are suggested:

1.) Ventilation systems
2.) Cooling devices/climate controls
3.) Compressors
4.) Exhaust gases
5.) Waste water from (industrial) processes
6.) Cooling water from (industrial) processes
7.) Waste from (industrial) processes
8.) Heating of buildings
9.) Warm water production
10.) Process heat demand

The question to each source type deal with the quantity, temperature, timeline, etc.

Furthermore, the AEA suggests the following methodology for concrete excess-heat assessment of selected facilities according to the Bavarian Heat Map (*www.energieatlas.bayern.de*) in order to improve the data quality if necessary:

After receiving the data from the questionnaire, the collected information can further be validated through selected on-site inspections in facilities of particular importance. In this case, the following parameters have to be taken into account: ventilation systems, air-conditioning units, compressors, exhaust emissions, process water, wastes as well as the demand for space heating, warm water demand, process heat demand etc. The data should be double-checked with the help of the selected companies.

After that, the data-analysis and concrete assessment of the excess-heat suppliers can be performed. The facilities should be assessed using the following criteria:

- A: Maximal thermal output (division by 300kW, max. 10 points)
- B: Excess-heat quantity per year (division by 1.850 MWh/a, max. 10 points)
- C: Temporal heat amount: year-round availability (factor: 3), availability September-May (factor: 2), availability June-August (factor: 1). The full utilization per annum (excess-heat quantity per year divided by maximal thermal output) has to be multiplied with these factors. The result is assessed as follows: (2800-3500: 1 point; 3500-4500: 2 points, 4500-5500: 3 points, 5500-7000: 4 points, 7000-8500: 5 points, 8500-11000: 6 points, 11000-13500: 7 points, 13500-17000: 8 points, 17000-21000: 9 points, >21000: 10 points)
- D: Temperature: <100°C: 10°C are subtracted, the result is then divided by 10; 100°C-130°C: 9 points, >130°C 10 points etc.

The overall assessment per category is then calculated as follows:

$$\text{Assessment per category} = \frac{A + B + C + (D * 2)}{5}$$

As a result, the points per category can be calculated.

Hereby, the highest score per category is defined as starting point. The other results have to be a summed up and divided by the number of excess heat sources at the facility. The result is then added to the starting value. The classification is then performed as follows:

If the overall result is > 8, there is high potential, 3-8 means moderate potential, <3 low potential. Facilities with high potential need to have a minimum of 3 points in every category, otherwise they are classified as “moderate potential”.

By using the address-data, the excess-heat potential can then be easily integrated into the existing “iSPACE”-map.

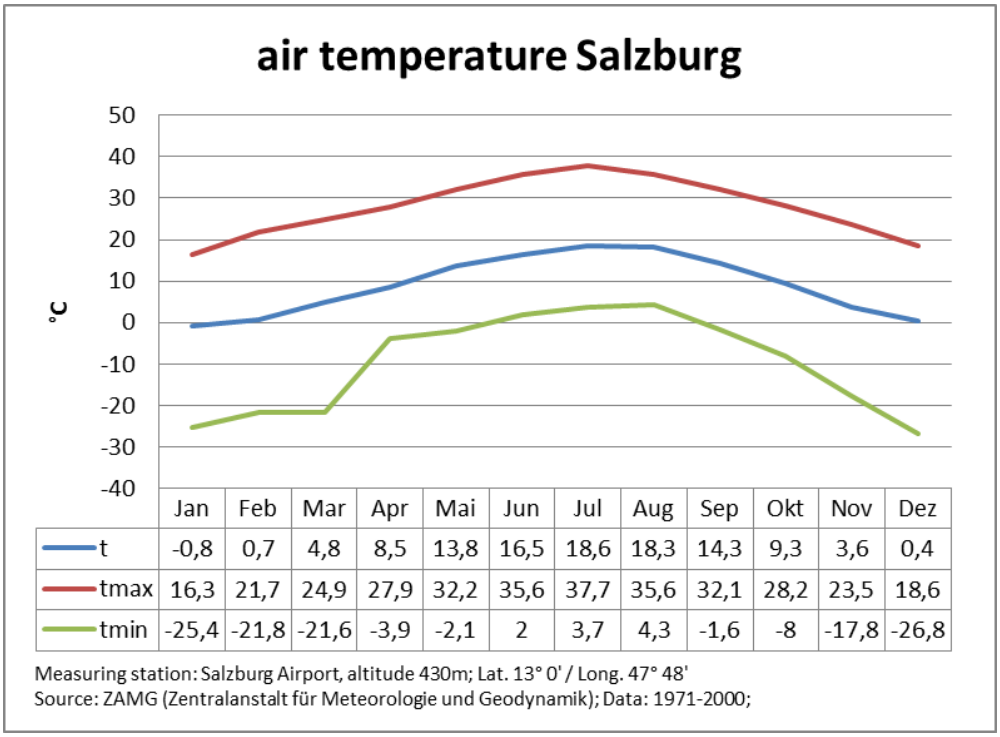
Step 7: Definition of next steps (Country-Governance-Committee, CGC)

In Order to turn the results of the excess-heat assessment into concrete action, the CGC will sign a memorandum of understanding (MoU) considering the results of the project RES H/C SPREAD.

2 Addtionally required data

In order to map the cooling demand of an area, there is demand for information on climate conditions, heating and cooling degree days. The AEA discussed and recommended a methodology for calculating the cooling demand, e.g. for residential buildings: Based on the existing heat-map, areas with a very dense heating demand can be identified. These areas are principally also suitable for the development of a cooling grid. Residential buildings are excluded due to the little demand for cooling. The annual cooling demand can be calculated using the national standard "ÖNORM B 8110-5:2010" ("thermal insulation in building construction – part 5: model of climate and user profiles: cooling demand of buildings"). In this standard, the cooling load (W/m²) for a certain period of time (t) is indicated. These can be multiplied with the annual days (d) of cooling demand (suggestion: average daytime temperature > 18,3°C) and the gross floor area (m²).

For this calculation, the general climate conditions of the region are of great importance, as the following section illustrates.



	Jan	Feb	Mar	Apr	Mai	Jun	Jul	Aug	Sep	Okt	Nov	Dez
t	-0,8	0,7	4,8	8,5	13,8	16,5	18,6	18,3	14,3	9,3	3,6	0,4
tmax	16,3	21,7	24,9	27,9	32,2	35,6	37,7	35,6	32,1	28,2	23,5	18,6
tmin	-25,4	-21,8	-21,6	-3,9	-2,1	2	3,7	4,3	-1,6	-8	-17,8	-26,8

Measuring station: Salzburg Airport, altitude 430m; Lat. 13° 0' / Long. 47° 48'
Source: ZAMG (Zentralanstalt für Meteorologie und Geodynamik); Data: 1971-2000;

According to ÖNORM B 8110-5, the average temperature per month mainly depends on the altitude (m above sea level). According to measured data from the year 1961 on, Austria is therefore divided into seven different climate zones. Due to its topographic conditions, only two different climate zones are important for the Salzburg region.

The heating degree days are calculated with the following formula:

$$\text{heating degree days}_{20/12}\text{Kd} = \sum_{i} (\Theta i, h - \Theta e, i) * di$$

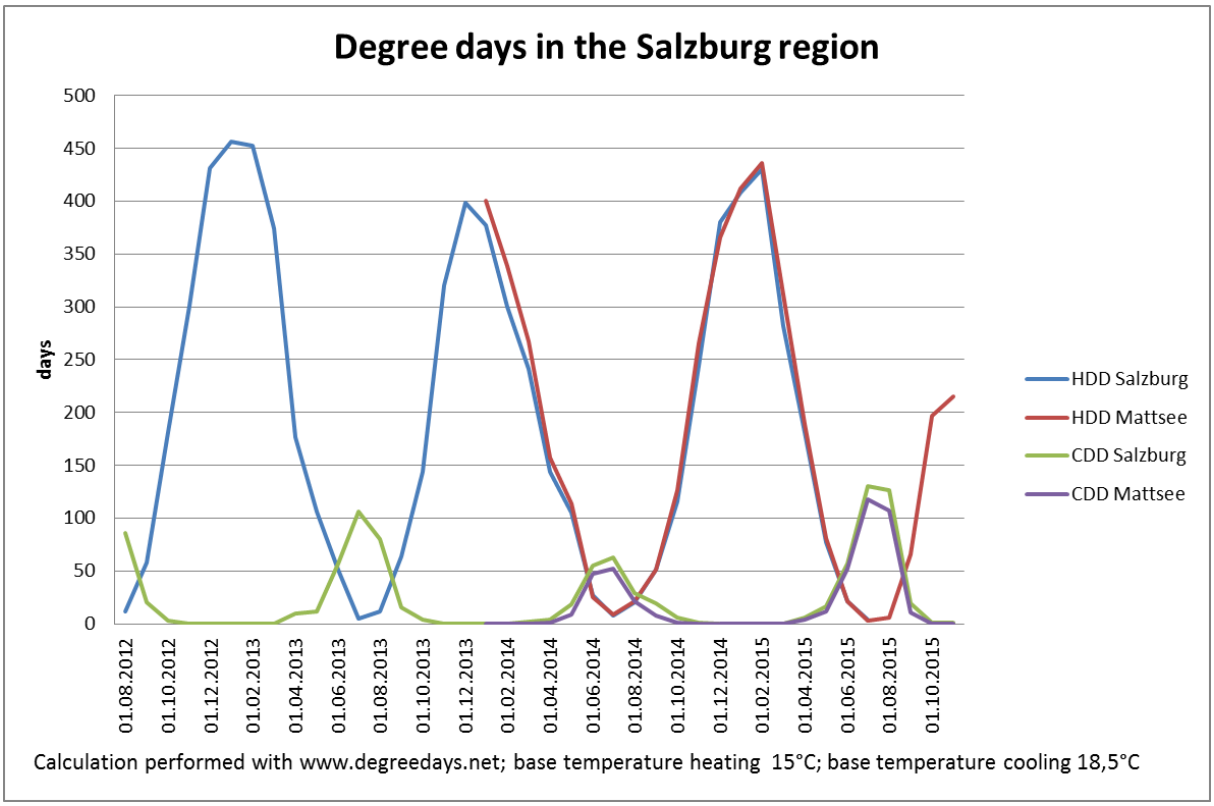
$\boldsymbol{\Theta}$i,h = indoor temperature (generally 20°C)

$\boldsymbol{\Theta}$e,i = daily average outdoor temperature

di = days with $\boldsymbol{\Theta}$e,I < 12°C (The AEA suggests 15°C because this ist an average value for Austrian buildings according to installers and producers of heating systems. Furthermore it is suggested to use 15°C instead of $\Theta i, h$ in the formula.)

For the calculation of the outdoor temperature also the air humidity and the solar radiation are taken into account.

The average heating degree days have been estimated using the website *www.degreedays.net*.



The base temperatures have been fixed to 15°C (HDD) and 18,5°C (CDD) according to expert opinion.

Summing up, the analysis in the Salzburg region is principally carried out on two levels (regional, municipal). The regional and municipal levels are linked within the CGC, since the regional associations (which represent the municipalities) are a very important part of the committee.

On the regional level, the developed methodology for quantifying the excess-heat potential and relevant sites as well as the other maps have intensively been discussed with the Country-Governance-Committee during the CGC-meetings and telephone conferences. As an important contribution to the existing planning activities in the region, the excess-heat supply can be integrated into the already existing heat map, which covers only the demand side.

On the other hand, specific questions are being analyzed also on municipal level. Within the network of “e5” municipalities, concrete goals e.g. regarding energy efficiency and GHG-emission reduction have to be fulfilled. The project RES H/C SPREAD contributes to these developments and helps to calculate e.g. the costs and benefits of the replacement of old oil boilers with modern biomass boilers. In a first analysis, remarkable saving potentials have been identified, also because the share of fossil fuel is very high in some municipalities (around 2/3). The implementation of heat pumps and solar heat devices could reduce the

energy costs remarkably. Even the implementation of new fossil fuel boilers could save around 25% of energy. Furthermore there is a high potential for additional forest biomass for energetic applications in the region, as already quantified in the mapping exercise. Moreover, promising excess heat potentials have been identified in some municipalities. All of these issues have been discussed with representatives of the municipalities as well as in the CGC-meetings.

3 Assumptions

The main innovation of the suggested methodology for assessing the regional excess heat potential is that it combines the "top-down" approach of "Stratego" with a "bottom-up" assessment with the involvement of regional stakeholders. The advantages are the generation of detailed data in a very high resolution and the intense collaboration with the country-governance-committee. Furthermore, the results regarding excess heat can be integrated in the existing heat map in the region and will be used in the planning activities. The data generated is also important for the cost benefit analysis.

Additionally, mapping of biomass potentials is very important for planning activities in the region. The calculation and illustration of the additional, sustainably usable forest biomass potential for energetic applications can be the basis for the planning of the further development of biomass district heating or the replacement of old oil boilers by pellet boilers. In combination with the located biomass heating- and CHP plants it can be used for detailed planning activities and is essential for scenario development within the cost-benefit-analysis.

Background information for mapping of RES H/C:

iSERV www.iservcmb.info

Bavarian Heat Map www.energieatlas.bayern.de

Stratego http://stratego-project.eu/local-maps/

SAGISonline https://www.salzburg.gv.at/bauenwohnen_/Seiten/sagis.aspx

Heating degree days www.degreedays.net

ÖNORM B 8110-5:2010 https://shop.austrian-standards.at