Biomass to transport fuel and power, case study installations in Finland and Ukraine. Similarities, differences and suggestions for development.

Presentation of the project: Development for Opportunities for Utilisation of Biomass Residues in the Renewable Sector of Ukraine

Pekka Sulamaa, SCL ltd
Yuri Matveev, SEC Biomass

5.2.2020 **VTT – beyond the obvious**

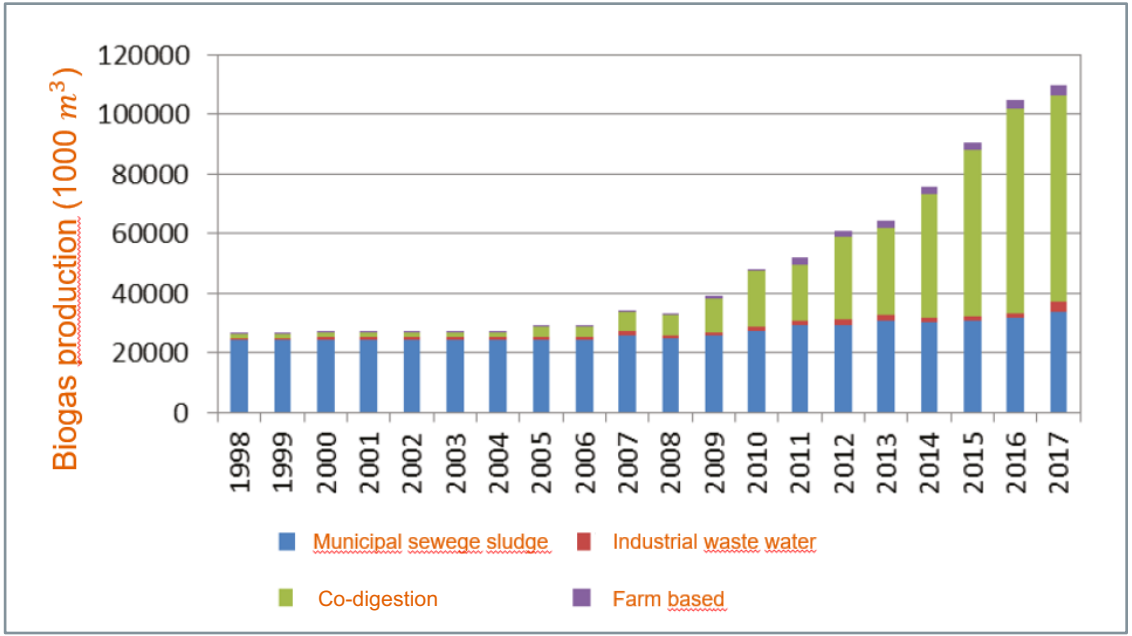
Background

Biogas sector in Finland

By the end of 2017 there were 43 integrated and 21 farm-based biogas plants operating in Finland. The integrated installations can further sub-divided into: waste water or sewage sludge installations by municipal (16) and industrial (5) basis. The rest are co-digestion facilities (22). In addition to these there are landfill sites for collecting biogas.

The energy produced with biogas in 2017 (0.7 TWh) corresponded to only about 0.5% of all renewable energy in Finland.

There is, however, potential for biogas production to be much larger (10 TWh).

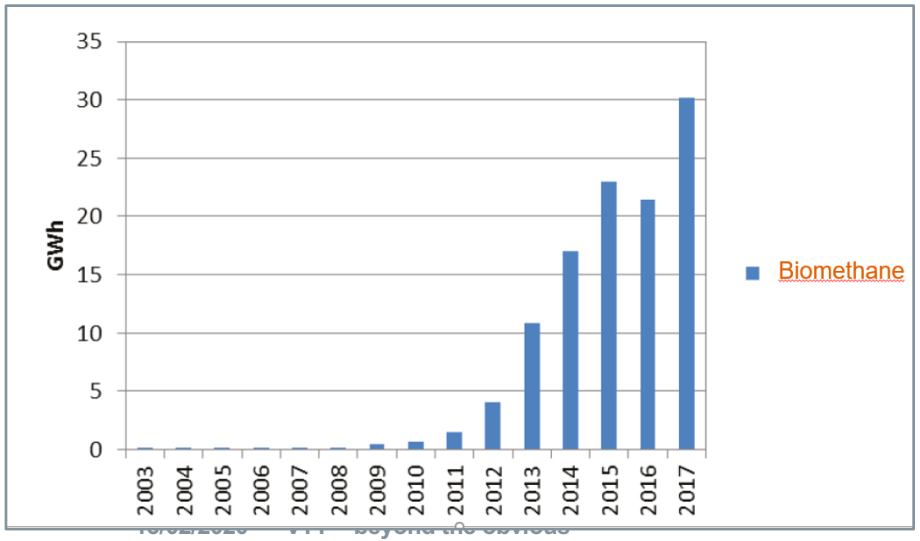


Biogas sector in Finland

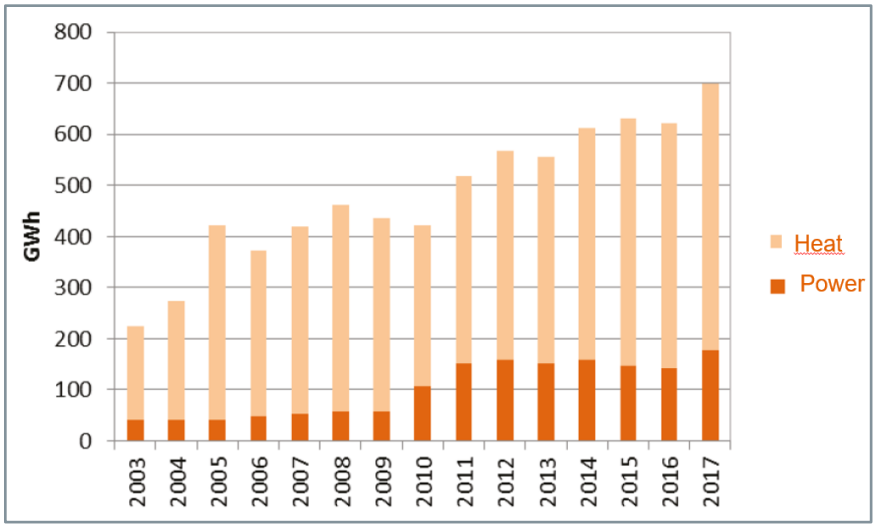
Biogas in transport use has increased especially in heavy transport sector as a result of political decisions. Biogas has been introduced as fuel for city buses and garbage trucks.

At the end of 2016 public gas filling stations there were 24 and at the end of 2017 the number increased to 34.

Biomethane production in Finland



Biogas heat and power production in Finland



Biogas cases : case 3 and 4

	Case 1 UA/FIN	Case 2 UA/FIN	Case 3 UA/FIN	Case 4 UA/FIN
Biomass source	Biomass from forestry and other industries (e.g. forestry residues, saw)	Biomass from forestry and other industries (e.g. forestry residues, saw)	Biomass from agriculture and agro industries (e.g. crop residues, straw, manure)	Biomass from agriculture and agro industries (e.g. crop residues, straw, manure)
Installation capacity	< 30MW	10MW to 30MW	1 -3 MW	3 -5 MW
Process type	Chipping wood/agri residues	Traditional pellet mill	Dry fermentation / biogas installation	Wet fermentation / biogas installation
Installation type	UA=CHP, FIN=HOB,	UA=HOB, FIN=HOB	UA=Biogas CHP FIN=biogas + HOB	UA=Biogas CHP FIN=biogas + HOB
Energy outputs	Heat and power, heat	Heat	UA=Heat and power, FIN= heat and transport fuel	UA=Heat and power FIN=heat and transport fuel
Installation (name/location) in Ukraine	*Biomass CHP installation of public utility Miskteplovodenergia in Kamyanets-Podilskyi City, Khmelnitsky region. 15MWth Biomass based CHP*	*Slavutych Boiler installation in Kiyv oblast, 10MW HOB based on wood chips*	*Gals-Agro company, Varvinsk raayon, Chernihiv region 1.2 MWe Pig manure, maize silage*	*Biogas installation of Rokytne sugar plant Ltd. in Rokytne town, Kyiv region. 2.4 MWe. Subtrates: sugar beet pulp, poultry litter cattle dung poultry litter*
Installation (name/location) in Finland	*Imatran Lämpö Virasoja heating installation , 30 MW + 5MW Biomass based HOB*	*Imatran Lämpö Rajapatsas, 4MW Biomass based HOB*	Palopuron Biokaasu Ltd ,*Nivos Energia Oy Biogas installation / Metener/ Grass and mixed manure / Dry fermentation/(2500 MWh transport fuel/a)*	*Jepuan Biokaasu Oy biogas installation /Doranova / Pig and mixed manure & crop residues/ heat output 3-4 MWth (~ 5000 MWh transport fuel/a)*

Two large and two small biogas cases under comparison

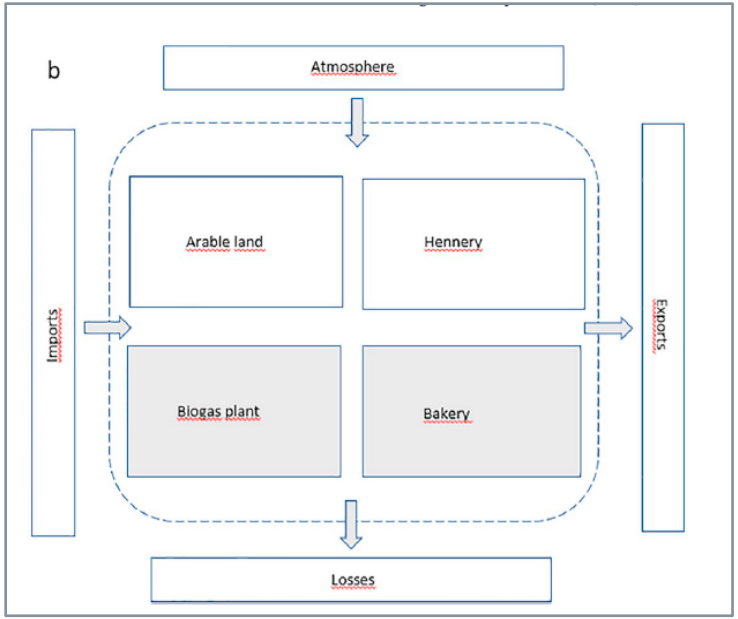
FIN Cases:

#3 Palopuro biogas plant
#4 Jepua biogas plant

Case 3 Palopuro

Part of organic farming system: Agro-ecological Symbiosis

- Biogas production - 2500 MWh/a
- Heat generation - 310 MWh/a (own use)
- Main fuels - grass silage 2 300,00 t/a; horse manure 1 000,00 t/a; Chicken manure 80,00 t/a
- Investment – 1,1 million euros
- Gas upgrading to biomethane - 1628 MWh/a
- Raw material consumption – 2470 MWh/year
- Energy efficiency of supply chain- 86 %



Case 3 Palopuro

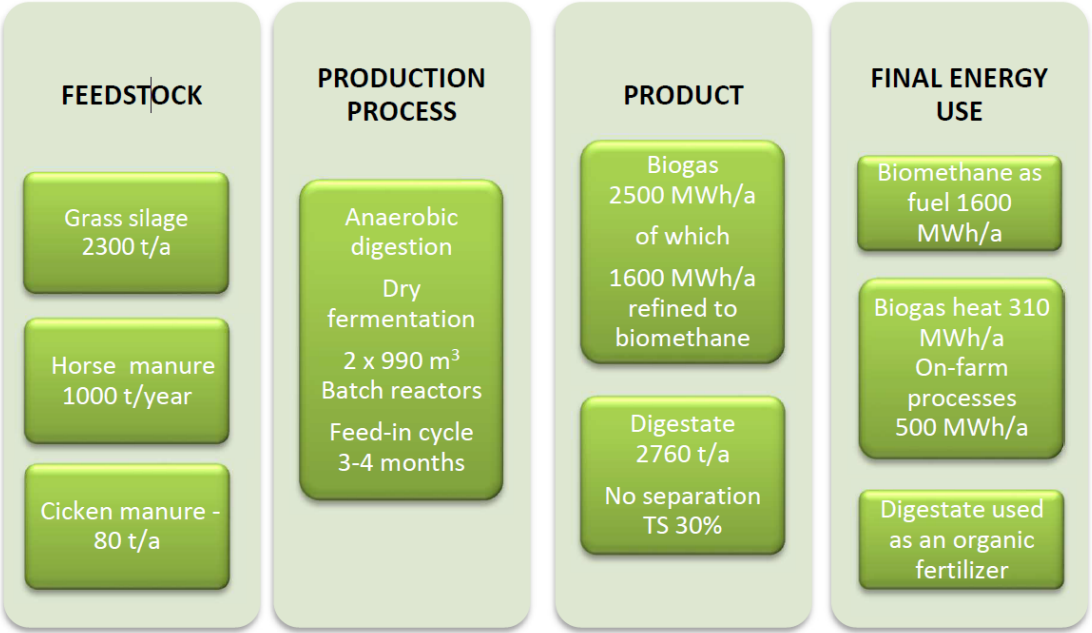
The feedstock is converted to biogas in two 800 m^3 dry fermentation batch reactors.

Feedstock owners: Knehtilän tila, local animal farmers/ horse stables. The silage is the most important feedstock with roughly 70 % share. For horse manure there is gate payments (amount of the payment not disclosed). The chicken manure is also collected from local operator.

Item	Units	Value
Raw materials input	t/year	3380
Raw materials input	MWh/year	2470
Biomethane production	MWh/year	1628
Power produced	MWh/year	0
Vehicle gas sold	MWh/year	1528
Heat produced own use	MWh/year	310
Raw materials use efficiency	%	86%

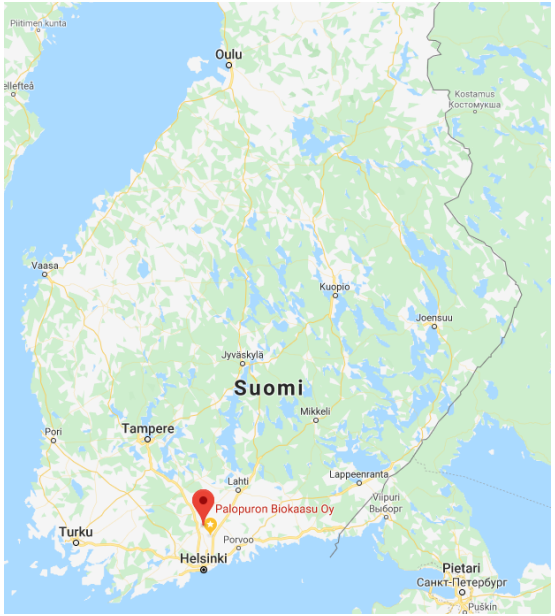
Country	Finland
Project name	Palopuro Biogas plant
Ownership	Main owner Nivos Energia Ltd (energy company)
Feedstock	Grass silage within crop rotation system. Chicken and horse manure.
Technology	Dry fermentation in batch reactors with biogas upgrade (water washing) to biomethane quality
Final energy use	The use of raw biogas for own plant heating, no electricity generation, the rest of biogas is upgraded to biomethane and used mostly as motor fuel

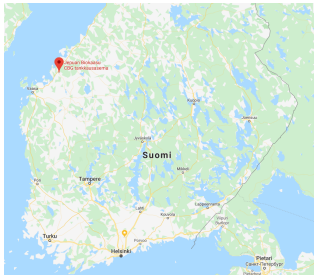
Palopuro Value chain



Palopuro biomethane production and sales

Own gas station for biogas close to the biogas plant





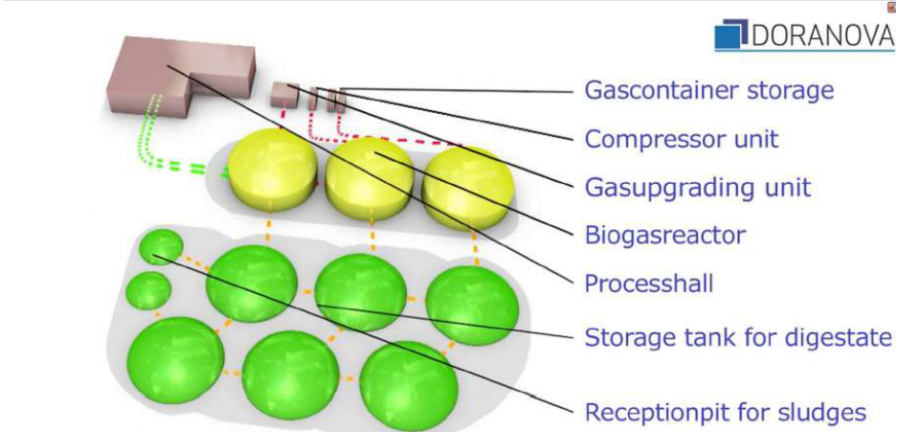
Case 4 Jepua

JEPUA

- Biogas production capacity – 3,5 MW
- Heat generation – 2,6 GWh/a (plant heating)
- Main fuels -
  - Pig and slaughter house manure 70 000-80 000 t/a
  - Biowaste from food and animal food industry
  - (vegetable waste, fish residues, etc.) 25 000 - 30 000 t/a
  - Grass and old ensilage 2 000 - 5 000 t/a
  - Other organic waste material 3500 t/a
- Investment – 12,5 million euros
- Gas upgrading to biomethane - 30 GWh/a
- Raw material consumption – 31 000 MWh/year
- Energy efficiency of supply chain - 91 %

Largest Biogas plant in Finland

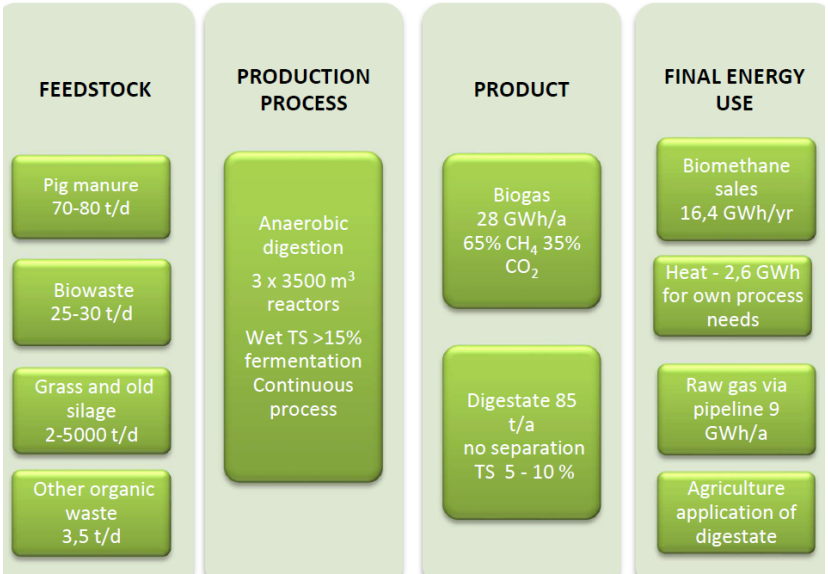
Located in West coast of Finland. The biogas plant, designed and delivered by Finnish company Doranova Ltd. in co-operation with the German Weltec Biopower GmbH was commissioned in fall 2013.



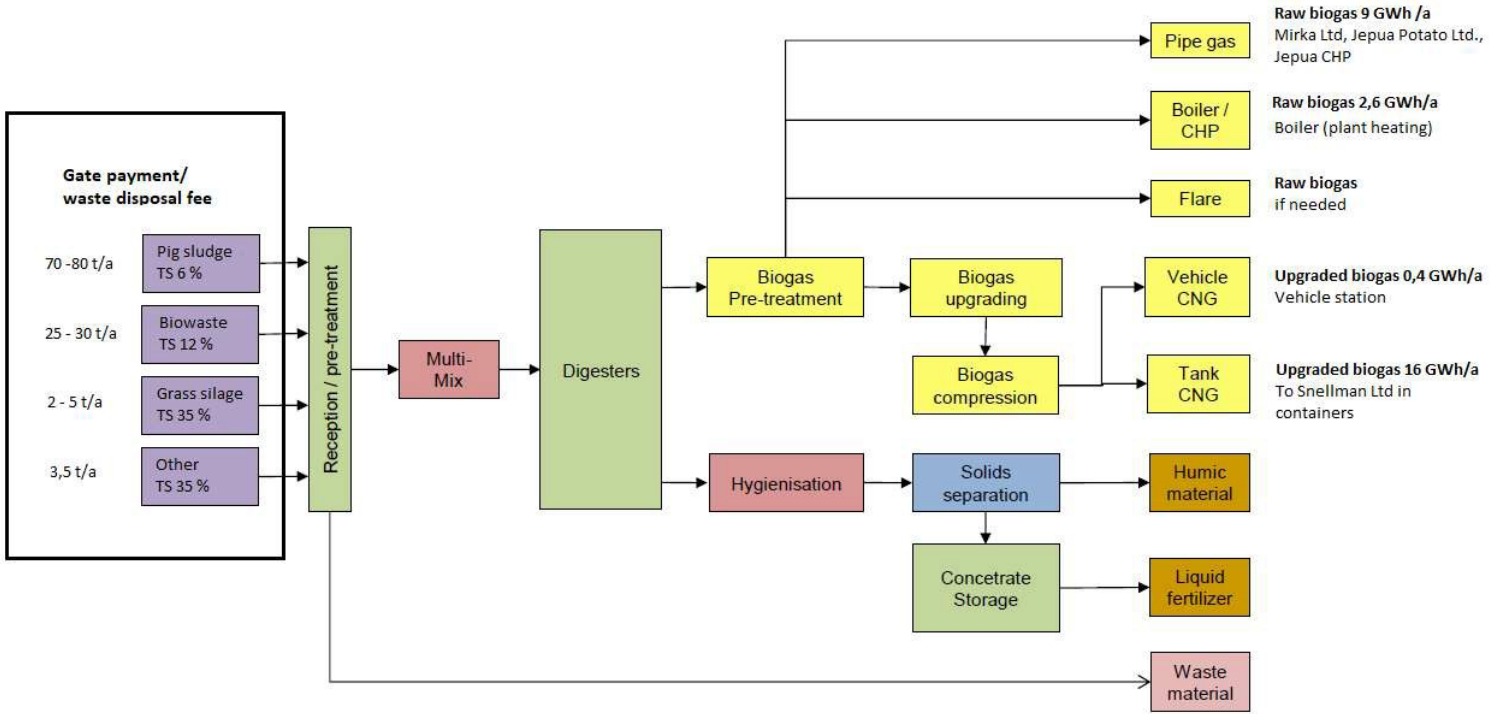
Jepua plant

The biogas plant consists of three 3500 m3 digesters with a total of 4800 m^3 gas buffer capacity. Fourth reactor is being build. The biogas plant operates both in thermophilic (56 - 60 °C) and mesophilic (30 - 45 °C) temperature range.
Hydraulic retention time for feedstock is 12 - 40 days depending on process temperature and raw material. Process is continuous and stirring follows specific program automatically.

Parameter	Unit	Value
Vehicle gas sold	MWh/a	400
Heat producd (if any)	MWh/a	2600
Raw material use efficiency	%	91

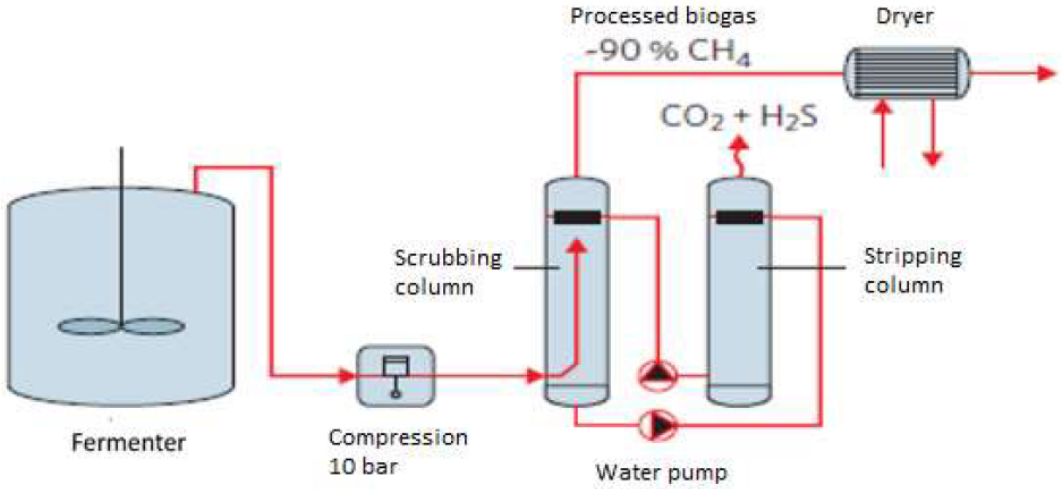


Value chain: Jepua plant



Biomethane processing: Jepua plant

For use as a transport fuel, biogas needs to be converted into biomethane, which means that most of the carbon dioxide, hydrogen sulphide, moisture and any low-level impurities must be removed. Carbon dioxide is removed because it lowers the calorific value of the gas. The simplest and most common method of converting biogas into transport fuel is water washing. In a water scrubber, carbon dioxide and hydrogen sulfide are soluble in water, but methane is insoluble in water



Biomethane processing: Jepua plant

The cost of biomethane fuel washer investment depends on the size of the washer. In Jepua it is 1,5 million euros. In addition to the washer a compressor station (200 000 euros) and possibly containers are needed (150 000 euros each) if there is no gas network.

Digesters, upgrading unit and compressor unit

Biomethane processing: Jepua plant

Jepua has own vehicle fuel distribution station for biomethane. Station includes double-sided dispenser for compressed biogas. The station is located besides the biogas plant.

Currently the price is: 1,40 – 1,50 €/kg, which is equivalent to 6 €/100 km. The station is open 24/7.

Summary of the Finnish cases

Two very different kind of plants from Finland - **lessons from these plants**

1. Large biogas plant with Biomethane upgrading JEPUA

- Modern technology connected to industrial food production residue utilization (Snellmann Ltd.)
- Biomethane upgrading which is transported in containers and sold from own station
- Biogas distribution to local school and industry
- Pipelines to transport slurry feed-in to the plant
- Jepua is currently setting up new dry fermentation unit which gives interesting information

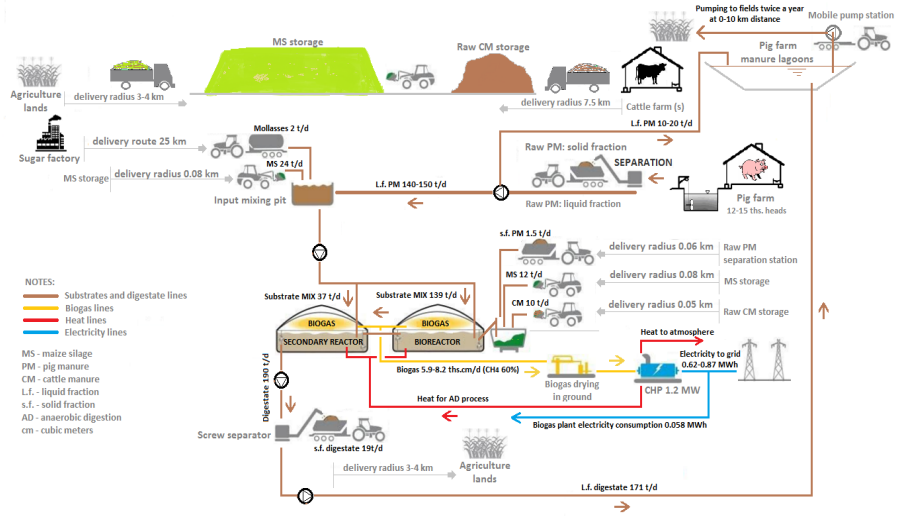
2. Small farm-based biogas plant with biomethane upgrading PALOPURO

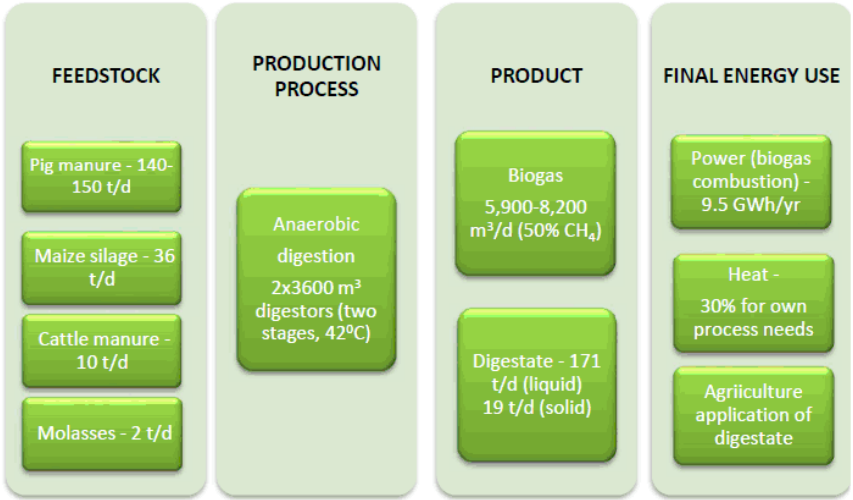
- Integrated farm-based plant with local food industry closely interacting with the Agroecological Symbiosis
- Biomethane distribution station
- Dry fermentation with batch reactors
- Interaction with organic farming
- Could be scaled-up to larger units in Ukraine

UA Cases:

#1 Gals-Agro Biogas plant
#2 Rokytne sugar plant

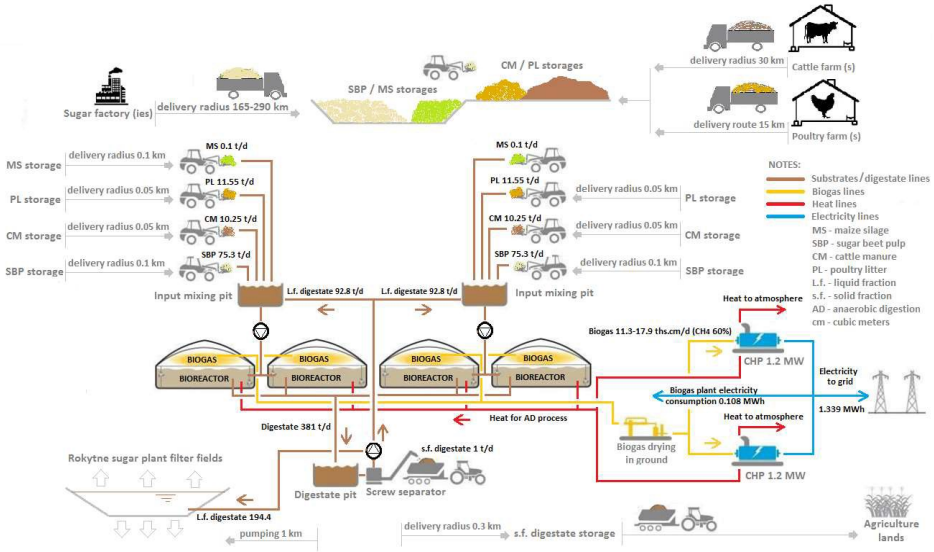
Case 3: Gals-Agro Biogas plant





Country	Ukraine
Project name	Gals-Agro Biogas plant
Ownership	Gals-Agro corporation
Feedstock	Own agricultural residuals and by-products (pig and cattle manure, molasses) and maize silage. No gate fee. Delivery within 7 km (manure), 30 km (molasses) by own transport
Technology	Standard wet process, raw biogas drying and desulfurization
Final energy use	Electricity generation in CHP unit for grid delivery and sell by FIT, heat for own process only, 1.2 MW_e

Case 4: Biogas plant at Rokytne sugar plant Ltd



Feedstock	Production process	Product	Final energy use
Sugar beet pulp - 150 t/d Chicken manure - 23 t/d Cattle manure - 20 t/d Maize silage - 0.2 t/d	Anaerobic digestion 4x3600 m^3 digestors (one stage, 42°C)	Biogas - 11,300-17,900 m^3/d (60% CH_4) Digestate - 195 m^3/d (liquid), 1 t/d (solid)	Power (biogas combustion) - 12.6 GWh/yr Heat - 30% for process needs Agriiculture application of digestate

Country	Ukraine
Project name	Biogas plant at Rokytne sugar plant Ltd.
Ownership	Silhospprodukt corporation
Feedstock	Purchased agricultural residuals and by-products (sugar beet pulp, cattle and chicken manure) and harvested for biogas maize silage. No gate fee
Technology	Standard wet process, raw biogas drying and desulfurization (4x3600m^3)
Final energy use	Electricity generation in CHP unit for grid delivery and sell by FIT, heat for own process only, 2x1.2 MW_e

Biomass to heat and power (biogas), Cases #3 and 4

Observed similarities, differences and suggestions for development

The similarities, contrasts and differences in the practices used in Finland and Ukraine (2)

Article	Ukraine	Finland
Main feedstocks	Predominant treatment of own raw materials, no gate fee. Purchasing if necessary.	Treatment of different raw materials including manure, centralized organic waste treatment based on gate fee
Typical transportation distance	Lack of raw materials may result in purchasing and long distance delivery (up to 300 km) usually by car	0-40 km (cars, piping)
Feedstock quality and quality control	Lack of feedstock quality control, bad quality of purchased materials possible	Quality control. Suppliers of feedstock are often consumers of digestate
Maize silage application	Maize silage harvesting for own biogas production	Not used
The average market price of feedstock, €/t	0-25 (10)	- (30-50) if gate fee applied
The market of services in transportation	Developed, no special vehicles	Developed, piping systems, special car with pressurised containers for biomethane
Priority of biogas utilization	Main driver - electricity production by green tariff (FIT), no heat utilisation	Priority of raw biogas for external heating, 2nd priority - biomethane, no power production (except CHP)

The similarities, contrasts and differences in the practices used in Finland and Ukraine (3)

Article	Ukraine	Finland
Biomethane use	No biogas upgrading to biomethane quality	Biomethane can be use as motor fuel (local feeling station) or delivered to industry consumers in mobile containers
Service of equipment, spare part availability, suppliers guaranty	Insufficient service of equipment and spare part supplier, lack of suppliers guaranty	Automatic operation, good service of equipment and spare part supplier, supplier's guaranty. Experienced local equipment suppliers
Digestate application	Digestate field application is limited and technically underdeveloped	Digestate field application among local farmers based on no-cost approach
Governmental support	Green tariff (FIT) for power from biogas	Governmental investment support (25%), fixed price for biomethane (1.5€/kg). High price of NG
Biomass electricity tariffs, €/kWh w/o VAT	0.1239	0.830
The level of biogas utilization for heating, %	20-30 (for process heating)	All available customers
Biomethane prospects	Legislation is needed	Lack of biomethane fuelling car and feeling stations, governmental goal for number of cars and fuelling station
Investor interest	Low interest of investors	Mid and high interest of investors

The value chain steps with most important gap impacts for biogas cases

- **Heat final use**. Problems with DH connection, heat from biogas is no competitive with heat from natural gas
- **Biogas/biomethane as energy product**. Low efficiency of energy conversion for power, heat losses. Lack of conditions for biomethane
- **Final use of motor fuel from biomethane.** Lack of legislation for biomethane, lack of governmental support, biomethane based motor fuel no competitive with natural gas price
- **Production.** Lack of supplier guaranties. Complicated procedure of project development (problems with connection to power greed)
- **Final use of digestate.** Lack of certification for organic fertilizer and farming, no machinery for digestate application
- **Feedstock from plant residuals.** Lack of experience in particular with lignocellulosic materials (straw), underdeveloped biofuel market

General recommendation for gap/ barriers removal in Ukraine

- Development of biomass market
- Extension of FIT Scheme for electricity produced from biomass/biogas/biomethane
- Provision of non-discriminatory third-party access to heat networks
- Update (raise) of stimulating tariff on heat energy from biomass/biogas
- General increasing of investment attractiveness of the bioenergy sector
- Resolving of practical problems and lack of experience to use agribiomass as fuel or raw materials
- Development of organic farming and digestate application
- Development of legal and regulatory framework for biomethane production and use

beyond

the obvious

Pekka Sulamaa, SCL ltd <pekka.sulamaa@sulamaa.fi>
Yuri Matveev, SEC Biomass <mtv@secbiomass.com>
www.vtt.fi

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