RELEVANT MODELS HIGHLIGHTING INTEGRATION AND COMBINATION OF TECHNOLOGIES

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1. INTRODUCTION and Description of the TEMPLATE

This deliverable gives an overview about the status quo of the 5 pilot sites before and after implementing the REEF2W technologies. The deliverable is also focusing on the benefits by implementing the REEF2W technologies from an energy point of view as well as from a social point of view. A template has been developed (see Annex 1) to collect the relevant information useful to properly describe the actual and prospective situation of the pilot sites and to have a better comparability of the sites. A short description of the planned use of technologies, their advantages and disadvantages and also the associated changes to the site are obtained. Benefits regarding energy and social points of view are inquired. Information reported in the next paragraphs was provided by each partner filling in the template.

2. PILOT SITE MONTEFELTRO SERVIZI

2.1. Description of Pilot site (actuel Situation)

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.

Short description of municipalities of the Valmarecchia

CASTELDELCI
surface area km^2: 49,21

altitude: 436 – 1355

inhabitants: 460

MAIOLO
surface area km^2: 24,40

altitude: 212 – 950

inhabitants: 830

NOVAFELTRIA

surface area km^2: 41,78

altitude: 164 – 883

inhabitants: 7.126

PENNABILLI

surface area km^2: 69,66

altitude: 298 – 1375

inhabitants: 2.850

SAN LEO

surface in km^2: 53,32

altitude: 122 – 787

inhabitants: 2.945

SANT'AGATA FELTRIA

surface area km^2: 79,30

altitude: 174 – 961

inhabitants: 2.130

TALAMELLO

surface area km^2: 10,53

altitude: 213 – 861

inhabitants: 1.088

Figure 1. Map of the High Valmarecchia.

Montefeltro Servizi S.r.l is a public company (in House) with share capital of Euro 119,000.00, owned by the 7 municipalities that are its members.

The administrative headquarters are located in the municipality of Novafeltria while there are three operating venues:

- one located in Novafeltria, we have a garage for all the trucks and operating machines;

- two located in the municipality of Maiolo in Cavallara: the Inter-municipal Environmental Center and the trans-shipment Center.

The Company carries out the following services:

- Environmental hygiene;
- Collection of urban solid waste unsorted and differentiated;
- Management of the Inter-municipal Environmental Center;
- Cemetery Services;
- Public announcements;
- Management of public parks.

The Company consists of a sole Director and 25 employees, of which 4 administrative / technical and 21 operators with different tasks.

The Company carries out its activities in the territory of the 7 Municipal Members which reaches an area of 328,26 Kmq with 17.374 inhabitants, representing 40% of the territory of the Province of Rimini and 5% of the total population of the Province.

The undifferentiated and differentiated collection are managed on six Municipalities of the seven total of High Valmarecchia area; in particular, services are managed for the Municipalities of Novafeltria, San Leo, Talamello, Pennabilli, S. Agata Feltria and Casteldelci, while the municipality of Maiolo performs it with internally, for economic reasons.

Collection of the undifferentiated fraction is carried out through road harvesting, while for the separate collection two systems are adopted: road harvesting through the proximity system and the direct delivery to the Inter-municipal Environmental Center, to which citizens of all Municipalities can directly confer.

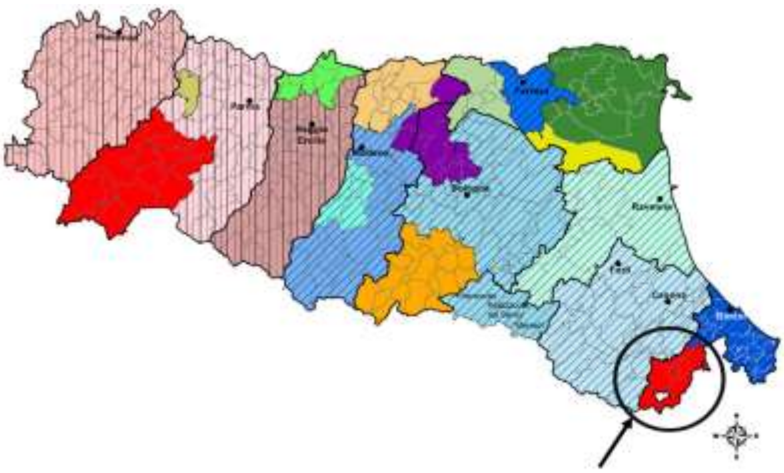


Figure 2. Geographical map of Emilia Romagna. The area covered by Montefeltro Servizi shown at the bottom right.

The collection of organic waste, it is currently carried out in three Municipalities out of seven and precisely Novafeltria, Talamello and San Leo.

Furthermore, Montefeltro Servizi is developing the possibility to manage urban wastewater in order to reduce management costs and disposal costs.

Table 1 below shows the quantities collected annually; it shows a steady increase in waste collected both for organic and for garden pruning and mulching.

Table 1. Total amounts of biowaste by waste codes from 2011 to 2016.

WASTE DIFFERENTIATED		
Year	**Waste Code and Description**	
	200108 - Biodegradable kitchen and canteen waste	**200201** - Biodegradable waste
	Amount of waste [t/year]	
2011	150.019	1.452
2012	193.179	2.307
2013	231.610	15.960
2014	258.119	94.370
2015	253.407	133.080
2016	312.292	195.001

Waste Service

The Integrated Waste Management Service (SGRU) consists of a range of activities to optimize waste management, including road sweeping activities and must be managed in accordance with principles of efficiency, cost-effectiveness, transparency, technical and economic feasibility and in compliance with national and EU standards.

The Integrated Waste Management Service is organized, as envisaged by Legislative Decree 152/2006 "Uniform Text of the Environment" based on the best territorial areas identified by each Region, together with the definition of the specific sphere of government. Government of the area that the Emilia Romagna Region, with Regional Law no. 23/2011 has entrusted to ATERSIR, which, in compliance with national and EU legislation on the reliance of local public services of economic importance, provides, distributes and manages the integrated waste management service.

The functions of ATERSIR relate in particular to the organization of the services, the choice of the management form, the determination of the tariffs to the users in matters of competence, the management and its control.

Waste management takes place in accordance with the hierarchy enshrined in the EU Directive 98/2008 / EU, aiming to identify, in order of priority, the best environmental option.

Since the approval of Regional Law no. 25 of 1999 and until December 31, 2011 the system of regulation and organization of the integrated water service and integrated waste management service in Emilia-Romagna was mainly based on the provincial-level action at the nine Agencies Territorial Optimal, special forms of cooperation between local authorities. Each agency operates on the basis of a convention concluded between all the municipalities of each province and the province.

With L.R. 23/2011, the Emilia-Romagna Region has identified a single optimal territorial area comprising the entire regional territory (and possibly in special cases also external communes adjacent to the regional border) by reassigning the functions of provincial agencies to a new public body with autonomy administrative, accounting and technical services, the Emilia-Romagna Territorial Agency Water and Waste Services (ATERSIR).

2.2. Descipription of Pilot Site inlcuding REEF2W Technologies

Main focus of the REEF 2W technologies are: utilization of biowaste collected in the High Valmarecchia zone, biogas upgrade to the quality of natural gas, and sustainable solution for the produced sludge.

Montefeltro Servizi has need to find a feasible solution for the treatment of collected biowaste.

Costs incurred by the Company to dispose of organic waste, during the year 2017 are:

- cost for organic fraction 90 euro/ton;

- costs for pruning 35 euro/ton;

To date, the Company has not implemented any process within its territory; the amount of waste is low, but growing, according to a better collection and a better sorting of the different fractions of wastes. The easiest way to use organic wastes could be the anaerobic digestion process, but the low amount of wastes available could be a problem for the application of this technology. Being a small reality you could think of other process technologies, such as composting, gasification or hydrothermal carbonization.

The tool that will be implemented within the REEF 2W project will have, therefore, the purpose of clarifying the type and quantity of waste managed, which is the best process on which to invest.

For sure the possibility the anaerobic digestion process can have the advantage of an easy and consolidated technology with no or limited environmental impacts, and with the advantage of the possibility to redistribute in agriculture the residues reach in nutrients (nitrogen and phosphorus).

On the other side other possible technologies like gasification can represent a good alternative with the possibility to recovery energy also with small amounts of biomasses, and with the possibility to use different kinds of biomasses, not only green biomasses as usually request for the anaerobic digestion.

The use of this approach will allow to use the of other biomasses coming not only from the organic waste collection, but also those coming for agricultural and agro-industrial activities that actually are sent at other specialized centres for the treatment.

In the meantime it will be possible to collect also the sludge deriving from the wastewater treatment plants distributed in territory.

In the territory are present ten small treatment plant that dispose their sludge in specialized treatment centers more than 50 km far away.

In the table below the locations of the treatment plants and their potentiality in terms of population served and in terms of filtered sludge production is shown.

The total potentiality of the area served by the Utility is about 1.220 tons/d.

Treatment plant	PE served	Estimated sludge production kg tq/d	kg tss/d
Novafeltria	5.000	500	0,03
Sant'Agata Feltria	1.500	150	0,03
Talamello	800	80	0,03
San Leo	2.500	250	0,03
Casteldelci	150	15	0,03
Pennabilli	2.300	230	0,03

Also this amount is quite limited, but can contribute at the provision of organic matter to be used.

2.3. Descipription of benefits by implimenting REEF2W Technologies

It is a long period of time that Montefeltro is looking for technologies that could reduce the energetic impact of the waste treatment in Valmarecchia and in the meantime could reduce the road traffic due to the waste transport.

The limited amounts of waste available doesn't allow to identify a priority technology that could treat most of the available organic wastes, in particular in the optic to recovery energy.

For this reason the use of the DSS REEF 2W will help the utility to have a better view of the possible advantages of the different technologies but also of their costs.

The expected advantage will be mainly the reduction of the transport costs to other treatment centres of the wastes and the possibility to redistribute the collected energy locally for the municipal swimming pool heating or for the production of electricity to use for some public use.

3. PILOT SITE BERLIN SCHÖNERLINDE

3.1. Description of Pilot site (actual situation)

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 demonstration site WWTP Schönerlinde sewage treatment plant is in operation from 1985 and located in the north of Berlin in Wandlitz, OT Schönerlinde (Figure 1). The effluent from the wastewater treatment plant in Schönerlinde is released into the Nordgraben channel that confluences with the river Tegeler flow. The Tegel lake water is used for bank filtration and artificial groundwater recharge. The treated wastewater portion is close to 50% in the winter period and 33% in the summer half year (Jekel and Gruenheid, 2008). Thus, the WWTP Schönerlinde is one of the important wastewater treatment plants for the water cycle in Berlin with a treatment capacity of 105.00 cubic meters per day (dry weather).

In 2012 BWB installed three wind turbines, each with an output of two megawatts at the wastewater treatment plant Schönerlinde. 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).

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

TECHNOLOGICAL DESCRIPTION

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).

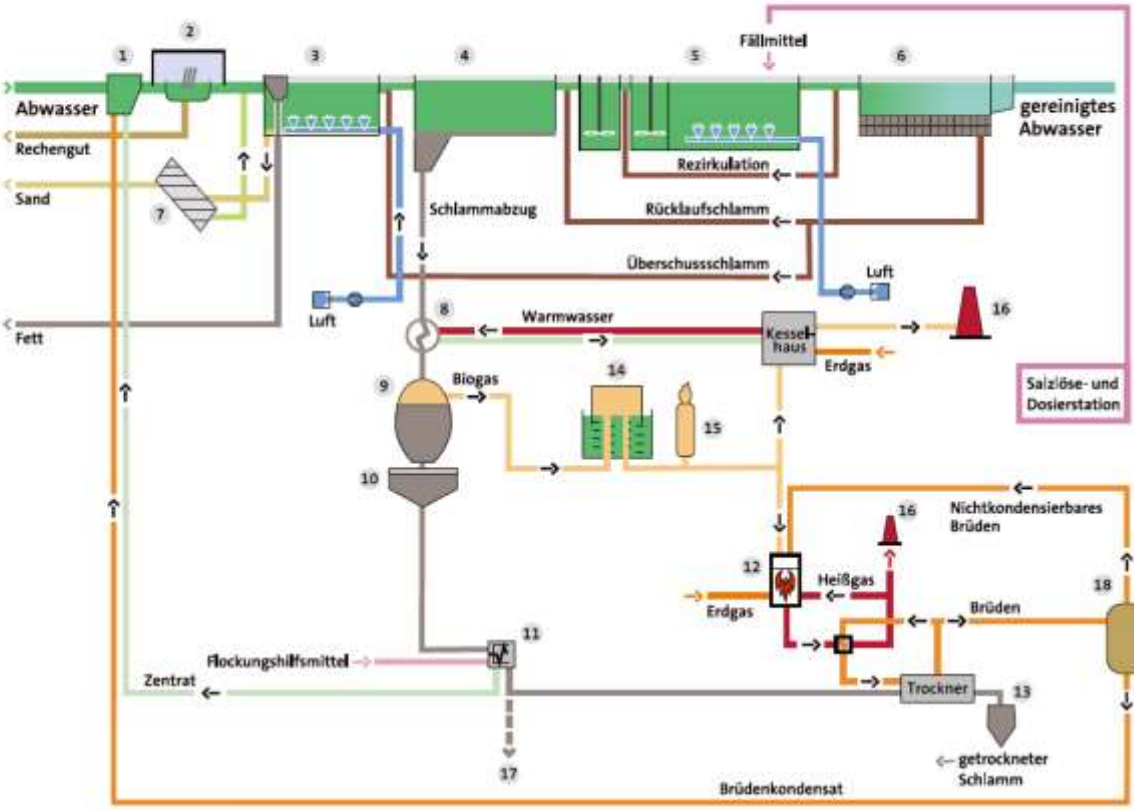


Figure 2: Process scheme of wastewater treatment in Schönerlinde (BWB, 2017a)

Treatment capacity:

105,000 cubic meters per day wastewater (dry weather), approx. 850,000 population equivalent (based on BOD5 value)

Mechanical treatment:

Five rake screens remove 1.5 tons of screenings from the wastewater daily. Three aerated double grit chamber classifier approximately two tons of sand per day. Eight rectangular sedimentation tanks are available as Pre-treatment tanks with a total volume of 14,800 cubic meters.

Biological purification:

The aeration tanks consist of eight basins as anaerobic zone, as well as fourteen basins as anoxic and aerobic zone. These have a total volume of 130,500 cubic meters. Aeration systems installed in the activated sludge tank consists of membrane aerators as well as ceramic aerators. As clarification serve twelve rectangular tanks with a total volume of 42,660 cubic meters and two round basins with a total volume of 10,500 cubic meters. Table 1 gives the key operation parameters at Schönerlinde sewage treatment plant.

Table 1: operation parameters of Schönerlinde sewage treatment plant (Miehe, 2010)

Parameters	Value	Unit	Parameters	Value	Unit
sludge age	17.8	d	hydraulics retention time (HRT)	22.8	h
sludge load	0.09	kg BOD_5/(kg DM•d)	Flocculants doses	13.7	mg Fe^{2+}/L
volumetric load	0.34	kg BOD_5/(m^3•d)	Oxygen concentration in in activated sludge basin	2.1	mg O_2/L
dry matter in activated sludge basin	3.7	g/L	wastewater temperature	18.9	°C

Biogas utilization:

The produced biogas is stored in two gas containers and used for drying the sewage sludge, for heating purposes and for power generation.

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). Based on the values of measuring devices, connection values and operating hours, the following energy consumption of the individual processes were estimated from the WWTP operator (Schwieger, 2017):

- mechanical cleaning 3%,
- biological purification 69.1%
- Sludge utilization (digestion, drainage, drying) 15.5%
- superior 8.9%
- rest 3.5%

3.2. Description of Pilot Site inlcuding REEF2W Technologies

- **Description of your pilot site by including your REEF2W Technologies**
  - **What will be the technologies implemented on your site?**
    - **a) Short description of the REEF2W technologies you will implement**

Alkaline thermal hydrolysis:

The Disintegration of sludge will act as a pre-treatment before anaerobic digestion. Objective is to destroy floc structure and with higher energy input to dissolve cell walls. This disintegration achieves the transformation of non-biodegradable organic substances into bioavailable ones resulting in higher degradation rates of the volatile substances. Result is an increased biogas yield. Figure 3 shows the commercially available PONDUS® process as an example of a full scale application.

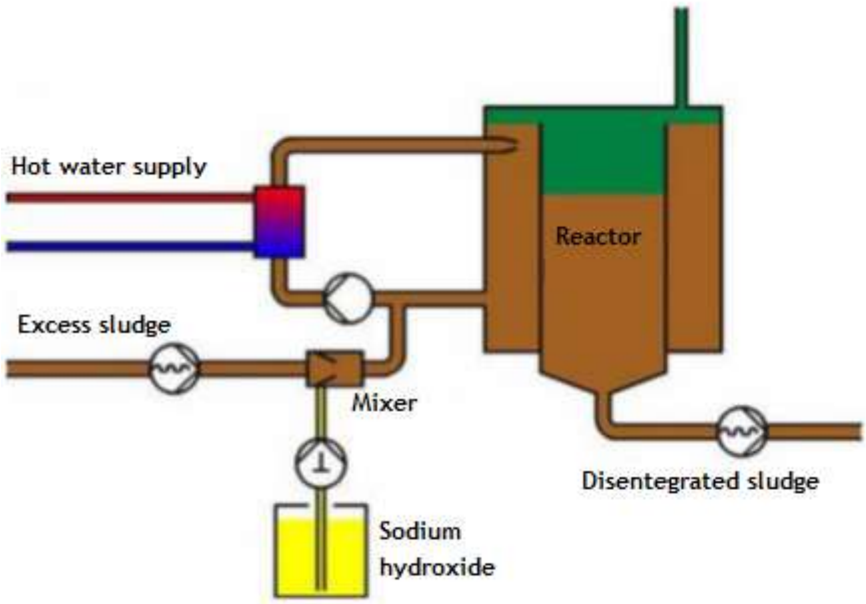


Figure 3: PONDUS® process (PONDUS GmbH)

Biogas upgrading

Biogas from anaerobic digestions contains large amounts of carbon dioxide and smaller amounts of other impurities such water vapour, ammonia and H2S which need to be removed if a high quality biomethane suitable for grid injection is desired. Biogas upgrading separates the raw biogas into a methane rich product stream and a CO2 rich offgas. This is a state of the art process for gas separation with the possibility to use different commercially available technologies to achieve the goal. As there is no technology that fits for every site specific circumstances a careful selection has to be made. Figure 4 shows the general principle of gas separation for biogas upgrading.

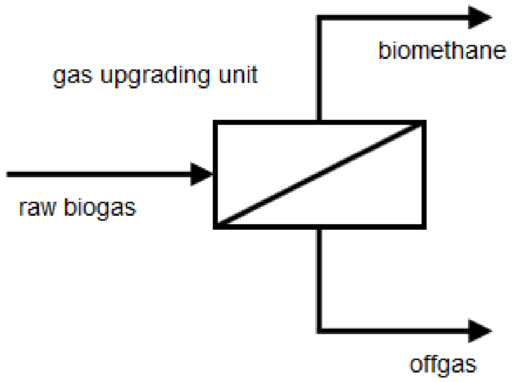


Figure 4: general principle of biogas upgrading

The following upgrading process technologies are considered:

- Pressurized water scrubbing (PWS) is the physical absorption of the carbon dioxide into the inorganic solvent water. Separation principle is the difference in solubility. CO_2 is more soluble in the scrubbing water than methane and therefore removed.
- Amine scrubbing is the chemical absorption into an organic agent containing an amine solution with higher loads and selectivity than water scrubbing. A substantial amount of heat is needed for regeneration of the scrubbing solution. This process will most likely be implemented as there is an existing full scale bio gas upgrading unit at a Berlin waste management facility digesting OFMSW. Because the operating company is in possession of the city of Berlin like the Water Works, it is possible to profit of their experiences.
- Gas separation with membranes uses the different partial pressures of compounds as driving force through materials with favourable selectivity for CH_4/CO_2 separation.
- During Pressure Swing Adsorption (PSA) the separation principle is based on different adsorption behaviours of gas components on solid surface under pressure.

Electrolysis

Electrolysis is process where an electrical current forces water into a redoxreaction at the electrodes resulting in the generation of oxygen and hydrogen. The two main readily available technologies are alkaline and polymer electrolyte membrane (PEM) electrolysis.

In alkaline electrolysis an ion-permeable membrane separates the cathode and the anode from each other. The electrolyte is basically made of water mixed with 20-40% of potassium hydroxide (KOH). In this reaction, the electrical current at the cathode splits the water into hydroxide-ions and hydrogen. The hydroxide ions can migrate through the separator to the anode and oxidise to O2. Both oxygen and hydrogen are released as gas.

During PEM compared with alkaline electrolyser the water is fed at the anode side. As a result the produced hydrogen does not need a water separation. The proton conducting membrane (often sulfonate polymer) separates the anode and the cathode. Electrodes are attached on both sides of the membrane and are treated with platinum group metals. During operation, oxygen is oxidised and electrons are released. The produced H+ ions migrate through the PEM towards the cathode side and are reduced to hydrogen gas.

Biological methanation

In this process biogas or pure carbon dioxide and hydrogen are injected in a separate reactor. Microorganisms of the family of methanogenic Archaea convert the CO2 and injected H2 into methane.

b) Pro and cons of your REEF2W technologies implemented

technology	advantages	disadvantages
Chemical disintegration (PONDUS® process)	Increased biogas yield through increased degradation rate of biological matter Lower hydraulic retention times possible (i.e. smaller vessels) VS reduction (i.e. les digestate)	Heat demand (70°C) Chemical demand (NaOH, 2L/m³) Higher return load of NH_4-N
Biogas upgrading	Biomethane stream as substitute for natural gas (for grid injection or use as vehicle fuel)	Energy input (heat, electrical) Less biogas for local energy production and local use
Electrolysis	Hydrogen stream for grid injection or methanation Electrolyzer as stabilization for electrical energy grid Storing of surplus renewable energy possible (power-to-gas)	High energy demand Energy efficiency Operating times limited by energy market Legal classification regarding energy fees

Biological methanation	Biomethane quality Commercially available Good partial load capability Flexible and robust	External reactor needed Hydrogen less soluble in water than CO_2 Energy demand for mixing and pumping Nutrients for microorganisms needed Excess water as product of reaction

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.

How will your pilot site change?

a) Schemata of the new pilot site including the new REEF2W Technologies

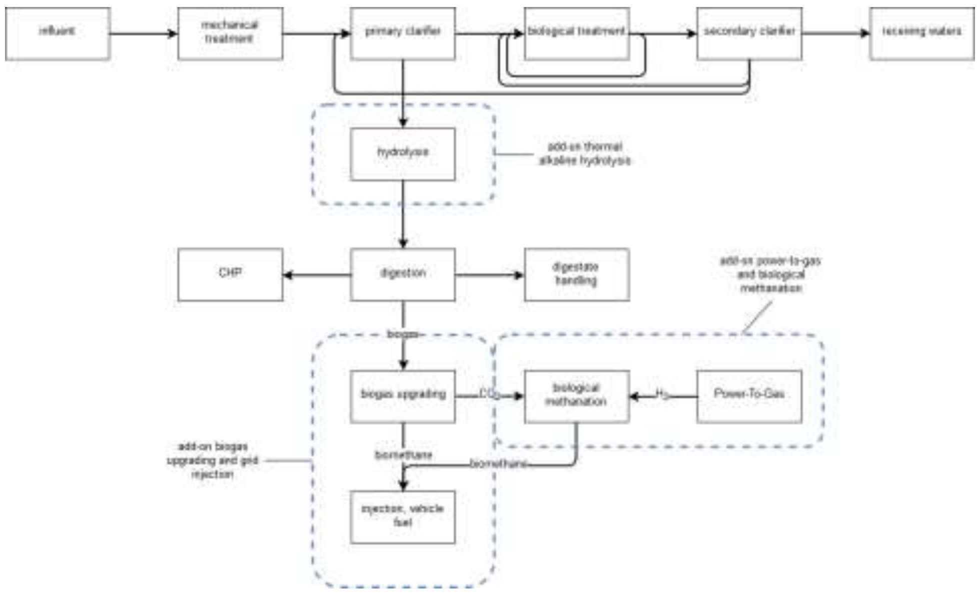


Figure 5: schemata of the new pilot site including the new REEF 2W technologies

b) Description of the “new” pilot site compared to the state-of-the art model

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.

A biogas upgrading unit will receive the biogas produced during anaerobic digestion and valorize the stream into biomethane. Only a small footprint is needed even in the case of upgrading the full biogas stream.

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.

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 biomethane. The vessel and its accessories only have a small footprint.

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 entire footprint needed for the intended REEF 2W technologies is manageable as the stages themselves need each about a few standard container sized areas and on the WWTP grounds is enough space for this expansion.

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 CO2 source and for the grid injection. A sole injection of hydrogen into the natural gas grid would in some circumstances be possible, but is not considered.

3.3. Description of benefits by implimenting REEF2W Technologies

Description of the main benefit by changing your state-of-the-art pilot to a REEF2W pilot from:

a) An energy point of view?

The hydrolysis step will enhance the biogas yield.

With biogas upgrading the sewage gas will be converted into the superior and more versatile product biomethane.

Electrolysis unit can act as electrical energy grid stabilization 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 energy rich gases such hydrogen or biomethane after methanation.

The side product oxygen generated during electrolysis can be fed into the biological treatment 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.

In absolute terms the plant can increase its self-sufficiency or store the energy as hydrogen or biomethane in the natural gas grid.

b) A social point of view? (e.g.: Less emissions; less waste to deposit)

With sludge disintegration and higher biogas yield the overall mass of digestate for utilization or disposal is reduced.

With upgrading biogas the production of biomethane, a "green gas", is achieved and can be marketed as such. After grid injection a credit for virtual use e.g. as vehicle fuel for the owner's fleet is possible.

With the Power-to-gas module surplus renewable energy can be stored. Carbon dioxide from biogas upgrading can be used to produce a fully renewable biomethane stream.

3.4. References

- Bauer, F., et al. (2013). Biogas upgrading – Review of commercial technologies. (SGC Rapport; Vol. 270), Svenskt Gastekniskt Center AB.
- Brears, R.C., 2017. Berlin transitioning towards urban water security, Urban Water Security. Wiley Online Library, pp. 151-164.
- BWB, 2017a. Infobaltt: Klärwerk Schönerlinde, Modernste Technik für die Abwasserreinigung Berlins. Berliner Wasserbetriebe, www.bwb.de.
- DWA. 2016: DWA-M 302 Klärschlammdesintegration. Hennef, Germany, DWA Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall e.V.
- Franzke, U., 2011. Sewage Sludge Treatment in Large Cities Using the Example of Berlin, in: Pelloni, K.J.T.-K.L. (Ed.), Waste Manage. (Oxford). TK Verlag, Berlin, p. 693 to 698.
- Jekel, M., Gruenheid, S., 2008. Indirect water reuse for human consumption in Germany: the case of Berlin. Jiminez, B.; Asano, T.(Hg.): Water Reuse. An International Survey of current practice, issues and needs. ISBN: 9781843390893. Scientific and Technical Report, 401-413.

- Kabbe, C., Bäger, D., Mancke, R., 2014. Deliverable of project P-Pot: Phosphorus potential in Berlin (in German), http://www.kompetenz-wasser.de/wp-content/uploads/2017/05/20140325-p-pot_bericht_uep2-11400.pdf.
- Miehe, U., 2010. Performance of technical barriers for the removal of anthropogenic trace pollutants - wastewater treatment plants and dual media filtration (in German). Technische Universität Berlin, Berlin.
- Remy, C.; Diercks, K.: POWERSTEP deliverable D3.1: Best practices for improved sludge digestion.2016.
- Schwieger, K., 2017. Personal communication with BWB staff.

4. PILOT SITE RHV TRATTNACHTAL

4.1. Description of Pilot site -former Situation:

In Austria almost every sewage plant bigger than 30.000 population equivalents is equipped with an anaerobic sludge treatment = digester.

The digested sludge comes from two different stages of the sewage plant:

- The preliminary sedimentation
- The excess sludge produced during biological treatment

The RHV-Trattnachtal produces daily ap. 100m^3 preliminary sludge with a dry matter content of 3-6% and 20m^3 excess sludge with 2-3% dry matter. The digestion needs heat energy, because the sludge is ap. 20°C colder than the digester that should have around 40°C.

In 2006, as a reference year for the former situation, the combined heat and power unit generated 933.300 kW/h (that equals ap. 100 kW$_{el}$ and 120 kw$_{th}$). This had a 65% share of the total needed electricity.

2006	electricity consumption	electricity production	electricity purchase	sludge amount
Jänner	140.323	94.969	45.354	199
Februar	140.968	90.662	50.306	185
März	142.628	95.189	47.439	98
April	130.893	53.889	77.004	218
Mai	123.261	70.883	52.378	186
Juni	114.626	58.627	55.999	203
Juli	101.283	58.474	42.809	224
August	97.509	60.359	37.150	276
September	84.295	54.096	30.199	231
Oktober	117.720	97.688	20.032	203
November	119.184	97.945	21.239	200
Dezember	122.021	100.519	21.502	175
Total	**1.434.711 kWh**	**933.300 kWh**	**501.411 kWh**	**2.398 tons**
		65%	**35%**	

In 2006, natural gas with costs of 23.000€ was needed to heat the digester during winter season. The bought electricity had costs of 57.000€. The sludge production reached 2.400 tons.

4.2. Description of Pilot site -current situation:

In 2008 the RHV Trattnachtal implemented the Biogas Trattnachtal GmbH and started a waste cofermentation. This changed the energy need and output of the sewage plant drastically as the numbers from 2016 prove.

2016	electricity consumption	electricity production	electricity sold	sludge amount
Jänner	168.899	211.747	58.211	115
Februar	149.077	181.081	53.869	426
März	173.502	383.497	211.333	647
April	148.559	268.447	122.211	393
Mai	160.642	306.903	147.813	357
Juni	161.110	307.335	147.629	394
Juli	174.095	316.455	144.555	286
August	169.399	283.867	117.463	183
September	177.051	338.089	161.318	320
Oktober	178.516	345.993	168.552	401
November	179.390	379.889	200.978	391
Dezember	200.731	421.157	220.799	402
Total	**2.040.971**	**3.744.460**	**1.754.731**	**4.315**
	53%	**100%**	**47%**	

The energy consumption rose significantly by 40%. This is mainly due to the fact that the RHV tried to set up technologies on the plant using the own electricity instead of bought chemicals, so a decanter press and a membrane filtration was put in operation.

The energy production rose by nearly 400%, so the biogas plant can now easily provide the needed electricity for the sewage plant. The biogas plant is selling the electricity for 12c/kWh to the RHV Trattnachtal and the surplus electricity is sold to the grid. The market price for electricity is quite low and fluctuating between 6-3c/kWh over the last 6 years. 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 the waste fermentation.

Heat production and consumption 2006 and 2016

	2006*	2016
district heating	0	153
chiller	40	177
digester heat	1500	1890
buildings	270	342
sanitation	0	153
total use	1770	2385
production	1200	2684
natural gas	570	0

Explanation:

- district heating: since 2009 the biogas plant delivers heat to one farmhouse
- chiller: heat loss due to missing heat use
- digester heat: 2016 the digesters were considerable warmer than in 2006
- buildings: all sewage plant buildings that need to be heated during winter
- sanitation: part of the biogas plant
- production: heat production with the combined heat and power
- natural gas: used for heat production to heat the digesters
- 2006 numbers are calculated, 2016 numbers are measured!

The main aspect of the heat use is the replacement of natural gas heating on the sewage plant, which costs at least 4c per kWh in Austria.

4.2.1. Waste fermentation

Organic waste has a significantly higher energy density than sludge (up to 100 times more) and can increase the biogas production significantly. But a great diversity of organic waste is produced so a deeper look to the pros and contras is needed.

<u>Solid bio-waste:</u>
Solid bio-waste is often contaminated with plastic, metal etc., so a sorting line is needed to minimize the impurities before further handling. Solid biowaste has to be stored in closed halls because of the odor (that has to be treated with a biological filter) and it emits press water that has to be handled. Solid waste needs a mixing pit to be pumped (and then sanitized) or a feeder that transports the solids via screws into

the digester. The technical requirements for solid organic waste are considerably higher, so the waste fee also has to be higher = > 30€/t

Liquid bio-waste:
Liquids are normally homogeneous and with no or low contamination. The main exception is separated fat from restaurants and canteens, with a lot of impurities. Liquefied biowaste contains a lot of smaller plastic particles, because of the preceding sorting and shredding. Liquids can be stored in closed tanks that are connected to a biological filter. From there they are pumped into the digester. The technical equipment is quite simple, a pump and a cutter and if needed a sanitation unit. Because of the simple technique the waste fee for liquids can be as low as 5€/t.

4.2.2. Problems

Foam
Stored liquids can produce a high amount of foam, which can cause an overflow of the tank with subsequent flooding of the surrounding tank area. The cause of foam is hard to detect and can best be handled by filling tanks just up to 75% (if possible).

Secondly foam problems can occur inside the digester, because organic material can cause biological troubles, which end up in a foam layer in the digester. The foam can find its way into the gas pipes and cause big problems because the foam can flush down to the CHP.

So the digester needs a foam-detection and an automatic water dosing unit, to prevent the foam layer from growing. Additionally the feeding of high energy waste should be done in small portions and more often and be stopped immediately when foam is detected.

Biological digester problems
The digester needs time and proper conditions to reduce organic carbon by producing biogas. If the amount of carbon gets too high and/or the temperature of the digester is changing too fast and/or the needed nutrients are missing the biogas production swindles and the microbiologically produced acids cause a pH-drop from 7 to <5 and the biogas process stops.

Biogas manure/sewage sludge use

The cofermentation of sludge and waste increased the sewage sludge production of the RHV-Trattnachtal considerably. It nearly doubled from ap. 2300t/a to 4500t/a, so the costs for the afterwards utilization also doubled. As long as the produced quality is within the guidelines for the use as fertilizer, the costs for the RHV-Trattnachtal are about 35€/t (app. 50% of the incineration costs). But the sludge has to be stored from November to March because in this period the use as a fertilizer is not allowed. The RHV has to use a press to minimize the sludge volume to app. 12t/d. It is not possible to store the sludge in liquid phase and use it directly, because this would need ap. 100 days x 120m3 sludge = 12.000m3 storage volume.

Odor

A sewage plant is always a place, where certain odors will occur. But the typically sewage odor has little in common with the odor from organic waste. Therefore, the odor can be a serious threat to a good relationship with the neighbors of the sewage plant. The odor from waste delivery to storage and use has to be minimized with a biological filter, otherwise problems are for sure.

CHP (combined heat and power) unit

The CHP can cost a lot of money via maintenance, especially when the biogas quality is not OK. The CHP cannot cope with sulfur and water (vapor). Sulfur causes corrosion and ruins the motor oil, the water vapor in the biogas will condense and cause trouble when this happens inside the CHP. The sulfur must be minimized by either a biological stage, or a chemical precipitation. The H2S level in the gas should be <100 ppm before entering the CHP. The water vapor can be reduced with a long (buried) pipe with at least 2 condensate traps where the water is removed.

Electricity tariff

The most economical way of using the produced electricity is to use it directly on the sewage plant. But as soon as you produce more energy than needed you should have a feed in tariff instead of a market price. The market price has constantly fallen over the past 5 years and now lies below 4 Cent per kWh, so the earnings are very low. A much better option is to apply for a granted feed in tariff (if there is one) which should be at least twice as high as the current market price.

4.2.3. 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 and an average performance of 50.000 population equivalents (PE), 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 to the treated water volume of 2016:

- 2.000.000 kWh electricity for 5.900.000 m^3 waste water **= 0,34 kWh per m^3 wastewater**

4.2.4. 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 their surface.

Per m^3 sludge that has to be heated the following heat energy is needed:

- 1,16 kWh/m^3 x ($T_{outgoing}$ minus $T_{incoming}$)
- The temperature of the outgoing material corresponds with the temperature of the digester (assumed 35°C). The temperature of the incoming material is the average sludge temperature (assumed 15°C). So the sludge must be warmed up 20°C
- =1,16 kWh/m^3 x 20 = 23,2 kWh per m^3 digested sludge

- The digesters of the RHV Trattnachtal have a volume of 2 x 2000 m^3 and a daily input of 120m^3 sludge
- = 120 x 23,2 = 2.784 kWh heat energy a day
- The heat loss of the digesters depends on the size of the surface, its heat insulation and the temperature difference of $T_{digester}$ minus $T_{outside}$
- In the case of the RHV Trattnachtal these are 1000m^2 surface with a heat loss of 1 W per m^2 and °C temperature difference (average outside temperature = 11°C/a)
- =1000 x 1 x (35-11) = 24 kW per digester tower
- This leads to a yearly heat demand of: 24h 365d x (24 kW x 2) + 2.784 kWh x 365) = 420.480 + 1.016.160 = 1,5 Mio. kWh for both digesters

The heat loss through the surface causes app. 1/3% of the total heat demand of the digesters of the RHV-Trattnachtal, 2/3 of the heat is needed for warming the sludge.

4.2.5. Heat and power - lessons learned

Every sewage plant operating digester(s) and a combined heat and power station faces problems in heating them during wintertime. So normally additional natural gas (RHV Trattnachtal 2006: app. 57.000m^3) has to be used to deliver enough heat.

The produced electricity can provide up to 2/3 of the needed electricity to operate the sewage plant, at least 1/3 has to be bought externally. There is usually no or little surplus energy that is delivered to the grid.

With cofermentation 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. Additionally surplus heat and electricity is produced and should be properly used. The surplus electricity should be sold as eco-electricity for a higher price than the market price. The surplus heat can be used for external heating but it is quite hard to find a fitting solution because the surplus is mainly in summer.

Another obstacle is the remaining sludge that can be used as fertilizer in agriculture, or to produce compost or it has to be incinerated. The waste digestion leads to an increase in the sludge amount, so it is very important to know how to use it afterwards.

4.2.6. Things to do

To achieve a total heat use over the year a heat piping system seems the only solution. To generate enough heat in winter an additional heat source is needed and this can be the waste water, which is between 11°C und 20° C warm. Every day a minimum flow of 10.000m^3 wastewater enters the sewage plant. With the aid of heat pumps 10.000 x 4 x 1,19 = ap. 4,8 MW thermal energy could be generated. This would be enough to run a district heating from the sewage plant to Wallern an der Trattnach und Bad Schallerbach.

4.3. Description of Pilot Site inlcuding REEF2W Technologies

The idea is to combine the existing heat and power generation of sewage and biogas with the future technology of heat pumps running on waste water.

Every sewage plant has waste water entering the plant day by day. Depending on its temperature the waste water can have a significant energy potential that is worth using.

The best place to do this on site of the RHV –Trattnachtal is after the final clarifying basins before the effluent is discharged into the Trattnach because:

- It combines the maximum water flow with the least fluctuation compared to the sewage channels leading to the plant
- The waste water is cleaned and without impurities
- The cooling of the effluent has no effect on the sewage plant and the Trattnach

The unsolved questions are:

- What size of the heat pumps are optimal
- Where to put them
- Is there enough heat demand in Wallern and Bad Schallerbach to build such a long heat pipe system?
- What temperature can be economically reached in the flow line?
- How to integrate the high temperature heat from CHP with to low temperature heat of the heat pumps

If the district heating system would be erected it would have the following impact on the RHV-Trattnachtal

- The whole heat from the CHP could be used
- The whole produced electricity could be used on site
- No more selling of low price electricity
- The RHV-Trattnachtal would generate more income by selling heat
- Possible heat source wastewater at the final clarification basins

The new pilot site would add the following installations:

- Heat pumps
- Buffer store
- Ap. 6km heat pipes

4.4. Description of benefits by implimenting REEF2W Technologies

Changes of the energy flow due to the district heating with heat pumps and CHP heat:

The Biogas plant has to sell surplus energy to a relatively low price (3-6c/kWh) to the grid. With the heat pumps the whole electric energy could be sold internally for app. 12c/kWh. 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 heat pumps have the task to deliver additional heat in winter, when the CHP heat is not available due to heating the sewage plant digestors.

The RHV-Trattnachtal could be a perfect example of using the new waster heat technology and a lot of other sewage plant all over Europe could do the same.

Changes from a social point of view

It is still relatively unknown that waster has a huge heat potential. Changing a sewage plant from sole water treatment to a district heating plant will change the public view drastically. Heat from wastewater is can replace natural gas and oil for heating purposes and so be a great ecological advance.

5. PILOT SITE PRAGUE

5.1. Description of Pilot site (actual situation)

Prague is situated in central part of Czech Republic. It is the capital of Czech Rep. and city area is placed on river Vltava and hilly country around. Prague population is 1 280 500 inhabitants. Central Prague WWTP is large site with capacity of 1 641 000 PE, WWTP is mechanical-biological system with thermophilic anaerobic digestion of sludge. WWTP is situated on the northern part of Prague at river island, very close to residential areas. Now, there is new biological treatment line in construction.

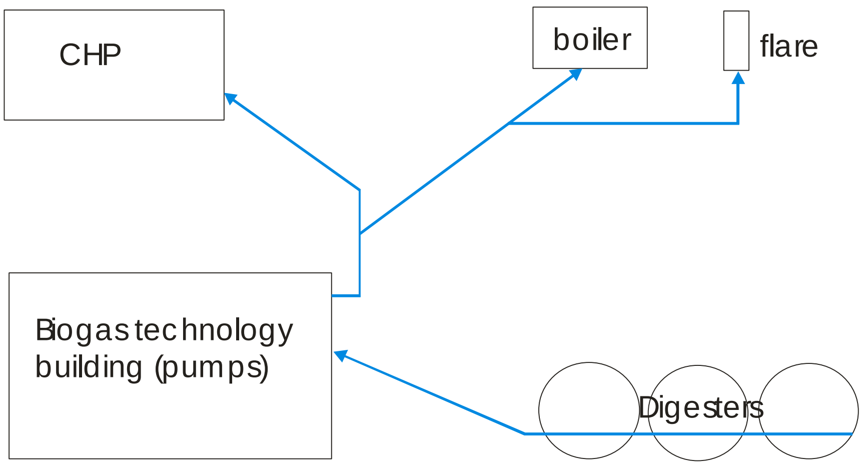
Sludge produced at Prague WWTP is processed by thermophilic anaerobic digestion (AD). WWTP Prague is the largest biogas production site in Czech Republic. There is:

5 x 4380 m³ digester (1stage)

5 x 4000 m³ digester (2 stage)

5 x 6000 m³ gas storage

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



Veolia operates Prague central WWTP including sludge line with AD thermophilic process. The biogas is now incinerated at CHP plant 5 MW of electricity (gas piston engines) with limited heat utilizing, which affected overall energy efficiency.

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 %

5.2. Description of Pilot Site inlcuding REEF2W Technologies

As REEF 2W technology is considered to be biogas upgrading unit situated at WWTP close to digesters and current biogas utilisation (CHP). The biomethane plant can positively affect energy efficiency of WWTP and reduce air pollution generated by public transport.

After detailed case-study there was choice between PSA and membrane technology. PSA has higher price, but lower operation cost, membrane technology offers lower investment cost and higher operation costs. Due to priorities of the project, the membrane biogas upgrading method was selected for Prague project.

Technology consists of membrane biogas upgrading unit and bioCNG vehicle filling station.

The bioCNG own station is connected to the existing raw biogas transport pipeline (pipeline to CHP). It contains a unit for additional special biogas pretreatment (removal of H2S), gas drying and cooling unit, a compressor unit with filtration, a membrane separation unit itself, 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 other 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 compressor, gas drying device, balancing pressure container - these again in the container version and also covered its own dispenser stand with the payment terminal (here again the assumption of automatic unmanned operation).

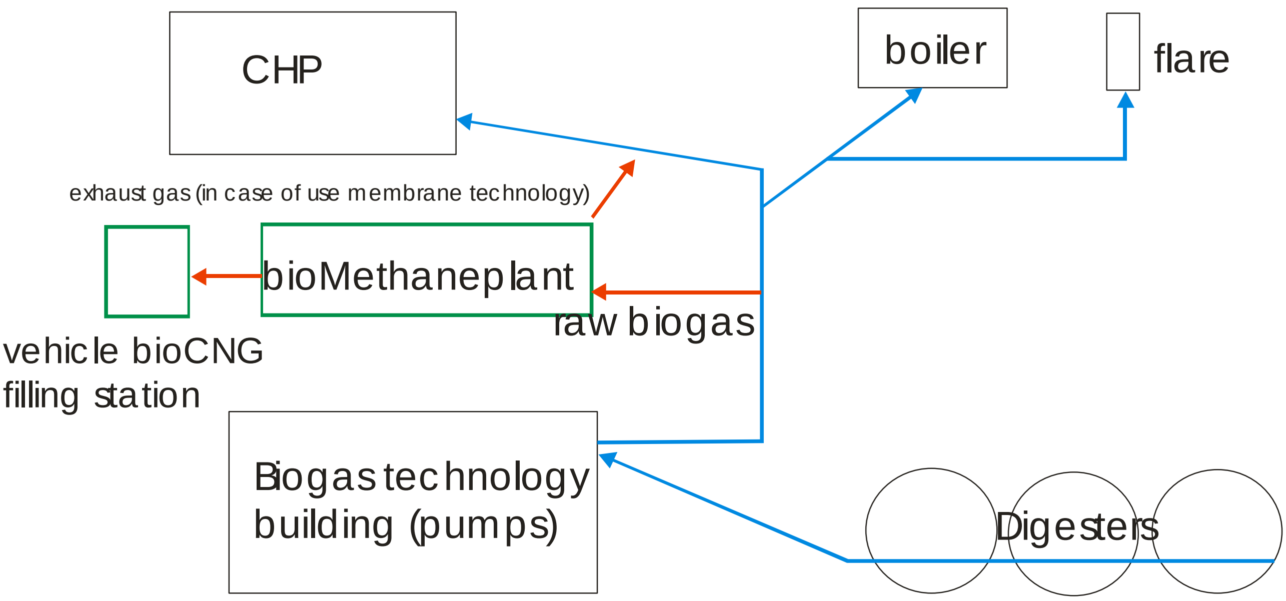
For compressed gas filling stations for motor vehicles, TDG G 304 02 of the Czech Gas Association is available, which specifies the conditions for the location, execution, testing and operation of CNG fast-moving stations for motor vehicles if the inlet pressure does not exceed 0.03 MPa, the compressor does not exceed 20.3/h and the compressor internal volume does not exceed 0.5 m^3.

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

Pros: Biomethane plant will use now unused biogas, It rise efficiency of energy use at WWTP Prague, membrane unit has low investment cost and sufficient efficiency, upgraded biogas – biomethane is possible to use as bioCNG as vehicle fuel (primary use), or as biomethane injected to public natural gas grid (now considered as future variant of development).

Cons: In compare to PSA technology, there are higher operation costs, generally – biogas upgrading technology is complex and high pressure device with high maintenance and operation standards demand. In Czech Republic is now not guaranteed biomethane price or subsidy for bioCNG vehicles.

Installation of biogas upgrading unit causes only minor changes to WWTP site. Installed technology is small and compact situated in standard containers. Only small part of produced biogas (now not used) will be upgraded.



5.3. Description of benefits by implimenting REEF2W Technologies

Biogas upgrading unit will operate with 250Nm³/hour of raw biogas. Biomethane production will be 160 Nm³/hour. It meant that 2500 kg of CNG per day will be produced. By energy It means 1370 kWh of green energy will be produced from – now unused biogas.

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.

6. PILOT SITE ZAGREB ZCH

6.1. Description of Pilot site (actual situation)

City of Zagreb is the largest city in Croatia with approximately 800,000 inhabitants and a density of 1,200 inh/km². With the surrounding areas, total population of the City is around one million of inhabitants. Food and beverage processing is traditional and one of the most important local branches of industry, and it achieves the highest total revenue and employs the most people.

Figure 6: Location of city of Zagreb

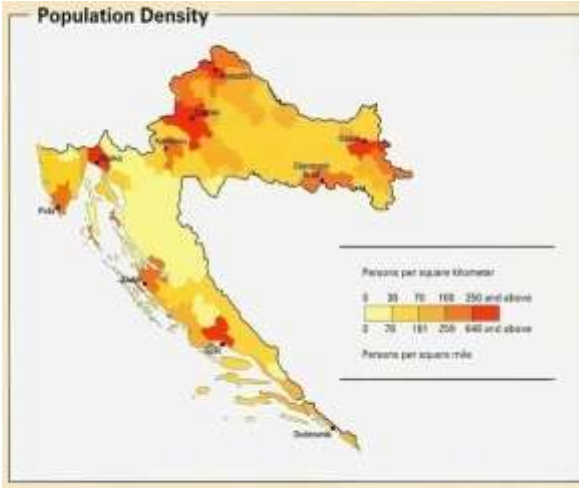


Figure 7: Population density in Croatia

Municipal wastes in the city of Zagreb are managed by a Zagreb Holding – Čistoća (ZCH). It is a city owned company whose purpose is the realization of public cleaning service, collection, transportation, treatment and disposal of MSW within the City of Zagreb. For the processes of treatment, recovery and disposal landfill site Jakuševec – Prudinec is in use.

Figure 8: ZCH waste collection trucks

Figure 9: Separate collection in Zagreb

Figure 10: Landfill "Jakuševec"

Figure 11: Composting unit in Zagreb

As in any other EU country, largest portion of mixed municipal solid waste (MSW) is biowaste. It is mostly kitchen and green waste with an average of 30 percent of total amounts. The main figures regarding waste management and numbers of companies in FAB industry in the City of Zagreb are shown in the Table 2tables Table 2 Table 3.

Table 2: Main figures regarding the waste management in the City of Zagreb (ZCH 2015)

City of Zagreb	
Amount of collected municipal solid waste in 2015 (t)	215,373
Potential amount of municipal biowaste in 2015 (t), 30% of total amounts	64,612
Amount of collected biowaste by ZCH in 2015 (t)	4,674

Table 3: Number of companies in FAB industry in the City of Zagreb

Industry	No. of companies
Food production	85
Beverage production	8
Tobacco industry	1

In the City of Zagreb, ZCH is certain amounts of the kitchen of waste collecting from a number of restaurants and hotels, and delivering to the composting plants where it is mixed with the garden waste collected from public areas. Larger waste producers including food and beverage industry and shopping malls are also separating biowaste, as well as market places in the City (total number of markets in the City is 18). These actions have led to the increase of total biowaste amounts sent to the composting plant (Figure 12). The overview of all biowaste categories collected in the City of Zagreb is presented in the table Table 4.

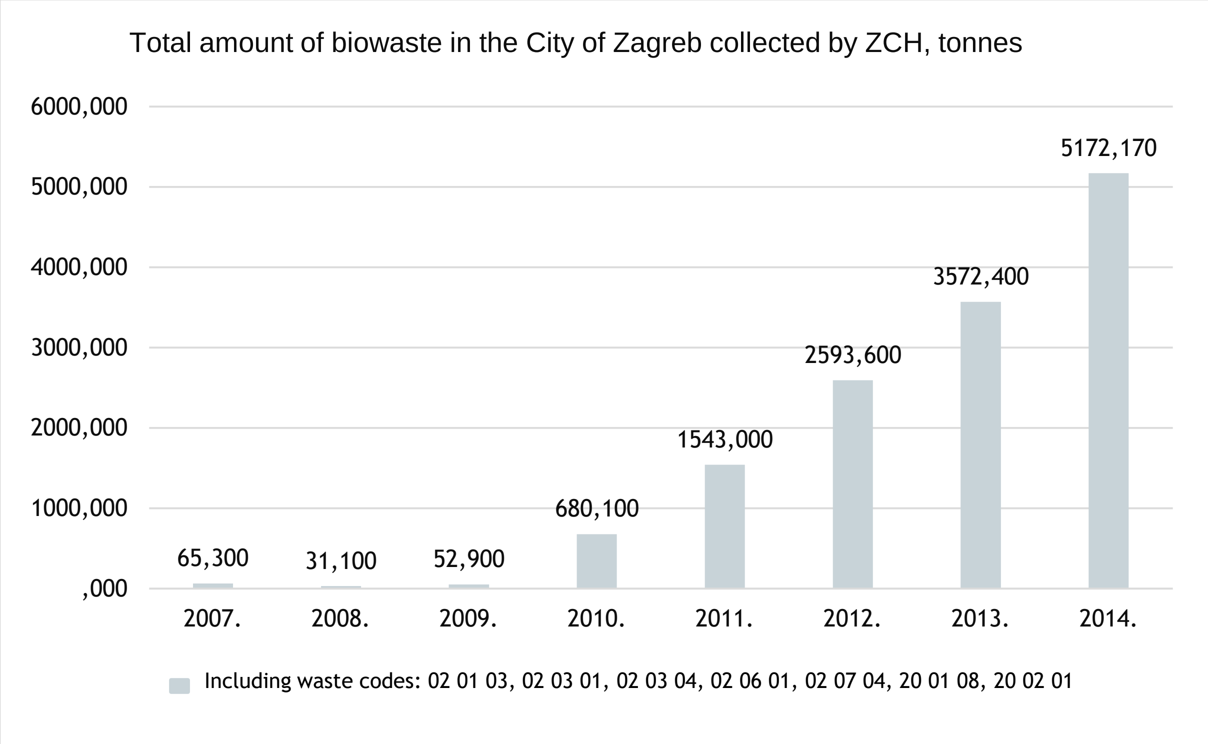


Figure 12: Increase of collected biowaste in the City of Zagreb (2007-2014)

Table 4: Total amounts of biowaste by waste codes in the City of Zagreb collected by ZCH and other waste management companies in 2013

Waste code	Waste description	Amount of waste (t)
02 01 03	plant-tissue waste	66.32
02 01 06	wastes from forestry	58.00
02 03 01	sludge from washing, cleaning, peeling, centrifuging and separation	197.84
02 03 04	materials unsuitable for consumption or processing	1,939.92
02 03 99	wastes not otherwise specified	41.80
02 06 01	materials unsuitable for consumption or processing	1.54
02 07 01	wastes from washing, cleaning and mechanical reduction of raw materials	32.62
02 07 04	materials unsuitable for consumption or processing	1,504.42
02 07 05	sludge from on-site effluent treatment	4.56
02 07 99	wastes not otherwise specified	10.08
20 01 08	biodegradable kitchen and canteen waste	158.22
20 01 25	edible oil and fat	380.20
20 02 01	biodegradable waste	1,940.41
Total		**6,335.93**

As mentioned before, the significant portion of above presented quantities is from marketplaces within the City. Having in mind the total potential of produced biowaste in the City, these amounts are still not that significant and complete biowaste collection needs improvements. The action of improving that system is underway, where significant improvement is expected in the future due to the legal obligation to start the collection of biowaste from households.

Over the past five years various projects were prepared and actions conducted in Zagreb in which particular attention has been paid to the biowaste collection improvement linked with a previously mentioned legal obligations Croatia has regarding the decrease of biodegradable waste landfilling Also, over the years ZCH has performed many surveys and inquiries regarding the potential of biowaste in the City from different waste producers. Table 5 shows an estimation on possible quantities of biowaste in Zagreb suitable for anaerobic digestion and biogas/biomethane production.

Table 5: Total estimated quantities of biowaste in the City of Zagreb

Input	Amount, t/year
Biowaste from shopping centers and households	5,000
Biowaste from kitchens and restaurants	10,000
Market biowaste	3,000
Industrial biodegradable waste (brewery, diary, food processing)	1,500
Expired milk & eggs	500
TOTAL	**20,000**

An estimate provided in the table above can outline the expected potential in the City, combining industrial biodegradable waste, biowaste from restaurants, expired products and biowaste from shopping centres and citizens, which are all included in this project.

The company ZOV (Zagreb wastewater Ltd.) founded in Zagreb in 1998, is responsible for design, financing, construction and operation of the Central wastewater treatment plant Zagreb (CWWTZ) and related infrastructure. The CWWTZ project is the first concession for a wastewater treatment plant in Croatia that enabled the City of Zagreb to harmonize and be in compliance with the environmental standards of European Union in the field of environmental and water protection. Pursuant to the Concession Agreement between the City of Zagreb and ZOV, ZOV designed and completed the construction of CWWTZ in 2007, and now is responsible for the management and operation of the facilities and regular maintenance. The location and overview of the CWWTZ is presented in the figures Figure **13**and Figure **14**.

Figure 13: Location of the CWWTZ

Figure 14: Overview of the CWWTZ

6.2. Description of Pilot Site inlcuding REEF2W Technologies

The CWWTZ has mechanical and biological treatment (AD) and total capacity is 1.2 mil PE and demand of 27,790 m3/h (BOD 90,000 kg/day). More than 70% of electricity demand is settled from its own production in biogas plant.

Regarding the consideration of the REEF 2W technology, main focus are on: utilization of biowaste collected in the City of Zagreb, biogas upgrade to the quality of CNG, and sustainable solution for the produced sludge (Figure 15).

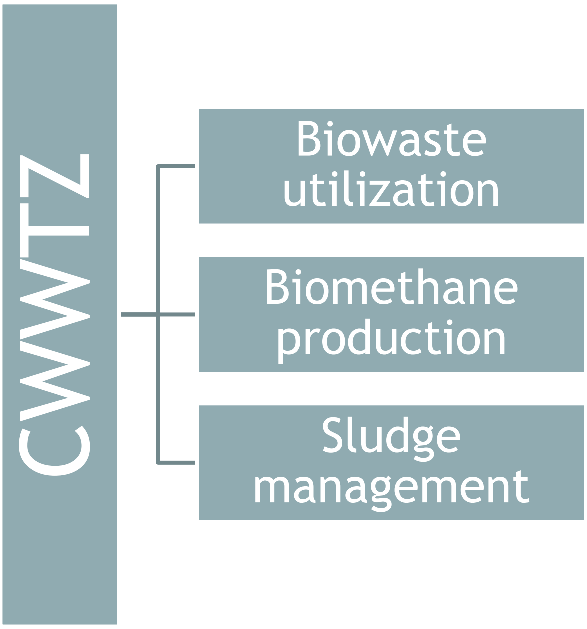


Figure 15: Proposed implementation of the REEF2W technologies in Zagreb

<u>Biowaste utilization</u>

City of Zagreb has a need to find a feasible solution for the treatment of collected biowaste. In this sense, location of the CWWTZ is highly suitable due to assess the city urban zoning and land use. In the case of the proposed location, city's urban plans have classified this area and communal, which allows further steps in the development of biowaste facility and biogas and biomethane production. Another important issue in choosing this location is the fact it might be the most suitable one considering public acceptance. Also considering transportation routes and logistics for future biowaste trucks, this location is one of the best ones. The location is easily accessible from the main city's road. The location is also relatively easy accessible from the main city's highway bypass.

Figure 16: Zoning regulation around pilot site

Biomethane production

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 transportation and logistical point of view. Also, the proposed location is excellent as the pilot site for biomethane plant because the main natural gas high pressure pipeline passes right next to the location. This means the produced biomethane could be easily injected into the natural gas grid.

Sludge management

The one of main issues that CWWTZ is facing is regarding the sustainable management of waste sludge, which is landfilled at the location. According to available data on sludge amounts, an average amount is approximately 50,000t per year, containing approximately 30% of dry matter average. Proposed solution is regarding the utilization of sludge on agricultural soils as effective way for treatment where the cycle of substance circulation is satisfied. However, seasonal restrictions on the application to agricultural land (e.g. flood, frozen soil or vegetation season) require careful planning between the production and application of sludge as fertilizer in agricultural production. Likewise, when sludge does not meet the agricultural application standard, it requires an alternative way of using, for example, composting or incineration.

6.3. Description of benefits by implimenting REEF2W Technologies

Energy utilization of biowaste will gain biogas production at the CWWTZ and therefore increase the total energy production at site. The utilization of biomethane as a biofuel will have also many benefits. It is especially interesting due to the fact that City of Zagreb, through its public transport company (ZET), already has certain CNG fleet of busses.

Different EU legislations address the issue of sustainable biowaste management since it is a priority to have high human and environmental protection standards during the whole waste management process. Anaerobic digestion in closed systems with proper control measures will generate high yields of biogas/biomethane. 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. Anaerobic digestion has become a standard technology for the treatment of separately collected digestible organic fraction of municipal waste in many countries, producing biogas/biomethane which can be used as a renewable biofuel, as well as digestate which can be used as a plant fertilizer.

7. ANNEX 1

RELEVANT MODELS HIGHLIGHTING INTEGRATION AND COMBINATION OF TECHNOLOGIES

24/04/2018

DESCRIPTION OF PILOT SITE (ACTUAL SITUATION)

- Please use information from Deliverable D.T.1.1.3 (Study showing the state-of-the-art of your pilot)

DESCRIPTION OF PILOT SITE INLCUDING REEF2W TECHNOLOGIES

- Description of your pilot site by including your REEF2W Technologies
  - What will be the technologies implemented on your site?
    a) Short description of the REEF2W technologies you will implement
    b) Pro and cons of your REEF2W technologies implemented
  - How will your pilot site change?
    a) Schemata of the new pilot site including the new REEF2W Technologies
    b) Description of the "new" pilot site compared to the state-of-the art model

DESCIPRIPTION OF BENEFITS BY IMPLIMENTING REEF2W TECHNOLOGIES

- Description of the main benefit by changing your state-of-the-art pilot to a REEF2W pilot from:
    a) An energy point of view?
    b) A social point of view? (e.g.: Less emissions; less waste to deposit; …)