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

DT 1.1.2

DESCRIPTIONS OF BEST PRACTICES SELECTED

30/3/2018

ENEA Italian National Agency for New Technologies, Energy and Sustainable Economic Development
Unioncamere Veneto
ZAGREBAČKI HOLDING d.o.o.
VEOLIA
Montefeltro servizi
BOKU
adelphi
UNIVERSITY OF CHEMISTRY AND TECHNOLOGY PRAGUE
REGIONALNA ENERGETSKA AGENCIJA SJEVEROZAPADNE HRVATSKE
Reinhaltungsverband Trattnachtal
Biogas Trattnachtal GmbH
KOMPETENZZENTRUM Wasser Berlin

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1. Introduction

In this deliverable, according to the technologies described in the DT 1.1.1, are presented some of the most interesting best practices in the field of sludge treatment and management and organic fraction of municipal solid wastes. The idea is to describe some application in this field able to sho how implement the anaerobic digestion process also in already existing plants, how it is possible to improve the specific production of gas from some substrate using some quite simple technology.

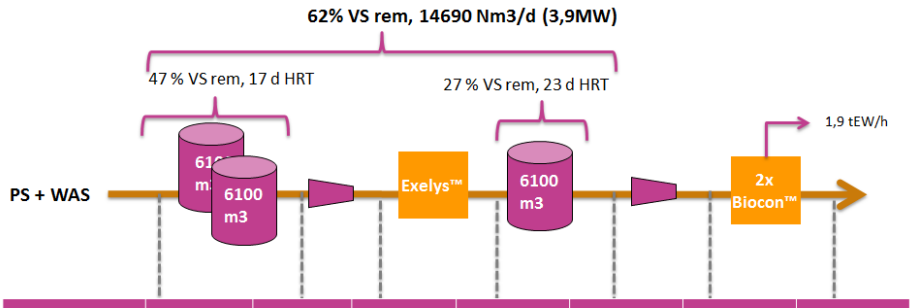
Also in the sector of the gas and heat use some example is described. In particular some simple technology for the gas cleaning and some a bit more complex for the biogas upgrading.

2. PRETREATMENTS

2.1. Sludge amount reduction by Exelys Thermal hydrolysis Marquette-lez-Lille

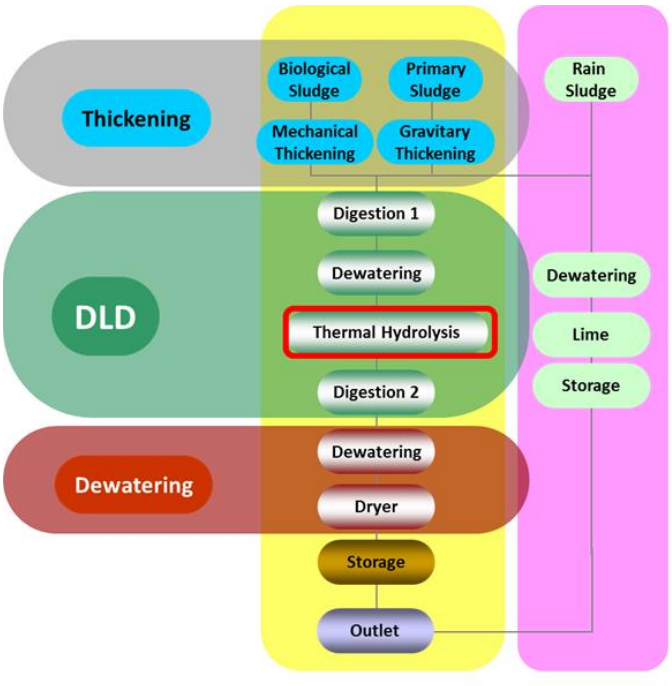
Country	*France*
Region	*Hauts de France*
City	*Lille*
Types of plants involved	*Exelys Sludge Thermal Hydrolysis*
For additional information	*Veolia provides technology delivery of Exelys system via Veolia Danish subsidiary Kruger A/S. Veolia operates Marquette lez Lille WWTP.*
Timescale	*Full operation since 2015*
General Description	*The new Marquette-lez-Lille wastewater treatment plant, one of the largest in France, is built to answer the needs of a growing population, according to the highest sustainability and technology standards. The plant will have the capacity to treat wastewater from an equivalent population of 620,000. It will feature two separate treatment trains, one for wastewater (2.8 m3/s) and one for stormwater (5.3 m3/s).* *For sludge treatment, the implementation of Exelys, a new thermal hydrolysis process from Veolia, will reduce the quantity of sludge produced by 20-40% and increase the production of biogas by 15-30% compared to a standard digestion.* *The total sludge amount entering the DLD system is design to be 42 TDS/d. The THP process operate at a temperature 140-170 C and 6-7 bars of pressure. The energy consumption can be from a Steam*
WHAT CONTRIBUTED TO THIS PROJECT'S SUCCESS?	

Difficulties and Solutions	*For Exelys hydrolysis there was little technical problems during initial phase of operation – hydrolyser foaming and operation management. Now there is significant effect of sludge volume reduction and biogas*



Concentration (%)	6	4	23	11	9,5	32	90
VS (%)	65	49			41		
metric ton DS/ d	42	29,0			25	22,7	22,6
metric ton / d	714	714			263	71	25,1

Efectivity of Exelys diagram e



Lille plant scheme

	*Marquette lez Lille WWTP*

2.2. Ultrawaves ultrasound system for anaerobic digestion of sludge improvement in Bamberg

Country	*Germany*
Region	*Bavaria*
City	*Bamberg*
Types of plants involved	*WWTP for 230.000 p.e.* *Actual Load 330.000 p.e.* *Primary sludge (PS) and thickened waste activated sludge (TWAS)* *Separate WAS thickening* *Centrifuge* *Sludge stabilization:* *Anaerobic, 3 digesters (2 x 2,000 m³, 1 x 3,000 m³)*
For additional information	*~ 70 – 100 m³/d at 2 - 3 kWh/m³ increase of total biogas production about 10%*
Timescale	*Sonication of 30% (in 2004) - 80% (in 2008) of the WAS*

General Description	*The installation of the Utrasound technology was studied to improve the sludge removal and avoid the construction of a new digestor.* *After a test 5 years long the result was an increase of the sludge degradation and an increase of the biogas production with a just small increase of the energy consumption due at the technology application.*
WHAT CONTRIBUTED TO THIS PROJECT'S SUCCESS?	
	This in one of the most new and interesting technologies for WWTPs. It works on both sides of the sludge volatile solids reduction and on the increase of the biogas production. *This is a very important aspect for the project because the costs of the sludge management and the poor specific biogas production of this substrate.*
Difficulties and Solutions	

General view of the Bamberg WWTP

Ultrasound sludge treatment unit

2.3. Thermal pressure hydrolysis in Geiselbullach

Country	*Germany*

Region	*Bavaria*
City	*Geiselbullach*
Types of plants involved	*- Wastewater treatment plant* *- Thermal pressure hydrolysis (Cambi)*
For additional	
Timescale	
General Description	*Before the hydrolysis takes place, the excess sludge is dewatered up to 15% of total solids. In the thermal pressure hydrolysis, the dewatered sludge is heated up to 160 °C at a pressure of 6 bar via steam addition. The sludge remains at the high pressure for 1.5 h, before a pressure drop takes place. Thus, the disintegration profits from two effects: the thermal hydrolysis and the high pressure-drop (steam explosion). Due to these effects, the cell membranes are disrupted and subsequently, the substrate availability for digestion is increased.*
WHAT CONTRIBUTED TO THIS PROJECT'S SUCCESS?	
	The thermal pressure hydrolysis increased the substrate availability and thus, the biogas production rate by 20% (www.klaerwerk.info) to 50% (www.ca-mbi.com). Furthermore, the dewatering of the digestate was enhanced.
Difficulties and Solutions	

Wastewater treatment plant in Geiselbullach (www.amperverband.de)

2.4. Thermal hydrolysis in Howdon

Country	*United Kingdom*
Region	*North East England*
City	*Wallsend*
Types of plants involved	*Municipal wastewater treatment plant* *CAMBI thermal hydrolysis* *Digester*
For additional	
Timescale	*The thermal hydrolysis was implemented in 2012 at the wastewater treatment plant in Howdon.*

General Description	*The wastewater treatment plant is designed for 1,000,000 people equivalent. In the thermal hydrolysis, 40,000 t of dry solids per year are treated at a temperature of 165 °C for 30 min. The temperature is achieved using direct steam injection.*
WHAT CONTRIBUTED TO THIS PROJECT'S SUCCESS?	
	The thermal hydrolysis reduced NWL's (Northumbrian Water Ltd.) carbon footprint by about 50 000 t CO_2/ year.
Difficulties and Solutions	

Advanced Digestion plant under construction including twin stream Cambi THP - PHOTO by Steve Mayes - Courtesy of Northumbrian Water Ltd

(www.waterprojectsonline.com/case_studies/2012/Northumbrian_Howdon_2012

.pdf)

2.5. Thermal alkaline hydrolysis in Gifhorn

Country	*Germany*
Region	*Lower Saxony*
City	*Gifhorn*
Types of plants involved	*- Wastewater treatment plant* *- Thermal alkaline hydrolysis*
For additional	
Timescale	*The thermal alkaline hydrolysis was implemented in 2005 at the wastewater treatment plant in Gifhorn.*

General Description	*In the thermal alkaline hydrolysis, the cell membranes of the excess sludge are disrupted by heat at a temperature ranging between 60 and 70 °C and an alkaline solution such as sodium hydroxide. Thus, the substrate availability for digestion is increased. The cell disruption degree is between 40 and 50%.* *The flowrate of the sludge is 1 m³/h and the retention time in the reactor is 2 hours. The electrical energy demand ranges between 0.9 and 1 kWh/m^3_{sludge}. The heat in the discharged sludge is reused for the digestion process.*
WHAT CONTRIBUTED TO THIS PROJECT'S SUCCESS?	
	The thermal alkaline hydrolysis increased the substrate availability and thus, the biogas production rate by 30%. Furthermore, the dewatering of the digestate was enhanced.
Difficulties and Solutions	*In winter, observed difficulties were a low buffer of thermal energy and massive foam formation in the digester. The thermal alkaline hydrolysis solved both problems due to a higher gas production and the destruction of foam forming extracellular polymeric substances (EPS).*

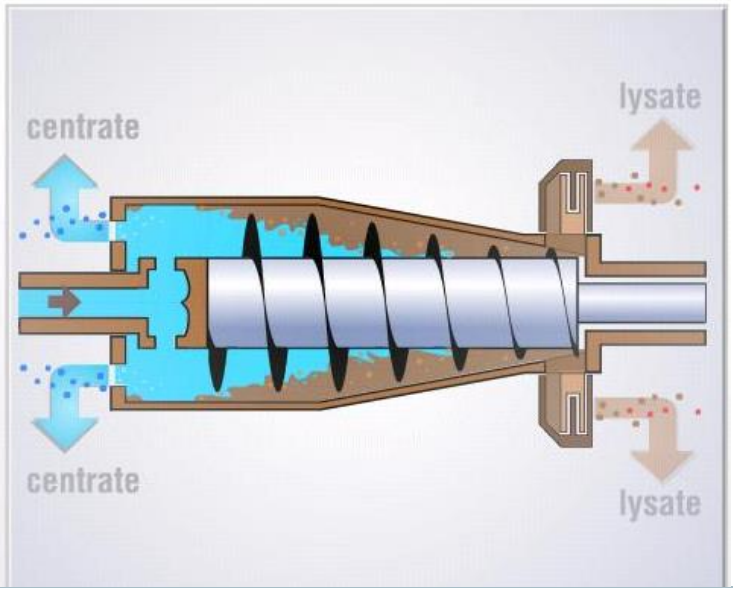
	*Reactor for the thermal alkaline hydrolysis at the wastewater treatment plant in Gifhorn* *(www.pondus-verfahren.de)*
	*Pipe in pipe heat exchanger* *(www.pondus-verfahren.de)*

2.6. LYSATE CENTRIFUGE

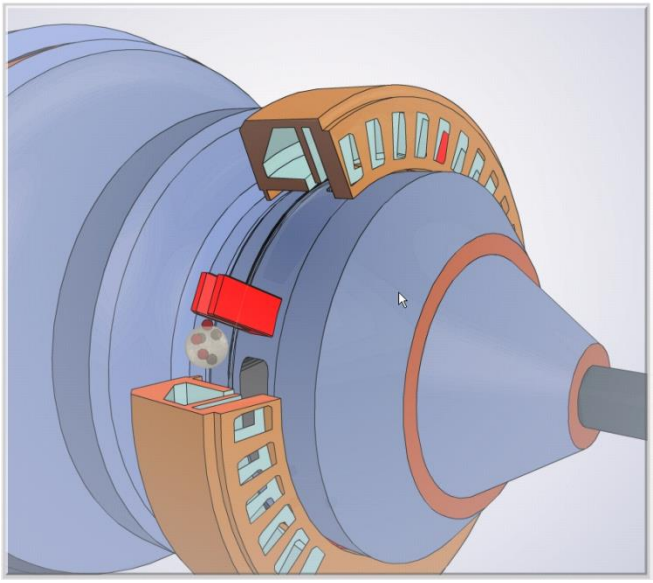
Country	*Czech Republic*

Region	*Central Europe*
City	*Prague*
Types of plants	*Municipal WWTP of 1.250,000 PE*
For additional information	*Zabranska, J., Dohanyos, M., Jenicek, P., Kutil, J., 2006. Disintegration of excess activated sludge - evaluation and experience of full-scale applications. Water*
Timescale	*text*
General Description	*12 digesters, each with a useful volume of 4823 m3. Digesters are two-staged, the 1st stage is operated in a semi-continuous way with 24 feedings daily, heated and completely mixed, the 2nd stage digester is provided with a gasholder and without heating and mixing. Operational temperature in the 1st stage digesters is thermophilic (55 °C), temperature of the 2nd stage digester dropped down only to 52 °C.* *Disintegration by thickening lysate centrifuge was applied to increase degradability of sludge and biogas production.* *Important features:*
WHAT CONTRIBUTED TO THIS PROJECT'S SUCCESS?	
	Implementation of thermophilic anaerobic digestion (55 °C) combined with excess sludge disintegration by means of lysate-thickening centrifuge brought the increment of specific biogas production from 0.470 to 0.650 Nm3.kg-1 VS input. *Electric energy corresponds to 115 MWh/d and heat energy to 178 MWh/d for daily loading of 80,000 kg VS with biogas specific production rate 0.65 Nm3/kg (VS)*
Difficulties and Solutions	*Material of knife is important.* *Abrasion of steel knifes was quite fast and frequent change was needed.* *As solution was found the carbide coating of knifes.*

- Thickening lysate centrifuge -



Operational scheme -

	*Disintagrating knifes detail*

3. ANAEROBIC DIGESTION PROCESS

3.1. Anaerobic digestion plant Rimini

Country	*Italy*
Region	*Emilia Romagna*
City	*Rimini*
Types of plants involved	*Dry Anaerobic digestion plant and composting*
For additional information	*text*
Timescale	*Realization of composting plant 2008; ugrading to dry biogas anaerobic digestion 2011*
General Description	*The platform receives 45.000tons/year of organic fraction of municipal solid wastes (OFMSW).* *11 anaerobic biocells are used with an average retention time of 25 days to perform the anaerobic digestion of the material.* *Cells are working in parallel, and the gas is collected cleaned and finally burned in 2 CHP units of 499kW.* *Electricity produced is distributed in the public net the heat is used to warm up digestors and for other technical uses in the buildings of the platform.* *On the roof of the plant a photovoltaic plant of 176kWp is installed*

WHAT CONTRIBUTED TO THIS PROJECT'S SUCCESS?	
	This is one of the few examples of anaerobic digestion of OFMSW in Europe. The advantage of this technology is that it is quite simple and it doesn't require many machineries as pumps, mixers, separators. The biomass is introduced using a bulldozer and the biogas production starts almost naturally. *It is a possible technology in those cases where the water management could be a problem. It is a good technology to revamp composting plants because the management of the organic matter is quite similar as well as the machineries.* *Although the production decrease in this kind of plants it is possible to use also low quality OFMSW because the problems deriving from the inert material doesn't generate problems at pumps or pipelines.*
Difficulties and Solutions	*This kind of plant requires a quite lasge space for the construction of the biocelles, and an area for the management of the organic matter.* *If low quality of OFMSW is used then there is a problem to use this material as compost. It is important for the final disposal of the compost to have a high quality of the collection.*

Anaerobic Biocell open -

Raw material management area CHP Units

Compsting area

CHP Units

3.2. Anaerobic digestion plant ALBAIRATE Milan

Country	*Italy*
Region	*Lombardia*
City	*Albairate*
Types of plants involved	*Total capacity of the plant: 70.000 tons/y OFMSW and lignocellulosic material* *Power installed: 2 MW* *Electric energy produced: 15GW/y* *Thermal energy produced: 15GW/y* *Digestate disposal: composting in biocells and field application and gardening 15.000tons7year*
For additional information	*Electricity used for the internal needs and for sold at the net. Thermal energy heating of the digestors, heating of the air for composting, heating of offices and sanitary water*
Timescale	*Aerobic plant 2007; new Anaerobic Digestion section and fast composting of biosolids 2013*
General Description	*In this plant the raw material in selected and then milled. The process water is used to increase the umidity content of the substrate to a level of 8-9% of volatile solids.* *The digestions maintained in mesophilic conditions and .the digested material is separated. Water goes at the wastewater treatment plant, instead remaining solid material is further treated and added with wood material to produce high quality of compost.* *The biogas, before its use in a CHP unit is biologically desulfurized.*

WHAT CONTRIBUTED TO THIS PROJECT'S SUCCESS?	
	This plant is a good example of how in the presence of a good governmental sustain it is possible to transform a energy consuming composting treatment plant in an energy producing waste treatment platform.
Difficulties and Solutions	*Mainly legal and authoritative problems. From the technical point of view no particular problems encountered*

General view of the Treatment Platform

Top View of the anaerobic digestion units

Composting Pile

3.3. Central wastewater treatment plant Zagreb (CWWTZ)

Country	*Croatia*
Region	*Zagreb*
City	*City of Zagreb*
Types of plants	*Mechanical and biological treatment / AD*
For additional	*Energy utilization of biogas*
Timescale	*CWWTZ started operation*

General Description	*Zagrebačke otpadne vode d.o.o. (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, through its sister company Zagrebačke otpadne vode-upravljanje i pogon d.o.o./Zagreb wastewater-management and operation Ltd. is responsible for the management and operation of the facilities and regular maintenance.* *ZOV is owned by a consortium consisting of WTE Wassertechnik GmbH (WTE) from Essen, innogy Aqua GmbH from Mülheim and city company Vodoprivreda Zagreb d.d. (VZ)/Water Management Ltd.* *WTE, the main partner in this project, is a daughter company of the Austrian group EVN AG, the largest company in the field of water supply and wastewater treatment in Lower Austria. The main activity of WTE is design, construction and management of waste water treatment plants, drinking water treatment plants, thermal waste treatment and heat and power production plants, both in Germany and abroad.* *Innogy Aqua company within the innogy SE Group holds interests in RWW (Rheinisch-Westfälische Wasserwerksgesellschaft mbH), IWW (Rheinisch-Westfälisches Institut für Wasserforschung) and the Central for wastewater treatment plant of the city of Zagreb.VZ (Vodoprivreda Zagreb d.d.) as the Croatian founder company deals with the maintenance of natural waterways and groundwater in the city of Zagreb, restoration and water management and water protection. VZ (Vodoprivreda Zagreb d.d.) is also responsible for the protection and monitoring of the Sava River.*

WHAT CONTRIBUTED TO THIS PROJECT'S SUCCESS?	
Difficulties and Solutions	*Total plant 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.* *Main improvements are possible regarding the utilization of biowaste collected in the City of Zagreb.* *Biogas upgrade and usage as a biofuel or injection in the current natural gas grid is also a possibility in order to improve current operation of the plant.* *Produced sludge requires activities i order to find a sustainable solution.*

Overview of the Waste water treatment plant in Zagreb (source: www.

4. BIOGAS LINE

4.1. Biogas upgrading with amine scrubbing at Gasendal

Country	*Sweden*
Region	*Götaland*
City	*Göteborg*
Types of plants involved	*Municipal wastewater treatment plant* *Digester*
For additional	
Timescale	*The upgrading plant was commissioned in May 2007.*
General Description	*The plant receives biogas produced by anaerobic digestion at the wastewater plant Gryaab AB through 3km pipes. It is upgraded with a chemical absorption process using an amine solution.* *The upgraded biogas results in bio-methane which is injected in the grid at 4bars. The feed-in capacitiy of the grid injection is 880 m³/h. Furthermore, the biomethane is used as vehicle fuel.*
WHAT CONTRIBUTED TO THIS PROJECT'S SUCCESS?	

	This was Göteborg Energi's first biogas upgrading plant and at the time of commissioning the largest biogas upgrading facility in the world. *This plant contributed to a CO_2 emission reduction of 18,000 t of Göteborg Energi's carbon footprint.* *Due to chemical additives at the WWTP the biogas contains very low concentrations of H_2S, therefore the activated carbon filter only needs to be regenerated every 2-3 years.* *Each batch of amine solution can be used for 5 years.* *The heat from the upgrading process is captured to keep the road access free of ice.*
Difficulties and Solutions	

Biogas upgrading plant Gothenburg, Sweden with a raw biogas capacity of 1600m³/h (Source: Cirmac)

	*Biogas upgrading plant "Gasendal" at Görteborg, Sweden*

4.2. Biogas upgrading at the wastewater treatment plant in Didcot

Country	*United Kingdom*
Region	*Oxfordshire*
City	*Didcot*
Types of plants involved	*Municipal wastewater treatment plant* *Digester*
For additional information	
Timescale	*The first injection of biomethane into the gas distribution network was accomplished in 2010.*

General Description	*100 Nm³/h raw biogas produced from excess sludge is upgraded with pressurised water scrubbing to 98% methane and injected into the gas grid with a biomethane feed-in capacitiy of 65m³/h, enough for the heat demand of 200 homes.*
WHAT CONTRIBUTED TO THIS PROJECT'S SUCCESS?	
	This was the first Biogas-to-Grid plant in the United Kingdom. The project demonstrates the feasibility of biogas injections plants and proved to be major success. Significant opportunities to reduce the capital and operating costs have been identified, making it easier for future biomethane injection projects to go ahead. With the gained experience the interest and confidence for further plants was created.
Difficulties and Solutions	

	*Biogas reactors, gas bag and pressurised water scrubbing unit*

4.3. Power to gas at the Avedøre wastewater treatment plant

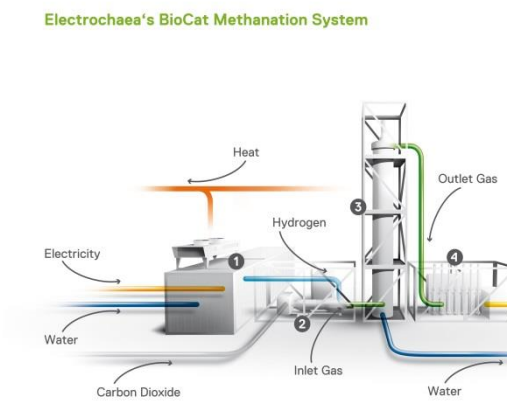
Country	*Denmark*
Region	*Hovedstaden*
City	*Hvidovre*
Types of plants involved	*Municipal wastewater treatment plant* *Alkaline electrolysis*
For additional	
Timescale	*The power to gas unit was implemented in 2016.*

General Description	*The wastewater treatment plant is designed for 345,000 people equivalent and treats 25-30 million m³ of wastewater. At this plant, a 1MW-power to gas unit using biological catalysis is implemented. The facility uses wind energy produced in times of lower power demand as well as excess solar power to produce hydrogen in an alkaline electrolyzer with 100 m³ H_2/h. Together with CO_2, the hydrogen is converted to CH_4 by microorganisms in the biological methanation. The will be injected into a 4-bar gas distribution grid.*
WHAT CONTRIBUTED TO THIS PROJECT'S SUCCESS?	
	First results show that more than 95% of the CO_2 of the biogas stream is converted into CH_4. The upgraded gas will be injected into the gas distribution grid. *The by-products heat and oxygen can be utilized on-site. The oxygen will be injected in the activated sludge treatment basins, resulting in a decrease of up to 80% of the volume of gas for aeration. The heat is injected to the local heat grid and utilized locally.*

Difficulties and Solutions	*Over 3,500 hours of operation have proven that the technology works at large scale. In the beginning there were some minor problems with the flare, with the biogas supply and with some valves. But now the plant is working very stable and efficient.* *The biggest hurdle at the moment is to develop a profitable business case. As there is no definition of methane produced via biological methanation it is not foreseen in any regulatory rules and therefore doesn´t get the same price as biomethane produced from biogas does.* *The project partners have identified this problem and discussions with grid operators and regulatory bodies are ongoing to find a solution.*

biomethanation reactor using CO2 produced in the digesters to perform biogas-upgrading for gas grid injection

electrolyzer from hydrogenics delivering hydrogen to the BioCat methanation plant and oxygen to the waste water treatment plant

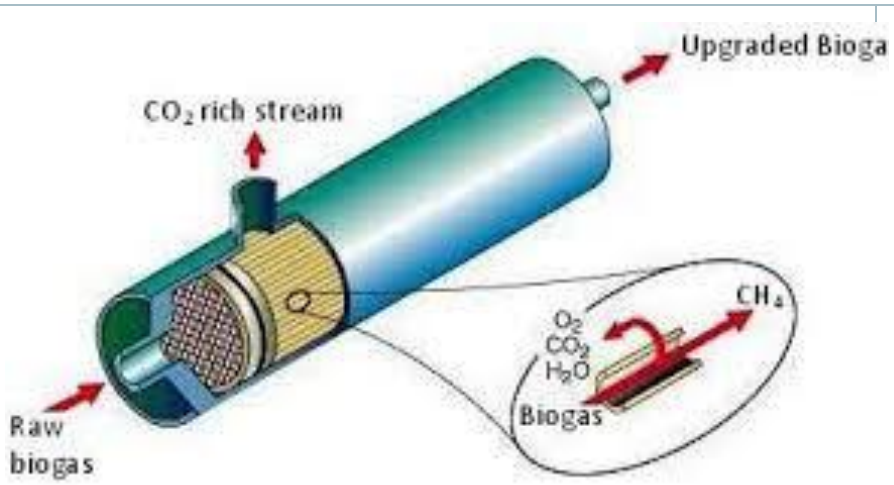


This three-dimensional drawing visualizes the material flows and facility components for the BioCat methanation system at Avedøre.

4.4. Biomethane upgrading by membranes

Country	*France*
Region	*Auvergne-Rhône-Alpes region*
City	*Grenoble*
Types of plants involved	*Municipal WWTP of 500,000 PE*
For additional information	*http://www.waterworld.com/articles/wwi/print/volume-30/issue-2/technology-case-studies/france-liquefied-biogas-from-wastewater.html* *https://www.bioenergie-promotion.fr/50540/11-mai-2017-valorisation-des-boues-depuration-des-eaux-par-le-biomethane/biomethane/?11+mai+2017%2C+valorisation+*
Timescale	

General Description	*The principle of methane separation is gas permeation membranes are removing carbon dioxide, hydrogen sulfide, and water vapor in one step using pressure as driving force for permeation.* *Gaz Electricité de Grenoble and SUEZ have commissioned in September 2016, the second biogas purification and biomethane injection unit into France.* *In Grenoble WWTP is operated membrane unit and biomethane injection system which can produce 17 GWh / year.* *Part of biogas produced (320 Nm^3/h) is treated by membrane unit producing 200 Nm^3/h of biomethane which can cover the operation of 700 CNG city buses.*
WHAT CONTRIBUTED TO THIS PROJECT'S SUCCESS?	
	Good cooperation of all stakeholders.
Difficulties and Solutions	*Not presented*



Separation principle

WWTP digesters -

Membrane technology

4.5. Anaerobic digestion plant ACEA PINEROLESE

Country	*Italy*
Region	*Piedmont*
City	*Pinerolo*
Types of plants involved	*Anaerobic digestion of solid wastes and sludge, composting plant for the valorisation of digestate (together with green residue), upgrading unit for the*
For additional information	
Timescale	*Realization AD plant year: 2003* *Realization biogas upgrading plant: 2014* *Realization composting plant: 2000*

General Description	*Substrated treated: mainly organic fraction of municipal solid waste and, in small amounts, wastewaters from local food industry supply* *wastes ton/year: 60000 t/y* *Sludge ton/year: 0 t/y* *Population served:150000 inhabitants* *Area served sqkm: 47 municipalities (http://www.arpa.piemonte.it/reporting/rapporto-pinerolese/inquadramento-territoriale/superficie-territoriale)* *Anaerobic digestion plant* *Working temperature 55 °C* *Volume 5000 m^3 (two reactors of 2500 m^3 each)* *HRT: 14 days* *Biogas production: around 19000 Nm^3/day* *Biogas use: for heat and electricity production* *CHP unit kW power: nominal power: 3 $MW_{thermal}$ and 3 $MW_{electrical}$* *Biogas upgrading* *Technology used: two units of purification (water stripping column and membrane filtration)* *Short description of the technology: Water adsorption column combined with membrane; methane production up to 60 Sm^3/h. Inlet biogas: up to 120 Nm^3/h; 40-55 °C, 20 mmbar. Outlet methane: 5 atm, methane recovery higher than 98 % (< 2 % losses). Compliancy with: "Codice di Rete Snam Rete Gas" and UNITR 11537:2016* *Energy consumed: 0,3 kWhel/Sm^3biogas* *Use of Biomethane: transport use, to grid injection (under development)* *Use of CO_2: emission to air, production of bio-hydrogen (under development)* *Digestated use: compost production* *Liquid fraction %: 74* *Solid fraction %: 26*
WHAT CONTRIBUTED TO THIS PROJECT'S SUCCESS?	

	This is a good example and the first in Italy of the advanced treatment of the Biogas for grid ingestion or for the use as biofuel. The difficulties that this company encounter in the realization and use of the gas produced due mainly at legislative problems will be a good experience to share with other countries to prevent this kind of bottle neck
Difficulties and Solutions	*Mainly legislative problems have occurred in implementing the technology due to the time consumed in defining the technical standard (from 2011 to 2016) and the definition of the incentive (03/2018).*

Overview of the platform with the WWTP and the solid waste management area

Anaerobic Digestors and CHP units

Pilot biogas Upgrading Unit

Composting Material

4.6. Biogas upgrading with membranes at Beverwijk, Netherlands

Country	*The Netherlands*
Region	*North Holland*
City	*Beverwijk*
Types of plants involved	*Municipal wastewater treatment plant* *Digester* *Membrane upgrading of biogas* *Cryogenic liquefaction of CO_2*
For additional	

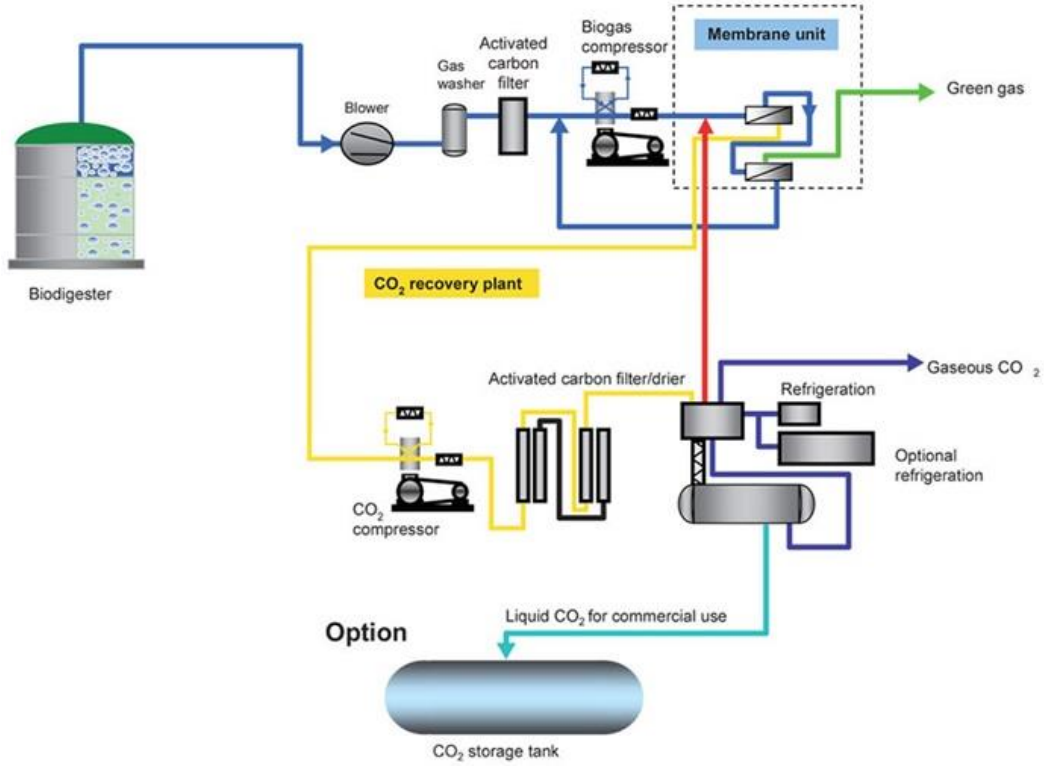
Timescale[1]	*Operation of the new membrane upgrading started in 2011.*
General Description[2][3]	*The upgraded facility receives biogas from the wastewater treatment plant's anerobic digestion. With membrane technology's capacity of more than 2 mio. m³ biogas production can be increased to 1.28 mio. m³ biomethane per year.* *The produced biomethane is fed into the natural gas grid andy isused to partly fuel the plant owner's CNG-powered vehicle fleet. The by-product CO_2 is cryogenically processed and liquefied. The recovered CO_2 is used to adjust the pH values during the wastewater treatment process.*
WHAT CONTRIBUTED TO THIS PROJECT'S SUCCESS?	

[1] Source: http://www.biogaspartner.de/en/project-map/project-examples-europe/beverwijk.html

[2] Source: https://foodandbeverage.pentair.com/~/media/websites/food-and-beverage/downloads/haffmans/biogas-upgrading/biogas_upgrading_haffmans_case-study_beverwijk.pdf

[3] http://www.biogaspartner.de/en/project-map/project-examples-europe/beverwijk.html

	The new upgrading capacity replaced a smaller one and is capable to produce and feed in 1.28 mio m³ of biomethane into the natural gas grid according to Dutch authorities. That equals the annual consumption of 700 households. Additionally, a part of the biomethane is used to fuel CNG cars at an on-site filling station. The owner plans to add 50 more cars to the existing fleet of 19. Other water authorities in the Netherlands have shown interest in running their cars with the biomethane from Beverwijk. *During the cryogenically processing of the CO_2 stream remaining methane is captured and a recovery of 100 % biomethane is achieved. The CO_2 is used on-site to adjust pH values during wastewater treatment and can be potentially applied in greenhouses or in food and beverage applications.* *The project has the potential to serve as a model for additional projects and promote the benefits of biogas upgrading.*
Difficulties and Solutions	



The picture illustrates the process steps for biogas upgrading and CO_2 recovery at Beverwijk WWTP.[4]

[4]Source: https://foodandbeverage.pentair.com/en/case-studies/hhnk-beverwijk

The biogas upgrading unit at Beverwijk WWTP is located in the upper centre of the picture within two standard 40-foot container.[5]

5. DIGESTATE LINE

5.1. Biogas for the gas grid produced at a wastewater treatment plant in Wiener Neustadt, Austria

Country	*Austria*
Region	*Niederösterreich (Lower Austria)*
City	*Wiener Neustadt*
Types of plants	*Biogas production from sewage gas and cofermentation for gas grid*
For additional	
Timescale	*In operation since 2011*

[5] Source: Google Maps (2018): https://www.google.de/maps/place/RWZI+-+Beverwijk/@52.4735861,4.6672314,15z/data=!4m2!3m1!1s0x0:0x2e10636feb607d99?sa=X&ved=2ahUKEwiTyZrF77TaAhVQblAKHVyyBWcQ_BIwCnoECAAQfQ

General Description	*The wastewater treatment plant in Wiener Neustadt Süd produces more renewable energy than it needs, calculated on an annual basis. In March 2011 a biogas upgrading plant was put into service by the local energy supplier EVN. Since then it refines the gas from sewage sludge and cogeneration (mainly from biofuel industry) to gas grid quality and thus is fed into the grid.* *This biogas upgrading plant, initiated by both the treatment plant director and EVN, was only possible due to a close cooperation: While the wastewater treatment plant is responsible for producing raw biogas out of the sludge and coferment, EVN cleans and upgrades the gas and is doing the injection into the grid. On average 120 m³ biomethane per hour are fed into the grid – this means a power of around 1.3 MW. This sums up to an annual amount of 1,100,000 m³ per year, covering the consumption of more than 1,000 average Lower Austrian households. Moreover it leads to annual CO2 savings of approx. 2,000 tons.* *Source (text and photos): https://www.biomethanregister.at/de/teilnehmer/biomethanproduzent/wiener-neustadt*
WHAT CONTRIBUTED TO THIS PROJECT'S SUCCESS?	
	There is a lot of biofuel production in the area; therefore the cofermentation potential is very high. Moreover the actors in the wastewater treatment plant and the local grid operator were both interesting in this solution and cooperated closely.
Difficulties and Solutions	*The plant has been running in the last 7 years without any severe problems – much more reliable than expected due to the novelty of the system.*

	- biogas cleaning and upgrading plant Wiener Neustadt; source: EVN -

6. DIGESTATE LINE

6.1. Microaration of digesting material

Country	*Slovak Republic*
Region	
City	*Bratislava*
Types of plants	*WWTP of 350,000 PE*

For additional information	*Microaeration*
Timescale	
General Description	*Dosing of limited amount of air in the recirculation stream of digester with the aim of sulphide oxidation to elemental sulphur and hence biogas desulfurization*
WHAT CONTRIBUTED TO THIS PROJECT'S SUCCESS?	
	The recovery of sulphur is one of the issues of the circular economy strategy. *With this technology that is well tested it is possible to increase the sulphur content of the digestate and remove it from the gas stream preventing the damage of the engines, or the other upgrading devices.*
Difficulties and Solutions	*No particular technical difficulties have been encountered in the application of this technique.*

7. HEAT RECOVERY

7.1. Wastewater heat from sewage for heating a municipal swimming pool in Marseille, France

Country	*France*
Region	*Département Bouches-du-Rhône*
City	*Marseille*
Types of plants involved	*Waste heat from sewage, municipal swimming pool*
For additional information	
Timescale	*In operation since Summer 2012*

General Description	*The pools of the prestigious Cercle des Nageurs de Marseille (CNM) are (partly) heated with low-temperature energy from a nearby sewage. The concept was designed by Veolia and is named Energido. An external heat exchanger was installed that transfers the heat from the sewage to a secondary (clean) water cycle, which supplies the heat pumps. This solution keeps the temperature of the Olympic swimming pools at 27°C all year round and preheats the hot water for the changing rooms too. The sewage water temperature is around 15 to 17 degrees. The power of the heat pumps amounts to 250 kW, the annual performance factor is around 4.5. There are two heating circuits: one for the pools (about 27°C inlet temperature) and for hot water preheating (35°C inlet temperature). About 1.12 GWh/a of fossil energy are saved compared to the former state. The total costs were around 1.14 M€. Not only does the CNM save 35% on its annual energy bill, but 230 tons of CO2 emissions are also avoided every year. In the Departement of Arras a similar solution was introduced.* *Sources: http://www.geothermie-perspectives.fr/sites/default/files/reference_marseille_avril_2014.pdf https://www.eauxdemarseille.fr/Nos-realisations/Un-chauffage-ecologique-pour-les-eaux-du-bassin-olympique-marseillais*
WHAT CONTRIBUTED TO THIS PROJECT'S SUCCESS?	
	The CNM itself as well as the Regional Parliament and Ademe took about one third of the costs each, therefore the investor only took a small part of the costs. On one hand the heating temperatures to be achieved are comparably low (pre-heating). On the other hand the sewage temperature is around 15 to 17 degrees, which allows high efficiency. The filtration and disinfection systems were modernized at the same time which might have led to substantial cost reductions.
Difficulties and Solutions	*no difficulties reported*

	- swimming pool, heated by wastewater, source: Veolia -

8. Conlusions

The above list of best practices show how there are several opportunities to implement solutions for the increase of EE & RES in waste and wastewater treatments plants.

These solutions not always and not necessarily can be found inside the treatment platform, but especially in the case of heat recovery according to the specific local situations it is possible to have a good integration between wastes treatments and social advantages.

In any case the consideration that it will be possible to do is that the development of these integrated infrastructures need a strict cooperation among city planners, city administrators, utilities managers and legislation development.

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