Danish Energy Agency

Ea Energy Analyses

IB Tech

Biogas plants in Denmark and Mexico

Danish Climate and Energy Partnership Programme in Mexico 2017-2020
Bioenergy

INDEX

INTRODUCTION

The Energy Partnership Programme between Mexico and Denmark seeks to provide input for a Mexican biomass roadmap that includes the implementation of an action plan and feasibility studies, as well as the proposal of additional incentives to promote a sustainable use of biomass in the energy mix.

The present document, "Biogas plants in Denmark and Mexico", describes eleven (11) biogas plants, six (6) of them located in Denmark and the remaining five (5) plants in Mexico. Each plant in Mexico was visited by the technical consultants of this Programme. The Danish Plants were described by Danish Energy AgencyThe information shown was supplied by the responsible of each plant.

The Datasheets contain a brief description of the process as well as figures related to amount of influent, technology used, anaerobic reactors capacity, biogas production and final use. Moreover, when available, costs related to investment, operation and maintenance are shown. Finally, collateral benefits such as GHG reduction, digestate use and employment in the biogas plant are quantified when possible.

Ultimately, these datasheets are intended to illustrate the "state of the art" of biogas technology plants in Denmark and Mexico. All these plants are examples of waste valorization.

Experts involved in this work:

Danish Energy Agency

- Bodil Harder, *MSc*

Consultancy company IBTech®

- Benly Liliana Ramírez Higareda, *MSc*
- Rafael Leyva Huitrón, *Eng.*
- Raúl Chimil Molina, *MEng*
- Jorge Edgardo López Hernández, *Eng*

Billund Water & Energy

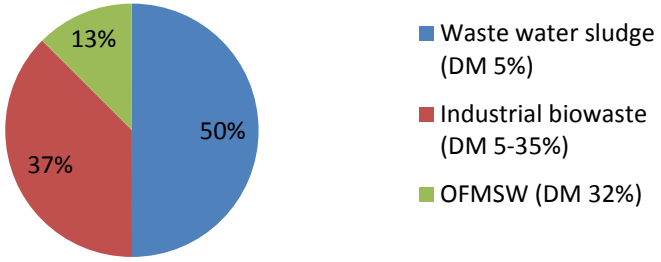
Billund Vand og Energi A/S, Denmark, is a public utility company providing services in water supply and waste management to the municipality of Billund. The Grindsted Renseanlæg established in 1997 is a wastewater treatment plant combined with a co-digestion facility where industrial and municipal bio-waste from the municipality is digested together with waste-water sludge. The plant was upgraded in 2016 into Billund Biorefinery with new technologies in order to increase biogas production, minimize energy consumption, enhance process control and improve effluent quality.

Vision

The vision of the project was to combine strong environmental technologies in water purification and biogas in one significant full-scale demonstration project.

Biomass feedstocks

The bio-digesters are fed with source separated organic waste from households (collected in paper bags) and industrial bio-waste together with municipal wastewater sludge.



Start of operation:
1997

Capacity:
Digester volume 4200 m3
61.000 tonnes /year (4900 t DM)

Type of digestion:
CSTR, two step, first step thermophilic and second step mesophilic, wet

Retention time
12 + 20 = 32 days

Dry matter content
8 % in average input

Biogas Production:
2 mio. Nm^3 CH_4 /year
(33 Nm^3 CH_4/t ww)

Utilization of gas:
Electricity: 6.7 GWh/year
Heat: 14.7 GWh/year
Own consumption:
Electricity: 3.8 GWh/year
Heat: 8.8 GWh/year.

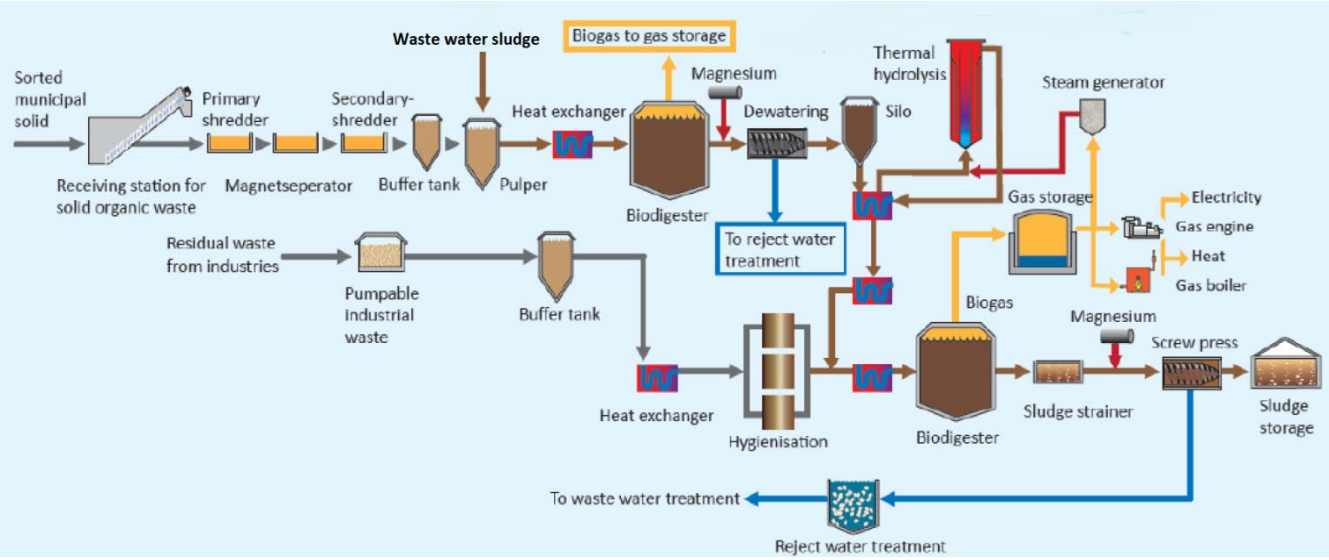
Utilization of digestate:
Fertilizer on crop land

Distance to spreading area
0 – 30 km

Permanent jobs
15 related to biogas on plant

Investment biogas plant:
USD 7.5 mio. biogas plant
USD 0.8 mio. pre-treatment OFMSW and industrial biowaste
USD 1.1 mio. motor generators

O&M costs/year:
USD 1.8 mio. (biogas production)



Production and gas use

The OFMSW collected from the residents of Billund municipality is pre-treated at the receiving station where it is shredded followed by a magnetic separation of iron. The resulting food waste is pulped and transferred to the thermophilic reactor in the required quantity. The digestate from this reactor is thermally hydrolyzed and combined with the industrial organic wastes and pumped to the mesophilic digester.

The industrial feedstocks are pasteurized prior to the mesophilic anaerobic digestion, which enables the facility to accept wastes such as slaughterhouse wastes and microbial biomass, which require sanitization according to EU laws.

The digestate from the anaerobic digestion is dewatered and the solid fraction, that contains nitrogen and phosphorus, is reused as organic sanitized fertilizer for crops on local farmland. The reject water from the dewatering process is high in Ammonia and is processed with the energy efficient nitrogen removal process of Anammox bacteria.

Of the nutrients in the input feedstocks, 95% of the phosphorus is reused as fertilizer on farmland. The biogas is used for production of electricity and heat. A part of the heat is used on the facility for the processes, and the remaining is sold to the municipal district heating system. The energy production is 1.7 times more than what is used in the entire company, this includes the supply of drinking water, sewerage, wastewater cleaning and the production of energy itself. Excess electricity is sold to the grid.

Billund Vand og Energi A/S, Grindsted Landevej 40. 7200 Grindsted
post@billundvand.dk. www.billundvand.dk

Specification sheet for Billund

1. Sources of information:

www.billundvand.dk
https://www.billundvand.dk/files/files/2014-1_Billund_Vand_redeg%C3%B8relse.pdf
https://www.billundvand.dk/side5777-cid-5773.html
https://www.billundvand.dk/files/files/Afvandet%20slam%20juni%202017%20-%20udvidet.pdf
BILLUND BIOREFINERY – ADVANCING THE RECYCLE CIRCLE Gilbert, A. B.Veolia Water Technologies (UK), European Biosolids and Organic Resources Conference 15-16 November, Edinburgh, Scotland

2. Specify investment costs, what is included?

The investment in the biogas plant includes tanks, 2 digesters, thermal hydrolysis plant, gas cleaning, heat exchanger system and 1 storage tank for gas.
The investment in the pretreatment includes receiving station, separator and pulper for the organic fraction of municipal solid waste (OFMSW) and tanks and equipment for the industrial biowaste.
The wastewater treatment plant is not included in the investment costs.
1 USD = 6.37 DKK

3. Specify O & M costs, what is included?

	Specification	Estimated total costs USD/year
Personnel	5 employees	0.5 mio.
Electricity (for stirring etc)		0.09 mio
Heat (Biogas)	Own production	no costs
Administration and insurance		0.06 mio
Maintenance and other operational costs		7 mio
Transport	diverse	0.10 mio

Pretreatment of the OFMSW and industrial biowaste is included in the O&M costs.

4. Who has supplied and approved the data?

Chitra S. Raju, Billund Vand & Energi A/S
Randi H. Nielsen, Billund Vand og Energi A/S
Ole Johnsen, CEO, Billund Vand & Energi A/S

5. Which years do the data cover?

2016/2017

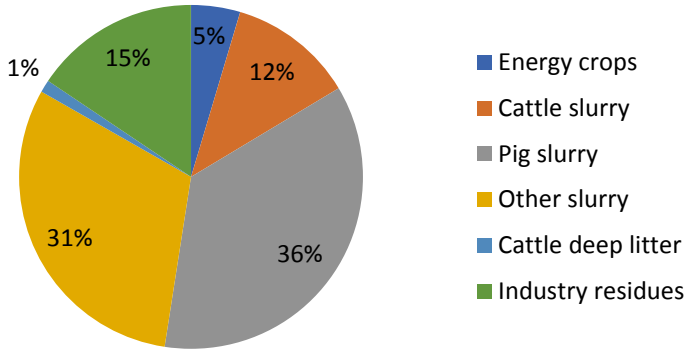
Combigas

The biogas plant at Gundebølsvej, Hemmet, was built in 2012 by the Danish company Combigas that design, develop and support biogas solutions.

Vision

The plant was built in order to demonstrate a medium size standardized decentralized farm biogas plant appropriate for realizing the municipality, Ringkøbing-Skjern's Energy plan. In the plan the municipality set high goals for the utilization of biogas from manure from its many life stock producers. In addition Combigas wanted to demonstrate the use of heat pumps for heating the digesters, a semi-automatic management software and a new biomass intake system for mixing of solid biomasses with pig slurry.

Biomass feedstocks



Start of operation:
2012

Capacity:
36,500 t/year, 100 t/day

Type of digestion:
Continuously stirred tank reactor (CSTR), 2 step thermophilic wet

Retention time
34 days

Drymatter content (DM)
12 % in average input

Distance to suppliers of manure:
majority < 5 km

Biogas Production:
1.5 mio. m^3 biogas/year
(27 m^3 CH_4/t)

Utilization of gas:
Until 2015 power to grid produced by a 750 KWe motor and heat for local use. From 2015: upgrading to Natural Gas Grid

Utilization of digestate:
Fertilizer on crop land

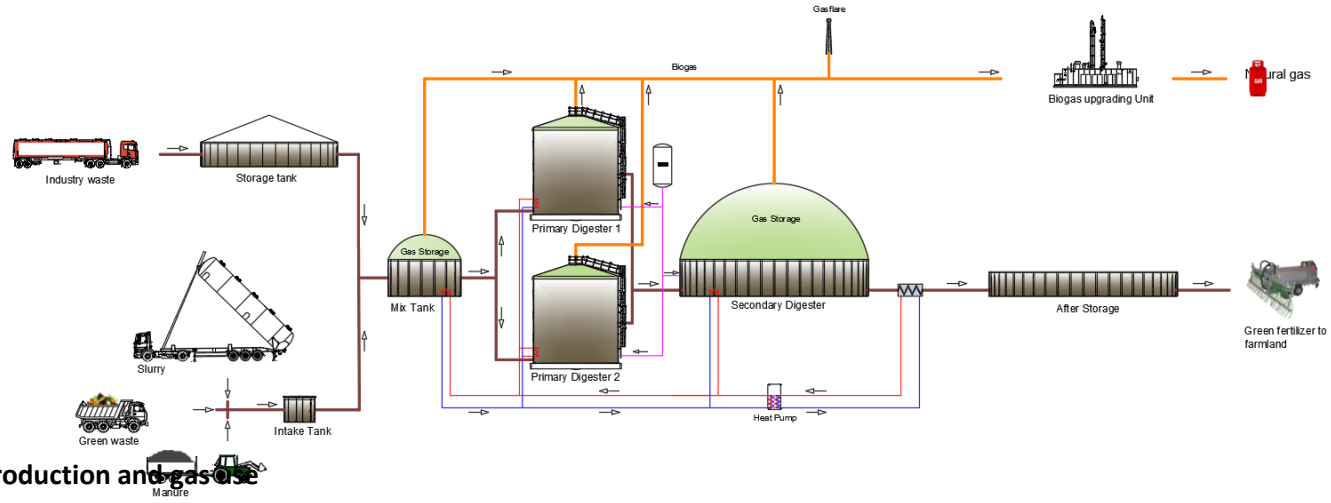
Distance to spreading area
0 – 15 km

Permanent jobs created: 3

Investment biogas plant:
USD 1.95 mio.

O&M costs/year:
USD 0.27 mio. (excl. transport)

Biomass inlet	Pretreatment	Fermentation	Gas upgrading	Final products



Production and gas use

The plant uses slurry and manure from pig, cattle, mink and poultry farms. In addition it uses energy crops and agricultural and industrial residues. The majority of the slurry is pumped to the plant from farms up to 5 km away through buried pipes. In addition the plant receives trucks with biomass.

The biogas was first used for Combined Heat and Power generation in a large gas engine. The power was sold to the grid and the heat was used in local farms. In 2015 an upgrading facility was built. The facility has a capacity of 16 million m^3 of biogas pr. year and is currently handling gas from 3 different biogas plants all located within 6 kilometres from the upgrading station.

Benefits

In addition to the renewable energy production the estimated benefits of the production is reduced CO_2e emissions from manure management and production of digestate as biofertilizer for farmers.

Manufacturer and Operator:

Combigas ApS
Ryttervangen 11C,
7323 Give,
Danmark
admin@combigas.com
www.combigas.com

Frank Wennerberg,
CEO Combigas

Specification sheet for Combigas

1. Sources of information:

http://www.combigas.com
https://ens.dk/sites/ens.dk/files/Bioenergi/02.02.2016_slutrapport_taskforce_faglig_del.pdf
https://ens.dk/sites/ens.dk/files/Bioenergi/oekonomirapport_udvikling_og_effektivisering_final.pdf
https://www.energiteknologi.dk/node/1135

2. Specify investment costs, what is included?

Biogas plant as illustrated inclusive 2 tanks, 2 digesters, gas cleaning, one tank for digested biomass. CHP – plant and udgrading facility is not included. Trucks are not included as transport is outsourced.

3. Specify O & M costs, what is included?

	Specification	Estimated total costs[2] USD/year
Personnel	1,5 employees 1.9 USD/ton	65,934
Electricity (for stirring, etc)	13 kWh/ton[i]	71,429
Heat (power for heat pumps)	11 kWh/ton[1]	60,440
Administration and insurance	0.6 USD/ton	21,978
Maintenance and other operational costs	2.4 USD/ton[1]	82,418
Transport	Up to 80 km transport of feedstocks 11 USD/ton[1]	384,615

[1] https://ens.dk/sites/ens.dk/files/Bioenergi/oekonomirapport_udvikling_og_effektivisering_final.pdf
[2]Totals are calculated using 35,000 tons/year based on the source above

Purchase of biomass is not included in O&M. O&M =267,000 USD excl. transport and biomass and 651,000 incl. transport.

1 USD = 6.37 DKK

4. Value of gas
The value of produced biogas from Danish biogas plants is highly dependent on current subsidy, gas utilisation and actual commercial agreement in each individual case. The highest value is obtained if gas is used for combined heat and electricity production, or if the gas is exported to the natural gas grid. The net value of the gas will in these cases typically be around USD 0.6 /m^3 methane. Net value is defined as income from energy sales minus costs of gas cleaning and conversion processes. Due to competition from other renewable energy sources, the value is expected to decrease somewhat in the future.

5. Who has approved the data? CEO Frank Wennerberg, Combigas

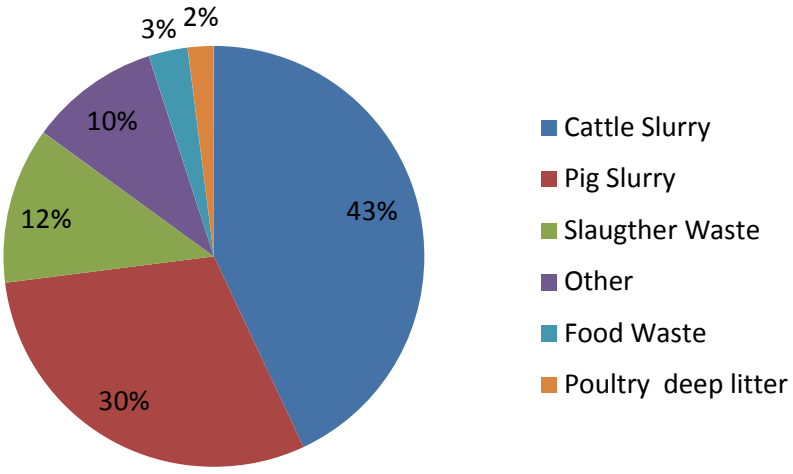
6. Which years do the data cover? 2014, except the composition of feedstocks which is from 2015 - 16

Horsens Bioenergi

Horsens Bioenergi's co-digestion plant produces biogas from manure from local farmers and organic waste from food industries including one of Europe's largest pig slaughter houses situated very close to the plant. Horsens Bioenergi upgrades the biogas to natural gas through an upgrading plant located on the site. The plant is architecturally tailored to the landscape and the natural surroundings.

Biomass feedstocks

The plant treats primarily cattle and pig manure, slaughter house waste and food waste. The plant is also fed with poultry deep litter and other available residues. All feedstocks are pasteurized in order to kill bacteria before the biomass enters the digester.



Start of operation:
2014

Capacity:
240,000 t/year
Two digesters of 8.000 m^3 each
Two storage tanks with gas collection of 1,500 m^3

Type of digestion:
CSTR. Two step mesophilic.

Retention time
25 days

Dry matter content
10 % in average input

Distance to suppliers of manure:
up to 15 km

Biogas Production:
13 mio. Nm^3 biogas/year
8 mio. Nm3 CH^4/year (33 m^3/t)

Utilization of gas:
Upgrading to natural gas grid

Utilization of digestate:
Fertilizer on farm land up to 15 km away.

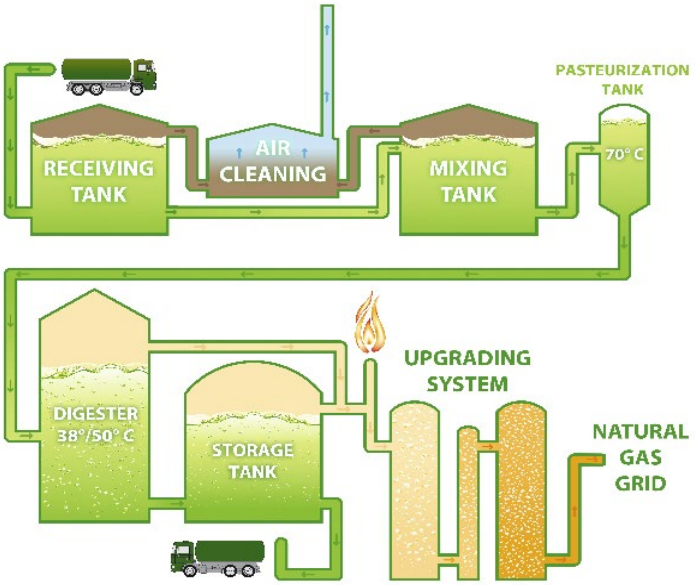
Permanent jobs created:
7 at the biogas plant

Investment biogas plant:
Biogas plant: 11.5 mio. USD

O&M costs/year:
2 mio. USD/year

Production and gas use

The plant was built with a receiving tank, pasteurization tanks, 2 digesters of 8,000 m^3, two covered storage tanks with gas collection of 1,500 m^3, gas storage of 3000 m^3 and the upgrading facility. A biological air cleaning system prevents odor nuisances. The digesters are heated by a heat exchanger system, where the pasteurized biomass is simultaneously cooled down to the process temperature in the subsequent digestion step. Additional heat is produced by a gas boiler.



Horsens Bioenergi's trucks transport the slurry from the local farmers to the plant and returns it after degassing. The digestate is used as fertilizer on farm land.

The biogas produced is upgraded in a water scrubbing plant and injected at 4 bar in the natural gas network 1.6 km away.

Horsens Bioenergi treats organic waste from one of Europe's largest pig slaughterhouses situated very close to the plant.

Recent plant expansion

The biogas plant was in 2016 extended with a third digester and an ammine scrubber as second upgrading facility. Daka ReFood constructed also in 2016 a pre-treatment plant for food waste one the same premises. The plant sorts the food waste from the packaging and sends the food waste to the biogas plant's digesters, where it is mixed with the existing biomass.

Manufacturer:

Bigadan A/S
Vroldvej 168
DK-8660 Skanderborg
Danmark
www.bigadan.dk
mail@bigadan.dk

Upgrading plant:
Malmberg www.malmberg.se
Ammongas www.ammongas.dk

Operator:

Horsens Bioenergi ApS
Ålkærgårdvej 13
DK-8700 Horsens
www.horsensbioenergi.dk
horsens@horsensbioenergi.dk

HORSENS BIOENERGI

Specification sheet for Horsens

1. Sources of information:

https://horsensbioenergi.dk/
Horsens Bioenergi and Bigadan. Horsens Bioenergi is a subsidiary company to Bigadan.
VVM-redegørelse for et biogasanlæg ved Østbirkvej

2. Specify investment costs, what is included?

Biogas plant as originally built in 2013 – 14 consisting of a receiving tank, three pasteurization tanks, 2 digesters of 8000 m3, two covered storage tanks with gas collection of 1500 m3, gas storage of 3000 m3, gas boiler and the biological air cleaning system. X trucks are included. The upgrading facility is not included.
1 USD = 6.37 DKK

3. Specify O & M costs, what is included?

3. Specify O & M costs, what is included?

	Specification		Estimated total costs USD:
Personnel	7 employees incl. 4 truck drivers		625.685
Electricity (for stirring etc.)	1450 MWh	0.12 USD DKK/kWh	181.483
Heat (Natural Gas)	265.000 m3	0.43 USD DKK/M3	115.773
Administration and insurance			112.672
Other operational costs, including maintenance and diesel for trucks?	240.000 ton	3.9 USD DKK /ton	938.857

Not included in O& M is purchase of biomass feedstocks and financial costs. Upgrading plant not included.

5. Who has approved the data?

Henrik Laursen, Bigadan
Torben Ravn Pedersen , Bigadan
Henrik Bie, Horsens Bioenergi

6. Which years do the data cover?

2015

Kroghsminde

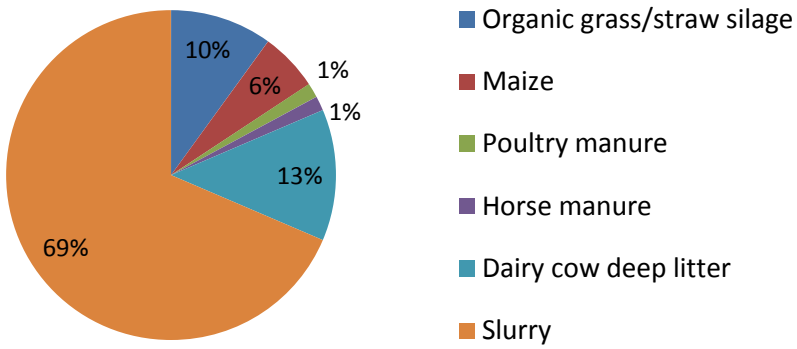
Kroghsminde biogas plant was built by the organic farmer and milk producer Jens Krogh in 2015. Jens Krogh has 110 dairy cows and 435 ha of crop production and pastures.

Vision

The idea emerged from the need to find a sustainable supply of liquid organic fertilizer and a wish to take concrete action concerning climate change by producing green energy. Through the biogas plant, nutrients from manure can be used better and nutrients from new types of biomass can be included in the nutrient supply.

Biomass feedstocks

The plant uses feedstocks from the farm and from four other organic farms with dairy cows and poultry. The suppliers of manure get digestate with a higher fertilizer quality back. N content is frequently measured. Sometimes maize and grass are purchased.



Start of operation:
2015

Capacity:
Reactor volume:
1,200 + 1,880 m3
Input of feedstocks: 70 t/day

Type of digestion:
CSTR. Two step thermophilic wet

Retention time
44 days

Dry matter content
17-18 % in average input

Distance to suppliers of manure:
up to 8 km (5 km in average)

Biogas Production:
1,2 mio. Nm^3 biogas/year
0,75 mio. Nm3 CH_4/year

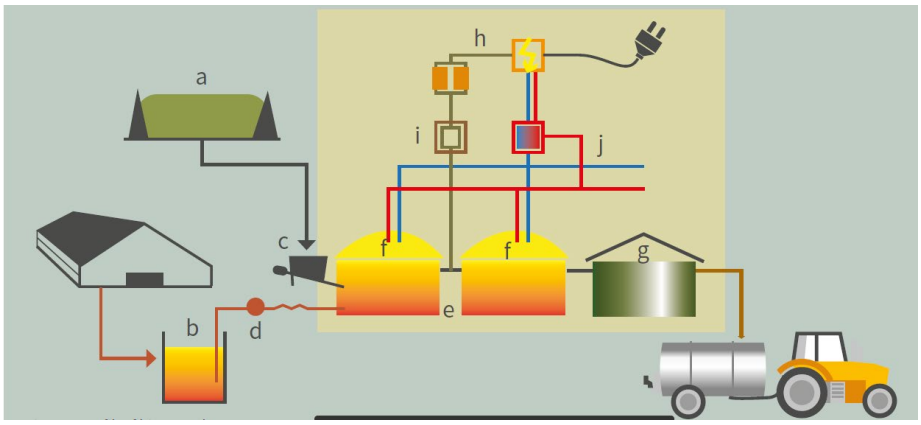
Utilization of gas:
Electricity: 340 kW motor
2.7 mio. kWh/year to grid
Heat: 3,2 mio. kWh/year

Utilization of digestate:
Fertilizer on organic crop land
up to 8 km away (5 km in average)

Permanent jobs created: 0,25 man year (0,25 in the local area)

Investment biogas plant:
USD 1.4. mio. for biogas plant
USD 0.4 mio. for motor generator

O&M costs/year:
0.18 mio. USD



a. storage of solid biomass
b. tank for liquid biomass (slurry)
c. feeding equipment for solids
d. pump
e. digester 1 and 2
f. gas outlet to gas storage
g. storage tank for digestate
h. motor generator, gas cleaning
i. condensate well
j. heating system

Production and gas use

The plant is specifically designed for digestion of feedstocks with high dry matter content. The "paddelgigant" is used for stirring, as it is especially designed for substrates with a high proportion of fibrous material as grass silage and manure. Parts of the digester material are extracted and pumped through a macerator before it is injected into the digester again. This "ruminant system" makes it possible to handle floating layer and get the microorganisms to break it down. The biogas is used for electricity generation in a 340 kW gas engine. The power is sold to the grid and the heat is used for heating up the digesters.

Benefits

A very important benefit is the production of digestate as liquid biofertilizer for organic farmers, as they are not able to use mineral fertilizer. By using grass from meadows and sensitive natural areas, nutrients are moved to production areas. Further the plant produces renewable energy and reduces methane emissions from storage of manure. Other benefits are reduction of odor from the application of manure, a more flexible crop rotation and less disease germs and weed seeds in the manure.

Manufacturer:

JH BioEnergi
Lundholmvej 41
7500 Holstebro
Tlf.: +45 88 44 21 00
http://jh-bioenergi.dk

Based on biogas technology from Biogastechnik Süd
https://www.biogastechnik-sued.de/

Operator:

Jens Krogh, Kroghsminde
Tarpvej 15, Strellev
6870 Ølgod
Email: kroghsminde@mail.dk
www.kroghsminde.dk

Specification sheet for Kroghsminde

1. Sources of information:

www.kroghsminde.dk
http://okologi.dk/media/2022158/biogasanlaeg_web.pdf
http://jh-bioenergi.dk
Jens Krogh

2. Specify investment costs, what is included?

Investment cost of the biogas plant: DKK 8.8 mio. for the plant as illustrated, inclusive biomass storage, 2 digesters, tanks, and gas cleaning. Investment costs of motor/generator: DKK 2.6 mio.
Trucks are not included as transport is outsourced.
1 USD = 6.37 DKK

3. Specify O & M costs, what is included?

	Specification	Estimated total costs USD/year
Personnel	0,25 employees (excl. x truck drivers)	17,631
Electricity (for stirring etc)	180.000 kWh/year	17,728
Administration and insurance		40,200
Maintenance and other operational costs		82,663
Transport,	10 km average km transport of feedstocks deep litter (50 kr/ton) slurry (20 kr/ton)	20,375

Purchase of biomass feedstocks (e.g. maize) is not included. O&M of motor generator is included.

4. Who has supplied and approved the data?

Jens Krogh

5. Which years do the data cover?

2016

Madsen Bioenergi

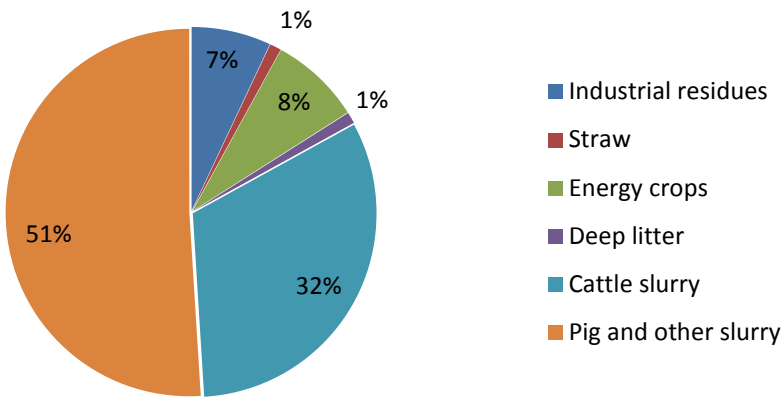
Madsen Bioenergy is owned by 3 brothers: Kim Madsen, Boe Madsen and Per Madsen. Kim and Per have pig production and together the brothers run 350 hectares, where they grow corn, grass, grain and seed for harvest. The biogas plant is centrally located between the 3 brothers.

Vision

The idea behind the plant was to create a new business area that could utilize agricultural residues, produce valuable fertilizers and supply renewable green gas to the natural gas grid.

Biomass feedstocks

The plants treats primarily pork and cattle manure and deep litter from the brothers owns farms and from other farmers. The plant is also fed with pretreated straw and energy crops like corn and grass.



Start of operation:
2014

Capacity:
Total tank volume: 34.000 m3,
Reactor volume: 27,600 m3
Input of feedstocks: 146.000 tonnes/year, 400 t/day

Type of digestion:
CSTR. Five step at 47° C.

Retention time
85 days

Dry matter content
13 % in average input

Distance to suppliers of manure:
up to 10 km

Biogas Production:
~5 mio. Nm^3 CH_4 /year
34 Nm^3 CH_4/t ww

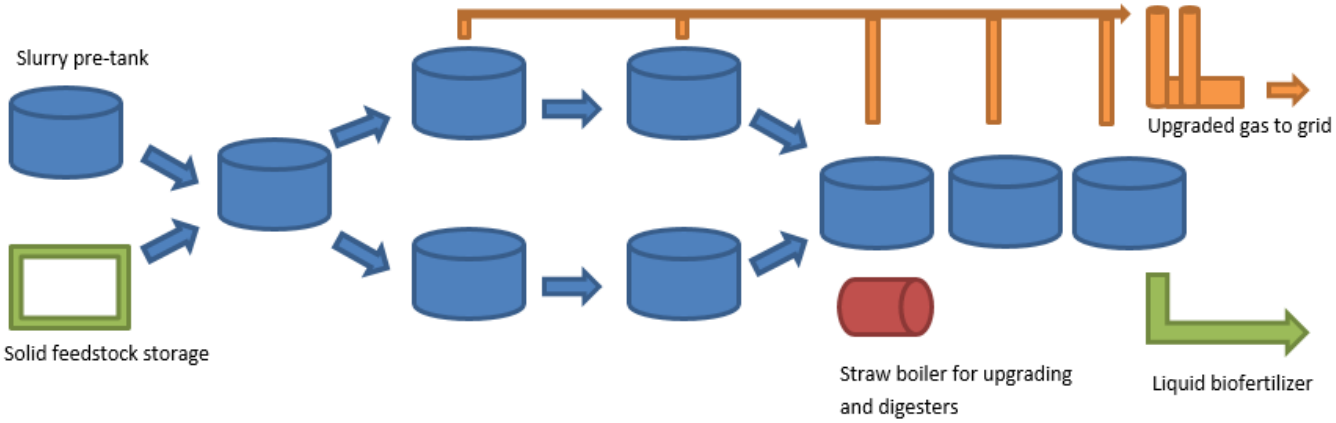
Utilization of gas:
Upgrading to natural gas grid
Transport fuel

Utilization of digestate:
Fertilizer on organic crop land up to 15 km away

Permanent jobs created:
3 at plant, 2 in the local area

Investment biogas plant:
Biogas plant: 7 mio. USD
Upgrading plant: 3.1 mio. USD

O&M costs/year:
1.3 mio. USD/year



Production and gas use

The plant consists of a mixer tank, 2 digesters of 4,600 m3, two secondary digesters of 4,600 m3 and 3 covered storage tanks with gas collection. A biological ventilation air purification plant prevents odor nuisances. The biogas plant is designed to treat deep litter and straw with pretreatment and feeding facilities and a long retention time in order to reach a complete digestion of the feedstocks. The different feedstocks are mixed in the mixer tank fitted with a stirrer with "cutting knives" mounted on the propellers. After the mixing tank, the biomass is pumped into the 2 parallel digesters through a macerator, which further comminutes the biomass. The digesters are heated using heat pumps collecting heat from storage tanks, a straw boiler and excess heat from the upgrading facility.

The daily operation and maintenance of the biogas plant is carried out by Kim, Boe and Per. The biogas plant is controlled, regulated and monitored by a control program that can send alarms to the operator and "log" all important parameters such as biomass, gas production, temperature, etc. A part of the degassed biomass is separated in solid and liquid in order to optimize the fertilizer value. Some of the solids are returned to the biogas plant, and the rest is used for soil improvement. The digestate is used as fertilizer on 4000 ha, of which 200 are owned by the brothers.

The biogas produced is upgraded in an ammine scrubbing plant and injected at 4 bar in the natural gas network via an 11 km long gas line.

The brothers have got their own gas station, where they now can fuel their car with upgraded biogas.

Manufacturer:

Biogas plant

Lundsby Biogas A/S
Niels Pedersens Allé 2,
8830 Tjele
info@lundsbybiogas.dk
www.lundsbybiogas.dk

Upgrading plant:
Ammongas
www.ammongas.dk

Operator:

Kim, Boe and Per Madsen
Madsen Bionergi
Skivevej 47, Balling
7860 Spøttrup
info@madsenbioenergi.dk
www.madsenbioenergi.dk

Specification sheet for Madsen

1. Sources of information:

www.madsenbioenergi.dk
http://www.biopress.dk/PDF/brodrene-madsen-har-styr-pa-gassen
https://www.skive.dk/media/3965/biogasanlaeg.pdf
http://www.skive-her.dk/nyheder/nyheder/madsen-bioenergi-har-faaet-gastankstation-og-gasbil.htm
https://ens.dk/sites/ens.dk/files/Bioenergi/02.02.2016_slutrapport_taskforce_faglig_del.pdf
https://ens.dk/sites/ens.dk/files/Bioenergi/oekonomirapport_udvikling_og_effektivisering_final.pdf
https://www.youtube.com/watch?v=pOO0JE0bfRU
Boe Madsen, Madsen Bioenergi

2. Specify investment costs, what is included?

Biogas plant includes biomass storage, pretreatment facilities, slurry pre-tank, mixer-tank, 4 reactors, 3 storage tanks with gascollection, 1 delivery tank and gas cleaning facility. Trucks are not included as transport is outsourced. Upgrading plant includes the Ammongas upgrading plant and a compression station.
1 USD = 6.37 DKK

3. Specify O & M costs, what is included?

	Specification		Estimated total costs USD/year
Personnel	3 employees	70,526 USD/year	211,583
Electricity (for stirring etc)	2.500.000 kWh/year	0,10 USD/kWh	
Heat	7.000.000 kWh/year	0,02 USD/kWh	197,477
Administration and insurance			54,854
Maintenance and other operational costs	2,2% of investment in biogas plant		155,158
Transport	5-10 average km transport of slurry slurry for 20 DKK/ton	3,1 USD for all slurry 400*0,83*20 *365	376,141
Total			1,263,993

Upgrading plant not included. Purchase of biomass feedstocks is not included. Heat from the boiler is supplying the upgrading plant and reused to heat the digesters.

4. Who has supplied and approved the data?

Boe Madsen

5. Which years do the data cover? Investment: 2014 other: 2016/2017

Solrød biogas

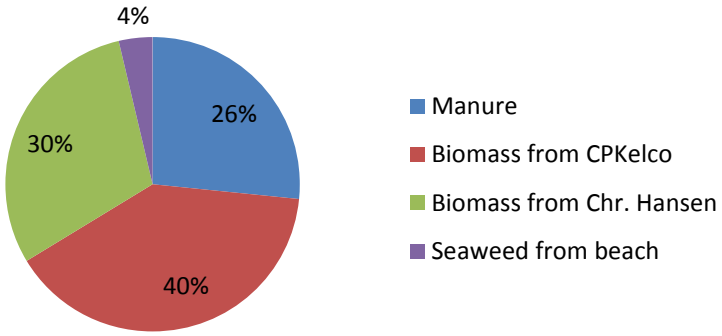
Solrød Biogas A/S was founded May 2014. The public-private development process involved the city council, Solrød Municipality, the local energy supplier, private feedstock suppliers and researchers from Roskilde University.

Vision

Solrød Biogas is driven by the vision of implementing CO2 neutral energy solutions, while solving important climate and environmental challenges in Solrød Municipality.

The idea emerged from the need to find a sustainable solution to the community´s odor problem, caused by seaweed fouling the beach of Køge Bay. Simultaneously, the Solrød Municipality also wished to take concrete action concerning climate change by producing green energy. As local industries also had challenges finding beneficial outlets for their wastes and by-products, they became involved in the projects plans.

Biomass feedstocks



Start of operation:
2015

Capacity:
200.000 t/year

Type of digestion:
Two step thermophilic wet

Retention time
28 days

Drymatter content
10 % in average input

Distance to suppliers of manure: 0 – 25 km

Biogas Production:
6 mio. Nm^3 CH_4 /year (30 m^3/t)

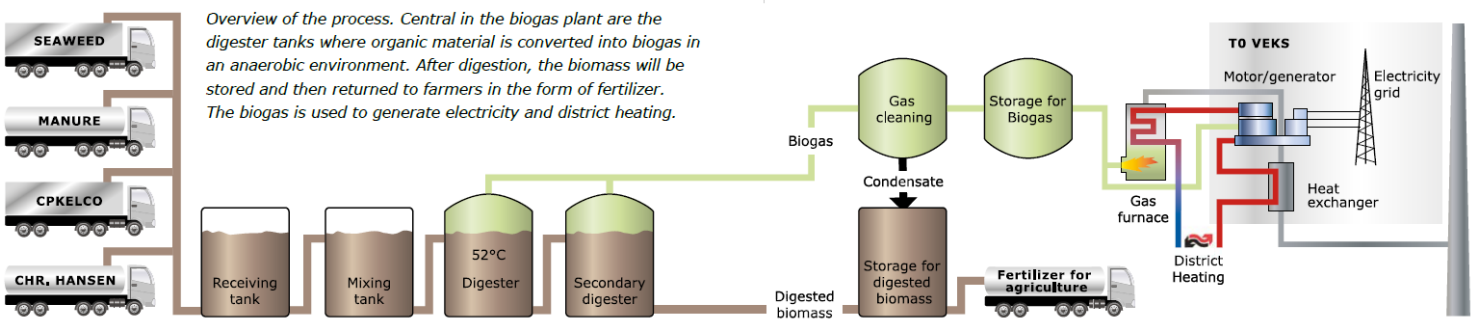
Utilization of gas:
Electricity: 23 GWh/year to grid
Heat: 28 GWh/year for district heating to ~1,700 households

Utilization of digestate:
190,000 tonnes of digestate are spread as fertilizer on crop land 0 – 40 km away

Permanent jobs created: 14

Investment biogas plant:
USD 14 mio. exclusive CHP

O&M costs/year:
USD 3.7 mio. /year



Overview of the process. Central in the biogas plant are the digester tanks where organic material is converted into biogas in an anaerobic environment. After digestion, the biomass will be stored and then returned to farmers in the form of fertilizer. The biogas is used to generate electricity and district heating.

Production and gas use

The plant uses by-products from the pectin and carrageenan production at CP Kelco, biomass residues from the bioscience company Chr. Hansen, liquid manure from pig and cattle farms and seaweed from Køge Bay. The plant receives about 25 trucks with biomass per day.

The biogas is used for CHP generation in a large gas engine. The power is sold to the grid and the heat is supplied to the local district heating system which is operated by Vestegnens Kraftvarmeselskab I/S and owned by 12 municipalities as stakeholders. The energy production of the biogas plant and the anticipated savings of CO2e contribute to achieving Solrød Municipality's ambitious climate target of reducing the municipality's greenhouse gases by 55 percent by 2025.

Benefits

In addition to the renewable energy production the estimated benefits of the production is reduced CO2e emissions, lower costs of waste transport and production of digestate as biofertilizer for farmers.

Environmental benefits include reduced leaching of N to aquatic environment by 62 tonnes /year, which is 70% of the requirement for Køge Bay and, reduced leaching of P the aquatic environment by 9 tonnes, which is 100% of the requirement for Køge Bay. Additional benefits are reduced odor nuisance from the beach/seaweed and improved sea water quality and higher recreational value of the maritime coastal area.

Manufacturer:

Bigadan A/S
Vroldvej 168
8660 Skanderborg
Tlf: +45 86 57 90 90
Fax: +45 86 57 90 93
mail@bigadan.dk
www.bigadan.dk

Operator:

Bigadan A/S on behalf of

Solrød Biogas A/S
Åmarken 6
4623 Lille Skensved
Mail: info@solrodbiogas.dk
www.solrodbiogas.dk

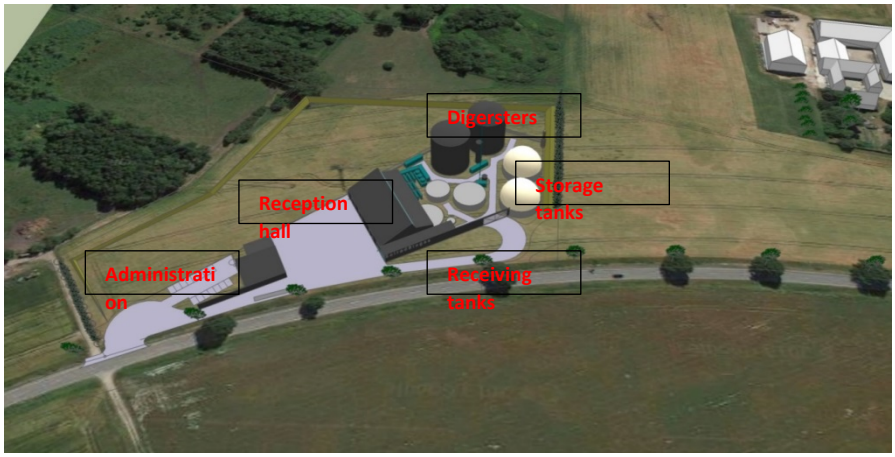
Specification sheet for Solrød

1. Sources of information:

www.solrodbiogas.dk
http://www.ieabioenergy.com/publications/solrod-biogas-towards-a-circular-economy/
https://solrodbiogas.dk/wp-content/uploads/2016/10/8.-Rapport-om-Solr%C3%B8d-Biogas_uk.pdf

2. Specify investment costs, what is included?

Biogas plant as illustrated inclusive 2 tanks, 2 digesters, gas cleaning, 2 storage tanks for gas and digested biomass, two biological odor treatment systems, heat exchangers and several mechanic pretreatment units. Besides a large building for administration, meetings and visitors. The CHP – plant and external storage tanks are not included.



Investment	USD exclusive of VAT
Purchase of land	0,4 mio.
Road construction, terrain, embankment, fence, plants and trees	1,3 mio.
Buildings	2,5 mio.
Receiving and storage tanks	0,9 mio.
Digersters	3,1 mio.
Pipes, exchangers, etc.	1,0 mio.
Power and SRO (Supervisory Control And Data Acquisition, SCADA)	0,9 mio.
Other/sundry expenses (including counseling etc.)	1,5 mio.
Unforeseen	0,6 mio.
Project development	1,6 mio.
Total sum	**14,1 mio.**

3. Specify O & M costs, what is included?

	Specification	Estimated total costs USD/year
Operation	Including personnel, maintenance of equipment etc.	0,8 mio.
Other operational costs	Including electricity (2000 MWh) for stirring etc.	0,5 mio.
Heat	Self-supplying from biogas	-
Administration	Including personnel, insurance, financial audit, counseling etc.	0,4 mio.
Transport - feedstock	Between 6-25 km. Primary feedstock (pectin) derives from CP Kelco 6 km away (using main roads).	0,5 mio.
Transport – digestate	To farmers 5-40 km away.	1,4 mio.
Compensation to farmers	Rental of storage tanks etc.	0,1 mio.
Total		3,7 mio.

1 USD = 6.37 DKK

Not included is O&M of CHP-Plant.

4. Who has supplied and approved the data?

Mikkel Busck, Teknik og Miljø
Solrød Kommune, Solrød Center 1
2680 Solrød Strand

5. Which years do the data cover?

2015/2017

Atotonilco WWTP

Located in the Atotonilco de Tula municipality the Atotonilco Wastewater Treatment Plant (WWTP) is the largest facility of his kind in Mexico and Latin America (by capacity) and the

Start of operation: Dec. 2017

Capacity of sludge input:
26 000 m^3/day (design)
23 250 m^3/day (real)
(wet weight 4% TS);

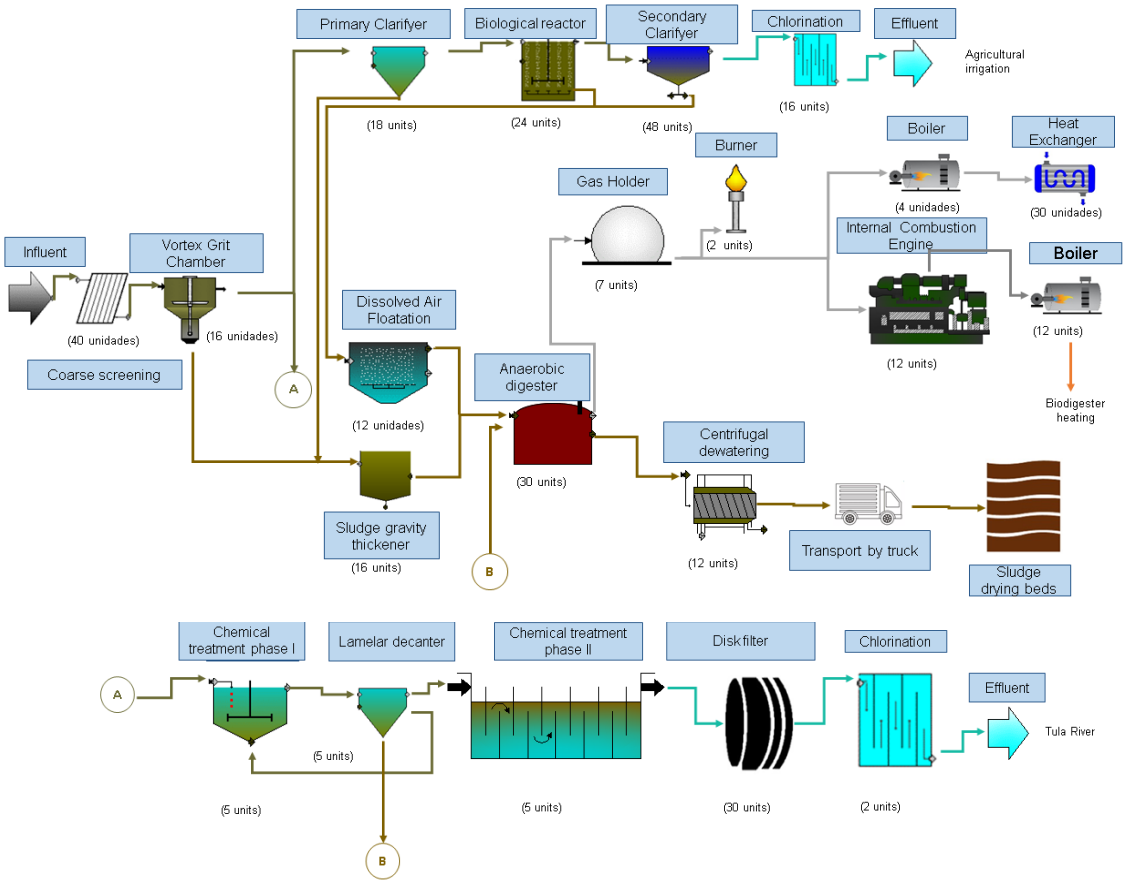
Digester's volume: 390 000 m^3
(30 x 13 000 m^3)

Capacity of sludge purge:
339 450 ton/year (dry weight)

Type of feedstock:
Primary and Secondary Sludge from wastewater treatment plant @ 4% TS.

Type of digestion:
Digester, Mesophilic at 38°C.

Retention time of digesters
From 15 to 30 days (design)



largest in the world built in a single phase.

Process diagram

Biogas production occurs in the anaerobic digester, which receives primary and secondary sludge. The facility has a cleaning system for the biogas (condensation system, iron sponge and activated carbon filter); there is no upgrading.

Production and gas use

CHP generate power to recover energy and supply between 65% and 70% of their own electric demand.

Benefits

The WWTP was designed to treat 60% of the wastewater from the Valley of Mexico. The wastewater effluent complies with Mexican regulation NOM-001-SEMARNAT-1997 for agriculture irrigation rivers. Digested sludge complies with Mexican regulation for CLASS C biosolids under NOM-004-SEMARNAT-2002, so it could be used for soil improvement.

Operation and Maintenance consortium:
Aguas Tratadas del Valle de México S. A. de C. V (until 2035) integrated by:

- Promotora del Desarrollo de América Latina, S.A. de C.V (Ideal): 51% of the shares
- Atlatec S.A de C.V.: 24.5% of the shares
- Acciona Agua S.A.: 24.5% of the shares

A: Av. Insurgentes Sur 3500, Tlalpan, Ciudad de México, Mexico
T: +52 778 735 9500,
+52-55-56254900,
+52-55-11031300
M: anatienzar@acciona.com
roberto.villanueva@atlatec.com

http://www.ideal.com.mx/infraestructura/agua/

Distance to suppliers:
Wastewater comes from Mexico City (80km).
Sludge is generated on-site.

Biogas Production:
150 000 – 200 000 Nm^3 biogas/day.
i.e. 3.8 – 5.1 Nm^3 CH_4/sludge tonne (@4% TS).

Utilization of biogas:
Electric power generation (CHP).
Electric installed capacity: 32 MWe (12 x 2.7 MW)
Electricity production: 197 GWh/year.
Heat production: 260 GWh/year.

Utilization of digestate:
Landfilling (dewatered).

Distance to spreading area:
On-site landfill, estimated capacity for 25 years.

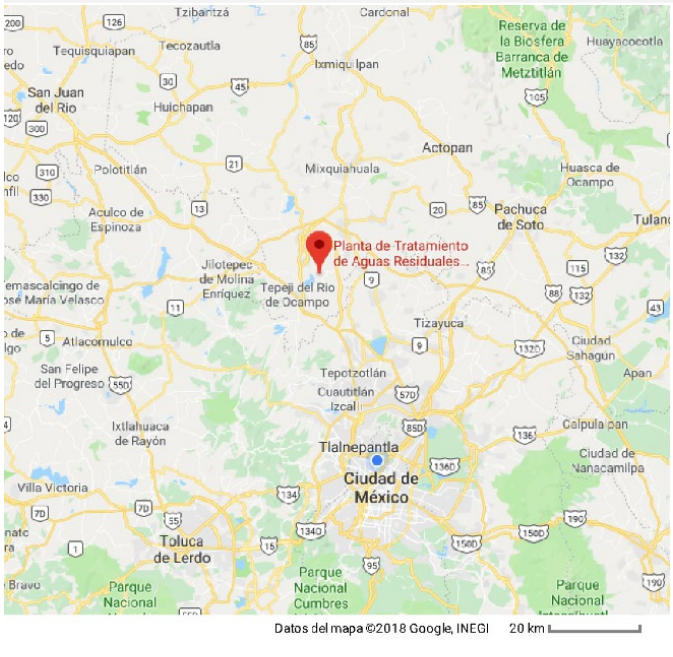
Permanent jobs created:
132

Investment biogas plant:
Not Available

O&M costs/year:
Not Available

CO_2 savings
800 000 tonnes CO_2/year

Dry matter content of the sludge
3 – 4 %



Specification sheet for Atotonilco

1. Sources of information:

- Plant personnel
- Contractor website: http://www.ideal.com.mx/infraestructura/agua/
- Contractor financial report http://www.ideal.com.mx/wp-content/uploads/2018/07/IDEAL-2Q18.pdf
- Official site of the CONAGUA. www.gob.mx/conagua

2. Specify investment costs, what is included?

Not Available

3. Specify O & M costs, what is included?

	Specification	Estimated total costs
Personnel	Not Available	Not Available
Electricity (for stirring etc.)	Not Available	Not Available
Heat	Not Available	Not Available
Administration and insurance	Not Available	Not Available
Maintenance and other operational costs	Not Available	Not Available
Transport	Not Available	Not Available

4. Who has supplied and approved the data?

Antonio Atienzar España, General Director. +52 778 735 9500; 5035, anatienzar@acciona.com
Roberto Villanueva Camacho, BE, Technical Director. +52 778 735 9500;5093, roberto.villanueva@atlatec.com

5. Which years do the data cover?

2018

6. Green House Gas (GHG) savings calculations

Clean energy production (electricity)	114 654	$tonCO_2$/year
Clean energy production (heat)	63 521	$tonCO_2$/year
Emissions avoided due to wastewater treatment	621 825	$tonCO_2$/year
Total GHG reduction	**800 000**	**$tonCO_2$/year**

Assumptions:

Electrical emission factor	0.582$tonCO_2$/MWh
Heat emission factor (natural gas)	2.27$kgCO_2/m^3$ natural gas
Anaerobic degradation of raw wastewater discharged	65 %

Los Camichines VTP

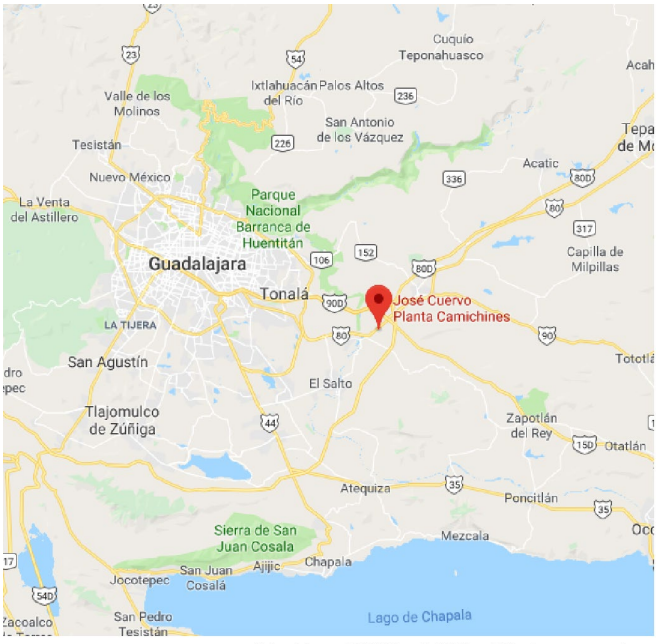
The vinasses are the warm liquid by-product of the tequila production. “Los Camichines Distillery” is one of the two Jose Cuervo’s liquor production facilities in Mexico; the plant produces Tequila and “Tequila 100% de Agave”. Los Camichines Vinasse Treatment Plant (VTP) from Casa Cuervo S. A. de C. V. operates with one anaerobic reactor within the VTP, which discharges treated water to “La Laja” river.

Vision

To treat the wastewater on-site for complying with Mexican discharge regulations and reducing pollution.

Process diagram

After the screening, cooling and equalization, the vinasses enter to an IC reactor. Biogas and sludge from anaerobic digester are handled on-site. The sludge purge is dewatered and composted at irregular and infrequent rate to be useful as biofertilizer.



Start of operation:
2012

Capacity of influent:
1 200 m^3/day (design);
1 000m^3/day (real);

Digester volume: 1 700 m^3

Sludge production output:
22 ton/year (real)

Type of feedstock:
Vinasse from tequila (35 kgCOD/m^3)

Type of digestion:
IC (Internal Circulation) reactor – Paques®, mesophilic(36°C)

Retention time in the reactor:
3 days (design)
2 days(real)

Organic load:
21 kg COD/m^3-day (real)

Dry matter content:
TS= 94 kg/m^3; VS=57 kg/m^3

Distance to suppliers:
On-site generation-

Biogas Production:
10 000 Nm^3biogas/day
i.e. 7 Nm^3 CH_4/m^3 vinasses (real)

Utilization of gas:
Burning in boiler for steam generation.
Heat: aprox. 14.3 GWh/year

Operator/ Owner:
Casa Cuervo S. A. de C. V.
Marco Jovani Rodriguez Carbajal
(VTP coordinator)
T: +52 33 3284 9300 ;3806
A: Calle Reforma 134-138, Centro San José, La Laja, Jal., Mexico
mjrodriguez@cuervo.com.mx
cuervo.com.mx/

Manufacturer:
HI-PRO Ecológicos S. A. de C. V.

T: +52 55 5368 1344
A: Calz. Azcapotzalco La Villa 1189, San Bartolo Atepehuacan, 07730 Ciudad de México, Mexico
contacto@hipro.com.mx
www.micromedia.com.mx

Production and gas use

The biogas is stored in the gasholder and burned in the industrial boilers for generating steam that is useful in the Tequila production.

Benefits

The VTP reduces the environmental impact, saves aprox. 1.6 million m^3/year of natural gas consumption and reduces wastewater greenhouse gas emissions. Income from saving natural gas accounts $ 159,774 USD a year. The plant discharges to a Class C federal waterbody according to the Mexican regulation NOM-001-SEMARNAT-1997 and the Federal Dues Law.

Utilization of digestate:
Composting.

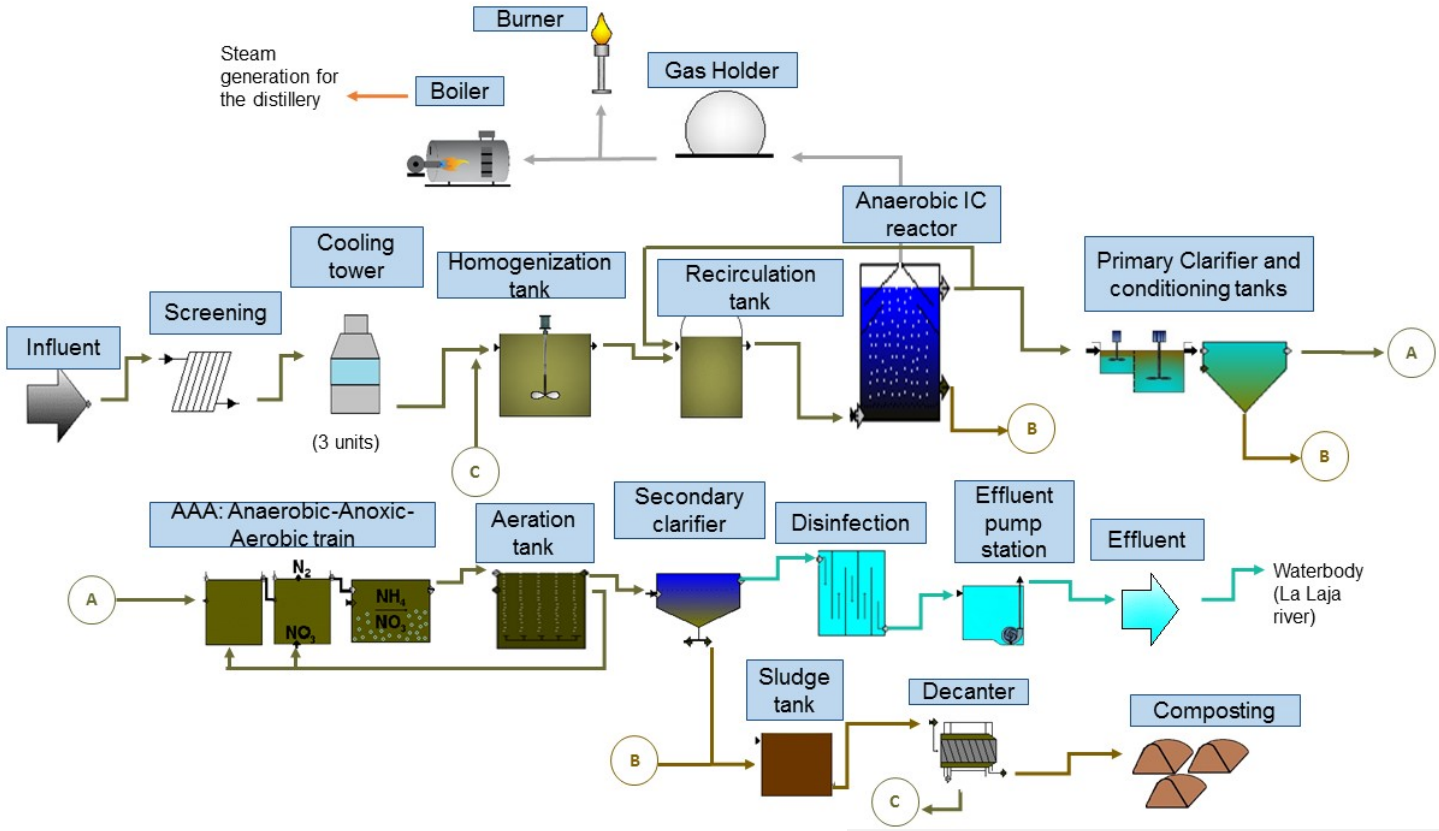
Distance to spreading area
40 km on company's land.

Permanent jobs created
9

Investment biogas plant:
$8 647 434 million USD (2018) for the entire VTP (59% of that for the anaerobic system).

O&M costs/year:
$888 803 USD of 2018.

CO_2 savings:
3 700 tonnes CO_2/year.



Specification sheet for Los Camichines VTP

1. Sources of information:

- Plant personnel.
- Informe Anual 2016. José Cuervo. Accessed: Nov 26,2018.
  Available at: http://milenio3.com.mx/jose-cuervo/2016/instalaciones-de-produccion-y-embotellamiento/

2. Specify investment costs, what is included?

Entire VTP, including the anaerobic system.

3. Specify O & M costs, what is included?

	Specification	Estimated total costs USD/year (average between 2015 and 2017)
Personnel	9 persons	$77,024
Electricity (for stirring etc)	Control, pumps, stirring and compressing	$98,925
Heat	No cost	No cost
Administration and insurance	Depreciation	$286,931
Maintenance and other operational costs	Maintenance, biosolids, studies, and materials	$398,873
Transport	Not Applicable	Not Applicable

4. Who has supplied and approved the data?

Ramiro Vera Hernández, Los Camichines plant manager. +52 (33) 373 50466

5. Which years do the data cover?

2012-2018

6. Green House Gas (GHG) savings calculations

Clean energy production (heat)	3 700	$tonCO_2$/year
Total GHG reduction	**3 700 $tonCO_2$/year**	

Assumptions:

Heat emission factor (natural gas)	2.27	$kgCO_2/m^3$ natural gas

Planta TIF 333 WWTP

The Planta TIF 333 is the local slaughterhouse of León municipality, Guanajuato, Mexico. The facility operates under the legal name "Rastro Frigorífico y Servicios Integrales del Bajío S. A. de C. V." The plant has its own farms and each month slaughters 9 000 bovine, 15 000 porcine and 600 ovine (or goat) animals. The plant has covered anaerobic lagoons, solar water heating installation, and several nationwide certifications.

Vision

To comply with Mexican regulation "NOM-001-SEMARNAT-1996", while using waste blood as biogas feedstock for later process water heating in the slaughterhouse.

Process diagram

The Wastewater Treatment Plant (WWTP) integrates anaerobic lagoons, Sequencing Batch Reactors (SBR), filtration and chlorination prior to discharging the treated water. Sludge production is small and the drying beds for the plant are almost free from sludge disposal. There is no upgrading for the biogas.

Production and gas use

The anaerobic lagoon currently generates biogas that is useful for heating the process water of the slaughterhouse. The biogas is compressed before its use in 3 boilers (30bhp, 60bhp & 100bhp) that operates simultaneously. The biogas is cleaned by filtration prior

Start of operation: 2003

Capacity of influent: 500 m^3/day (real)
700 m^3/day (design maximum)

Digester volume:
15 400 m^3 (2 x 7 700 m^3)

Capacity of sludge output: 0.4 tonne/year (real)

Type of feedstock for biogas:
Slaughterhouse red stream.

Type of digestion: Anaerobic Lagoon, mesophilic.

Retention time in digester: 31 days (real).
19 days (design).

Dry matter content:
Not Available. Typical @ 1% TS

Distance to suppliers:
On-site feedstock production.

Biogas Production:
878 Nm^3 biogas/day
i.e. 1.05 Nm^3 CH_4/m^3 influent

Utilization of gas: Heating in boilers.
Estimated 5.1 GWh/year, according to diesel oils savings.

Utilization of digestate: Biofertilizer on-site.

Distance to spreading area
<100 m (on-site garden)

Permanent jobs created: 5

Investment biogas plant:
$789 742 (2018-USD)

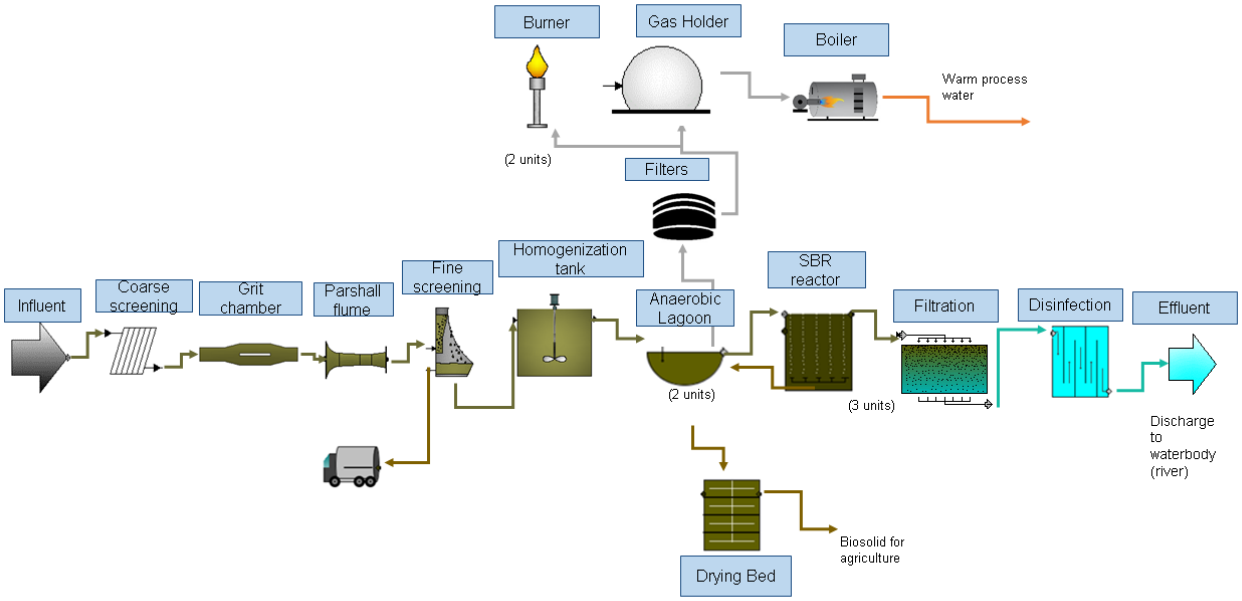
O&M costs/year:
$46,310 USD of 2018

CO_2 savings
1329 tonnes CO_2/year

to the storage in the gas holder. The filter includes iron sponge, charcoal and wood chips.

Benefits

The main benefit of biogas use is the Diesel oil saving (512 000 liters/year). In addition, the digestate is useful as biofertilizer; however, the plant operator considers that its generation is negligible.

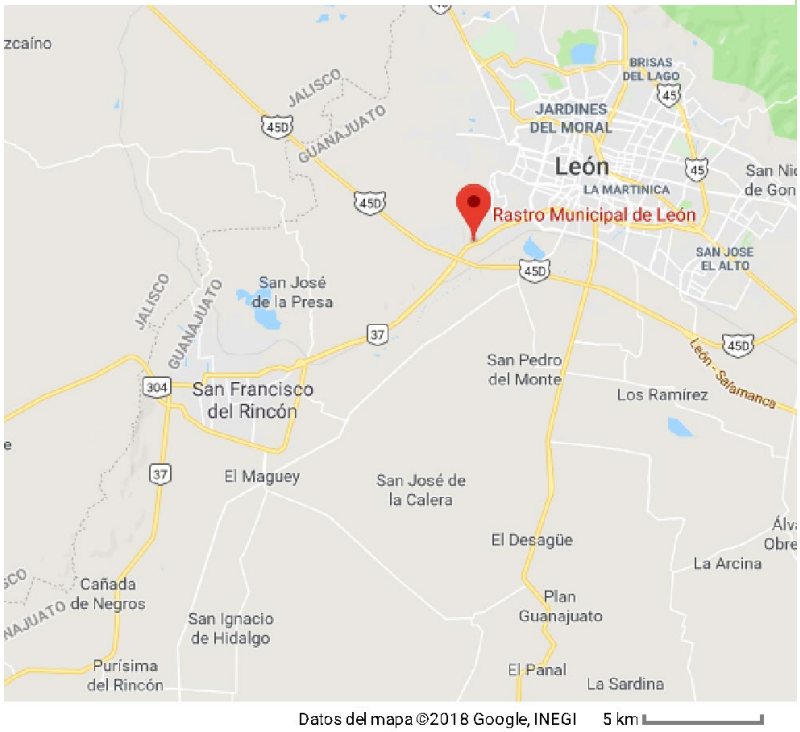


Manufacturer:

Universidad Tecnológica de León, Tel (477) 7 10 00 20
Universidad de Guanajuato (Chemical Faculty)
Tel: +52 (473) 732 00 06, webugto@ugto.mx
SAYERCEN - Servicios Ambientales y de Energías Renovables del Centro S.A. de C.V. , +52 461 51820 , +52(461)1745648 ,
enriquez.juana@sayercen.com
juanaenriquez@hotmail.com
www.sayercen.com

Operator:

Ashl Estrada, Engineer.
Rastro Frigorífico y Servicios Integrales del Bajío, S. A. de C. V.
Carr. León-San Francisco Km. 6. Col. Campo Verde, CP 37434
Tlf: +52 (477)778-0095
M: carlos.munoz@rastroleon.com.mx
http://rastro-tif-leon.wixsite.com/rastro-frigorifico



Specification sheet for Planta Tiff

1. Sources of information:

- Plant personnel
- Website: http://rastro-tif-leon.wixsite.com/rastro-frigorifico

2. Specify investment costs, what is included?

Entire plant.

3. Specify O & M costs, what is included?

	Specification	Estimated total costs USD/year
Personnel	5 employees	$40,521
Electricity (for biogas compressing	Not Available	Not Available
Heat	Not Applicable	Not Applicable
Administration and insurance	Not Available	Not Available
Maintenance and other operational costs	Maintenance	$6,665
Transport	Not Applicable	Not Applicable

4. Who has supplied and approved the data?

MVZ. Carlos Muñoz Salcedo. Production Manager.

5. Which years do the data cover?

2018

6. Green House Gas (GHG) savings calculations

Clean energy production (heat)	1 329	$tonCO_2$/year
Total GHG reduction	**1 329**	**$tonCO_2$/year**

Assumptions:

Heat emission factor (diesel) 2.596 $tonCO_2/m^3$ diesel

San Jerónimo WWTP

The inter-municipal water operator for Purísima and San Francisco del Rincón municipalities (SITRATA) was created in January 2012. In September of that same year, the construction of the San Jerónimo Waste Water Treatment Plant (WWTP) began. The plant has an anaerobic digester which digests primary and secondary sludge from the WWTP.

Vision

SITRATA is driven by the vision of being a reliable, transparent and efficient operator in the sanitation of wastewater. SITRATA pursue the use of the resources generated by their own processes, contributing continuously with sustainable development.

Start of operation:
24 de Abril del 2013

Capacity of sludge input:
143 m^3/day (design)
68 - 90 m^3/day (real)
Digester's volume: 2 500 m^3

Type of feedstock for biogas:
Primary and secondary of sludge from WWTP.

Type of digestion:
Digester, One stage, mesophilic

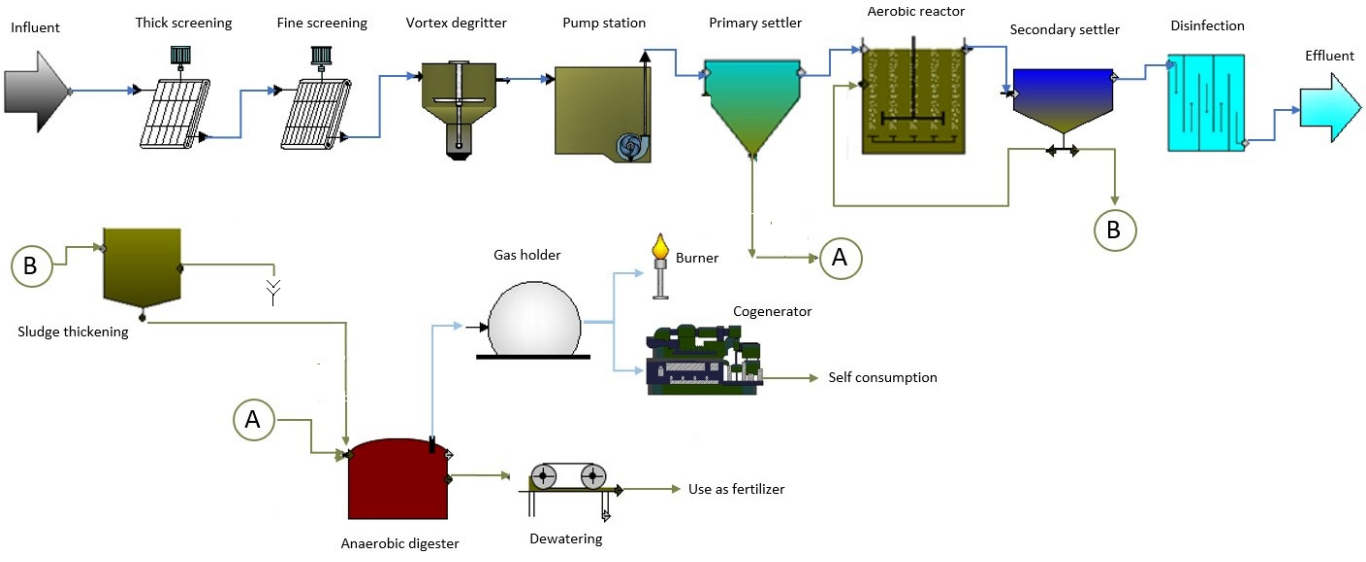
Retention time in digester:
17.5 days (design)
28 - 37 days (real)

Dry matter content of sludge:
4 % TS

Distance to suppliers:
On-site production.

Biogas Production:
800-1200 Nm^3 biogas/day (real)
i.e. 5.6-6.2 Nm^3 CH_4/tonne sludge (real)

Process diagram



Production and gas use

The gas is used in a motor generator to produce electricity and in a boiler to produce heat. Both are used for self-consumption at the plant.

Currently, the WWTP operates with 56% of the expected wastewater flow and thus, the CHP is underutilized. CHP only operates 3 to 4 hours a day, so an average of just 439 kWh of electricity is produced daily. The energy produced today is used to supply 10 % of the electrical requirements of the WWTP. The thermal energy produced by the CHP is not used to heat the digester (opportunity area). This plant is part of one of the prefeasibility studies to use co-substrates due to the potential capacity of the cogenerator. Desulfurization is done with ferrochloride on-line to the sludge pipes. There is no upgrading of the biogas.

Benefits

In addition to the clean energy production, about 5 300 ton/year (wet weight, 19%TS) of digestate can be used as biofertilizer by farmers. The wastewater effluent complies with Mexican regulation NOM-001-SEMARNAT-1996, as well as the sludge monitoring under the regulation NOM-004-SEMARNAT-2002.

Manufacturer:

FYPASA Construcciones

Nicolás San Juan 1515, Col. del Valle, Benito Juárez, CDMX
Tlf: +52 9183 6855
contacto@fypasa.com.mx
www.fypasa.com.mx

Operator:

SITRATA

Camino a San Jerónimo s/n, San Jerónimo, Purísima del Rincón, Guanajuato
Tlf: +52 476 743 7939
Mail: direccionsitrata@gmail.com
www.sitrata.org

Utilization of gas:
Combined heat and Power (CHP)
Installed capacity: 370 kWe
Electricity: 158 MWh/year for self-consumption in the WWTP.
Heat: 902 MWh/year (similar to 102 500 m^3natural gas /year) use directly from the biogas (not from cogeneration)

Utilization of digestate:
5 298 tonnes/year of digestate (wet, 19%TS) are spread as fertilizer on crop land

Distance to spreading area
7 km

Permanent jobs created
24

Investment biogas plant:
$2 663 564 USD @ 2018.

O&M costs/year:
$102 697 USD/year @2018

CO_2 savings
325 tonnes CO_2/year

Specification sheet for San Jeronimo

1. Sources of information:

http://www.sitrata.gob.mx

http://www.fypasa.com.mx

2. Specify investment costs, what is included?

Anaerobic digestion equipment USD$ 708,232 (prices of 2012-2013, no civil works included)

Co-generator with auxiliary equipment USD$ 456,726 (prices of 2012-2013, no civil works included)

3. Specify O & M costs, what is included?

	Specification	Estimated total costs USD/year
Personnel	24 Employees	$17,474
Electricity	Compressor	$13,308
Heat (Biogas)	Own production	No costs
Administration and insurance		$26,000
Maintenance and other operational costs	Maintenance of the cogenerator Guascor	$1,825
Transport	Transporting sludge to the crops	$14,090

4. Who has supplied and approved the data?

Ing. Diego Isaac Dávila Cano. Managing Director of SITRATA

5. Which years do the data cover?

2016-2018

6. Green House Gas (GHG) Calculations

Clean energy production (electricity)	92	$tonCO_2$/year
Clean energy production (heat)	233	$tonCO_2$/year
Total GHG reduction	**325**	**$tonCO_2$/year**

Assumptions:

Electrical emission factor	0.582	$tonCO_2$/MWh
Heat emission factor (natural gas)	2.27	$kgCO_2/m^3$ natural gas

Granja Porcina Topoyanes

Danish Energy Agency

Topoyanes Farm WWTP

The Topoyanes Farm Wastewater Treatment Plant (WWTP) generates electric power and treated water from swine (hog) dung raised on site. The covered lagoons are built with geomembrane, liner and HDPE (High Density PolyEthylene) cover, and treat the manure from 1 000 pigs.

Vision

To generate biogas from pig manure to provide electric power to the grid, under an interconnection agreement with the utility provider (Comisión Federal de Electricidad-CFE).

Process diagram

The treatment train for biogas production includes two parallel anaerobic lagoons. The plant was designed (excluding biodigester) by the current plant manager (owner). There is no upgrading of the biogas in the plant. Desulfurization is achieved with a two-cartridge iron chip filter. The motor generators are currently under major maintenance since October 2018.

Production and gas use

Biogas production takes place in both parallel anaerobic lagoons. Two engines are responsible for the electric power generation using biogas. The installed capacity is 60 kWe per engine (total: 120 kWel); however, the motor

Start of operation: 2008

Capacity of influent: Pig manure
160 m^3/day (design)
33 m^3/day (real)

Digester volume:
7 200 m^3 (2 x 3 600 m^3) anaerobic biodigesters.

Sludge purge:
400-600 m^3 (real) every two years in a single operation for both biodigesters.

Type of digestion: Anaerobic lagoon. Mesophilic.

Retention time in digester:
45 days (design)
220 days (real).

Dry matter content
5.4% (TS), 3.2% (VS)

Distance to suppliers:
On-site feedstock production.

Biogas Production:
1 113 Nm^3 biogas/day for two lagoons
(i.e. 23 Nm^3 CH_4/m^3 @5.4%)

Utilization of gas:
Electric power generation (internal combustion).
Installed capacity:120kWe (2 x 60 kWe)
Electric generation aprox. 480 MWh/year

Utilization of digestate:
Biofertilizer on-site.

Distance to spreading area
<100 m (on-site terrain).

Permanent jobs created: 4

Investment biogas plant:
WWTP: $23 million MXN
($1 670 298 USD-2008) for each lagoon, including interconnection equipment of
$38 333 (USD-2008).

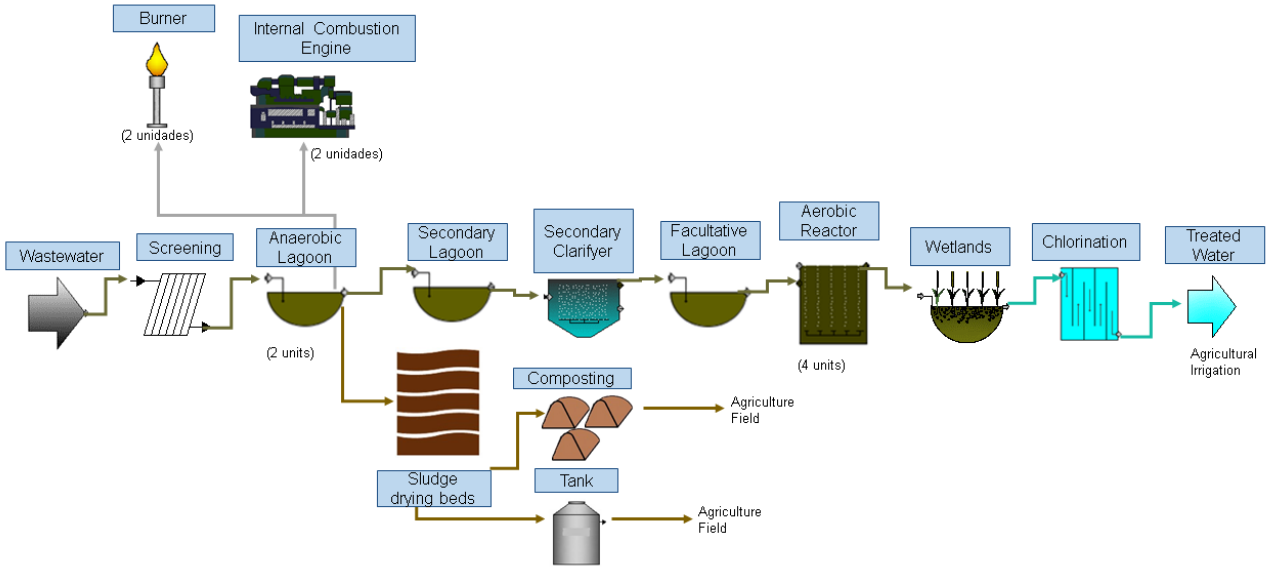
O&M costs/year:
$235 000 MXN ($11 750-USD of 2018).

CO_2 abatement:
280 tonnes CO_2/year.

generators were never able to produce electricity under nominal power, generating only approximately 30 kWe each (aprox. 60 kWe in total, flaring the remaining biogas). The generated power is currently useful only for self-consumption.

Benefits

Electric power generation from swine manure is the main asset with treated water for irrigation. Moreover, digestate is useful as biofertilizer on-site. An overall consequence of the manure treatment in the WWTP is the reduction of flies, odors and organic matter. The plant has been shown as an example of efficient operation due to the sludge mixing within the lagoons, which the plant manager started with manual pumping using a pump mounted in a cart. The mixing is realized on a regular basis 2 times per week during 4 o 5 hours each, showing that the biogas production increases because of suspending the sludge inside the lagoons. The sludge is purged once each two years. The objective of the interconnection agreement with Comisión Federal de Electricidad is to provide green energy to the grid and let the plant to be self-sufficient; however, the plant only uses power for self-consumption currently; the interconnection complies with distributed generation regulations and mitigates Green House Gases.



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Specification sheet for Topoyanes Farm

1. Sources of information:

Plant manager

2. Specify investment costs, what is included?

Entire WWTP and interconnection equipment.

3. Specify O & M costs, what is included?

	Specification	Estimated total costs USD/year
Personnel	4 employees for the plant	$10,000
Electricity (for stirring etc)	20 HP, 20 hours/week	Not Available
Heat	Not Applicable	Not Applicable
Administration and insurance	Not Applicable	Not Applicable
Maintenance and other operational costs	Blowers, Pump & liners	$500-$1,250
Desulfurization maintenance	Replacement of four cartridges per year (two each semester)	$2,500
Transport	Not Applicable	Not Applicable

4. Who has supplied and approved the data?

Francisco Treviño Priante; Plant Manager; granja.topoyanes@gmail.com.

5. Which years do the data cover?

2018

6. Green House Gas (GHG) Calculations

Clean energy production (electricity) 280 tonCO_2/year

Assumptions:

Electrical emission factor 0.582 tonCO_2/MWh

Key figures for the plants

Mexican Biogas Plants												
Name	**Type**	**Input/d (real)**	**Rententio n time**	**DM content**	**Gas production**		**CAPEX**	**OPEX**	**Production costs pr m3 over 10**	**CAPEX/ton treated per year**	**OPEX/ton treated per year**	
		ton/day	days (real)	%	Nm^3 CH_4/m^3	Million Nm3 CH4/ y	Million US$	Million US$/y	USD/m3	USD/ton treated/y	USD/ton treated/y	
Los Camichines VTP	IC	1000	2	0,1	7,0	2,6	5,1	0,60	0,44	14,0	1,6	9
Planta TIF 333 WWTP	AL	500	31	1,0	1,1	0,2	0,8	0,05	0,57	4,3	0,3	5
Topoyanes Farm WWTP	AL	33	220	5,4	23,0	0,3	3,3	0,01	1,18	271,0	1,0	4
San Jerónimo WWTP	CSTR	79	32	4,0	5,9	0,2	2,2	0,10	1,30	76,5	3,6	24
Atotonilco WWTP	CSTR	23250	17	4,0	4,5	37,8	NA	NA	NA	NA	NA	132

Danish Biogas Plants												
Name	**Type**	**Input/d (real)**	**Renten-tion time**	**DM content**	**Gas production**		**CAPEX**	**OPEX**	**costs pr m3 over 10 years**	**CAPEX/ton treated per year**	**OPEX/ton treated per year**	**Permanent jobs created**
		ton/day	days	% in average input	Nm^3 CH_4/ton	Million Nm3 CH4/y	Million US$	Million US$/y	USD/m3 CH4	USD/ton treated/y	USD/ton treated/y	
Billund Water & Energy	CSTR	167	32	8	32,8	2,0	7,5	1,84	1,29	122,5	30,1	15
Combigas	CSTR	100	34	12	26,7	1,0	1,9	0,27	0,47	53,3	7,3	3
Horsens Bioenergi	CSTR	658	25	10	33,3	8,0	11,5	1,98	0,39	47,7	8,2	7
Kroghsminde	CSTR	70	44	18	29,4	0,8	1,4	0,18	0,42	54,1	7,0	1
Madsen Bioenergi	CSTR	400	85	13	34,2	5,0	7,1	1,26	0,39	48,4	8,6	5
Solrød Biogas	CSTR	548	28	10	30,0	6,0	14,1	3,69	0,85	70,6	18,4	14