D.T2.1.1 REASONS/CONDITIONS LEADING TO THE CHOICE OF THE 5

Croatia

16/07/2018

1. Objective of the task:

In DT2.3.1, the pilot locations were selected. The main objective of this deliverable (D.T.2.1.1) is to identify the leading reasons for selecting the pilot locations, in this case the WWTP in Prague.

The deliverable draws on four deliverables finalised in Work Package 1.

- D.T1.2.1: Base line analysis of the current situation in the targeted utility companies/ territories
- D.T1.2.2: Relevant models highlighting integration and combination of technologies
- D.T1.2.3: Guiding document to demonstrate the benefits of implementation of REEF 2W plants
- D.T1.4.1: Detailed description of the methodology and criteria for location suitability

The deliverable is divided into three parts. First, an overview is provided about the initial situation at Central Prague WWTP (PCWTP), including the technological setup and its suitability. This is followed by an overview of the planned technological upgrade in the context of Reef2 W and the benefits accruing from it. The last part analyses the leading conditions including socio-economic and institutional aspects that qualified the WWTP for selection in Reef2W.

2. Initial Situation at the pilot site

The Central wastewater treatment plant Zagreb (CWWTZ) was completed in 2007 and counts as thethe first modern wastewater treatment plant (WWTP) in Zagreb. The WWTP complies with the environmental standards of the European Union in the field of environmental and water protection.

To date one of the main issues that CWWTZ is facing lies in the sustainable management of waste sludge. Sludge iscurrently landfilled at the location, total volumes of which measure up to approximately 50,000t per year on average. Of this approximately 30% is dry matter. In addition the municipality is in need to find a feasible solution for the treatment of collected bio-waste. At present bio-waste is partially collected from large producers. However of the majority of produced bio-waste is not recycled since household bio-waste is not subject to separate collection; it is disposed off as a mixed stream at an adjacent landfill. Significant improvement is expected in the future due to the legal obligation to start the collection of bio-waste from households.

The CWWTZ privides its services to 790.017 inhabitants of Zagreb and is operated by Zagrebacke Otpadne Vode d.o.o (ZOV), a private company that implemented the plant on the basis of funding from the European reconstruction and development bank. The operation of the plant is undertaken by the ZOV for a duration of at least 28 years.

The CWWTZ uses mechanical and biological treatment (AD). So far the sewage sludge is not undergoing any further treatment, but is discharged at an on-site landfill.

(Source: www.zov-zagreb.hr/en/home/)

Energy consumption

Sludge stabilization is being performed throughout the anaerobic process of biogas production. During this process half of the organic component in the sludge is turned into biogas and water. The plant has four digesters for AD, with each having a volume of 8.840 m^3. The daily energy output of produced biogas is 137.797 kWh/d. Its own biogas production covers more than 70% of the WWTP's electricity demand..

3. Technological Upgrade

Regarding the consideration of the REEF 2W technology, the main focus is on:

- utilization of bio-waste collected in the City of Zagreb;
- biogas upgrade to the quality of CNG;
- and sustainable solution for the produced sludge (Figure 1).

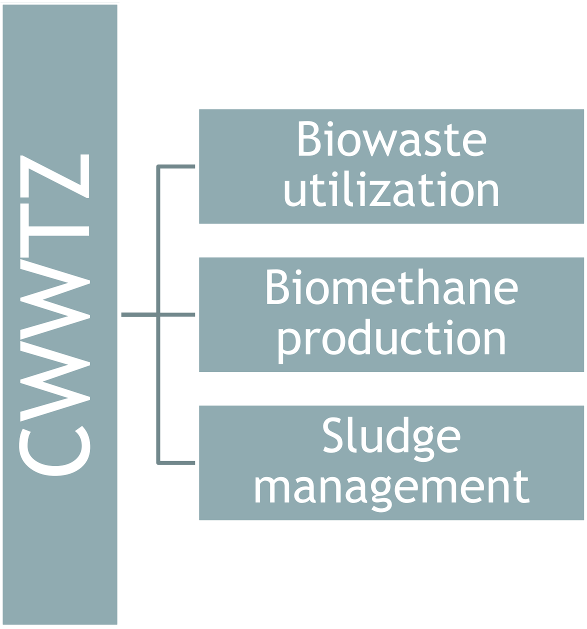


Figure 1: Proposed implementation of the REEF2W technologies in Zagreb

At the CWWTZ pilot site the implementation of a co-digestion plant is favoured.

To increase the biogas yield during anaerobic digestion bio-waste from the municipal solid waste collection is planned to be added to the sewage sludge. The biogas produced during ADshall then be upgraded into bio methane. The biomethane is subsequently planned to be injected into the natural gas grid, to which the plant lies in close proximity.

4. Expected Benefits

Efficient bio-waste use

City of Zagreb in January 2018 adopted the Decision on the manner of performing the public service of collecting mixed municipal waste and biodegradable municipal waste and services related to public service. This decision contained the obligation to start separate collection of biowaste within the city area.

Currently existing composting plants are not suitable for the treatment of bio-waste. The implementation of proposed REEF2W technology will hence be a significant benefit in order to treat separately collected bio-waste.

Reduced volumes of sludge

Total sludge disposal costs of large scale WWTPs such as the CWWTZ in Zagreb are approximately equal to personnel costs. The issue of final disposal of sludge at this side remains unsolved, which poses a big problem in the operation and maintenance of this plant. Therefore the treatment of the excess sludge by injection into a digester stabilises the sludge, minimizes the digestate and facilitates the further deposition of the sludge. Next to that it decreases the financial burden for sludge disposal.

Increased energy yield

Co-digestion of bio-waste and wastewater sludge increases the biogas yield. Energy utilization of bio-waste will increase biogas production at the CWWTZ and therefore increase the total energy production at site. The utilization of biomethane as a biofuel will have additional benefits as well. It is especially interesting due to the fact that City of Zagreb, through its public transport company (ZET), already has a fleet of busses that are fuelled by CNG.

Lowering landfill pressure

Separate collection of bio-waste will divert biodegradable waste from the landfill, which helps the City of Zagreb to fulfil targets set by current legislation.

Employment market development

New jobs are created by building a new employment segment in the waste collection and waste water treatment sector.

Alternative to incineration

The REEF2Water technology offers an innovative alternative to waste incineration and fosters the separation of municipal solid waste. Separate collection will divert biodegradable waste from landfill and have positive impact on overall employment. This is a step towards more sustainable waste management as it allows waste recovery and recycling, as well as the preservation of the natural resources.

5. Key Selection Criteria

Technological setup:

At the pilot site, a multitude of technological conditions favour the implementation of REEF2W solutions. The WWTP uses state-of-the-art technologies, being the first one in Croatia to comply with EU standards in the field of environmental and water protection, as was more thoroughly described in D2.4.1.

The proposed location already serves as the city's wastewater treatment plant and has the initial infrastructure necessary for accepting a biogas and biomethane plant, both from logistical point of view.

Location

Several factors make the location of the Zagreb WWTP suitable. It is situated close to the city centre with good connections for transport of biowaste in the future. At the same time, it was built with sufficient distance to residential areas. Public opposition, for example arising from complaints about odour, is hence unlikely to occur. Another central advantage is that the city's main high-pressure natural gas pipeline passes right next to the plant, making future grid injection of biomethane possibly uncomplicated.

Suitable scale and substrate

As the biggest WWTP in Croatia, the CWWTZ collects wastewater from 790.017 citizens and is designed for treatment of approximately. one million people. The sludge being produced at the WWTP in combination with the prospective addition of bio-waste from the municipal solid waste collection ensures sufficient quantities of digestible substrate. The use of biomethane is especially interesting due to the fact that the City of Zagreb, through its public transport company (ZET), already has certain Compressed Natural Gas (CNG) fleet of buses.

Biowaste availability

During recent years, collected bio-waste volumes have been increasing constantly in Zagreb. Despite needed improvements, nowhere else in Croatia than in the capital is there a greater availability of bio-waste . Over the past five years various projects were prepared and actions conducted in Zagreb to improve biowaste collection in response to fulfilling the EU’s targets on landfilled organic materials. The increased availability bio-waste also exerts pressure on regional and local governments to find disposal options for bio-waste, opening possible for co-fermentation in WWTPs.

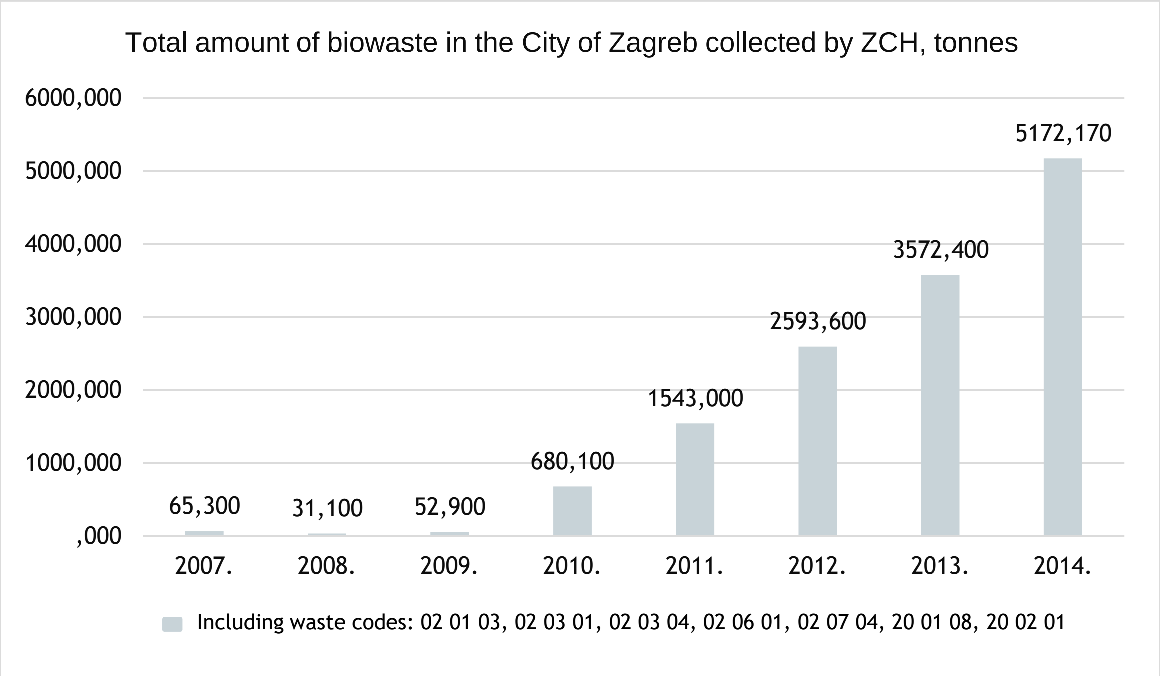


Figure 2: Increase of collected biowaste in the City of Zagreb (2007-2014)

Good basis for collaboration

The plant operator ZOV is largely owned by a consortium consisting of the German RWE Aqua GmbH and the Austrian WTE Wassertechnik. The collaboration with these internationally operating companies ensures necessary access to resources as well as a high level of skill and knowledge essential for the implementation of the technology and accurate maintenance. In addition the long-term agreement to operate the plant for 28 years enables the company and external investors to invest into long-term projects.

D.T2.1.1 REASONS/CONDITIONS LEADING TO THE CHOICE OF THE 5 PILOTS

Czech Republic

16/07/2018

1. Objective of the task:

In DT2.3.1, the pilot locations were selected. The main objective of this deliverable (D.T.2.1.1) is to identify the leading reasons for selecting the pilot locations, in this case the WWTP in Prague.

The deliverable draws on four deliverables finalised in Work Package 1.

- D.T1.2.1: Base line analysis of the current situation in the targeted utility companies/ territories
- D.T1.2.2: Relevant models highlighting integration and combination of technologies
- D.T1.2.3: Guiding document to demonstrate the benefits of implementation of REEF 2W plants
- D.T1.4.1: Detailed description of the methodology and criteria for location suitability

The deliverable is divided into three parts. First, an overview is provided about the initial situation at Central Prague WWTP (PCWTP), including the technological setup and its suitability. This is followed by an overview of the planned technological upgrade in the context of Reef2 W and the benefits accruing from it. The last part analyses the leading conditions including socio-economic and institutional aspects that qualified the WWTP for selection in Reef2W

2. Initial Situation at the Pilot Site

Figure 1: Picture of the PCWTP (l.)

The waste water treatment plant (WWTP) serving as the Czech pilot site is situated on the northern part of Prague, on a riverine island adjacent. to residential areas. It has a capacity of 1 641 000 PE The PCWTP is a mechanical-biological system with a sludge production of about 75 000 t, which is further treated in a thermophilic anaerobic digestion.

Technological details of PCWTP

The PCWTP removes carbon containing water pollutants through biological treatment and partially ammonia nitrogen by oxidative denitrification. Phosphorus is removed through precipitation of Fe(III) salts. The technological line consists of several grit, flowing debris and sand catches; primary sedimentation tanks; activation tanks with fine-bubble aerators; rotating biological contactors and regeneration tanks of back-flow sludge. After thickening the excessive sludge it is mixed with primary sludge and pumped into tiered digestion tanks which are temperated to 55 °C. The digested sludge is then dried by centrifugation.

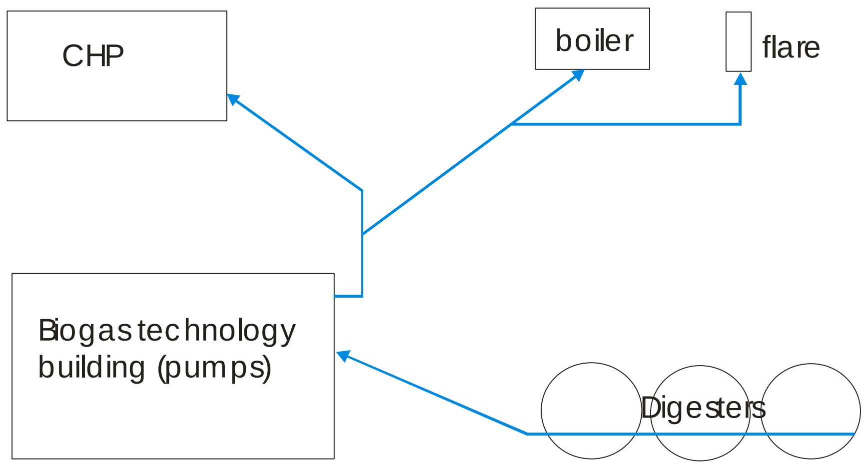
The WWTP in Prague is the largest biogas production site in Czech Republic. There is:

5 x 4380 m^3 digester (1stage)

5 x 4000 m^3 digester (2 stage)

5 x 6000 m^3 gas storage

3 x 0,95 + 2 x 1,25 MWel CHP



Veolia operates the PCWTP including the sludge line with AD thermophilic process. The biogas is now incinerated at the on-site CHP plant with an output of 5 MW of electricity (gas piston engines). Heat capture is limited, which renders the energy efficiency performance low.

Prague: anaerobic digestion of WWTP sludge

Biogas production (Nm^3/year)	18 066 974
Electricity production (kWh/year)	32 029 000
Plant self sufficiency	75 %
Biogas for other purposes (Nm^3/year) (now burned on flares without purpose)	1 150 000

Methane content of raw biogas	61 %

The PCWTP is producing ca 75 000 t per year of dry aerobic digested sludge for further processing - primarily composting and direct agricultural use.

3. Technological Upgrade

The REEF 2W technology at PCWTP encompasses a biogas upgrading to biomethane. The unit will be situated on the property of the WWTP Prague close to the digesters and the current biogas utilisation (CHP). Now the building permission proceedings are being carryied out and completion of the facility is planned for the first half of 2019.

After a detailed case study there was a decision over whether to choose PSA and membrane technology. PSA has a higher price, but lower operation cost. Membrane technology offers lower investment cost and higher operation costs. Due to priorities set within the project, the membrane biogas upgrading method was selected.

The technology consists of a membrane biogas upgrading unit and a compressed biomethane (bioCNG) vehicle filling station.

The biogas upgrading unit is connected to the existing raw biogas transport pipeline (pipeline from digester to CHP). It contains a unit for additional special biogas pre-treatment (removal of H_2S), gas drying and cooling unit, a compressor unit with filtration, a membrane separation unit, and a pressure control device for further distribution. The membrane separation unit is situated in a standard ISO20 container (width = 2.438 m, lengh = 6.058 m, height = 2.2348 m). Or another one according to the technology supplier). The container is mounted at the level of the terrain on the concrete blocks.

The filling station for vehicles contains a compressor, gas drying device, and a balancing pressure container - covering its own dispenser stand with the payment terminal (with the assumption of an automatic unmanned operation).

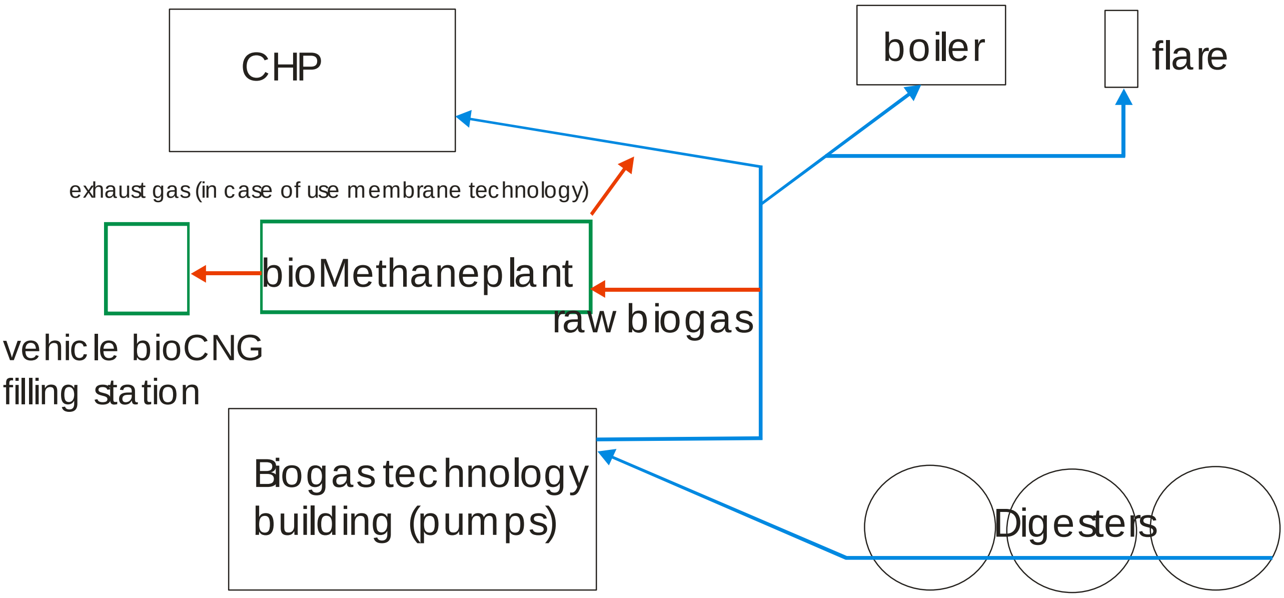
For compressed gas filling, stations for motor vehicles, TDG G 304 02 of the Czech Gas Association is available, which specifies the conditions for the location, execution, testing and operation of CNG fast-moving stations for motor vehicles if the inlet pressure does not exceed 0.03 MPa, the compressor does not exceed 20.3/h and the compressor internal volume does not exceed 0.5 m3.

The necessary space for the bioCNG vehicle filling station is approximately 12 x 8 m.

4. Expected Benefits

The biomethane plant will use currently unused biogas. It therefore raises the efficiency of energy use of theWWTP in Prague. The biomethane can be used as bioCNG in vehicle fuel (primary use), or as biomethane injected to the public natural gas grid (now considered as future variant of development, public natural gas grid is not easily accessible on the site).

The installation of the biogas upgrading unit causes only minor consequences to the WWTP site in terms of the space it used up. The installed technology has a small spatial footprintand is situated in standard containers. Only a small part of the produced biogas (now not used) will be upgraded.



The biogas upgrading unit will operate with 250 Nm^3/hour of raw biogas. Biomethane production will be 160 Nm^3/hour. This meansthat 2500 kg of bioCNG per day will be produced. This translates into 1370 kWh of green energy produced from currently unused biogas.

As a first biomethane project in Czech Republic, there is great opportunity to gain full operational experience with biomethane production technology which will build the basis for follow-uprenewable energy projects led by Veolia

Sales of bioCNG will achieve approx. 21 mio. CZK per year (840.000 EUR) in revenues. The price of bioCNG is comparable to common CNG price.

The biomethane plant can positively affect the energy efficiency of PCWTP and reduce air pollution generated by public transport.

By daily production, 15 – 100 vehicles (buses, cars) can be filled at filling station. The plant is not big, but it is the first bioCNG plant in Prague and (now also Czech Republic) and there is big potential of positive publicity for both renewable energy use and city of Prague.

About 2300 t of CO2 emission per year can be saved.

5. Key Selection Criteria

Location:

The Prague WTTP is one of the largest and the most modern wastewater treatment plants in Europe. It is located close to urban areas of Prague and very close to the public transport hub Prague-Dejvice which is used by a large fleet of public buses. The WWTP area itself offers sufficient space for accommodating the new bioCNG facility, which itself has a small spatial footprint.

Human resources:

At WWTP Prague there is experienced staff and laboratory background available for the biomethane project.

Energy Surplus: Currently, some of the produced biogas at WWTP Prague is not used, there is significant overproduction of biogas which is burned by flare. This sustainable surplus biogas enables the installation of the biomethane plant. Yet only a fraction of the biogas will be converted into biomethane, but in the future, there is the possibility to expand the biomethane unit and use more biogas to upgrading than CHP.

Suitability of technological Setup

Without certain minimum technological setup in place undertaking a comprehensive upgrading of wastewater-to-energy technologies is impossible. At the Prague WWTP, many of the technological pre-conditions exist that allow establishing and testing Reef2W solutions and many aspects revolving around integrated infrastructures and streams of the solid waste and wastewater systems.

Grid injection

The biomethane can be used as bioCNG in the transport sector (primary use), or as biomethane injected to the public natural gas grid (now considered as future variant of development). Also, given the close proximity of the WWTP to residential areas, there is potential demand for supplying excess heat via the district heating network.

Biomethane injection to the grid is technically possible (the grid is located in close distanceto the WWTP site) but there are several problems with piping because of issues relating to land ownership which prolonged permission procedures.

Public Perception:

The plant is the first bioCNG plant in Prague (now also in Czech Republic) and there is big potential for gaining positive publicity for both the city of Prague and Veolia. Biogas production at the Prague WWTP has a poor image due to challenges with frequent odour, noise caused by the CHP and anaerobic sludge production. This intervention can contribute to changing perceptions of WWTPs, from being a “public pain” to a provider of multiple benefits (including energy security and a healthy environment).

D.T2.1.1 REASONS/CONDITIONS LEADING TO THE CHOICE OF THE 5 PILOTS

Austria

19/07/2018

1. Objective of the task:

In DT2.3.1, the pilot locations were selected. The main objective of this deliverable (D.T.2.1.1) is to identify the leading reasons for selecting the pilot locations, in this case the wastewater treatment plant (WWTP) in Prague.

The deliverable draws on four deliverables finalised in Work Package 1.

- D.T1.2.1: Base line analysis of the current situation in the targeted utility companies/ territories
- D.T1.2.2: Relevant models highlighting integration and combination of technologies
- D.T1.2.3: Guiding document to demonstrate the benefits of implementation of REEF 2W plants
- D.T1.4.1: Detailed description of the methodology and criteria for location suitability

The deliverable is divided into three parts. First, an overview is provided about the initial situation at Central Prague WWTP (PCWTP), including the technological setup and its suitability. This is followed by an overview of the planned technological upgrade in the context of Reef2 W and the benefits accruing from it. The last part analyses the leading conditions including socio-economic and institutional aspects that qualified the WWTP for selection in Reef2W.

2. Initial Situation at the Pilot Site

Figure 1: Map of the wastewater treatment plant RHV Trattnachtal (Austrian pilot plant), source: RHV Trattnachtal

The WWTP serving as the Austrian pilot site is the plant of RHV Trattnachtal, located in Upper Austria (15 km north of Wels) with a capacity of 74.000 PE.

The sewage plant consists of:

- Preliminary sedimentation (1 x 1000m3)
- Aeration (2 x 2000m3)
- Final sedimentation (4 xx 1900m3)
- Digesters (2 x 2000m3)
- Gas storage (800m3)
- Sludge press and sludge e hall New built parts of the biogas plant:
- Receiving station (pump p and macerator)
- Storage tanks (3 tanks w with 120m3. 150m3 and 250m3)

• Sanitizing unit (2 x 7 m m3)

• Bio filter

• Flare

• 2 x 360 kWel MAN units

Processes:

The sludge of the preliminary sedimentation and the discharged sludge from the final sedimentation are pumped into the digesters. Per day an average amount of 120m3 sludge with approximately 3% dry matter is digested. Liquid sludge is stored in tanks and solid sludge is stored in the sludge hall. Depending on the sanitizing rules, bio- and slaughterhouse waste has to be sanitized according to o the EU-regulation: >70°C for min. 60 minutes and < 12mm particle size. All other material may be pumped into the digester without any heat treatment. Additionally to the 120m3 sludge a day, an average amount of 50m3 waste is pumped into the digesters. Solid material is re-liquified by inserting it into the thickener ,where the sludge is stored before being pumped into the digesters. With the aid of a powerful stirring unit the solids are mixed with the liquid to end up as a thick paste (up to 10-15%), which can be pumped. The digester can only handle material with no or little dry matter, because the stirring unit is too weak for a strong mixing effect. Additionally the digester has only a small surface on top, so swimming layers are hard to handle. Consequently the plant can more effectivelydigest liquids with a high COD and a low dry matter content. Sewage sludge can also be treated, because it has a small particle size, which does not cause swimming layers.

Co-fermentation

Since 2008 the Biogas Trattnachtal GmbH has been operating an on-site co-fermentation with waste. The Biogas Trattnachtal is fully owned by the RHV-Trattnachtal. The Biogas Trattnachtal GmbH is the holder of the permit for waste processing (marked green in Figure 1) and the RHV-Trattnachtal holds the permit for the wastewater treatment (marked blue and red). Both permits have to be obtained from the local government but from different departments, which leads to totally different permits concerning involved topics and technical experts.

Power demand of RHV WWTP

This is an overview of the power consumption of the RHV-Trattnachtal in the year 2016:

- total electricity need 2016 . 2 mio. kWh
- the screening and sand trap needed 9,28%
- the aeration needed 24,46%
- the return activated sludge cylce needed 17,33%
- the digesters incl. sludge line needed 10,51%
- diverse consumers 38,44%

The sewage plant has a maximum performance of 74.000 population equivalents (PE) and an average performance of 50.000PE, so this results in an electricity need of:

2.000.000 kWh/74.000 PT= 27 kWh per PE maximum performance

2.000.000 kWh/50.000 PT= 40 kWh per PE average performance

The electricity need can also be calculated in combination with the treated water volume of 2016, which amounts to 2.000.000 kWh of electricity for 5.900.000 m3 waste water, equaling0,34 kWh per m3 of wastewater.

Heat use of a sewage plant

Sewage plants with digesters have a considerable heat demand. On the one hand they have to heat high volumes of sludge day by day, on the other hand the digesters loose heat due to their surface.

3. Technological Upgrade

Generally, three strategies exist in order to optimize the energy balance (electricity and heat):

- Reducing the energy demand of the wastewater treatment plant
- Optimizing the energy output by using the resources that are available on-site
- Developing strategies to use the surplus (heat) energy at surrounding consumers' sites

Reducing the energy demand of the wastewater treatment plant

As it was shown by co-fermentation the WWTP's self-sufficiency of heat and electricity already exceeds 100 %. In order to use the heatsurplus and tmake a heat grid profitable, it is desirable to increase this surplus (in this respect also electricity is relevant as it can be used for heat pumps). As a rough rule 1 MW of heat power allows to install a heating grid of 1 km. For electricity already small amounts are useful if they can be fed into the grid.

There are several options to reduce the demand of electricity and heat which can be of interest for RHV Trattnachtal.

Reducing heat demand

*Insulation of the digester tower*s: An important option to reduce the heat demand is the insulation of the two digestion towers. At the moment they are insulated with a 9 cm glass wool layer. Under normal circumstances this should lead to an insulation value of about 0,45 W/m^2K. Glass wool is in principle quite resistant against humidity, but if it is kept between two layers and water can enter, the thermal insulation quality of glass wool decreases rapidly.

There are two options of enhancing insulation performance:

1.) If the problems of humidity is relevant in this case, the glass wool layer should be kept dry. This is a low cost investment.

2.) Extending the thickness of the insulation layer from 9 to 12 cm would result in better insulation values of about 0,18 W/m^2K (using PIR). This is a more considerableinvestment. Using biological insulation materials will be another option to be compared.

Optimize temperature in the digester tower: Another possibility is to optimize the temperature in the digester towers. Presently there is no need to reduce the heat demand as the surplus energy cannot be used anyhow. But as soon as there is a heat grid installed, optimization of heat demand in the digester is a key issue.

Minimizing water amount in the sludge: The larger the dry matter content in the sludge the less water needs to be warmed up. Therefore the sludge should be as dry as possible (ensuring that pumps can still work).

Reducing electricity demand

Aeration: One possible strategy to reduce heat demand is the optimization of aeration. Either the amount of oxygen per time can be adjusted or time can be designated in which there shall be no aeration at all. Moreover it depends on the amount and quality of the actual wastewater how much oxygen has to be pumped into the wastewater basins.

Other opportunities can be found by checking benchmark values of Austrian wastewater treatment plants.

Optimizing the energy output by using the resources that are available on-site

The two main energy sources of a wastewater treatment plant are:

- The thermal energy of the treated wastewater: It can be used for low temperature heat up to app. 65°C
- The energy in the sewage sludge (digester gas): It can be used for electricity and heat generation.

Other forms of locally available non-fossil energy sources are:

- On-site electricity generation:
  - Wind energy
  - Solar energy
  - Water power by using a height difference between wastewater treatment plant and “Vorfluter”.
- On-site heat generation:
  - Solar energy

The pilot example will deal with wastewater energy and optimized use of the digester gas.

Thermal energy of wastewater

The mean wastewater flow through the wastewater treatment plant is 688 m^3/h or 191 l/s in the years 2016 and 2017.

Analysis of the effluent wastewater on an hourly basis shows that 120 l/s are available permanently.

With a delta T of 2K an energy amount of 120 l/s*4,18 kJ/kgK*2K = 1 MW (1 kg corresponds to 1 liter of water) could be extracted from the wastewater permanently, resulting in an electric energy consumption for heat pumps (using a COP of 4) of 250 kW. In annual average the wastewater treatment plant has an electric surplus energy of 200 kW (the seasonal variations will be of importance as in January and February show the lowest surplus). This means that – using heat storages with an appropriate volume – most of the energy for heat pumps can come from the surplus energy of the WWTP. Taking into account that strategies for reducing the electric energy demand and maximizing the electric energy consumption are available and will be investigated regarding their practicability on this pilot plant, an even higher fraction of the electric energy for the heat pumps is realistic. Table 3 shows the detailed data for the amount of wastewater and its temperature.

Table 1: Wastewater amount and temperature in the pilot plant in the 2016 and 2017 average, source: RHV Trattnachtal

	m³ waste water	T effluent °C
Jan	505.787	9,6
Feb	468.334	10,3
Mär	542.247	11,4
Apr	555.607	12,9
Mai	647.611	15,0
Jun	444.780	18,3
Jul	472.397	19,2
Aug	451.656	19,4
Sep	417.945	17,1
Okt	460.046	15,0
Nov	455.621	12,4
Dez	602.284	10,6
year	6.024.315	14,3

<u>Digester gas (from sewage sludge and cofermentation)</u>

Optimizing the energy output from digester gas is a task that will be investigated.

In the development of energy supply strategies the digester gas plays a completely different role compared to the wastewater energy explained before:

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

Therefore the two resource groups serve for different heat demands (which are: low temperature domestic heat, high temperature domestic heat, domestic warm water, digester heat, etc.).

Stratified storage tanks can store thermal energy from both sources. An optimized storage strategy will help to cover all different heat energy needs.

Developing strategies to use the surplus (heat) energy at surrounding consumers' sites

WWTPs demand significant amounts of energy for the treatment process, but are at the same time interesting from an energetic point of view, as they can provide thermal energy and electricity. While electricity can be fed into an existing electricity network, the provision of thermal energy requires a district heating network. The spatial context of the WWTP and the presence of existing or future heat consumers, determine the potentials for an efficient integration of surplus heat into local energy supply concepts.

For a first analysis of the spatial context, the CORINE land cover (Coordination of information on the environment) program of the European Commission can be used. The CORINE land cover program comprises different land-use categories, from which the following three categories can be used for an initial analysis: (1) "Continuous urban fabric" – built structures with little coverage of vegetation and bare soils; (2) "Discontinuous urban fabric" – mixture of built structures and vegetated areas; (3) "Industrial or Commercial units" – built environment with few vegetated areas. This is an interesting approach to get a first idea about the spatial context of the WWTP and the location of possible heat customers in the surrounding area (Neugebauer et al. 2015). Based on this first analysis a rough classification of the pilot site can be undertaken. According to Neugebauer et al. (2015) three different types of WWTPs can be distinguished: (1) WWTPs "within the settlement"; (2) WWTPs "near to the settlement" and (3) WWTPs "far from the settlement". As illustrated in Figure 2, the pilot site in Wallern an der Trattnach, can be classified as "near to the settlement".

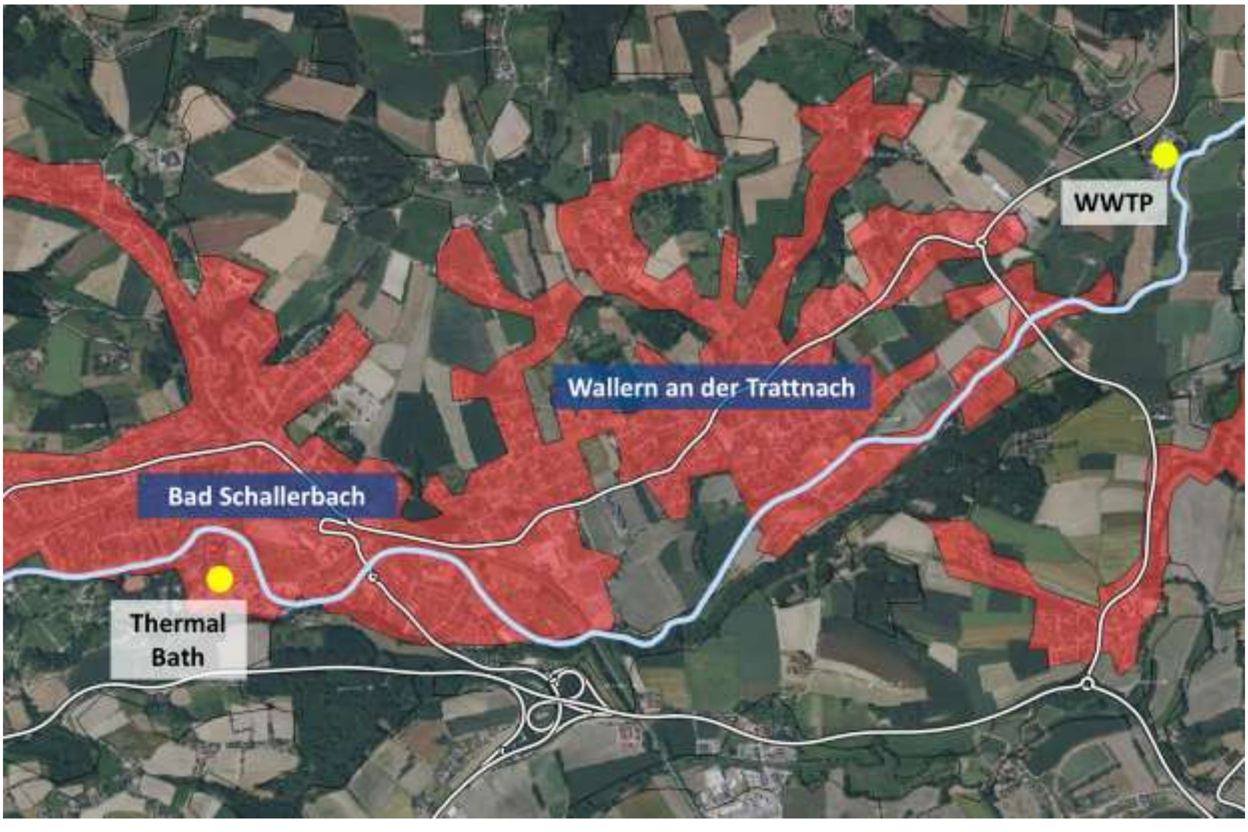


Figure 2: Visualization of the case study municipalities Bad Schallerbach and Wallern an der Trattnach, including CORINE land-cover category “discontinuous urban fabric” and two heat sources: WWTP and the Thermal Bath.

After the rough CORINE-analysis a selective identification of “key” heat customers in the WWTP’s surrounding should be carried out. Energy demand can arise from heating and cooling of

- Residential buildings
- Public buildings (e.g. schools, kindergarten, public swimming pools, hospitals, etc.)
- Commercial or industrial buildings

Additional thermal energy demand is generated by agriculture and forestry, as summarized in Neugebauer and Stöglehner (2015):

- Dewatering of wood chips, crops, medicinal or spice plants
- Heating and cooling of barns (e.g. for piglet breeding)
- Heating of greenhouses for the production of fruits, vegetables etc.
- Heating of aquaculture (for breeding fish or growing micro-algae)

If a district heating network should be developed, the distances between the heat source and the heat sink should be as short as possible. For the heat supply, two different supply systems can be distinguished: Warm district heating and cold district heating. Depending on the supply temperature, there are less heat losses in a cold district heating system, which means that greater distances can be covered. However, the closer the heat consumer is located to the WWTP the better, also for the economic feasibility of a district heating grid. Table 4 shows a rough estimation of the maximum distance between the WWTP and the energy consumer, depending on the particular heat capacity.

Table 2: Rough estimation of the economic feasibility, depending on the distance to the heat consumer (after Abwasserenergie 2017).

Estimating the economic feasibility	**Dimension of energy consumer (Heat capacity in kW)**				
	250 kW	500 kW	1000 kW	2000 kW	3000 kW
Maximum distance in m	100 m	500 m	1000 m	2000 m	3000 m

Depending on the consumer, different temperature levels might be necessary (e.g. high temperatures for industrial use and rather low temperature for new buildings with residential use). Furthermore, an optimization of spatial structures in order to enhance the overall heat demand can be carried out. In this context, the following questions arise: Is it possible to add additional buildings on open space? Is it possible to add additional storeys to already existing structures? Planners and authorities should also think about future agricultural or industrial/commercial developments close to the WWTP. Specifically, in our case-study, the town of Bad Schallerbach is known for its thermal spring. Therefore, this potential heat source located in appr. 4 km distance to the WWTP could be used to support and feed the district heating network.

After the initial rough analysis, more detailed analyses can be carried out. There are two main options for a more detailed identification of the energy demand: (1) Settlement related heat demand identification and (2) Buildings related heat demand identification. Using the first option, specific heat demand is allocated to a certain settlement type. Each settlement type is characterized by a particular building arrangement (e.g. density or population), building type (single family house, multi-storey building, etc.) and utilization (residential, commercial, mixed use, etc.). For the second option, a detailed calculation of the heat demand for every single object in the vicinity of a WWTP is carried out. For instance, heat demand values (kWh/m^2.a) dependent on building types and construction periods can be used in order to estimate the heat demand of residential buildings. The specific heat demand can be multiplied with the energy related area (e.g. m^2 of living space) which results in a total heat demand of a building.

4. Expected Benefits

Self-supply and additional energy for grid injection:

With co-fermentation it is possible to deliver 100% of the heat and electricity needed to operate a sewage plant. So the costs for the external power will minimize. At the RHV WWTP the energy production rose by nearly 400% after starting the co-fermentation, so the biogas plant can now easily provide the needed electricity for the sewage plant.

The surplus heat now has to be chilled with no extra benefit. With the district heating the whole CHP heat can be used for heating purposes.

The bulk of the surplus heat can be captured in summer. From a supplier's perspective, this is a challenge. Heat is mainly needed in winter for residential heating. At the same time, the WWTP itself requires considerably more heat for warming the sewage plant digesters.

The heat pumps have the task to deliver additional heat in winter, therewith balancing out the summer-winter gap.

Environmental benefits of the REEF2W solutions

Using wastewater as a thermal energy source can significantly reduce the environmental impacts (expressed in terms of CO_2 emissions, ecological footprint calculations or global warming potential – GWP) compared to the use of fossil energy sources like natural gas. In order to generate thermal energy from wastewater, heat exchangers and heat pumps are needed. For the operation, electricity is required and therefore an electricity mix that mainly consists of renewable energy sources should be used.

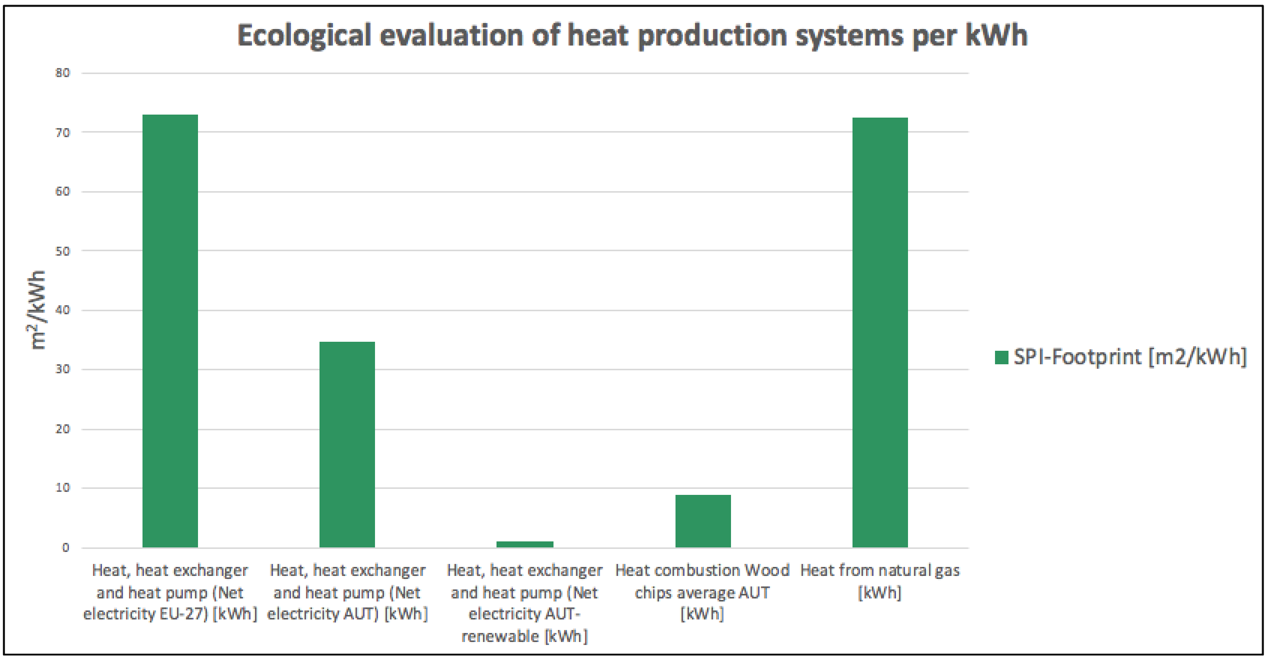


Figure 3: SPI calculations for different heat production systems (after Neugebauer et al. 2015)

Figure 3 illustrates a comparison between different heat production systems, that shows the influence of the electricity mix on the environmental impacts of the respective waste water related heat generation systems. Neugebauer et al. (2015) used the Sustainable Process Index (SPIonWeb) to calculate the ecological footprint of different heat production systems. The SPI is part of the ecological footprint family and is compatible with the EN ISO 14040 (ISO 2006). It assesses the life cycle impact and can therefore be used to evaluate environmental pressure. In figure 3 it can be seen that heat generated with heat exchangers and heat pumps, using a typical Austrian renewable electricity mix features the lowest footprint (m^2/kWh). In this case, the applied electricity mix has a huge impact on the footprint calculations.

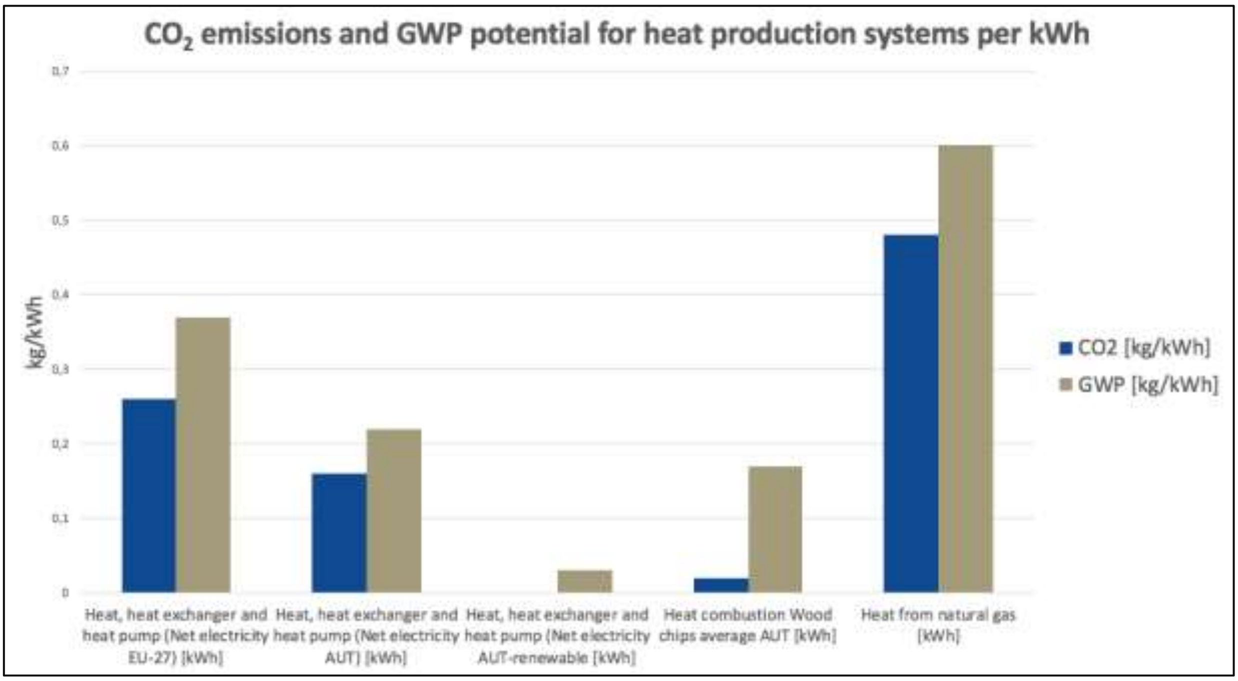


Figure 4: Calculation of CO_2 emissions and global warming potential for different heat production systems (after Neugebauer et al. 2015).

In figure 4, CO_2 emissions and GWP of different heat production systems are presented. Also in this case, heat produced with heat exchangers and heat pumps, using a typical Austrian renewable electricity mix is the most environmentally friendly option, especially compared to heat produced from natural gas.

A substitution of fossil energy sources is possible, if an economically feasible concept for a heating grid can be developed. As the rough energy potential from the wastewater treatment plant is 1 MW from wastewater + 0,25 MW electricity from renewables (resulting in 11,7 GWh/a) and approx. 1 GWh/a from digester gas (energy surplus after optimization), about 13 GWh/a of fossil energy consumption can be replaced by renewables from the wastewater treatment plant.

Economic benefits

Usually, the Biogas plant has to sell surplus electricity for a relatively low price (3-6c/kWh over the last six years) to the grid. With the upgrade through the heat pumps, the whole electric energy could be sold internally (to the RHV Trattnachtal) for app. 12c/kWh.

Establishing the connection to the heating grid will be a completely new business (although already now one nearby building is supplied with surplus heat). The economic feasibility of the grid is yet not calculated. However, an amount of 13 GWh/a at a price of 6 ct./kWh would mean a net turnover of € 780.000 per year.

In 2016 nearly half of the produced electricity was sold, so it is a much better option to get a subsidized tariff (usually around 8-10 c/kWh) from the state if there is one. The natural gas costs were below 5.000€ (mainly measuring and net costs) in 2016, the price for electricity from the grid summed up to app. 20.000€ (mostly measuring and net costs). One negative aspect is the massive increase of sewage sludge (it nearly doubled) because of the waste fermentation.

Improved Societal Perception

It is still relatively unknown that wastewater has a huge heat potential. Expanding the purpose of WWTPs from exclusively treating wastewater to providing electricity and heat will change the view by the public drastically. Heat from wastewater can replace natural gas and oil for heating purposes. This reduces the ecological footprint of WWTPs. But as decentralised form of energy supply wastewater-to-energy systems will also increase energy securing as they decrease the need for natural gas and oil imports.

5. Key Selection Criteria

In summary, the RHV Trattnachtal was chosen as a pilot because of the following reasons:

- It counts as a middle-sized WWTP with 74.000 PE, so best practices and learnings can be applied to other plants
- Infrastructure and operation of biogas production from sewage is in place
- Thecofermentation unit (the BiogasTrattnachtal GmbH) has been successfully implemented
- Good operation data material exists from 2010 up to now
- There is a surplus of heat which presently cannot be used
- A ainimum of 10.000m3 waste water a day is produced
- Distance to the next 2 villages with >5000 inhabitants is smaller than five km
- The management of the pilot plant is interested in installing a heat grid

Grid injection

The plant is connected to the natural gas grid and to the electrical grid.. Currently the plant does not need any natural gas because there is enough heat to cover internal demand. The same applies to electricity. The plant produces more electricity than needed, so it is delivering electricity up to 500kW to the grid. Only very infrequently is electricity needed from the grid run the plant.

The provision of thermal energy requires a district heating network, which there isn't currently. However, the municipalities of Bad Schallerbach and Wallern an der Trattnach are located within 5 Kilometers from the plant and especially in Bad Schallerbach there are a lot of hotels, baths, etc. in addition to residential areas with a rather high heat consumption density. Furthermore geothermal sources near Bad Schallerbach could be included which makes the grid more flexible.

Suitability of Technological Setup

Without certain minimum technological setup in place undertaking a comprehensive upgrading of wastewater-to-energy technologies is impossible. At RHV Trattnachtal, many of the technological pre-conditions exist that allow establishing and testing Reef2W solutions – from co-fermentation to grid-injection of electricity and natural gas. For example, running co-fermentation since 2008, many preconditions about the project's central goal – the integration of infrastructures and streams of the solid waste and wastewater systems – can be explored (e.g. the collection and logistics of bio-waste).In a similar vein, the plant already produces surplus energy, which allows to tap into experience with grid supply of the operator.

Innovation champion

Efforts to improve the energy performance at RHV-Trattnachtal have been mainly driven by the utility operator. This entails several advantages, which weighed into the decision to choose the RHV Trattnachtal as a pilot site in Reef2W. The utility operator has an intrinsic motivation in the topic and into further improving the EE and RE production. It was anticipated that such attitude will facilitate the various planned tasks in the context of Reef2W, for which good collaboration between the utility and BOKU are required. Additionally the operator's in-depth knowledge and expertise on the topic are promising in that the operator can provide key insights for the science the Reef2W consortium is developing.

Availability of bio-waste

Some food processing companies are located in the area surrounding the WWTP. The share of the agro industries is around 40% of the waste water, and 60% is coming from the population. The impact on the territory is mainly that a high share of the treated waste is coming from the surrounding area, so the transport is relatively short.

Nutrient recovery

The produced sludge used as fertilizer can replace fossil mineral fertilizer and is a perfect example of closed circle economy. It is also important to say, that the use as fertilizer is the only possible way to date how phosphorus can be returned into soils without using further guano-phosphor from abroad.

D.T2.1.1 REASONS/CONDITIONS LEADING TO THE CHOICE OF THE 5 PILOTS

Germany

18/07/2018

1. Objective of the task:

In DT2.3.1, the pilot locations were selected. The main objective of this deliverable (D.T.2.1.1) is to identify the leading reasons for selecting the pilot locations, in this case the WWTP in Prague.

The deliverable draws on four deliverables finalised in Work Package 1.

- D.T1.2.1: Base line analysis of the current situation in the targeted utility companies/ territories
- D.T1.2.2: Relevant models highlighting integration and combination of technologies
- D.T1.2.3: Guiding document to demonstrate the benefits of implementation of REEF 2W plants
- D.T1.4.1: Detailed description of the methodology and criteria for location suitability

The deliverable is divided into three parts. First, an overview is provided about the initial situation at Central Prague WWTP (PCWTP), including the technological setup and its suitability. This is followed by an overview of the planned technological upgrade in the context of Reef2 W and the benefits accruing from it. The last part analyses the leading conditions including socio-economic and institutional aspects that qualified the WWTP for selection in Reef2W.

2. Initial Situation at the pilot side

Figure 1: The location of Schönerlinde sewage treatment plant in Berlin (Source: BWB)

The WWTP Schönerlinde is a part of Berlin's Water Works (Berliner Wasserbetriebe – BWB), which provides 3.7 million people in Berlin and Brandenburg with drinking water, as well as collection and advanced biological wastewater treatment. The wastewater in Schönerlinde is treated by mechanical and biological processes with biological phosphate elimination in combination with nitrification and denitrification. The sewage sludge is digested in digesters with mesophilic digesting at approx. 35°C and subsequently drained in centrifuges. Figure 2 gives an overview of the treatment process at Schönerlinde sewage treatment plant. The following technical dates are from the information sheet of BWB (BWB, 2017a).

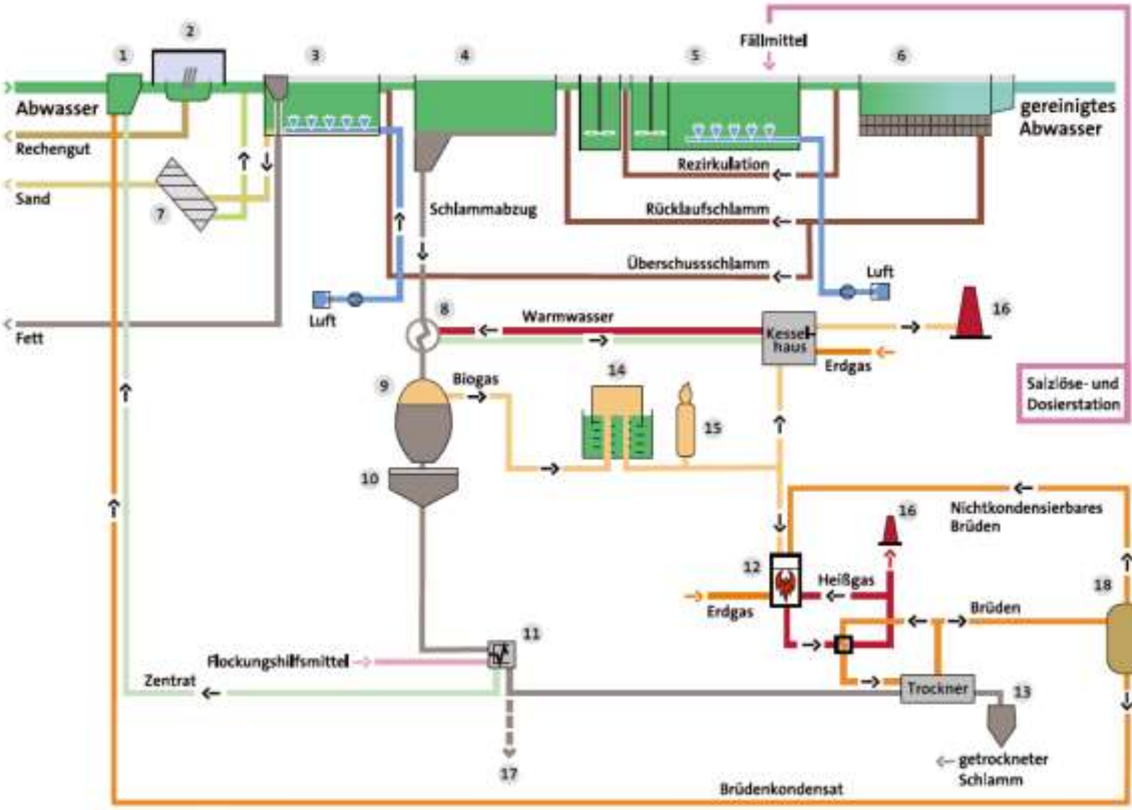


Figure 2: Process scheme of wastewater treatment in Schönerlinde (BWB, 2017a)

Treatment capacity:

The daily capacity amounts to 105,000 cubic meters per day wastewater (dry weather), which equates to approx. 850,000 PE (based on BOD5 value).

Energy consumption and production:

In 2016 WWTP Schönerlinde has a total energy consumption of 22,173,370 kWh and among them 8,283,508 kWh is generated from biogas and sludge (Schwieger, 2017).

3. Technological Upgrade

The integrated approach envisioned in Reef 2W encompasses a wide range of technological steps and processes. Except the enrichment of sludge through bio-waste to enhance biogas yields, many of them are realized at Schönerlinde. Steps will be established to increase the biogas yield through hydrolysis and to convert biogas into bio-methane. Additionally, facilities will be installed to take lower-value electricity from the grid turning it into hydrogen, which will be used together with carbon dioxide from biogas upgrading for producing further bio-methane.

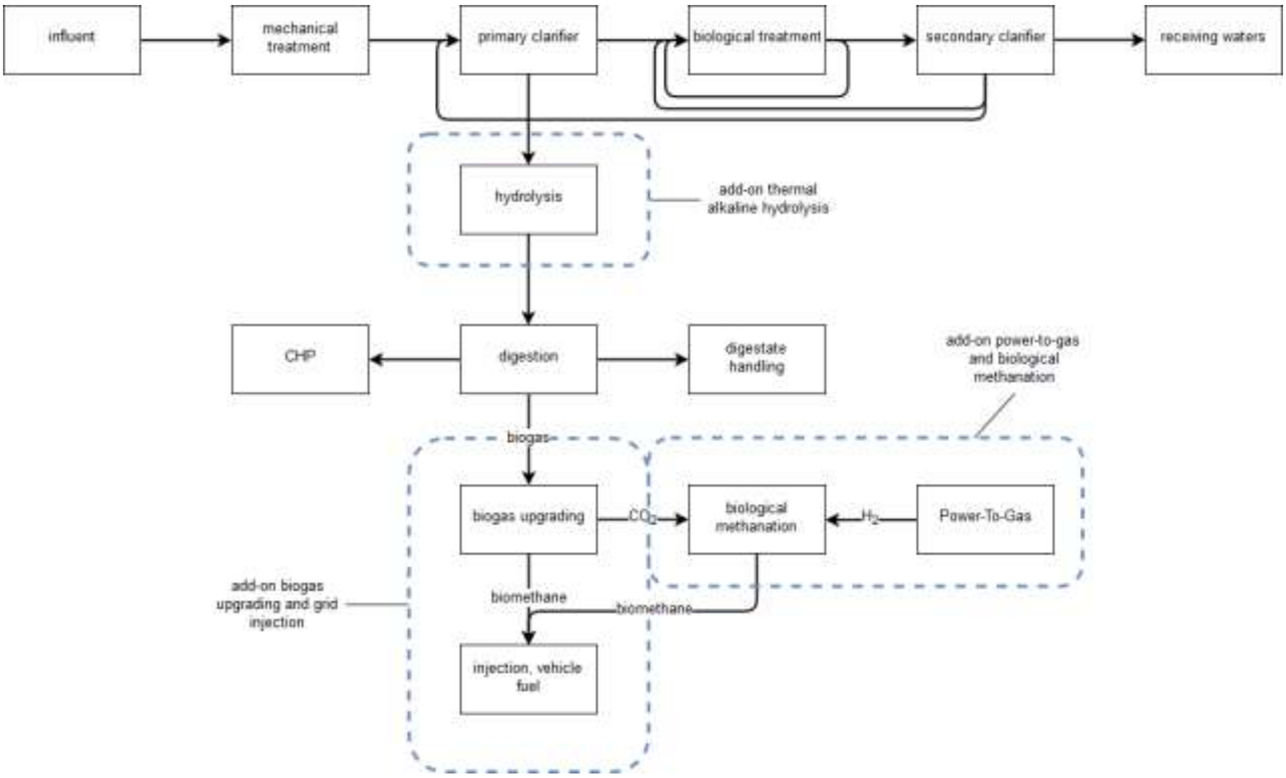


Figure 3: schemata of the new pilot site including the new REEF 2W technologies

a) Thermal Hydrolysis

The new pilot site will incorporate a thermal hydrolysis stage which will receive a part or the complete flow of the separated sludge from the primary clarifiers to increase the biogas yield during anaerobic digestion and reduce the overall digestate.

b) Biogas Upgrading

A biogas upgrading unit will receive the biogas produced during anaerobic digestion and upgrade it into bio-methane. Only a small footprint is needed even in the case of upgrading the full biogas stream.

c) Electrolysis Unit

The electrolysis unit will use electrical energy from the grid during low demand times or during surplus of renewable energies and produces a stream of hydrogen. The inevitably simultaneously formed oxygen stream will be fed into the biological treatment of the wastewater or can be used for the prospective ozonisation step as fourth treatment stage.

d) Grid Injection

Hydrogen produced in the electrolysis stage and the carbon dioxide stream from biogas upgrading will be injected into a biological methanation unit producing high quality bio-methane. The vessel and its accessories only have a small footprint.

Additionally, a grid injection site and required pipelines will be installed. This site is owned and operated by the grid owner who will also be responsible for calorific adjustment, odoration, compression and pressure control.

The hydrolysis stage and biogas upgrading can be independently operated and toggled on or off. The electrolysis/methanation stage needs the running biogas upgrading module as CO_2 source and for the grid injection.

4. Expected Benefits

Space:

The entire spatial footprint needed for the intended REEF 2W technologies is low as for each of the stages an area equating a few shipping containers is needed. The large territory on which the WWTP Schönerlinde is situated easily allows accommodating the REEF 2W technologies.

Increased biogas yield

The hydrolysis step can enhance the biogas yield, up to 50% according to PONDUS company's plant reference list. A realistic value is expected to be approximately 20-30%, if the secondary sludge stream is treated.

Biomethane production

With biogas upgrading the sewage gas will be converted into the superior and more versatile product bio-methane. Quality requirements for grid injection will be met. Since the produced biomethane originates from renewable resources, it can be marketed as such.

Grid stabilization

The electrolysis unit can act to stabilize the electricity grid during low demand times or times when the production by renewable energy sources (e.g. solar, wind) surpasses demand and would otherwise be shut off. The harvested energy can be stored in the form of gases such hydrogen or biomethane after methanation. The side product oxygen generated during electrolysis can be fed into the biological treatment process as a substitute for ambient air. Due to the oxygen content of 100% as opposed to 21% it is possible to save on aeration cost. Alternatively the oxygen can be used during the prospective ozonisation step to save on energy intensive ozone production.

The downside of implementing upgrading biogas for injecting into the public grid is the reduced/omitted local production of electrical energy in the CHP units. The missing energy has to be purchased from the public grid. Because the major part of electrical energy demand of the Schönerlinde WWTP is covered by the wind turbines, this will not be a substantive obstacle.

5. Key Selection Criteria

Suitable size of plant and utility

Scale played a crucial role in selecting Schönerlinde. BWB provides 3.7 million people in Berlin and Brandenburg with drinking water, as well as collection and advanced biological wastewater treatment. It is Germany's largest water and wastewater company. The importance arising from its size means that the company can devote sufficient resources to the project, but also has internal expertise to engage in the project. The WWTP Schönerlinde itself is one of the important wastewater treatment plants for the water cycle in Berlin with a treatment capacity of 105.000 cubic meters per day (dry weather). In the upcoming years the installation of an ozonisation unit as fourth treatment step is planned. This unit can profit from synergy effects with the electrolysis unit by using the oxygen stream.

Good basis for collaboration

KWB's mandate is to foster science, development and water management of the water sector. The water and wastewater company, Berliner Wasserbetriebe (BWB), is one among two shareholders of Kompetenzzentrum Wasser Berlin (KWB). KWB has therefore by nature a good relationsship to the utility at Schönerlinde, which is a key pre-condition for a project such as Reef 2W. It guarantees willingness of the wastewater utility to cooperate for the tool development, training events and other elementary parts of the project to a high degree.

Innovative utility

BWB has always been progressive in experimenting with energy self-supply of its water and wastewater infrastructures. Currently, 70 percent of the energy required to operate its six wastewater treatment plants is generated from biogas and sludge. At Schönerlinde, BWB installed three wind turbines, each with an output of two megawatts in 2012. While the cost of installing the turbines was EUR 11 million each, the three wind turbines combined produce 80-90% percent of total energy required to run the plant, saving BWB significant energy cost (Brears, 2017). This innovative spirit was a key criteria in choosing Schönerlinde among WWTPs in Berlin.

Suitability of Technological Setup

Without certain minimum technological setup in place, undertaking a comprehensive upgrading of wastewater-to-energy technologies like the one being pursued at Schönerlinde is impossible. In Schönerlinde, many of the technological pre-conditions exist that allow to establish and test Reef 2W solutions – from biogas upgrading over Power2Gas technologies and grid-injection. This is not always the case. Many WWTPs in Europe do not even have AD facilities.

D.T2.1.1 REASONS/CONDITIONS LEADING TO THE CHOICE OF THE 5

Italy

16/07/2018

1. Objective of the task:

In DT2.3.1, the pilot locations were selected. The main objective of this deliverable (D.T.2.1.1) is to identify the leading reasons for selecting the pilot locations, in this case the WWTP in Prague.

The deliverable draws on four deliverables finalised in Work Package 1.

- D.T1.2.1: Base line analysis of the current situation in the targeted utility companies/ territories
- D.T1.2.2: Relevant models highlighting integration and combination of technologies
- D.T1.2.3: Guiding document to demonstrate the benefits of implementation of REEF 2W plants
- D.T1.4.1: Detailed description of the methodology and criteria for location suitability

The deliverable is divided into three parts. First, an overview is provided about the initial situation at Central Prague WWTP (PCWTP), including the technological setup and its suitability. This is followed by an overview of the planned technological upgrade in the context of Reef2 W and the benefits accruing from it. The last part analyses the leading conditions including socio-economic and institutional aspects that qualified the WWTP for selection in Reef2W.

2. Initial Situation at the pilot site

The High Valmarecchia, crossed by the river of the same name, is enclosed between Tuscany, the Marche, the Republic of San Marino and Emilia-Romagna of which it is part.

The valley goes from the central Apennine to Rimini, in the heart of the Romagna Riviera, ranging from soft clay hills to sandstone and limestone spikes that rise here and there. It has always been a disputed territory and has a monumental and art heritage among the most singular in Italy, rich in some of the most beautiful fortresses, of boroughs with walls and towers, beautiful churches, small and great stories, linked to fights that saw the big families of Montefeltro and Malatesta antagonistic.

The High Valmarecchia is the ancient heart of Montefeltro: meta and stay since ancient times of famous men, from Dante to San Francesco, from Cagliostro to Ezra Pound; has recently reinforced its tourist attractiveness.

High Valmarecchia offers varied natural landscapes, dense woods, habitat of a rich and characteristic fauna, all enriched by sudden panoramic balconies, where the gaze is lost on the horizon, until you can see the sea. The Natural Park of Sasso Simone and Simoncello, of 4847 hectares, is located in the provinces of Rimini-Pesaro and Urbino, representing the 50% of Pennabilli's municipal territory.

By law no. 117 of August 3, 2009 the municipalities of Casteldelci, Maiolo, Novafeltria, Pennabilli, San Leo, Sant'Agata Feltria and Talamello from the Marche Region were aggregated to the Emilia-Romagna Region, within the province of Rimini, pursuant to Article 132, second paragraph, of the Italian Constitution.

In this environmental framework is located and works the treatment platform of Montefeltro. During the last years due to some change in the regional management of waste streams some relevant change was happen at the site level.

Due to the orographic configuration all the mentioned localities have their own wastewater treatment plant that recently change the management utility. Actually Montefeltro Servizi is no more managing them. One more change is that the treatment plant in Novafeltria will be closed in the next years, while wastewater of the municipality will be readdressed to a bigger treatment plant.

Due to this new and unexpected situation Montefeltro servizi is trying to modify its platform and consequently also the actions that where planned in the framework of the Project.

In this moment the Utility is just evaluating the possible available biomass collected from the territory, starting from the organic waste collection document

The starting point of this evaluation is the already collected material as shown in the table below:

Year	Municipal Organic Fraction Solid Waste Kg	Pruning Kg	Total Kg
2011	150019	1452	151471
2012	193179	2307	195486
2013	231610	15960	247570
2014	258119	94370	352489
2015	253407	133080	386487
2016	312292	195001	507293

As it is possible to see there is a large increase of available solid biomass. In the meantime there is the possibility to increase it collecting the sludge deriving from the local wastewater treatments, that could be evaluated in 2500 Mg/y.

To these materials it is possible collect also some other agricultural and industrial organic waste production that in this moment are still under estimation.

3. Technological Upgrade

Due to the previous considerations and the possible biomasses available it is almost impossible to follow the indication previously identified, and for this reason a new technological upgrade was defined.

Considering the large amount of dry wastes available and in the meantime the not large quantities collected probably a process of anaerobic digestion is quite difficult to implement. For this reason the next evaluations will be focussed in the possibility to utilize these biomasses in some combustion system and in particular in gasification and pyrolysis processes.

These kind of processes are in this moment more interesting that other because they can produce energy (heat or electricity) the can be easily used in the neighbourhood areas.

The dimensions of these devices can be easily adapted at the size of the user and final products fumes and biochar are easily manged. In particular biochar can be easily distributed in the field because their good content on nutrients and carbon.

4. Expected Benefits

The main benefits that it is possible evaluate from the proposed technologies is to shorten the waste cycle and prevent the environmental and economic costs of transport of in different specialized treatment platforms.

The other advantage is that the energy could be easily used directly in the treatment platform to treat the other non-organic wastes or distributed in the net.

With this approach could be the development of a market for the biochar that will be possible recovery.

Also the reduction of waste transport vehicles that should transport those wastes for more than 50 km is another big advantage that it is possible to mention for the implementation of this new approach.

5. Key Selection Criteria

<u>Technological setup:</u>

The choice of the future technology to implement will be defined when the evaluation of the available biomasses will be better defined. Although the process has been identified in a gasification process there are several factors that are still under evaluation and for this a complete and clear vision of the technology to adopt is not yet fully defined.

<u>Location</u>: For several reason, that are the already existing treatment platform, the central position of it respect at the other municipalities involved and the easiest way to reach

<u>Suitable scale and substrate:</u> considering the size of the area and the number of inhabitants served the possibility to implement a small scale gasifier could be a good example for other similar small municipalities, without a too large impact.