D.T4.3.3

PRE-ASSESMENT FOR EVALUATING THE SUITABILITY OF 15 2W PLANTS TO BECOME REEF 2W – AUSTRIAN CONTRIBUTION)

Content

1. INTRODUCTION

The pre-assessment of potential REEF 2W feasibility studies concerned the following Austrian locations (municipalities/wastewater utilities):

1. City of Kapfenberg, Wasserverband Mürzverband (wastewater association Mürzverband)
2. City of Vösendorf, Marktgemeinde Vösendorf (municipal wastewater association Vösendorf)
3. City of Wolkersdorf, Gemeinde Abwasserverband Wolkersdorf-Pilichsdorf-Großengersdorf (municipal wastewater association Wolkersdorf-Pilichsdorf-Großengersdorf)
4. City of Ottensheim, Klima- und Energie Region Urfahr West (climate and energy region Urfahr West) and Abwasservand Unteres Rodltal (wastewater asssociation Unteres Rodltal)
5. City of Rohrbach, Abwasserverband Mühltal und Region Böhmerwald (wastewater association Mühltal and Böhmerwald Region)

2. Methodology

Initially, a list with all necessary information for conducting the pre-assessment was send to the contact persons at each location. The data requirements for the REEF 2W tool provided the basis for data collection.

The data collection results (for each location) will be presented in the following order:

- Obtained information from local contact point (contact person)
- Location of the wastewater treatment plant (WWTP) or the potential energy generation site
- Size of the WWTP (capacity and current load)
- Inflow parameters
- Technologies applies (wastewater treatment and sludge stabilisation)
- Intention to participate in a REEF 2W feasibility study

The pre-assessment results (for each location) will be presented in the following order:

- Current energy balance (consumption and generation)
- Additional energy generation potential
- Overview on potential energy consumers
- Comparison of current and future energy potentials

Table 1 summarizes the methods used for data processing and evaluation.

Table 1: Applied methods to process and evaluate data (own presentation)

Aspects of pre-assessment	**Method**
Thermal energy potential of wastewater	$\mathbf{P_{RS} = Q_{RS} * C * \Delta T_{RS}}$ with heat recovery site RS, available heat potential P_{RS}, wastewater flow rate Q_{RS}, specific heat capacity C and temperature decrease due to heat recovery ΔT_{RS}
Biogas generation potential of digester tower	according to **DWA-M 368** (2014)
Thermal energy consumption of anaerobic sewage sludge treatment (digestor)	according to **Lindtner** (2008)
Thermal energy potential of digester gas based combined heat and power (CHP) generation	$\mathbf{CHP_{thermal} = Q_{CH4} * U * EFF_{thermal}}$ with available thermal energy potential $CHP_{thermal}$, biogas yield Q_{CH4}, energy content of biogas U and thermal efficiency $EFF_{thermal}$
Electric energy potential of digester gas based combined heat and power (CHP) generation	$\mathbf{CHP_{electric} = Q_{CH4} * U * EFF_{electric}}$ with available electric energy potential $CHP_{electric}$, biogas yield Q_{CH4}, energy content of biogas U and electric efficiency CHP $EFF_{electric}$
Electric energy potential of photovoltaics (PV)	$\mathbf{E_{PV} = Eff_{total} * Eff_{module} * R * P_{PV} * A_{module} / P_{module}}$ with available electric energy potential E_{PV}, efficiency of PV-system Eff_{total}, efficiency of PV-module Eff_{module}, Radiation R, output of PV-system P_{PV}, module area Amodule, module output P_{module}

3. Pre-assessments carried out in Austria

3.1. City of Kapfenberg

3.1.1. Introduction and general information

Information obtained

- the annual log of WWTP including WW-temperature, WW-flow, WW-load, sewage sludge amounts, biogas production, thermal and electric energy consumption and production, etc.
- monthly heat balance of the WWTP
- potential energy consumers in the vicinity of the WWTP

Location of the WWTP

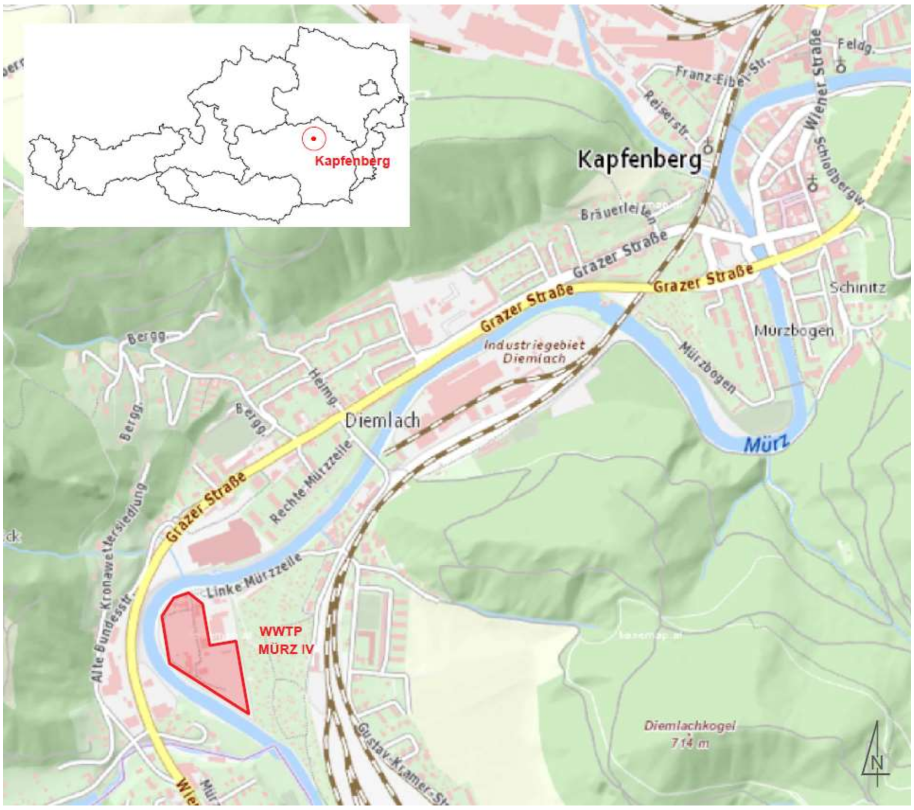

Figure 1: WWTP Kapfenberg (basemap.at, 2020, adapted)

Table 2: Information on WWTP Kapfenberg (own presentation)

Size of the WWTP		
Treatment capacity	49.000	PE60
Current load	44.017	PE60
Inflow parameters		
Wastewater flow (*)	6.672	m³/d
Wastewater temperature (**)	14,8	°C
COD (***)	679,8	mg/l

(*) Daily average, (**) Annual average, (***) Monthly average

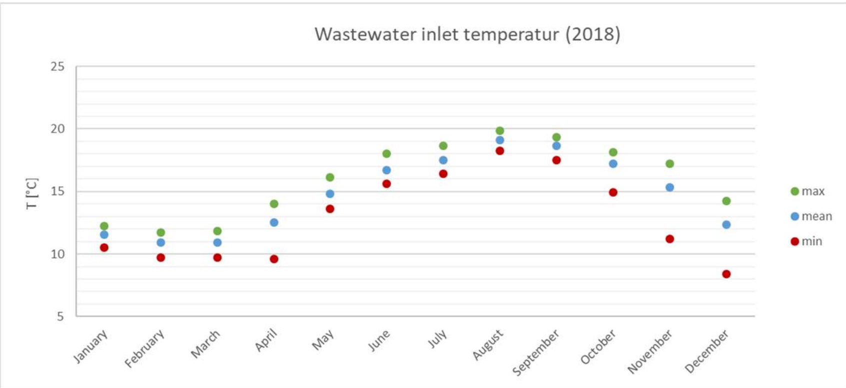

Figure 2: Wasterwater inlet temperature WWTP Kapfenberg 2018 (own representation)

Technologies applied

WWTP Kapfenberg is a single-stage active sludge WWTP with pre-denitrification, phosphate precipitation and anaerobic sludge stabilisation. The WWTP also includes a combined heat and power unit and a photovoltaic system.

Intention to participate in a REEF 2W feasibility study

The local representatives are interested in wastewater heat recovery in the WWTP's effluent to supply WWTP internal (low temperature) heat demand. Heat from the existing CHP unit shall be supplied to external (high temperature) heat demand.

3.1.2. Results of the pre-assessment

Table 3: Current energy balance WWTP Kapfenberg (own presentation)

Thermal and electric energy consumption		
Total thermal energy consumption (*)	5.528	kWh/d
Total electric energy consumption (*)	3.909	kWh/d
Thermal energy generation		
Combined heat and power plant (*)	3.106	kWh/d
Boiler (*)	2.561	kWh/d
Total thermal energy generation (*)	5.667	kWh/d
Electric energy generation		
Combined heat and power plant (*)	2.018	kWh/d
Photovoltaic (*)	198	kWh/d
Total electric energy generation (*)	2.216	kWh/d
Energy from anaerobic digestion		
Total biogas generation	458.087	m^3/y
Energy supply from external sources		
Total electric energy supply (*)	1.891	kWh/d
Total natural gas supply	37.622	m^3/y
Energy supply for external use		
Electric energy supply (*)	198	kWh/d

(*) Daily average 2018

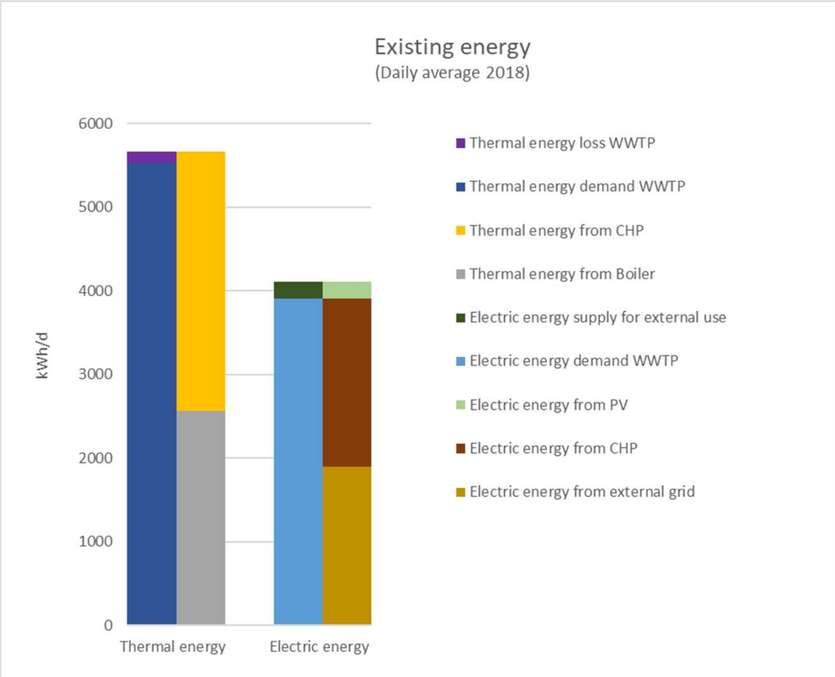

Figure 3: Current energy balance WWTP Kapfenberg 2018 (own representation)

Additional energy generation potential

Wastewater heat recovery potential has been calculated on basis of WWTP inflow. A heat pump (HP) with 600 kW is intended to estimate generated energy from wastewater. Photovoltaics with 250 kWp are applied to estimate the solar energy potential. The hydroelectric potential cannot be estimated yet, further details are missing.

Table 4: Additional energy generation potential WWTP Kapfenberg (own presentation)

Thermal energy potential		
Thermal energy potential HP (COP = 3.8)	12.312	kWh/d
Electric energy potential		
Electric energy potential PV	386	kWh/d

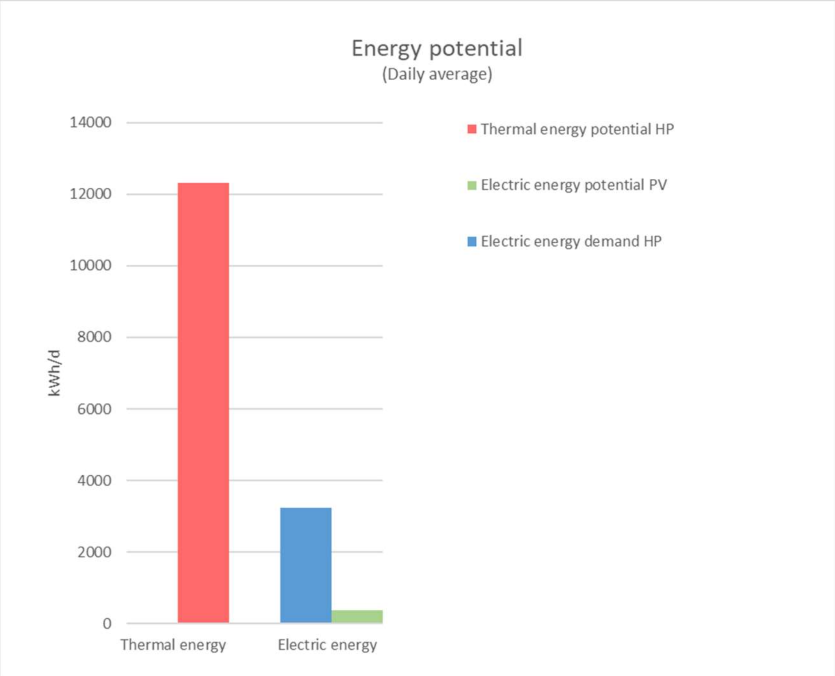

Figure 4: Energy potential WWTP Kapfenberg (own representation)

Overview on potential energy consumers

The WWTP is located within a low-density settlement area characterized by mixed-use. In addition to an apartment building under construction, thermal energy could maybe be feed into the district heating network.

Table 5: Information on potential energy consumers around the WWTP Kapfenberg (own presentation)

	energy demand		**distance**	
Apartment building “RIVERSIDE” (*)	2.340	kWh/d	350	m

(*) Daily average

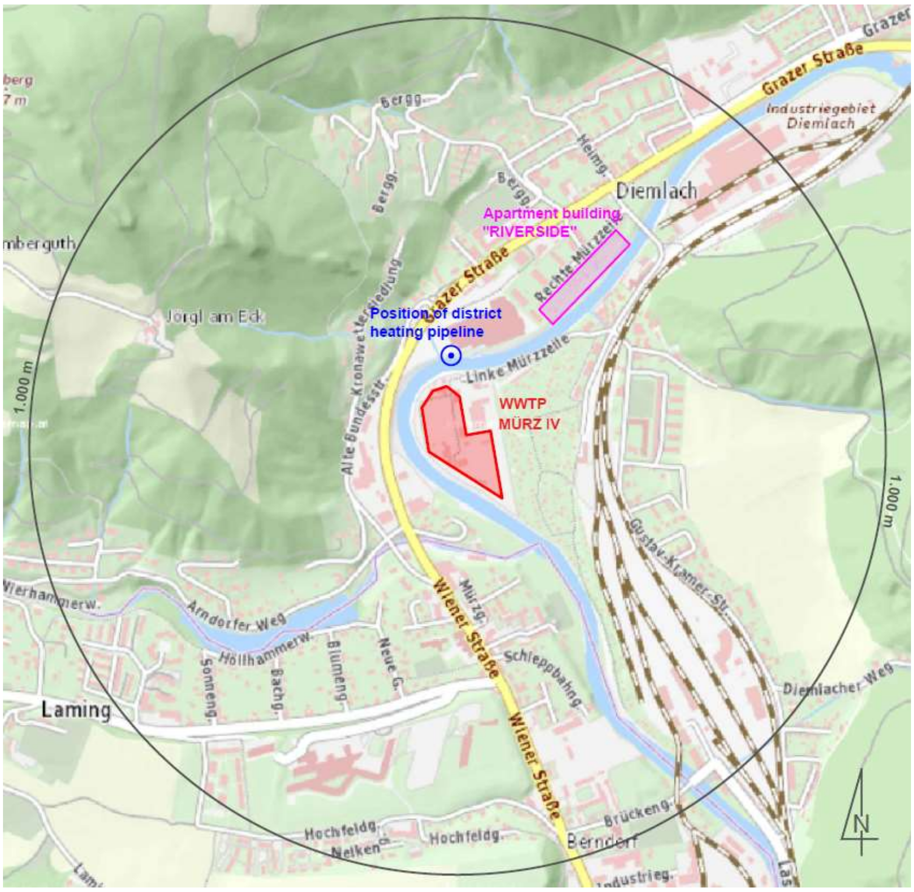

Figure 5: Overview on potential energy consumers around the WWTP Kapfenberg (basemap.at, 2020, adapted)

Comparison of current and future energy potentials

Various assumptions are made for the possible feasibility study. Thermal energy recovered from wastewater is used to cover full internal heat demand, potentially available surplus heat is used externally. No more natural gas is burned in the boiler. Thermal energy generated with the CHP unit is used for external supply or can be used in the WWTP if there is a large heat demand. The CHP unit is operated with biogas from the digester and electric energy generated is used completely at the WWTP.

Table 6: Comparison of current and future energy potentials WWTP Kapfenberg (own presentation)

Thermal energy		
Thermal energy demand WWTP (*)	4.707	kWh/d
Thermal energy supply for external use (HP & CHP) (*)	10.711	kWh/d
Thermal energy from CHP	3.106	kWh/d
Electric energy		
Electric energy demand WWTP (excl. HP)	3.909	kWh/d
Electric energy demand HP	3.240	kWh/d
Electric energy from CHP	2.623	kWh/d
Electric energy from external grid	3.942	kWh/d
Coverage of internal energy demand		
Thermal energy from HP (*)	262	%
Electric energy from CHP (*)	37	%
Electric energy from PV (*)	8.5	%
Coverage of external energy demand		
Apartment building "RIVERSIDE" (*)	458	%

(*) Daily average

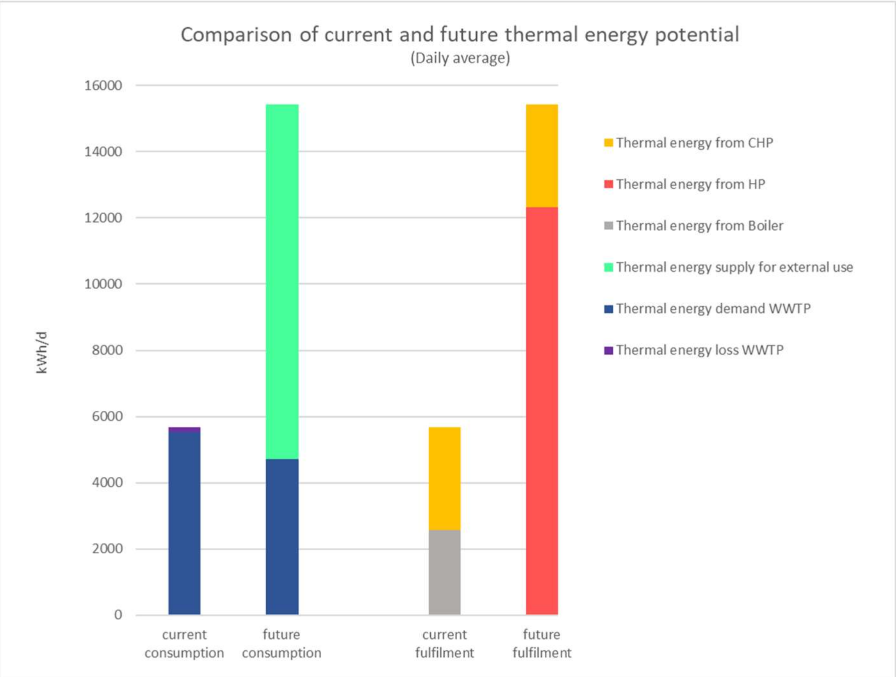

Figure 6: Comparison of current and future thermal energy potentials at the WWTP (own representation)

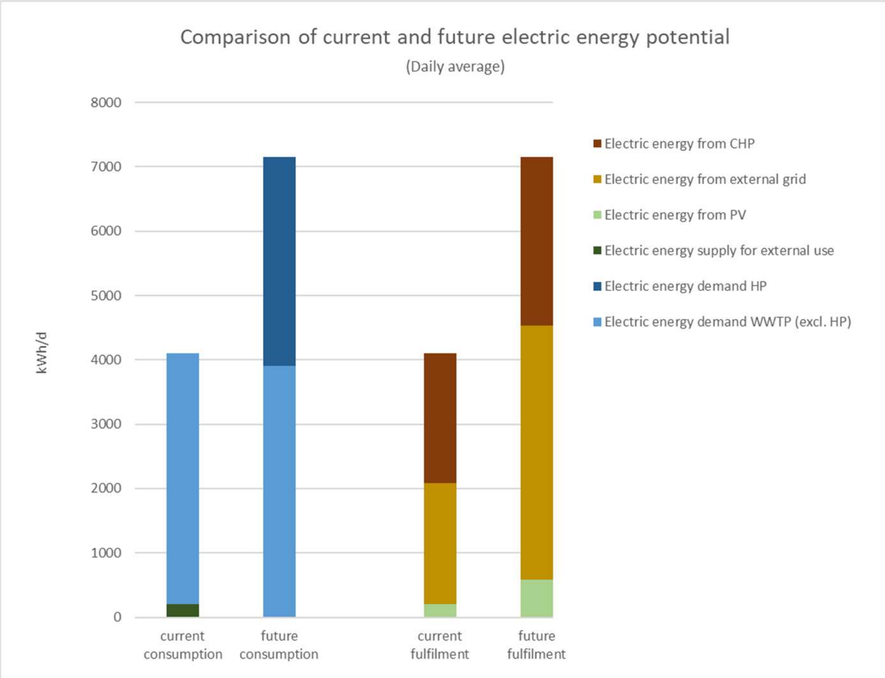

Figure 7: Comparison of current and future electric energy potential WWTP Kapfenberg (own representation)

3.2. City of Vösendorf

3.2.1. Introduction and general information

Information obtained

- the annual log of WWTP including WW-temperature, WW-flow, WW-load, sewage sludge amounts, thermal and electric energy consumption, etc.

Location of the WWTP

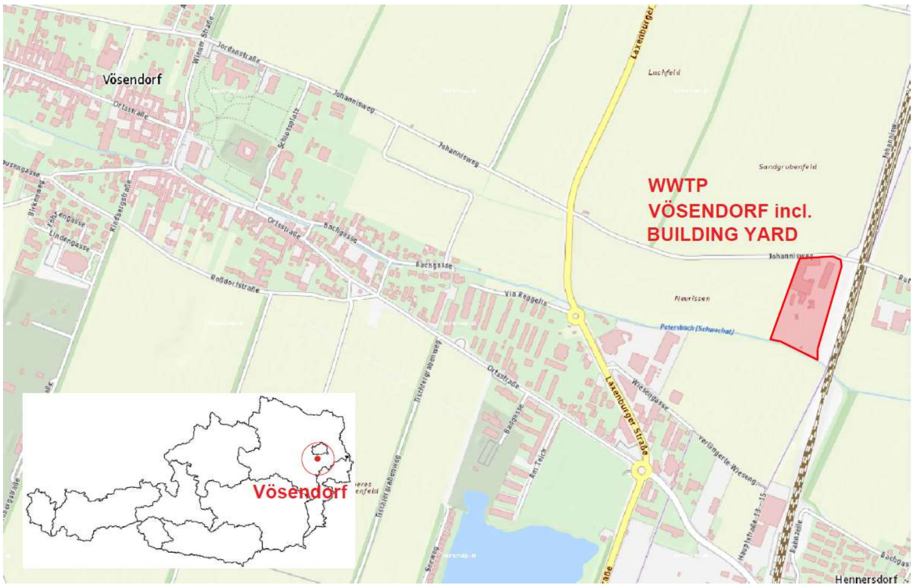

Figure 8: WWTP and building yard Vösendorf (basemap.at, 2020, adapted)

Table 7: Information on WWTP Vösendorf (own presentation)

Size of the WWTP		
Treatment capacity	20.000	PE120
Current load	16.000	PE120
Inflow parameters		
Wastewater flow (*)	3.863	m^3/d
Wastewater temperature (**)	10	°C
COD (***)	401	mg/l

(*) Daily average, (**) Winter average, (***) Monthly average

Technologies applied

WWTP Vösendorf is a single-stage active sludge WWTP with nitrification, simultaneous denitrification and aerobic sludge stabilisation. The WWTP also includes a photovoltaic system.

Intention to participate in a REEF 2W feasibility study

Due to population growth the WWTP has to be expanded. In this context, also the energetic context of the WWTP should be investigated. The local representatives are interested in the construction of an anaerobic digester as well as in wastewater heat recovery from the effluent. The energy shall be used for WWTP internal and external supply.

3.2.2. Results of the pre-assessment

Table 8: Current energy balance WWTP Vösendorf (own presentation)

Thermal and electric energy consumption		
Total thermal energy consumption (*)	822	kWh/d
Total electric energy consumption (*)	1.644	kWh/d
Thermal energy generation		
Thermal energy from Boiler (*)	822	kWh/d
Electric energy generation		
Thermal energy from PV (*)	96	kWh/d
Energy supply from external sources		
Total electric energy supply (*)	1.548	kWh/d
Total natural gas supply	39.474	m³/y

(*) Daily average 2018

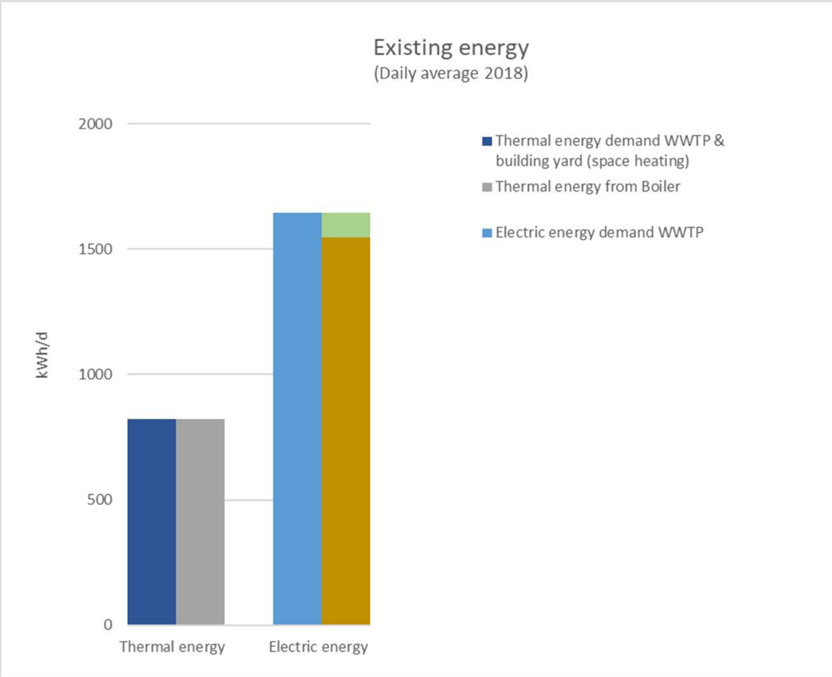

Figure 9: Existing energy WWTP Vösendorf 2018 (own representation)

Additional energy generation potential

In order to determine the energy potential, an expansion of the treatment capacity to 26.000 PE_{120} and the conversion to anaerobic sludge stabilisation shall be considered. In this context, a new CHP unit shall be applied and operated with biogas from anaerobic digestion. Wastewater heat recovery potential has been calculated on basis of WWTP inflow. A heat pump with 600 kW is intended. In addition, an expansion of the existing Photovoltaic of 150 kWp is considered. The hydroelectric potential cannot be estimated yet, further details are missing.

Table 9: Additional energy generation potential WWTP Vösendorf (own presentation)

Thermal energy potential		
Thermal energy potential HP (COP = 5)	13.860	kWh/d
Thermal energy potential CHP	1.125	kWh/d
Total thermal energy potential	14.985	kWh/d
Electric energy potential		
Electric energy potential PV	440	kWh/d
Electric energy potential CHP	743	kWh/d
Total electric energy potential	1183	kWh/d
Energy from anaerobic digestion		
Biogas generation potential	125.188	m^3/y

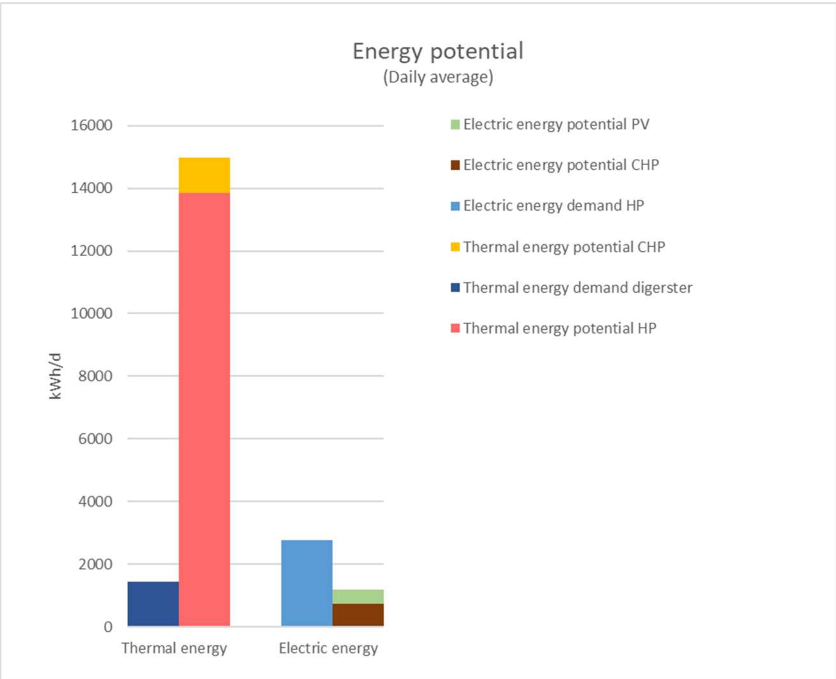

Figure 10: Energy potential WWTP Vösendorf (own representation)

Overview on potential energy consumers

The WWTP in Vösendorf is located within a medium-density settlement area characterized by mixed-use. Thermal energy could maybe be feed into the district heating network.

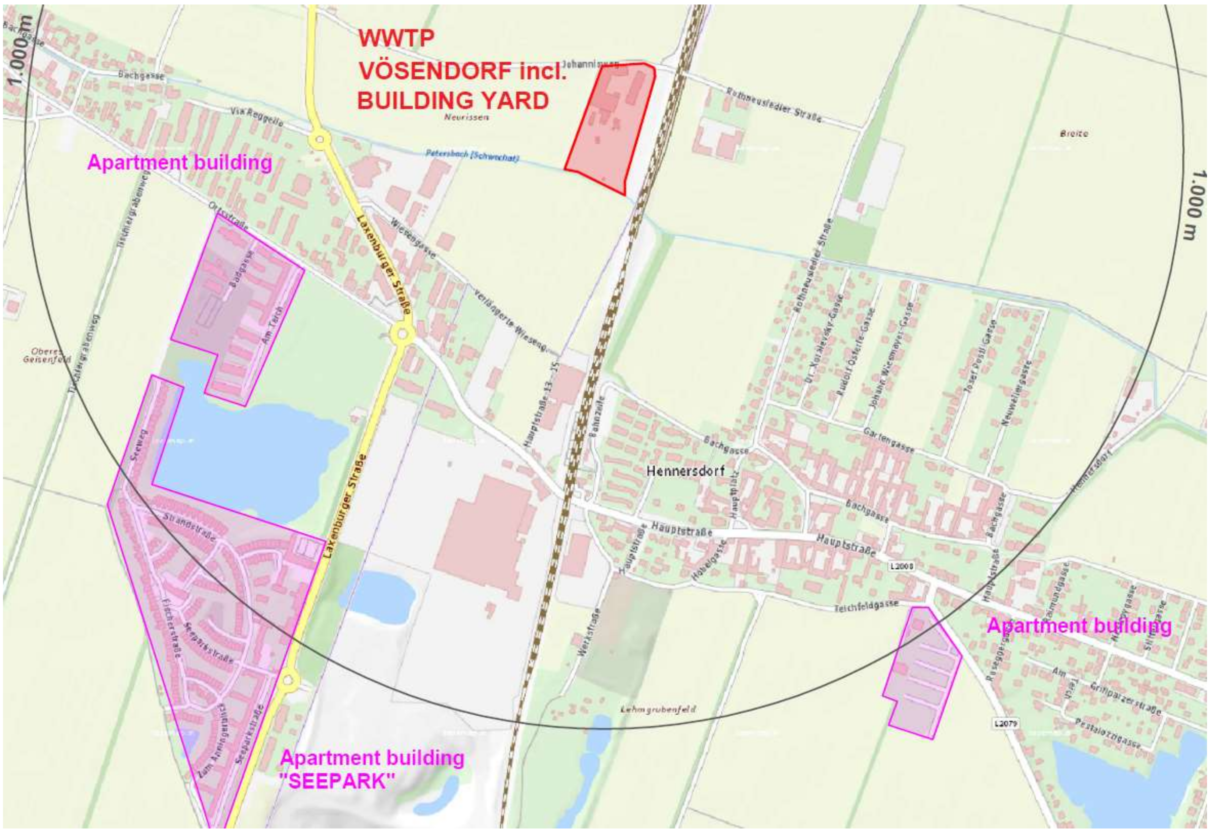

Figure 11: Overview on potential energy consumers around the WWTP Vösendorf (basemap.at, 2020, adapted)

Comparison of current and future energy potentials

Recovered thermal energy could be used to cover full internal heat demand, the surplus is to be used externally. No more natural gas is burned in the boiler. Thermal energy generated in the CHP unit is intended for external supply, but can be used additional in the WWTP if there is a large heat demand. The CHP is operated with biogas from the digester and electric energy generated is used completely on WWTP. To increase electric energy self-consumption, an expansion of 250 kWp photovoltaic is applied.

Table 10: Comparison of current and future energy potentials WWTP Vösendorf (own presentation)

Thermal energy		
Thermal energy demand WWTP & building yard (space heating) (*)	822	kWh/d
Thermal energy demand digester (*)	1.446	kWh/d
Thermal energy supply for external use (*)	12.699	kWh/d
Electric energy		
Electric energy demand WWTP (excl. HP) (*)	1.644	kWh/d
Electric energy demand HP (*)	2.752	kWh/d
Fulfilment of internal energy demand		
Thermal energy from HP (*)	611	%
Thermal energy from CHP (*)	50	%
Electric energy from CHP (*)	17	%
Electric energy from PV (*)	10	%

(*) Daily average

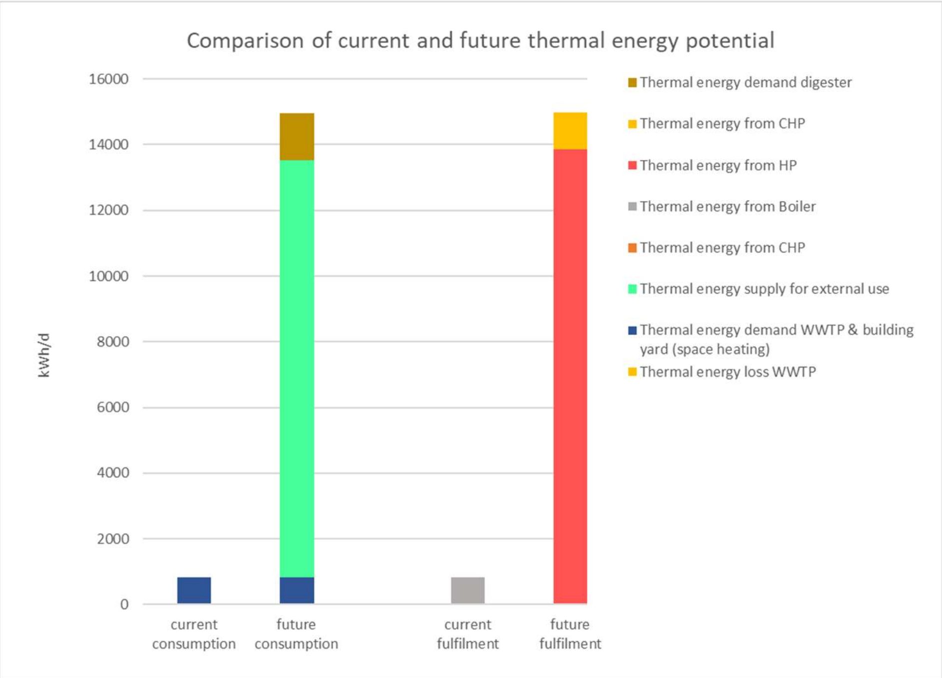

Figure 12: Comparison of current and future thermal energy potential WWTP Vösendorf (own representation)

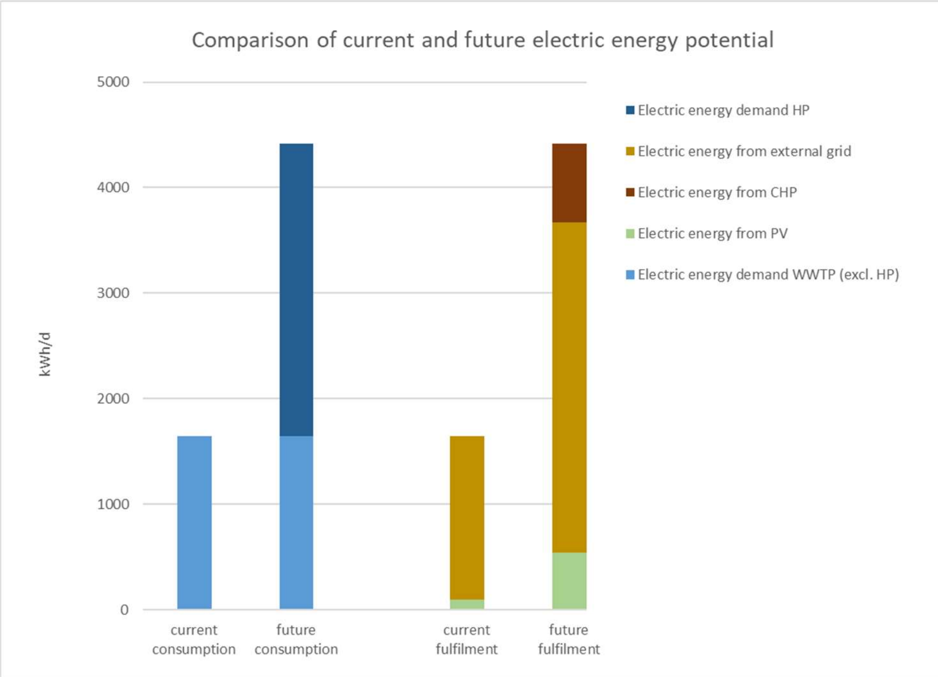

Figure 13: Comparison of current and future electric energy potential WWTP Vösendorf (own representation)

3.3. City of Wolkersdorf

3.3.1. Introduction and general information

Information obtained

- Capacity of the WWTP

Location of the WWTP

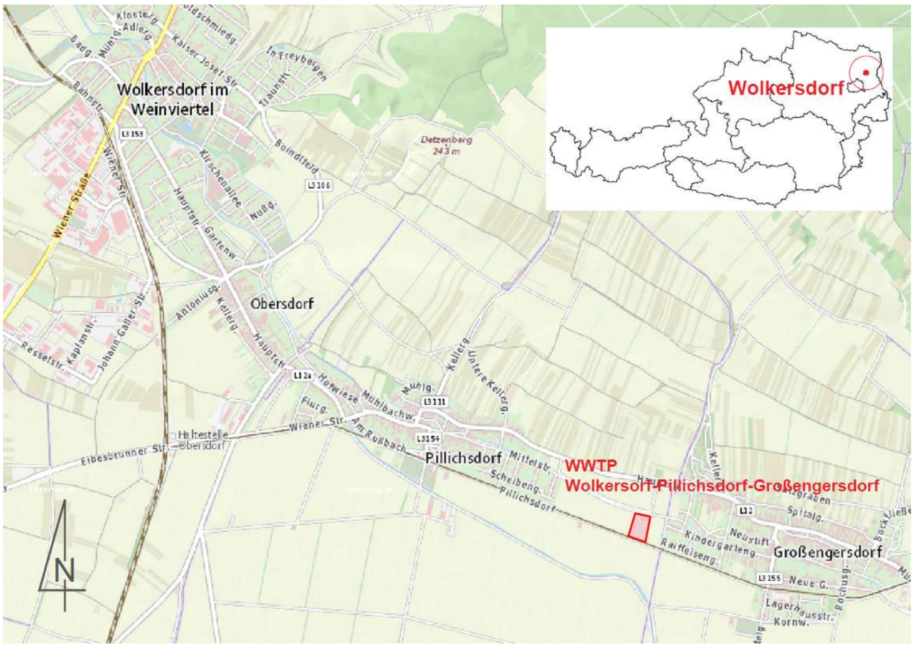

Figure 14: WWTP Wolkersdorf-Pillichsdorf-Großengergsdorf (basemap.at, 2020, adapted)

Table 11: Information on WWTP Wolkersdorf (own presentation)

Size of the WWTP		
Treatment capacity	35.000	PE

Inflow parameters and technologies applied

No information available yet. It seems, the WWTP is not equipped with an anaerobic digester yet.

Intention to participate in a REEF 2W feasibility study

The local representatives are interested in an energetic optimization including an increased energy generation for WWTP internal and external supply.

3.3.2. Results of the pre-assessment

Overview on potential energy consumers

WWTP Wolkersdorf-Pillichsdorf-Großengersdorf is located next to a low-density settlement and commercial area. Several small energy consumers are scattered around the WWTP.

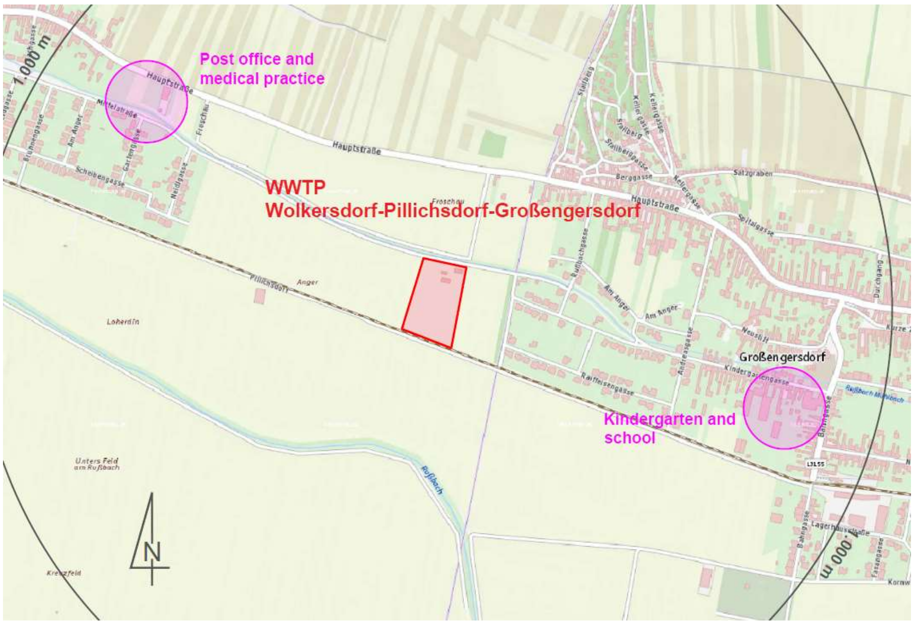

Figure 15: Overview on potential energy consumers around the WWTP (basemap.at, 2020, adapted)

No further information and data are available, consequently no results concerning the current energy balance, the additional energy generation potential and the comparison of current and future energy potential can be provided here.

3.4. City of Ottensheim

3.4.1. Introduction and general information

Information obtained

- WW-temperature and WW-flow at a in-sewer pumping station
- thermal and electric energy consumption and production of the intended heat consumer

Location of the potential energy generation site

Wastewater pumping station Ottensheim is 20 km upstream of the WWTP Linz-Asten.

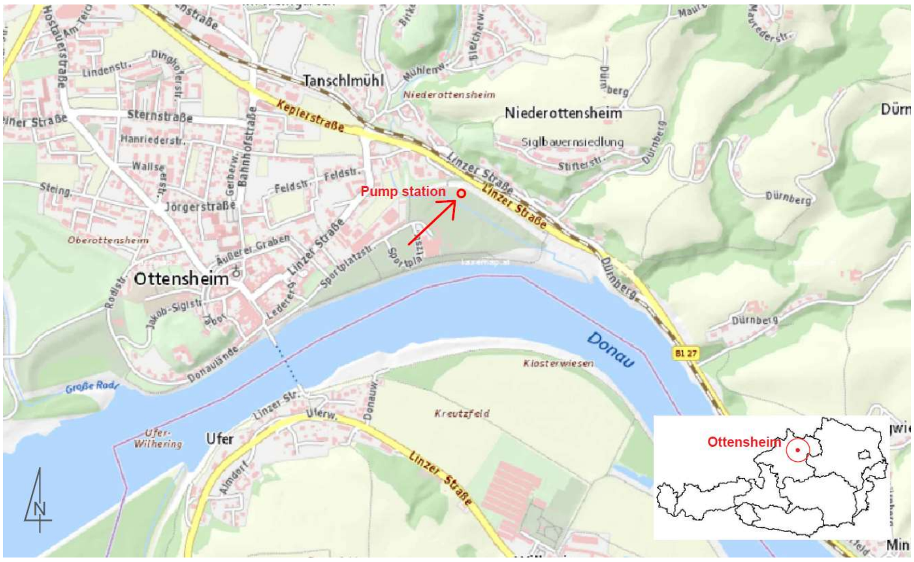

Figure 16: Location of pumping station Ottensheim (basemap.at, 2020, adapted)

Table 12: Size and flow parameters of the pumping station Ottensheim (own presentation)

Wastewater flow (*)	70	l/s
Wastewater temperature (**)	11.7	°C

(*) Dry weather flow, (**) Average December - January

Technologies applied

The pump sump has a dimension of approx. 2 x 4 m, the outflow pressure main a diameter of 500 mm. According to the responsible utility operator, the inflow main cannot be used as heat extracting point.

Intention to participate in a REEF 2W feasibility study

The local representatives are generally interested in the topic of energetic use of wastewater. However, their main concern is wastewater heat recovery. In their local specific context, they do not focus on the WWTP but on wastewater pumping station in the city.

3.4.2. Results of the pre-assessment

Current energy balance of pumping station Ottensheim

Concerning the current energy balance, no information on the electric energy consumption of the pumping station is available yet.

Energy potential

Wastewater heat recovery potential has been calculated on basis of the dry weather flow. Heat extraction take place in a bypass. A 120 kW Heat pump with a COP of 3.8 and approximately 2.200 operating hours is intended to supply the nearby energy consumers. At a dry weather flow of 70 l/s, the cooling of wastewater is around 0.3 K.

Table 13: Energy potential of pumping station Ottensheim (own presentation)

Thermal energy potential HP (COP = 3.8)	1.401	kWh/d
Electric energy demand HP	369	kWh/d

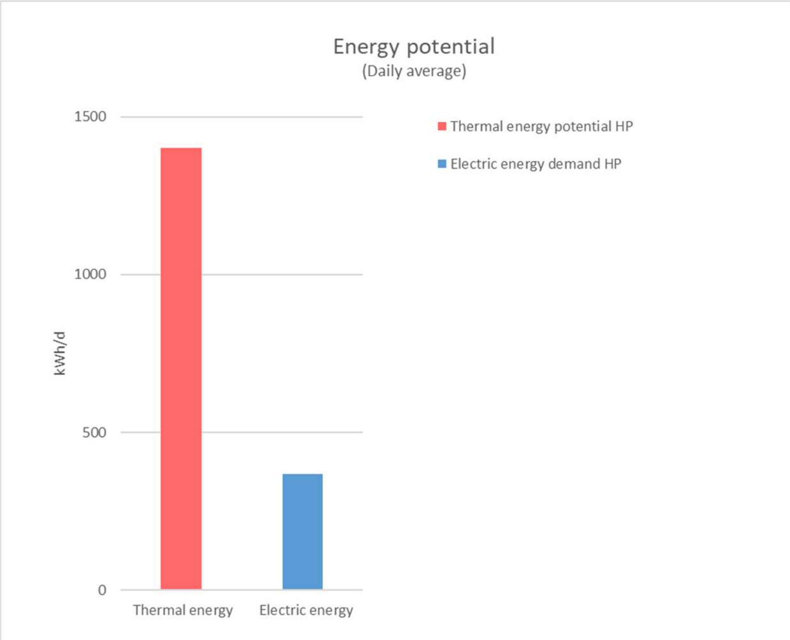

Figure 17: Energy potential of pumping station Ottensheim (own representation)

Overview on potential energy consumers

Pumping station Ottensheim is located within a low-density settlement and commercial area. A sports and event hall near the site will switch entirely to renewable energy.

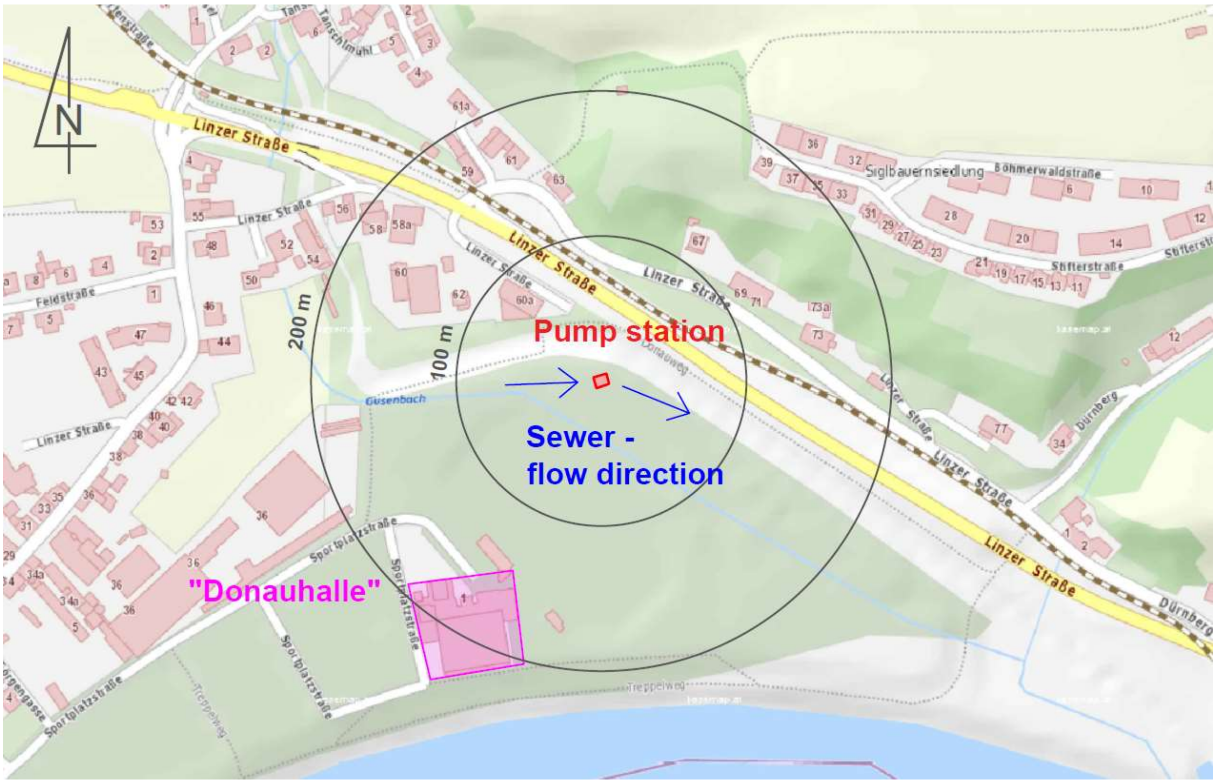

Figure 18: Overview on potential energy consumers at pumping station Ottensheim (basemap.at, 2020, adapted)

Table 14: Information on potential energy consumers around pumping station Ottensheim (own presentation)

Sports and event hall "DONAUHALLE"		
Distance	150	m
Thermal energy demand	2.780	kWh/d
Thermal energy from boiler	1.401	kWh/d
Thermal energy from solar thermal energy	3.106	kWh/d

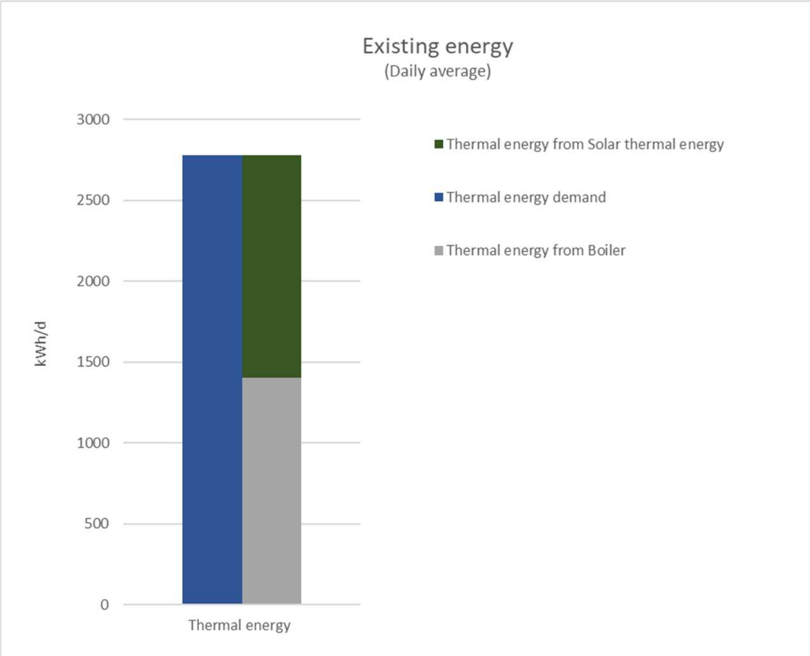

Figure 19: Existing energy balance (consumption) of "Donauhalle" Ottensheim (own representation)

Comparison of current and future energy potential

Restored thermal energy is used to cover a part of internal heat demand. No more natural gas is burned in the boiler.

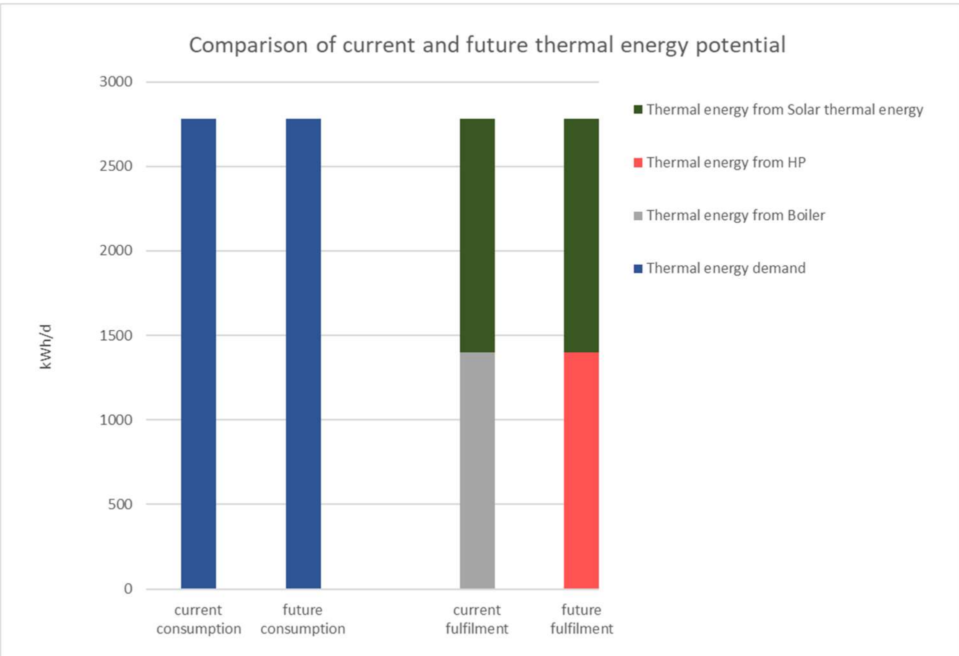

Figure 20: Comparison of current and future thermal energy potential "Donauhalle" (own representation)

3.5. City of Rohrbach

3.5.1. Introduction and general information

Information obtained

- recommended location for heat recovery and
- potential energy consumers

Location of the potential energy generation site

The considered in-sewer heat recovery site Rohrbach is around 6.5 km upstream of the WWTP.

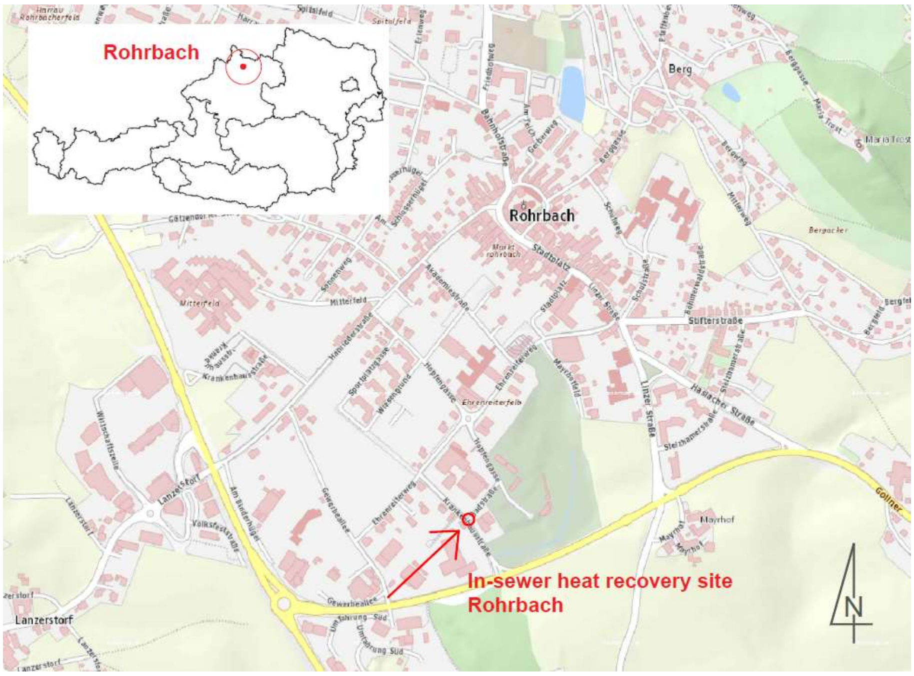

Figure 21: Location of potential in-sewer heat recovery site Rohrbach (basemap.at, 2020, adapted)

Size of the sewer, Flow parameters and Technologies applied

No information available yet.

Intention to participate in a REEF 2W feasibility study

The local representatives are generally interested in the topic of energetic use of wastewater. However, their main concern is wastewater heat recovery. In their local specific context, they do not focus on the WWTP but on in-sewer heat recovery in the city.

3.5.2. Results of the pre-assessment

Current energy balance of in sewer heat recovery site Rohrbach

The current energy balance cannot be displayed, as there is no installation under operation so fare.

Overview on potential energy consumers

The in-sewer heat recovery site is located within a medium-density settlement area with mixed use. In addition to an apartment building with 150 residential units and two secondary schools, a planned public indoor pool would be a potential heat consumer.

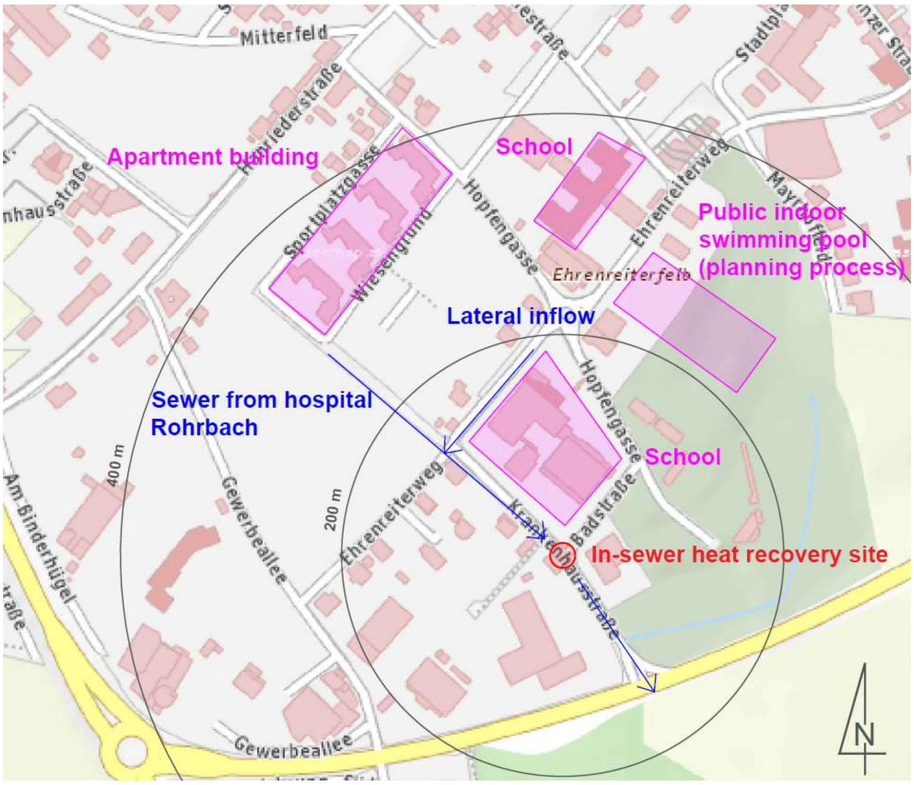

Figure 22: Overview on potential energy consumers Rohrbach (basemap.at, 2020, adapted)

The main sewer has a direct connection to the hospital Rohrbach with approximately 200 beds. Lateral inflow takes place in close vicinity to the in-sewer heat recovery site.

No further information and data are available yet, consequently also no results concerning the additional energy generation potential and the comparison of current and future energy potential can be provided here.

4. Conclusions

The following table summarizes the findings/results of the REEF 2W pre-assessment carried out in Austria.

Table 15: Summary of the pre-assessment Austria

#	Location	Main findings	Conclusions
1	WWTP Kapfenberg	• diverse technologies applied • sufficient heat recovery potential (for internal & external supply) • well-developed infrastructure for heat distribution • well-suited external consumer (new construction)	WWTP Kapfenberg provides good boundary conditions to increase internal energy efficiency and for integration into the local energy supply system. The local focus is on heat generation for WWTP internal and external supply.
2	WWTP Vösendorf	• great expansion & energy utilization potential • well-developed infrastructure for heat distribution • potential external energy consumers	WWTP Vösendorf provides interesting potentials for different technologies for renewable energy generation as well as for internal and external supply. The local focus is on anaerobic digestion and wastewater heat recovery for WWTP internal and external supply.
3	WWTP Wolkersdorf-Pilichsdorf-Großengersdorf (W-P-G)	• no infrastructure for heat distribution • existing data gaps (lack of information)	WWTP W-P-G appears interesting in terms of the possible application of different technologies for WWTP internal and external supply. However, several data gaps still have to be closed.
4	Pumping station Ottensheim	• thermal energy consumer in close vicinity • sufficient heat recovery potential (appropriate wastewater flow and temperature)	Pumping station Ottensheim appears quite suitable to cover the heat demand of the hall “Donauhalle”. However, the local focus is more on the sewer system than on the WWTP.
5	Sewer system Rohrbach	• well-suited external consumer (new construction) • existing data gaps (lack of information)	In-sewer heat recovery appears very promising at the intended site. However, the local focus is more on the sewer system than on the WWTP.

Concludingly, one can say that all five locations appear appropriate for a REEF 2W feasibility study. The potential to generate renewable energy from different technologies is certainly given. Even energy demand in the vicinity of the intended energy generations points could be identified. Two of the investigated sites refer to in-sewer energy generation. This is not the primary aim of REEF 2W. However, it addresses one of the REEF 2W technologies (wastewater heat recovery). Applying the REEF 2W approach (or parts of it) beyond the intended focus point (WWTPs) could be a good opportunity to further promote the entire issue. We will consider these aspects when selecting the additional Austrian REEF 2W feasibility study site.

5. Literature

basemap.at (2020) *Administration map of Austria*. Available at: https://www.basemap.at/.

DWA (2014) *DWA-M 368, Biological stabilization of sewage sludge*.

Lindtner, S. (2008) 'Guidelines for creating an energy concept for municipal WWTPs', p. 47. Available at: http://www.umweltfoerderung.at/uploads/energieleitfaden_endversion.pdf.