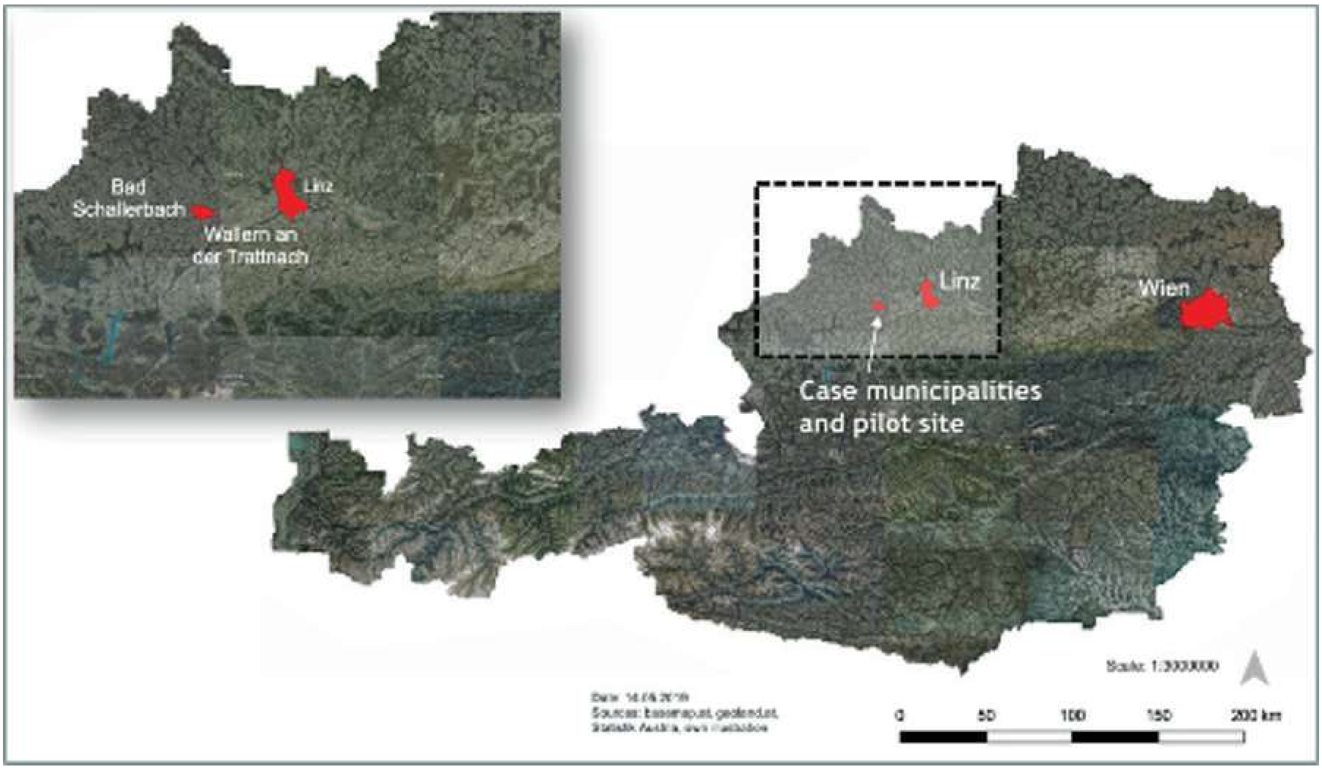
CASE STUDY AUSTRIA 3.6

3.6.1 Description of Wastewater Treatment Plant

The Austrian pilot WWTP is the plant of RHV Trattnachtal, located 15 km north of Wels in Upper Austria (Figure 3.11), with a capacity of 74.000 population equivalent (PE) and an annual wastewater flow volume of around 6 million m^3. Since 2008 a waste co-fermentation on the site of the WWTP has been implemented. The investigated strategies within this study are:

1. Reducing the energy demand of the WWTP
2. Increasing the energy output by using the resources available on-site
3. Developing strategies to use the surplus (heat) energy at surrounding consumers' sites

Figure 3.11
Location of the pilot WWTP in Upper Austria (Lichtenwoehrer et al., submitted)



Current energy consumption and production

The annual electricity consumption is 2,041 MWh (2016) which corresponds to 27.6 kWh per PE_{max} (74,000 PE) or 40.8 kWh per $PE_{average}$ (50.000 PE) or 0.34 kWh per m³ of wastewater (6,024,000 m³) and is split up into aeration (25%), return sludge cycle (17%), digesters incl. sludge line (11%), screening and sand trap (9%) and diverse consumers (38%). RHV has set up technologies using own electricity, e. g. for decanter press and for membrane filtration.

The surplus electricity (in 2016 1,755 MWh), which was nearly half of the produced electricity of 3,744 MWh, is sold to the grid for market price of only 3-6 Cent/kWh, therefore a subsidized tariff would be beneficial. The costs for natural gas were below 5,000 € (mainly measuring and net costs). Only 51 MWh were bought from the grid.

The heat consumption in 2016 amounted to 2,309,000 kWh, which is 31.2 kWh per PE_{max} or 46.2 kWh per $PE_{average}$ or 0.38 kWh per m³ of wastewater. 2,020,000 kWh were needed for digester heating (sludge treatment). The plant produces around 100 m3 preliminary sludge daily with a dry matter content of 3-6% and 20 m³ excess sludge with 2-3% dry matter. On the other hand, 2,848,000 kWh of heat were produced.

Compared to the Austrian benchmarking values (Lindtner, 2008), the total electric energy consumption (40.8 kWh/PEaverage) lies within the standard range of 20 to 50 kWh/PE, screening and sand trap (4 kWh/PE) lies above the standard range of 1-2 kWh/PE, aeration (10 kWh/PE) is below (11.5 to 22 kWh/PE) and the digesters incl. sludge line (4 kWh/PE) lie within the standard range of 2 to 7 kWh/PE. The heat consumption of 48 kWh/PE lies above the standard range of 0 to 30 kWh/PE, mainly due to a high consumption of digester towers (around 80 % of the total amount).

3.6.2 Technology upgrade of the pilot

Due to co-fermentation the WWTP has already over 100 % self-supply in electricity and heat. In order to use this heat via heat grid in an optimal way (as intended by above mentioned strategy 3), it is desirable to increase this surplus (as intended by strategies 1 and 2). Currently there is no need for this as the surplus energy cannot be used.

Reducing the energy demand

Insulation of the digester towers

Currently the digester towers are insulated with 9 cm of glass wool which corresponds to about 0.45 W/m²K. The heat consumption indicates that this value is higher. Therefore, it should be checked that the glass wool is dry. In any case, extending the thickness of the insulation from 9 to 12 cm and using PIR -Polyisocyanurate would result in better insulation values of about 0.18 W/m²K. Biological insulation materials would be another option. Around 300,000 kWh savings could be achieved.

Optimize temperature in the digester tower

The temperature should be as high as needed to produce biogas (production will slow down if digesters are kept too cold and the volume of the towers is limited), but as low as possible to minimize heat consumption. Up to 5 °C and 250,000 kWh/year are realistic values.

Reducing water amount in the sludge

The higher the dry matter content in the sludge the less water needs to be heated. Therefore, a preliminary dewatering of sludge before anaerobic digestion could be an option. The potential savings are in the same range as for the two previous measures.

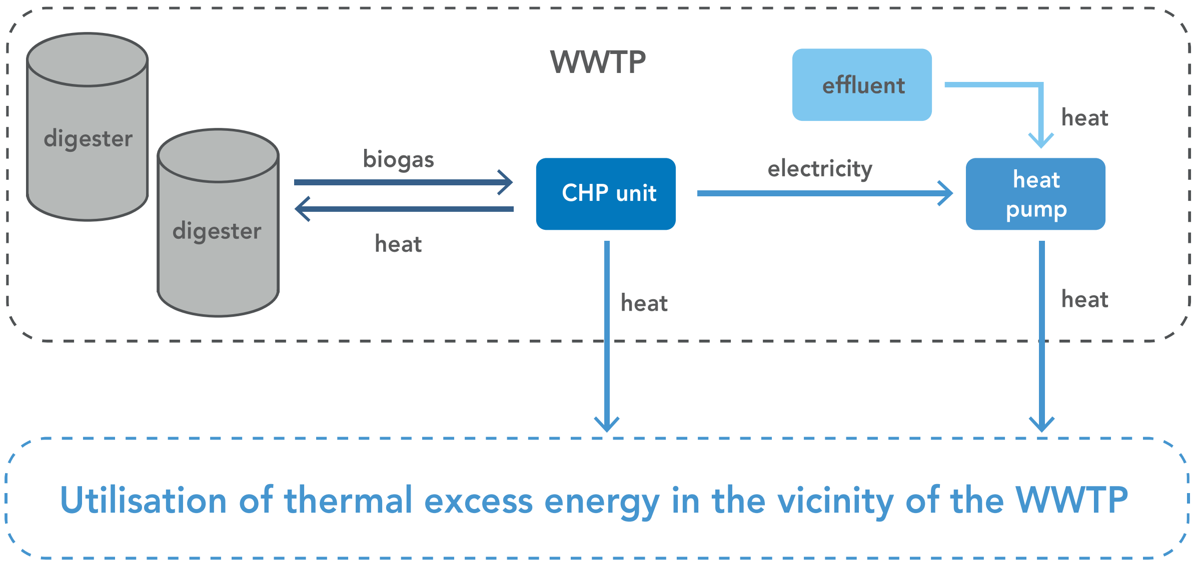
Optimizing the energy output

Main energy sources on a WWTP are the thermal energy of the wastewater (for heat up to 65 °C) and the energy from digester gas (for electricity and heat). Wind energy, solar energy and hydropower (applied for the effluent of the WWTP) are not considered as agreed with the WWTP operator.

Thermal energy content of wastewater-Heat recovery from wastewater

The mean wastewater flow at the WWTP is around 6,000,000 m³ per year or 191 l/s (average of 2016 and 2017), the minimum is 120 l/s. With a delta T of 2K a power of 120 l/s*4,18 kJ/kgK*2K = 1 MW can be extracted, resulting in an electricity consumption for heat pumps (COP = 4, which results from a mean source temperature of 14 °C, a mean supply temperature of 50 °C and a Carnot factor of 0.45) of 333 kW. In annual average the wastewater treatment plant has an electric surplus energy of 200 kW (January and February with lowest surplus), which means that heat pumps can be supplied by surplus electricity of the WWTP. The following illustration (Figure 3.12) shows the general approach of heat recovery from wastewater using surplus electricity for the heat pump operation.

Figure 3.12
Scheme of providing surplus heat from the wastewater treatment plant



As electric energy demand and consumption will be optimized, an even higher amount for the heat pumps is realistic. The wastewater temperature varies between 9.5 °C in January and 19.5 °C in August. Table 3.10 gives an overview on the wastewater heat recovery potential.

Table 3.10
Wastewater heat recovery potential

Mean used wastewater flow in l/s	Delta T in K	Heat extracted from wastewater in MWh/year	Needed electricity in MWh/ year	Total heat potential in MWh/ year	Mean thermal power in kW
120	2	8,788	2,929	11,717	1,338
120	4	17,576	5,859	23,435	2,675
191	2	13,988	4,663	18,650	2,129
191	4	27,975	9,325	37,300	4,258

A higher delta T or dimensioning the plant to use the complete wastewater flow increases the energy potential. The table 3.10 shows 4 scenarios and the resulting thermal energy potential. It has to be taken into account, that storage and grid losses will reduce the usable amount of heat.

Grid losses can typically be estimated to 15 % (Statistik Austria, 2020) with optimization potential for new grids with lower temperatures as planned in this case (and for higher densities), whereas storage losses highly depend on the system details. Lower demand in summer, repairs, shutdowns, etc. will further reduce the potential.

Digester gas utilization
The digester gas plays a completely different role compared to wastewater energy:

- It can be used for heat supply without using electric energy (e. g. for heat pumps),
- for heat supply at a high temperature level,
- and can additionally be used for electricity production.

Therefore, these two types of resources serve for different heat demands (e. g. low temperature domestic heat, high temperature domestic heat, domestic warm water, digester heat, etc.). An optimized storage strategy helps to cover all different heat energy needs.

3.6.3 Spatial assessment and potentials to utilise surplus energy from the WWTP

At the Austrian pilot site, a comprehensive spatial assessment was carried out. The goal was to evaluate the thermal energy demand in the vicinity of the treatment plant and to conceptualise a district heating network (DHN) in order to enable heat distribution. Further, the evaluated heat demand allows a comparison with the amount of recovered heat from wastewater.

The pilot plant is located approximately 1.8 km from the village centre of "Wallern an der Trattnach", which is the nearest case municipality. Further west "Bad Schallerbach" is located, which serves as the second case municipality. Within these two municipalities essential heat consumers, so called "thermal energy hotspots", were identified and assessed. Applying a spatial assessment, a total of 20 GWh/year of thermal energy demand was calculated. The conceptualised district heating network (DHN) has an overall length of 17,000 metres, connecting approximately 370 individual buildings. Considering the thermal energy demand and the lengths of the DHN, the connection density was calculated to be 1.2 MWh/m*year According to Nussbaumer et al. (2017), a connection density above 0.7 MWh/m*year is considered feasible.

3.6.4 Discussion

Energetic point of view

The REEF 2W solution of recovering thermal energy from wastewater will increase the overall energetic surplus of the WWTP. As indicated by the spatial assessment, there is sufficient heat demand in the vicinity of the WWTP to make use of this surplus. By changing the delta T and the maximum usable wastewater flow, the amount of heat recovery can be adapted to the demand. Finally, from an energetic point of view, the evaluated energy efficiency measures and the renewable energy provision will further contribute to a more sustainable energetic future, both within and outside the treatment plant.

Economic point of view

From an economic point of view the REEF 2W solution competes with various heating systems as gas heating, oil heating and wood heating systems. The dimensioning and the question who will take energy from the grid will influence tremendously the economic feasibility, as it influences the grid design and the relation to the sold amount of heat. Furthermore, the dimensioning of heat pumps and storages will play an important role as well as the price for electricity, the inserted interest rate and the expected lifetime of the system and its components. At this stage of research, a detailed economic analysis is not possible. However, parameters as high achievable heat density and usable own-produced electricity suggest good overall economic framework conditions.

Ecological point of view

From an ecological point of view the substitution of fossil energy with renewable energy sources can be considered as an essential goal. This substitution can be followed within the WWTP and beyond the WWTP. Besides internal energetic optimisations, the case study in Austria focused on providing surplus energy to the vicinity of the treatment plant. In this context, the current use of fossil energy in both case study municipalities is estimated at approximately 75% of the total energy consumption (Abart-Heriszt et al. 2019). Hence, heat recovery from wastewater as a renewable energy source able to replace fossil heating systems, of for example households or industries, is valued as an essential contribution to the ecological situation of the energy system.

3.6.5 Conclusion

In order to achieve the energy turn, holistic and integrated approaches are necessary. As part of the REEF 2W project, the presented feasibility study at the pilot site in Austria can be taken as a best-practice example on how to optimise the energetic situation at a WWTP, on how to generate surplus energy and finally on how to use the surplus energy in the vicinity of the treatment plant. Since heat accounts for a large share of the overall energy consumption, the substitution of fossil energy with renewable energy can be seen as a major contribution to the energy turn.