PIONEERING BIOGAS FARMING IN CENTRAL FINLAND

FARM SCALE BIOGAS PLANT PRODUCES VEHICLE FUEL, HEAT, ELECTRICITY AND BIO-FERTILIZER

SUMMARY

Kalmari farm is one of the pioneer farms producing biogas in Finland, and an excellent example of innovative use of biogas technology. The farm is self-sufficient in electricity, heat and vehicle fuel. Excess electricity is sold to the grid, and vehicle fuel sales exceeded 1000 MWh in 2011. The biogas plant digests cow manure and confectionery by-products, and in the future will also digest fat trap waste and liquid biowaste (under the EU animal by-products regulation). Occasionally smaller amounts of energy crops, mainly grass silage, are digested as well. Digestate is used as bio-fertilizer on the farm's own fields. Biogas technology on the Kalmari farm thus efficiently combines energy production, waste treatment and nutrient recycling.

Figure 1.
The patented Metener biogas upgrading technology (Jussi Läntelä, Metener Ltd.)

BACKGROUND

Kalmari farm is an old family farm in Laukaa and it is currently run by the eleventh generation of the same family. The history of the family farm can be traced back to the year 1666. The first biogas reactor was built and Combined Heat and Power (CHP) production started in 1998. Biogas has been upgraded to vehicle fuel since 2002. The original biogas reactor was replaced by a larger one in 2008 and the original small reactor now serves as a hygenization unit. The biogas production plant is a result of an individual farmer's vision, and has been developed and manufactured largely using the farmers own expertise. Existing farm machinery and facilities have been utilized during the construction, so the whole biogas production system was made at very low cost.

THE PROCESS

The main feedstock for digestion is the cow slurry from calves and milking cows (Table 1). The raw slurry is stored in a mixer tank, which acts as a buffer storage for feedstock. Mixed slurry is pumped to a 1000 m^3 mesophilic, continuous stirred reactor. Solid substrates are directly fed into the reactor, typically once a day. Retention time in the reactor is 100–150 days as there is unused capacity for future demand. After main digestion, digestate is transferred into a 1500 m^3 covered storage tank, which also provides capacity for biogas storage. The average residence in the storage tank is 6 months. Extended post-fermentation is important in order to decrease methanogenic activity in the digestate before it is used as bio-fertiliser, thereby cutting methane emissions. Post-fermentation adds up to 15 % to the total biogas yield. The current biogas plant is highly automated and much less labour intensive than the previous wood fuel based heating system on the farm.
Raw biogas contains around 62–64 % methane, 36–38 % carbon dioxide and small amounts of hydrogen sulphide. Raw biogas is dried by absorption and the resulting gas can be used directly in a converted Sisu engine which has 25 kW electric and 50 kW thermal capacities. In addition, the farm has an 80 kW gas boiler. Thermal energy is used for space heating, hot water and in crop drying. Electricity is mainly used on the farm and a small amount is sold to the grid. In general, direct energy use on the farm is more profitable than selling, due to transport costs and a relatively low electricity price in Finnish market.

For vehicle use, biogas is upgraded to 95 % methane content and pressurized to 270 bars using a self-designed biogas upgrading unit which is based on high-pressure water scrubbing (Figure 1). The farmer has fuelled his bi-fuel car since 2002 and nowadays there are approximately 50 local drivers utilizing upgraded biomethane for their vehicles (Figure 2). In total, around 100 customers now hold a biogas refueling card. A new refueling station was opened in March 2011 (Figure 3). This biogas plant has the capacity to produce biomethane for about 200 light-duty gas vehicles. Vehicle fuel is the most cost-effective way to utilize biogas. By utilizing upgraded biogas as a traffic fuel carbon dioxide, sulphur dioxide, nitrogen oxides and particulate emissions are significantly lower than when traditional liquid fossil fuels are used. Kalmari's pioneering work on biogas vehicles has generated a lot of public attention and this has contributed to a transition of Finnish policies concerning biogas usage in vehicles.

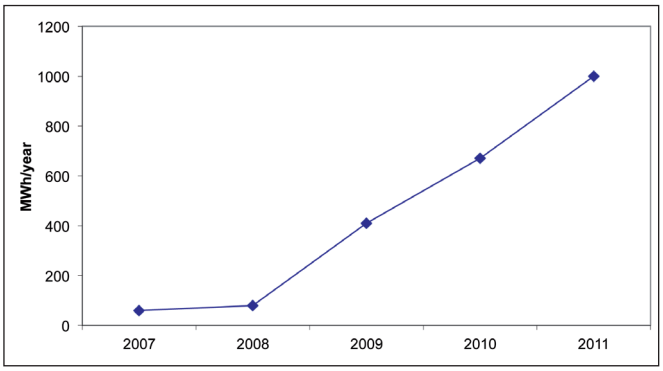

Figure 2. The increase in upgraded biomethane sales in years 2007–2011

Figure 3. New biomethane filling station on Kalmari farm (Outi Pakarinen).

Figure 4. Valtra dual-fuel biogas tractor in test use on the Kalmari farm (Metener Ltd.)

Table 1. Parameters of the Kalmari biogas farm

Biogas reactor	Reactor volume	1000 m^3
	Cow manure	2000 m^3/year
	Confectionary by-products	200 m^3/year
	Fat	600 m^3/year
	Post-storage tank	1500 m^3
Biogas (raw)	CH_4 content	62–64 %
CHP		25 kW_{el} 50 kW_{th}
Gas boiler		80 kW_{th}
Upgrading to traffic fuel	Capacity	50 Nm^3/h of raw biogas
	Electricity consumption	1.2–1.4 kWh/kg
	Water consumption	10 liter/kg
	CH_4 content	95% ± 2%
End-products	Electricity	75 MWh/year
	Heat	150 MWh/year
	Biomethane for traffic fuel	1000 MWh/year

Valtra Inc. (www.valtra.com), also located in Central Finland, has developed a biogas tractor with a dual-fuel engine. Valtra tractors use biomethane and small amounts of diesel for ignition. The biogas tractor has been in test use on the Kalmari farm (Figure 4), and the results are promising. With this new technology, fossil fuel consumption for energy crop cultivation and harvesting can be significantly reduced enabling almost carbon-neutral biogas production chain to be achieved.

BENEFITS

Previously, the main economic benefits from biogas for the farm came from reduced heating energy and fertilizer costs. The farm is self-sufficient in energy use and even the high heat demand in the coldest winter days is met with biogas. Nowadays the main economic benefit comes from vehicle fuel, which is exceeding income from milk. In addition to direct economic benefits the need for commercial fertilizer has been reduced by 60 % due to improved availability of nutrients in the digestate compared to raw cattle slurry. Additional benefits include reduced smell and better cow health due to decreased pathogen recycling. Environmental benefits arise from tapping renewable energy sources and reducing agricultural methane emissions.

RESEARCH AND DEVELOPMENT WORK

Kalmari biogas farm has raised interest among farmers for biogas systems. The farm project has also given a trigger for a new company, Metener Ltd, whose founders also include Mr. Kalmari himself. Metener provides turn-key deliveries of complete biogas systems and has designed and installed several biogas plants and upgrading units in Finland and Asia. The company also carries out development of biogas upgrading for automotive use from small low-cost solutions to larger scale plants. Moreover, Metener Ltd. has the capability to run pilot scale tests with different substrates intended for biogas production and provides consultancy and feasibility studies related to biogas production and utilization. The farm and Metener Ltd. have close co-operation with both local and international research institutes and development companies.

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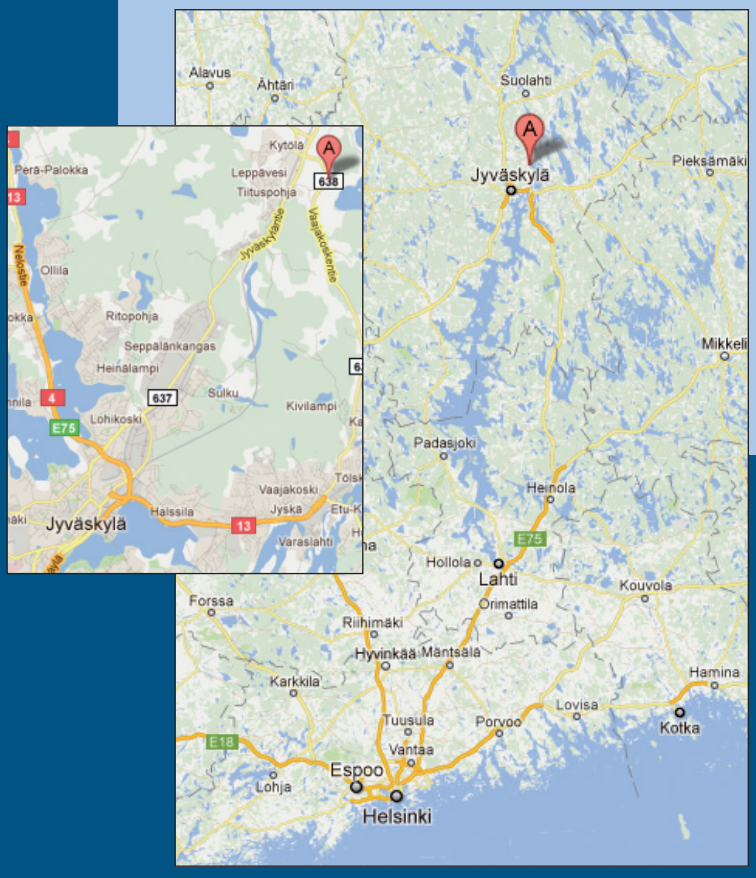

IEA Bioenergy Task 37 "Energy from Biogas"
http://www.iea-biogas.net/