Interreg CENTRAL EUROPE
European Union European Regional Development Fund
REEF 2W

DT 1.4.2

DESCRIPTION OF INFORMATION TO BE GATHERED FOR APPLYING THE METHODOLOGY

30/06/2018

*"**List** and **description** of **data needed for the implementation of methodology** (e.g. road conditions, environmental restrictions, energy grids, high-density urban areas, etc.)"*

Contents

1. Introduction

This deliverable is built upon DT 1.4.1., listing and describing the data that is needed to implement the methodology presented in DT 1.4.1. The information presented in this deliverable can be used to carry out the Urban Compatibility Assessment (UCA) of the REEF 2W project. The basic methodology is again highlighted in the following graph (Figure 1). As already mentioned in the previous deliverable, surplus energy from the Waste Water Treatment Plant (WWTP) can be provided in terms of (i) electricity, (ii) natural gas and (iii) thermal energy.

(i) Surplus electricity can be directly fed into the electricity grid. Since the WWTP also requires electricity, the plant has to be connected to the electricity grid and the question concerning the distance to the electricity grid does not arise.

(ii) The natural gas substitute from the WWTP can be fed into a gas grid, and does not require a detailed assessment of the urban context. If the WWTP is not already connected to a gas grid network, it is essential to know, if there is a grid available and how far the next gas-grid connection point is located. In this deliverable, tools to measure distances are presented (e.g. ArcGIS online map).

(iii) For the surplus thermal energy that can be provided at the WWTP a detailed urban compatibility assessment is necessary. The spatial context is essential, since thermal energy cannot be transported across large distances and potential consumers have to be identified in the vicinity of the WWTP. To use the surplus thermal energy, it is necessary to establish a district heating network (DHN). If a DHN is already available in the vicinity of the WWTP, it is essential to know the distance to the next connection point (similar to ii).

The following data description is therefore tailored to check the compatibility of supplying the WWTP surroundings with thermal energy. However, the analysis of the WWTP surrounding, as described in this deliverable, is inevitable to get detailed knowledge about potential heat consumers and therefore necessary whenever surplus energy can be provided by a WWTP.

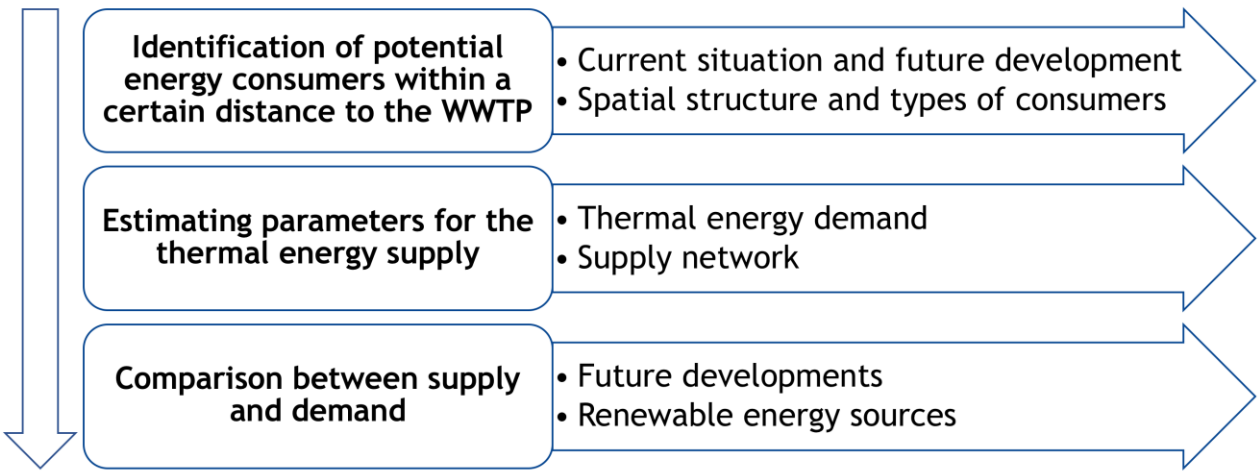

Figure 1: Methodology of the Urban Compatibility Assessment (UCA) (own illustration).

2. List and description of data needed for the implementation of the methodology

The following list and description of data needed for the implementation of the methodology is based on the original scheme presented in DT 1.4.1. Therefore, the same structure also applies for this Deliverable. First the data and information required for the identification of potential energy consumers within a certain distance to the WWTP is presented. The second part deals with information that can be used to estimate the thermal energy demand and to estimate the overall supply network lengths. Finally, the last chapter presents data required to assess future developments.

2.1. Identification of potential energy consumers within a certain distance to the WWTP

In order to identify potential energy consumers within a certain distance to the WWTP, DT 1.4.1 presented a distinction of WWTPs close to settlements or far from any settlements. Also some minimum requirements concerning the utilisation of surplus thermal energy was presented in DT 1.4.1. In this section, two approaches to gather data and information for a first assessment of the WWTPs location are presented: (1) Corine-land cover and (2) Austrian heat map.

INFO:
If distances or aerial measurements are required, tools like the ArcGIS online map can be used. The online map is freely accessible at

https://www.arcgis.com/home/webmap/viewer.html?useExisting=1

CORINE land cover

A brief introduction to the CORINE land cover (Coordination of information on the environment) program of the European Commission was already carried out in DT 1.2.3. In this deliverable a more detailed presentation of the three land-use categories (1) "Continuous urban fabric", (2) "Discontinuous urban fabric" and (3) Industrial or Commercial units" is presented. An example where CORINE land cover was already used, can be found in Neugebauer et al. (2015).

Data and maps needed to carry out a first analysis can be easily accessed and gathered from:

https://land.copernicus.eu/pan-european/corine-land-cover

There are also various national versions of the CORINE approach available. The following list presents national access points, from which data and information in a national context for the REEF2W can be gathered:

- **National access to CORINE land cover in Austria:**
  http://www.umweltbundesamt.at/rp_corine/
- **National access to CORINE land cover in Croatia:**
  http://corine.azo.hr/en#sthash.NezYJv1G.dpbs
- **National access to CORINE land cover in Czech Republic:**
  https://www.europeandataportal.eu/data/en/dataset/54622bbb-6730-4697-82be-6a64c0a80137

- **National access to CORINE land cover in Germany:** https://www.umweltbundesamt.de/themen/boden-landwirtschaft/flaechensparen-boeden-landschaften-erhalten/corine-land-cover-clc

- **National access to CORINE land cover in Italy:** http://www.sinanet.isprambiente.it/it/sia-ispra/download-mais/corine-land-cover or http://geoportale.isprambiente.it/?lang=en

Concerning the methodology, there are three main categories of interest that are described in more detailed in the following section (after Bossard et al. 2000):

- **Continuous urban fabric**

  „The continuous urban fabric class is assigned when the urban structures and transport network (i.e. impermeable surfaces) occupies more than 80 % of the surface area. This coverage percentage pertains to real ground surface."

- **Discontinuous urban fabric**

  "Between 30 to 80 % of the total surface should be impermeable.
  The discrimination between continuous and discontinuous urban fabric is set from the presence of vegetation visible in the satellite image illustrating either single houses with gardens or scattered apartment blocks with green areas between them."

- **Industrial or commercial units**

  "Artificially surfaced areas (with concrete, asphalt, tarmacadam, or stabilised, e.g. beaten earth) without vegetation occupy most of the area, which also contains buildings and/or vegetation."

An example for the pilot site in Austria can be found in the appendix.

European and national heat maps

On an European level there are various versions of "heat maps" available, that illustrate the thermal energy demand of an area on a raster level. Both the assessment of heat demand as well as cooling demand is available. The "Heat Roadmap Europe" aims to develop strategies or roadmaps for future sustainable and low-carbon heat supply. Started in 2016, over a period of 3 years, continuous results will be presented. Therefore, this might be an interesting source of information for the REEF2W project on a European level. European and national maps can be found on the homepage:

http://www.heatroadmap.eu/heat-roadmap-europe-4.php

Maps and data for national heat demands is available for all countries of the REEF2W project. Additionally, prospective district heating supply areas are shown in the online "Pan-European Thermal Atlas 4.2":

http://www.heatroadmap.eu/peta4.php.

Thermal atlases as well as excess heat atlases are available online for each participating country. There are both offline and online maps available. This approach can help to identify potential thermal energy consumers on a national level and to put energy demand into the WWTPs context. The total heat demand is presented as a raster layer, that can also be imported in a GIS system. There are certain heat demand classes from below 20 TJ/km^2 up to more than 300 TJ/km^2. The higher the heat demand for a certain area, the better the energetic and economic efficiency of spreading the heat in the form of a district heating system. In the appendix two examples concerning heat maps in Austria are presented.

2.2. Estimating parameters for the thermal energy supply

After identifying the exact location of the WWTP a first estimation of the thermal energy demand and supply can be carried out. This section is structured in accordance with DT 1.4.1. First, data and information required to estimate the thermal energy demand will be presented. The second part of this section deals with the supply network in the form of a district heating system (DHS).

2.2.1. Thermal energy demand

Starting with a settlement related thermal energy demand estimation, a building related estimation (split into residential, non-residential and special usages estimations) is following. Finally, parameters to check the feasibility of the thermal energy demand in a spatial context are presented.

Settlement related

The settlement related thermal energy demand estimation can be easily carried out by using literature as a starting point. Default values for settlement structures can be found and are freely available. The following tables present examples for different kinds of settlements and corresponding heat demand in MWh/(ha.a). However, the specific heat demand significantly depends on the local climatic situation. For instance, different full load hours will be applied in the northern part of Europe compared to the south of Europe. Therefore, the national context should be considered. It is also essential to know, that thermal energy demand heavily depends on the density of a settlement. In Hegger & Dettmar (2014) different densities for different settlement structures are presented (excerpt):

- Single family houses: 0,2
- Terraced houses: 0,6
- Urban block structure: 2,5
- Rural centre: 0,9
- Historical city centre: 2,5

Table 1 and Table 2 show examples of settlement types based on certain characteristics and corresponding heat demand in MWh/(ha.a). This is one possibility to get generalised information about the heat demand of certain settlement structures. Figure 2 shows how to estimate the settlement related heat demand, by multiplying the specific heat demand [MWh/(ha.a)] with the specific area [ha]. In the same figure a sample calculation of the study site is presented. The specific area can be measured by using for example ArcGIS online map or any national available online GIS application.

Table 1: Presentation of heat demand of specific energetic urban areas (after Hegger & Dettmar 2014).

Code	Settlement type/characteristics	Heat demand [MWh/ha.a]
EST1	Single family houses	140
EST2	Terraced houses	300
EST3	Linear development	430
EST4	Multi-storey buildings	460
EST5	Urban block structure	1060
EST6	Rural centre	500
EST7	Historical city centre	1010
EST8	City centre	2100
EST9	Commercial, office and administration	-
EST10	Industry	-

Table 2: Presentation of heat demand of specific energetic urban areas (after Stmug 2010).

Code	Settlement type/characteristics	Heat demand [MWh/ha.a]
EST1	Scattered settlement	260
EST2	Single family houses/semi-detached houses	450
EST3	Rural centre	500
EST4	Terraced houses	430
EST5	Multi-storey buildings low density	700
EST6	Multi-storey buildings high density	1000
EST7	Urban block structure	1050
EST8	City centre	1200
EST9	Historical city centre	1000
EST10	Public buildings etc.	-

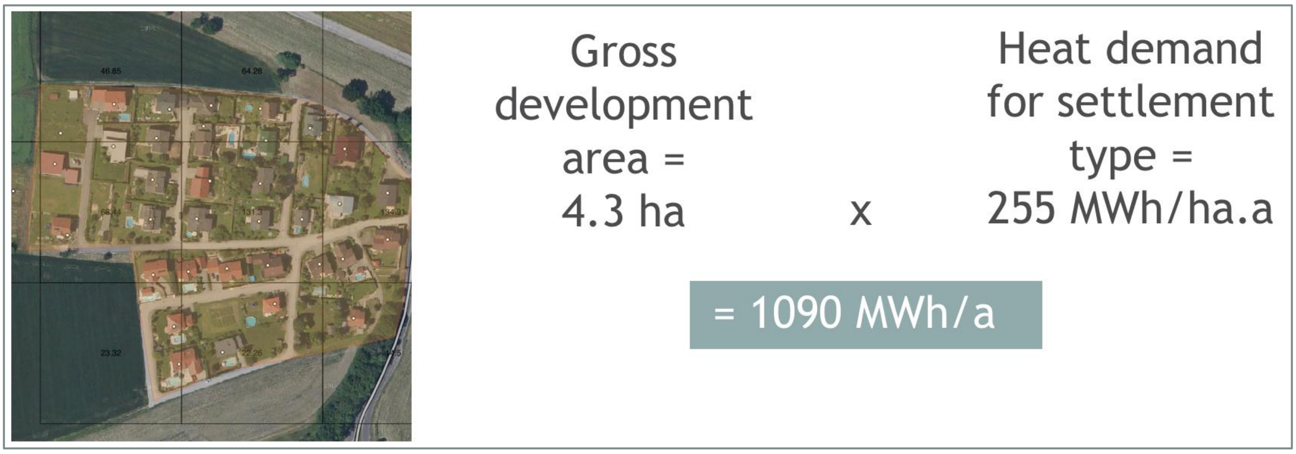

Figure 2: Sample calculation in study site (own illustration).

Building related

Concerning building related thermal energy demand estimation, the following differentiation into residential and non-residential is carried out (also see DT 1.4.1).

Residential

A very useful set of data can be gained from the TABULA program (also see Amtmann & Groß 2011). It is a free online tool available for every REEF2W participatory country except Croatia. The tool is freely available at:

http://webtool.building-typology.eu/?c=all#bm

The tabula approach uses different building types and construction periods in order to get a very detail specific thermal energy demand for residential buildings in kWh/m^2. Each participatory country of the TABULA project, exhibit different building types and different construction periods. Figure 3 shows a screenshot of the TABULA tool. A brief example for Austria can be found in the appendix.

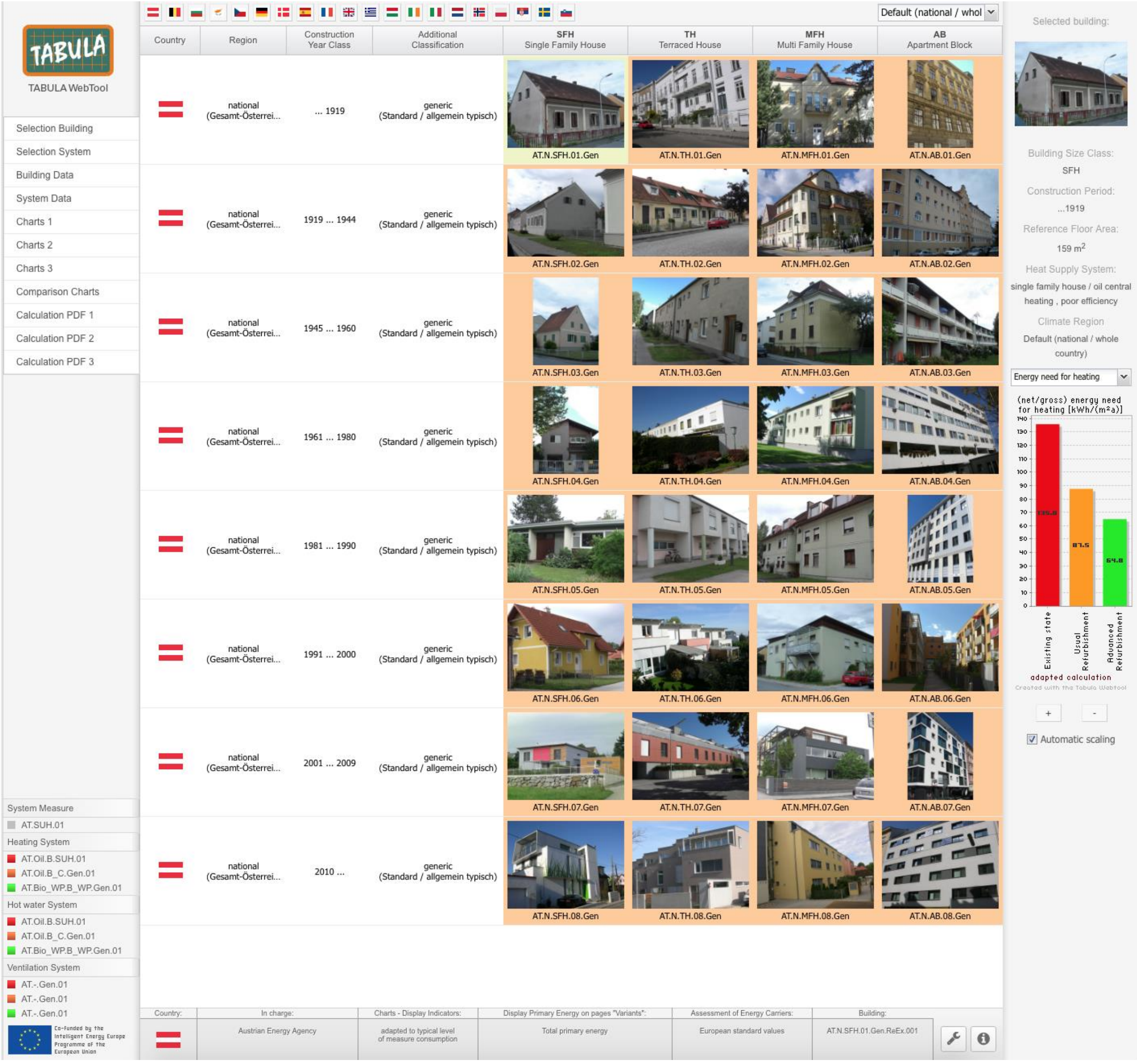

Figure 3: Illustration of the TABULA approach.

Non-residential

Whenever specific thermal energy demands [kWh/(m^2.a)] from literature are available, they can be applied for the estimation. For Austria, Germany and Switzerland for instance, there are specific values available for service buildings (Bayer et al. 2011): Food retailing, non-food retailing, accommodation, gastronomy, office buildings, and hospitals. The specific energy demand in kWh are presented either per square metre or per employee. Thus, the values can be applied for different approaches of estimation. For schools and kindergartens as well as offices and hotels additional information can be found in ÄdER (2016).

Special use: Commercial/industrial use and services

In order to get a first idea about different branches the European classification NACE or the corresponding national classification like ÖNACE in Austria can be used. There are various branches available from mining to manufacturing, transportation, education or health care. An overlap of different branches and corresponding thermal energy demand classification is presented in Stein et al. (2012) for Austria, Bulgaria, Germany, Greece and Poland. As already presented before, in Bayer et al. (2011) and ÄdER (2016) specific thermal energy demand in kWh/employee can be found. Alternatively, in order to get solid values on the basis of individual buildings, on-site inspections are recommended. Another approach is to carry out a survey and to ask potential heat consumers concerning their energy demand, using questionnaires.

Special use: Agriculture and forestry

To estimate thermal energy demands in agriculture or forestry, there are various models available like the one from Hangartner (2010) that deals with greenhouse modelling. Also, an excel based tool to estimate the overall energy demand of greenhouses is freely available at:

https://www.gewerbegas.info/erdgas-im-gewerbe/gartenbau/energiekalkulator

However, the exact energy demand also depends on the manufacturer and the kind of agricultural or forestry use. Therefore, generic values are difficult to be applied. On-site inspections or questioning the corresponding farmer might be necessary.

Parameter estimation heat demand

Regarding the feasibility of district heating systems, Nussbaumer et al. (2017) point out some essential key values (Table 3). Certain heat demand densities must be reached in order for a DHS to be economically realisable. Feasibility is given whenever a greater heat demand density of 70 (kWh/a.m^2) is reached.

Table 3: Feasibility of a district heating system (DHS) depending on heat demand densities in kWh/m^2.a (after Nussbaumer et al. 2017).

Feasibility of DHS	Heat demand density (kWh/a.m^2)
Not feasible	<50
Partly feasible	50 – 70
Feasible	>70

A quite contradictory statement originates from EnergieSchweiz (2017) where they pose values between 350 and 400 MWh/(ha.a) to be an economically feasible DHS.

2.2.2. Supply network

For transporting thermal energy, a district heating network (DHN) is necessary. With the help of a DHN it is possible to transport the energy from the WWTP to the heat consumer. However, in order to properly plan a DHN, the length of the pipe network has to be estimated. This section is divided into three parts: DHN length estimation within a settlement, DHN length estimation between settlements and the WWTP and parameters for checking the (economic) feasibility of a supply network.

Within settlement

An easy approach to estimate the total length of a district heating system within a settlement, is to use default values of around 200 to 300 metres of network per hectare settlement area (EnergieSchweiz 2017). For the actual thermal energy supply areas (settlements), these default values can be used.

Another option is to take streets as a basis. Since the majority of heat consumers are located along streets, the district heating network is mostly also located along streets. By using for example ArcGIS-online map the exact distances can be measured.

Connection of source & sink

However, in order to connect supply areas (settlements) among each other and to the WWTP, additional distance measurements have to be carried out. Here it is essential to highlight that it is also possible to build a district heating network across fields or generally along unsealed areas.

Parameter estimation supply network

The connection density [MWh/(m.a)] is an essential parameter that can be easily calculated by dividing the amount of thermal energy demand [MWh/a] with the total pipe lengths [m]. Generally, the connection density should be above 2 MWh/(a.m) (Nussbaumer et al. 2017).

Besides the connection density the following economic parameters are also important to consider on a strategic level: Mix of function (diverse utilisation correlates with more full load hours), parallel infrastructure (higher operation costs if more than one supply network is available), connection density (more efficient, if higher densities [MWh/km] are given), construction period of the district heating network (in the case of an already existing network), sealing of the surface (higher costs to build DHS along streets), supply temperature (more costs for higher temperatures), height difference in the terrain (pumping costs) and costs for the energy carrier (in this case surplus thermal energy from the WWTP) (Erker et al. 2018).

2.3. Current and future development

This section is split into two parts: Firstly, an overview on where to get data for the optimisation of spatial structures is given. Secondly, sources on where to get information about possible renewable energy sources are presented.

Optimisation of spatial structures

For identifying future additional buildings, specific knowledge of the permitted building stock has to be gathered. This specific knowledge can be gathered at local authorities. However, for a first rough analysis, aerial photos and land use plans as well as local development concepts can be used in order to identify areas for future developments. Land use plans illustrate possible utilisations of the land. Possible utilisation can be compared to the actual current utilisation. For instance, there might be areas that are devoted to building land, but are currently used for agriculture. Based on that information, future developments can be predicted and included for the planning of DHS.

EXAMPLE

In some cases, local energy plans are available that can either be found online or gathered at local authorities. For instance, on the webpage of the city of Vienna freely accessible information and data about new development projects can be found (e.g. https://www.wien.gv.at/stadtentwicklung/projekte/zielgebiete/donaufeld/planungsprozess-umsetzung.html). Thus, information and data can be gathered and future developments can be integrated in the planning process.

Moreover, also the possibility of building additional storeys to already existing buildings has to be considered. Information on this topic can also be gathered from land use plans or development plans. There, the possible number of residential units and the number of floors in a building can be found.

Concerning future thermal insulation of buildings, generalised values have to be estimated. Due to thermal insulation the total future thermal energy demand will change and has therefore to be considered in order to ensure long-term feasibility of a DHS.

Identification of renewable energy sources

Besides thermal insulation, the second aspect that might also reduce the overall thermal energy demand are renewable energy sources in the study area. Thus, an estimation concerning the amount of thermal energy potential has to be carried out. For estimating the solar energy yield of a specific area, the following tool can be used:

http://www.meteonorm.com/de/

The proposed tool can be used globally and is therefore beneficial for the application in the REEF2W project.

EXAMPLE

For federal states and cities in Austria, there are solar cadaster available, like the following in Vienna: https://www.wien.gv.at/stadtentwicklung/stadtvermessung/geodaten/solar/

Literature

Abwasserenergie (2017): Die Kläranlage als regionale Energiezelle. Klima- und Energiefonds, Wien. Online: http://www.abwasserenergie.at/fileadmin/energie_aus_abwasser/user_upload/Broschuere_Abwasserenergie_2017.pdf, Stand: 06.07.2018.

Amtmann, M., Groß, M. (2011): Eine Typologie Österreichischer Wohngebäude. Austrian Energy Agency, Wien.

Bayer, G., Sturm, T., Hinterseer, S. (2011): Kennzahlen zum Energieverbrauch in Dienstleistungsgebäuden. Österreichische Gesellschaft für Umwelt und Technik (ÖGUT), Wien.

ÄdER 2016 – Änderung der Energieeffizienz-Richtlinienverordnung 2016, BGBl. II Nr. 172/2016.

EnergieSchweiz (2017): Räumliche Energieplanung - Werkzeuge für eine zukunftstaugliche Wärme- und Kälteversorgung. EnergieSchweiz für Gemeinden, Sirnach.

Erker, S, Lichtenwöhrer, P., Zach, F, Stoeglehner, G (in press): Interdisciplinary decision tool for grid-bound heat supply systems in urban areas.

Bossard, M., Feranec, J., Otahel, J. (2000): CORINE land cover technical guide - Addendum 2000. European Environment Agency, Copenhagen. Online: http://www.pedz.uni-mannheim.de/daten/edz-bn/eua/00/tech40add.pdf, Stand: 06.07.2018.

Otter, P., Raber, W., Wichmann, K., 2013. Heizwerk Abwasser-Abwärme - Fachinformationen für Aufbau und Betrieb des Heizwerks Abwasser-Abwärme. inter 3 Institut für Ressourcenmanagement, Berlin.

Stein, B., Dascalaki, E., TABULA Project Team, 2012. Typology approaches for non-residential buildings in five European countries: existing information, concepts and outlook; (deliverable D9). IWU, Darmstadt.

Hegger, M., Dettmar, J. (Eds.) (2014): Energetische Stadtraumtypen: strukturelle und energetische Kennwerte von Stadträumen. Fraunhofer IRB Verl, Stuttgart.

StMUG – Bayerisches Staatsministerium für Umwelt und Gesundheit (2010): Leitfaden Energienutzungsplan – Teil1 Bestands- und Potenzialanalyse. Bayerisches Staatsministerium für Umwelt und Gesundheit (StMUG), Bayerisches Staatsministerium für Wirtschaft, Infrastruktur, Verkehr und Technologie (StMWIVT), Oberste Baubehörde im Bayerischen Staatsministerium des Innern (OBB), München. Online: http://www.coaching-kommunaler-klimaschutz.de/fileadmin/inhalte/Dokumente/StarterSet/LeitfadenEnergienutzungsplan-Teil1.pdf, Stand: 06.07.2018

Nussbaumer, T., Thalmann, S., Jenni, A., Ködel, J. (2017): Planungshandbuch Fernwärme. Bundesamt für Energie, Ittigen.

Web sources:

DORIS: https://doris.ooe.gv.at

BEV: http://www.bev.gv.at/portal/page?_pageid=713,1604790&_dad=portal&_schema=PORTAL

Heat Road Map EU 2018: http://www.heatroadmap.eu/heat-roadmap-europe-4.php

ArcGIS Map online: https://www.arcgis.com/home/webmap/viewer.html?useExisting=1

Europa-Universität Freiburg 2017 (Pan-European Thermal Atlas 4.2): http://www.heatroadmap.eu/peta4.php

3. APPENDIX

3.1. CORINE-land cover example for Austria

For the pilot site in Austria there is only discontinuous urban fabric in the WWTPs surrounding (see Figure 4) Although single objects of industry or commercial units are present, the overall assessment of this area can be sorted out to discontinuous urban fabric. The presented methodology is a rough assessment to get a first idea about the location of the pilot sites and how far potential thermal energy consumers are located from the WWTP. In Wallern an der Trattnach the WWTP is located <1km from potential heat consumers (see Figure 4).

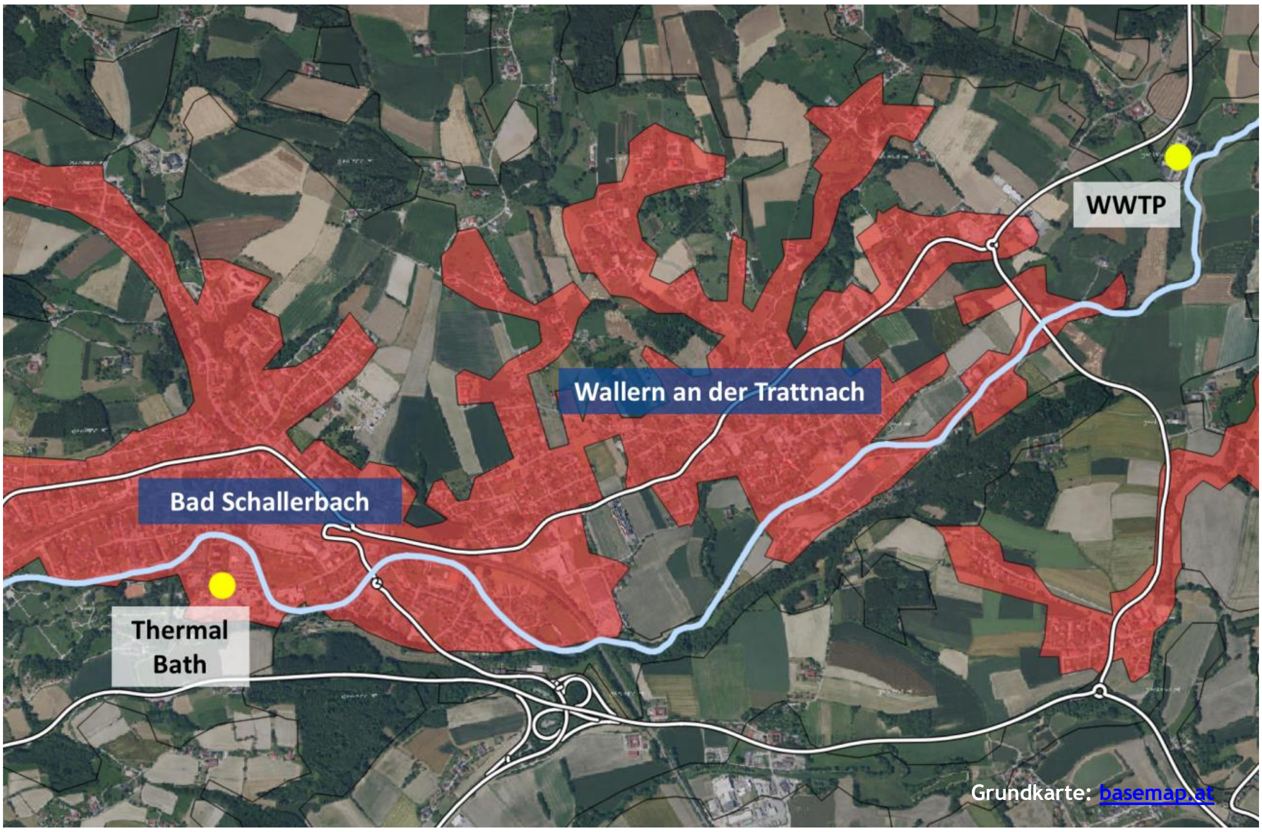

Figure 4: Presentation of Corine-land cover for the case study in Wallern an der Trattnach. WWTP: (top-right, yellow point) (Grundkarte: basemap.at).

3.2. National european heat map (Austria)

The following figure illustrates the two case municipalities in Austria “Bad Schallerbach” and “Wallern an der Trattnach”. The highlighted part is the prospective supply area for district heating systems derived from the “Pan European Thermal Atlas 4.2”:

http://www.heatroadmap.eu/peta4.php

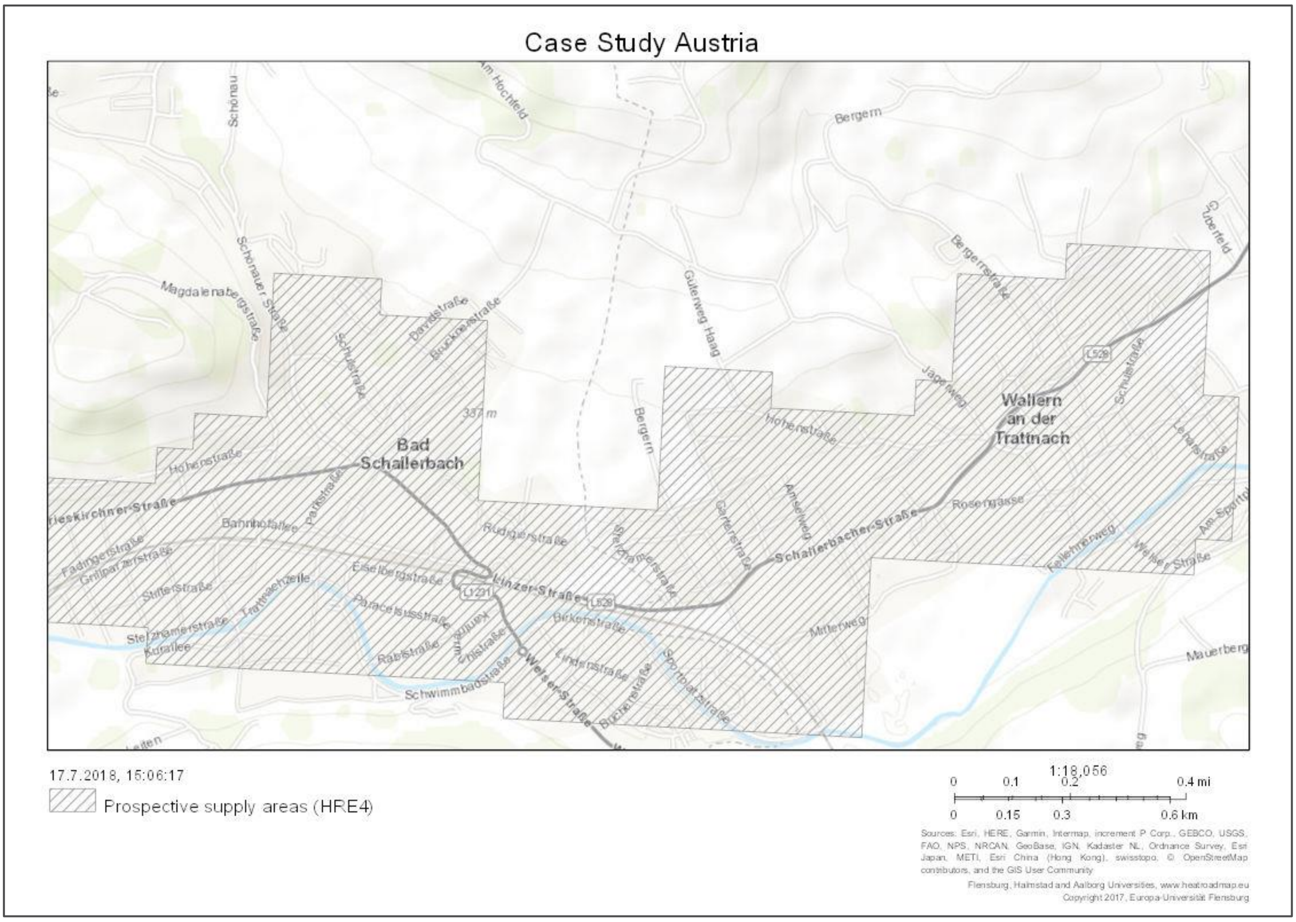

Figure 5: Perspective district heating supply area in the case study of Austria (Europa-Universität Freiburg 2017).

3.3. Heat map example for Austria

In Austria there is an even more detailed analysis of heat demand available (Figure 6). The “Austrian Heat Map” illustrates heating and cooling demand on a 250x250 raster layer. It also shows possible future scenarios for 2025. Since heating and cooling demand is also closely related to demographic development, also the future scenarios for population development is shown. Another advantage of this map is the possibility to identify already existing district heating networks, so it becomes rather easy to assess already existing grid-bound solutions in the vicinity of the WWTP.

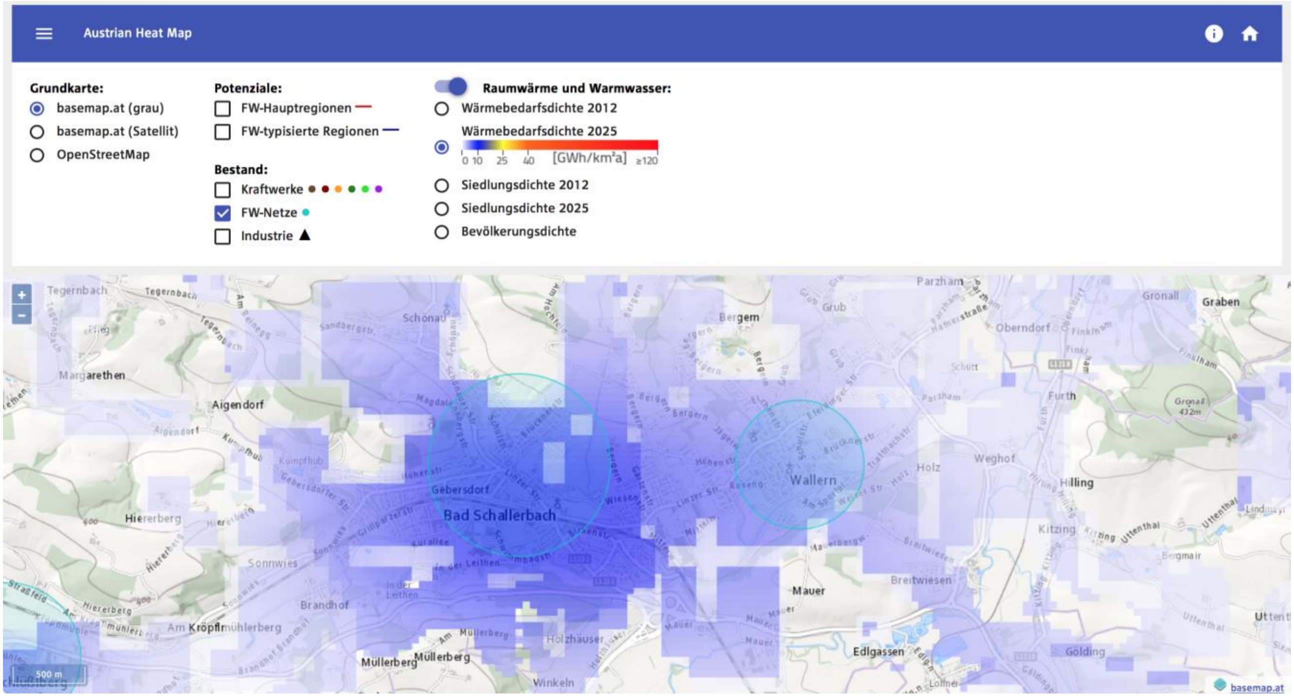

Figure 6: Sample of heat demand density at the sample site in 2025 (Austrian-heatmap).

3.4. TABULA example for Austria

For Austria there is a distinction between the following building types:

- Single-family house
- Terraced house
- Multi family house
- Apartment building

Concerning the construction period, there is a broad span from before 1919 up to the present. Here is the typical construction period separation for Austria:

- before 1919
- 1919-1944
- 1945-1960
- 1961-1980
- 1981-1990
- 1991-2000
- 2001-2009
- After 2010

The following two figures illustrate, how the specific heat demand of certain building types with corresponding construction period developed over time. Figure 7 shows the chronological development of the heat demand for a single-family house and Figure 8 for a multi-storey building in kWh/m^2. The data can be used to link it with the energy related area for each individual building derived from a building and dwelling register. The building and dwelling register in Austria is one option to gain specific data at a building level. In order to get to these data, a direct request at the target municipalities has to be conducted. Additional possibilities to gather data on a building level is to directly ask energy consumers, to conduct on-site inspections or to simply use aerial photos to identify at least building types.

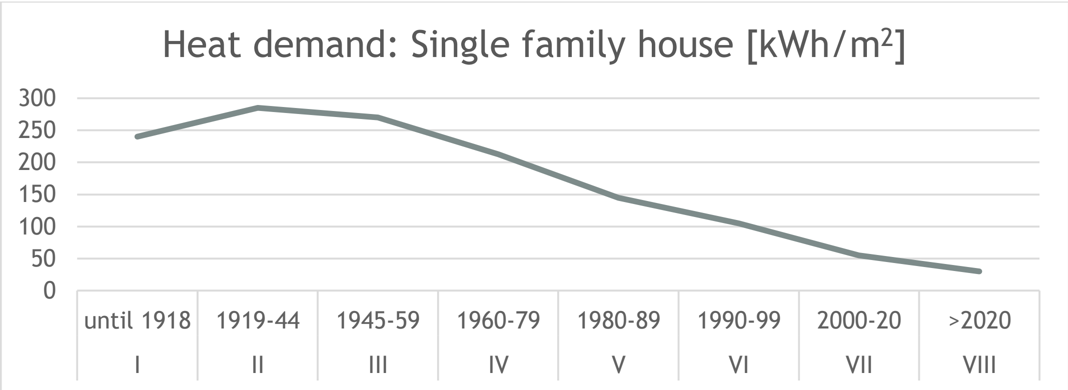

Figure 7: Heat demand over time for a single-family house (after Amtmann & Groß 2011)

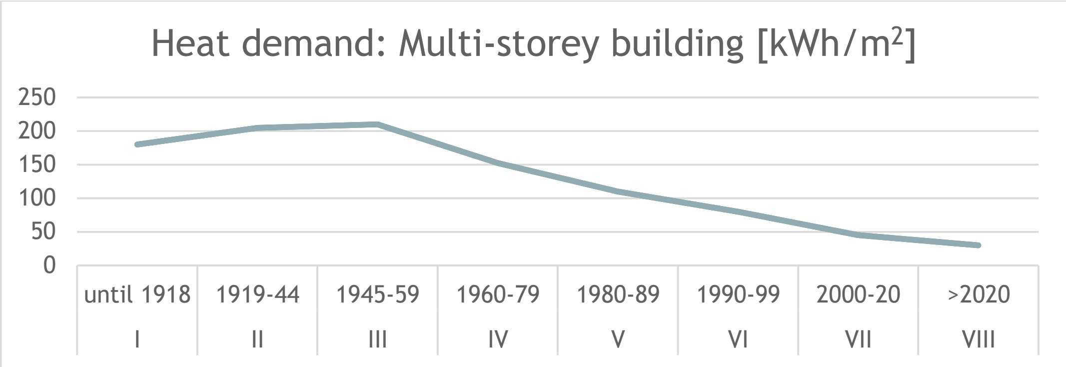

Figure 8: Heat demand over time for a multi-storey building (after Amtmann & Groß 2011)

3.5. Land use plan example in Upper Austria

Errore. L'origine riferimento non è stata trovata. shows the vicinity of the WWTP in Wallern an der Trattnach (land use plan), using online-GIS application "DORIS" in Upper Austria.

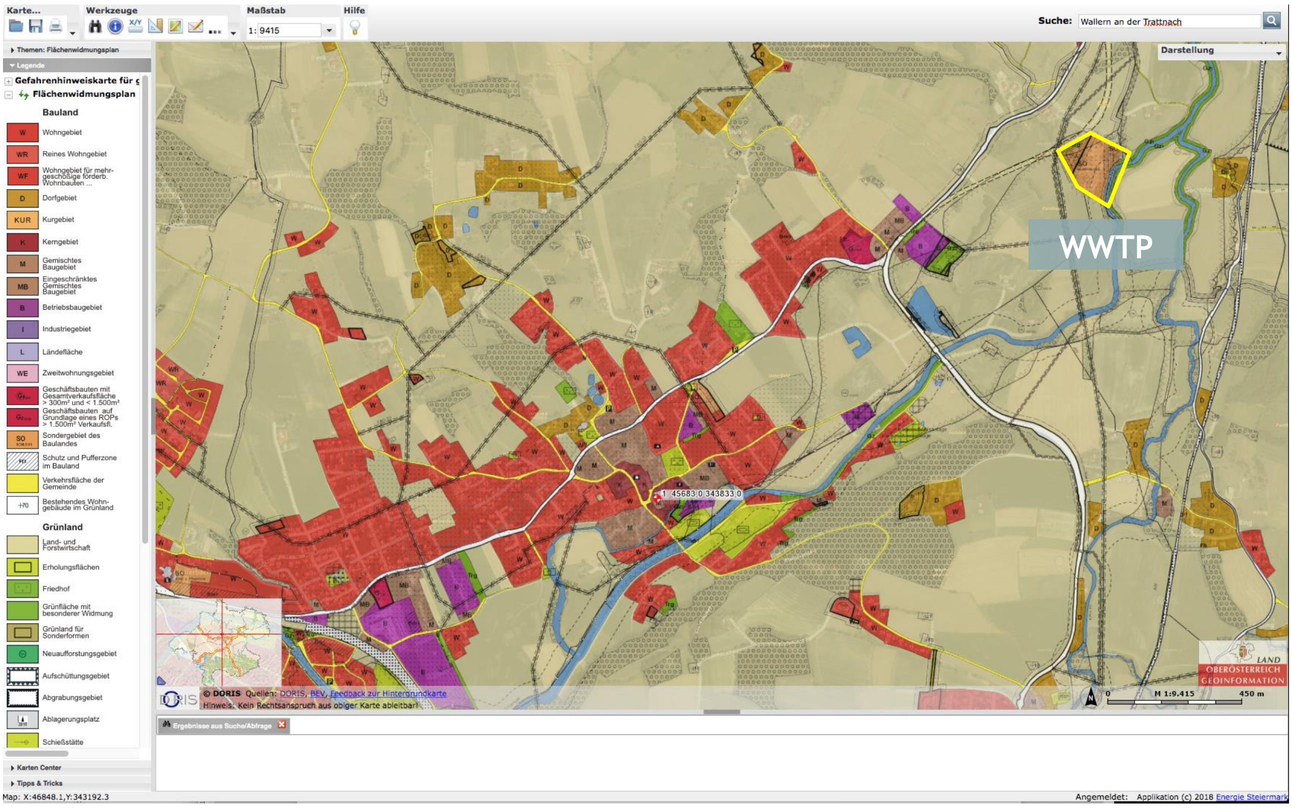

Figure 9: Illustration of the land use plan in the vicinity of the WWTP in Wallern an der Trattnach (DORIS s.a., BEV s.a.).