



UPGRADED BIOGAS FOR VEHICLE FUEL

*Experience from Sweden, France, Japan, Iceland and
Spain*

Written and Presented by Sean Molloy



Outline

- Who is Greenlane Biogas
- What is Biogas Upgrading
- How does the CSFR Biogas Upgrading technology work
- Where has this technology been used
- Why is Upgraded biogas a good fuel source
- How could Upgraded Biogas work in New Zealand



Greenlane Biogas

*Flotech is Greenlane Biogas' parent company
Flotech was incorporated in New Zealand in 1986*

*Greenlane Biogas' sole focus is the
development of the worlds most cutting edge
Biogas upgrading systems.*

Greenlane Biogas is one company within the Flotech group, with offices in **Sweden, Singapore, Australia** and **New Zealand**

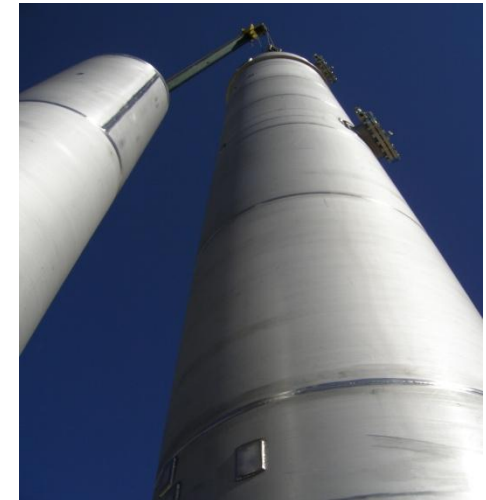




| | | |
|------|----------------------------------------------------------------------------------------|-----------------------------------------------|
| 1986 | First year of incorporation. Installation of CNG refueling stations & Heat exchangers. | |
| 1992 | Constructed first biogas upgrading system in Lille, France | 100 Nm ³ /hr (~60 ltrs/hr LEP) |
| 1994 | Sonzay, France | 100 Nm ³ /hr (~60 ltrs/hr LEP) |
| 1995 | Trollhättan, Sweden | 140 Nm ³ /hr (~85 ltrs/hr LEP) |
| 1997 | Linköping, Sweden | 660 Nm ³ /hr (~400 ltrs/hr LEP) |
| 1998 | Kalmar, Sweden | 90 Nm ³ /hr (~60 ltrs/hr LEP) |
| 1999 | Sorpa, Iceland | 90 Nm ³ /hr (~60 ltrs/hr LEP) |
| 2000 | Trollhättan 2, Sweden | 400 Nm ³ /hr (~240 ltrs/hr LEP) |
| 2004 | Kobe, Japan | 150 Nm ³ /hr (~90 ltrs/hr LEP) |
| 2006 | Linde, France | 1,200 Nm ³ /hr (~720 ltrs/hr LEP) |
| 2007 | Kobe, Japan | 660 Nm ³ /hr (~400 ltrs/hr LEP) |
| 2008 | Madrid Spain | 4,000 Nm ³ /hr (~2400 ltrs/hr LEP) |

Flow rates processed are given in terms of raw gas, not processed Biomethane

La Paloma, Madrid site during assembly



Madrid site during insulation installation



Greenlane Biogas Current projects

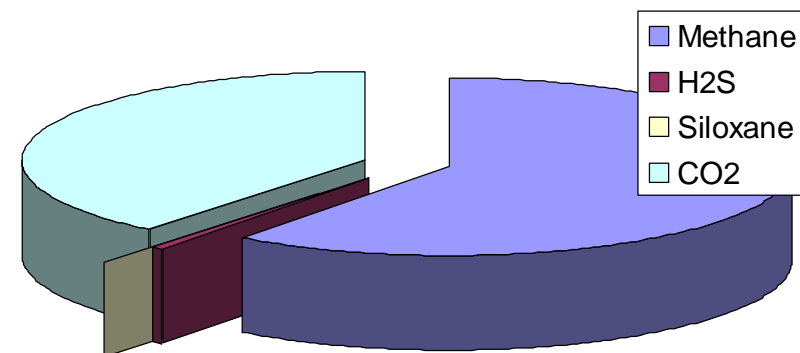
- 2008 Seoul, Korea
200 Nm³/hr
- 2009 Katrineholm, Sweden
80 Nm³/hr
- 2009 Motala, Sweden
80 Nm³/hr
- 2009 Marquette, France
90 Nm³/hr
- 2009 Guströv, Germany
10,000 Nm³/hr
- 2009 Örebro, Sweden
2,000 Nm³/hr



Biogas Upgrading



- *Methane is the only desired constituent for application as a fuel*
- *The Greenlane CSFR system separates the Bio-methane from the other gases*
- **CSFR – Compress Scrub Flash Recovery**



Biogas Upgrading



- CO₂ – Inert gas, reduces energy density
- H₂S – Very corrosive, Toxic
- Siloxane – is derived from the words silicon, oxygen and alkane.

Silica deposits = sand = engine failure

- Water – Results in condensate when compressed. Water condensate can become methane hydrate, which is a solid, when compressed to storage pressures.





How the Greenlane CSFR works

- Biogas is *compressed* to 6 – 9 atmospheres (roughly 3 times greater pressure than car tyres)
- Compressed biogas interacts with water in a '*Scrubbing*' vessel. CO₂, H₂S and Siloxanes are preferentially absorbed by the water.
- Methane absorbed is '*Flashed*' off, in a vessel at a lower pressure and recovered by returned it to the start of the process
- Product gas is dried before being analysed and sent off skid

How the Greenlane CSFR works



Scrub

Flash Recovery

Compress

Research and Development

...Working hard to stay the best



- **Hydrogen Sulphide:**

“Polishing” process *reduces H_2S carryover to 0.1ppm!* Viability of biogas for fuel cell vehicles improved further.

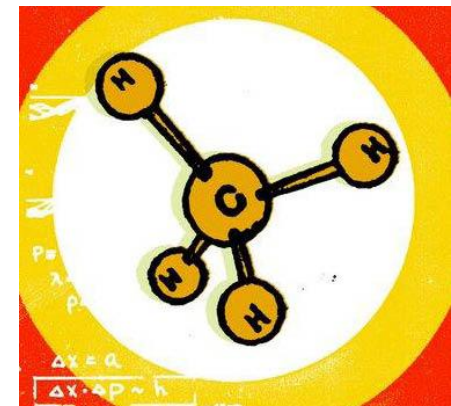
- **Siloxane:**

Greenlane CSFR system *removes virtually all of the siloxane* in raw biogas.

- **Cost of energy**

per cubic meter of gas upgraded critical to economics of operation. Techniques employed for energy efficiency include:

- Pump turbo recovery – Recovers energy from water exiting scrubber
- Real-time optimisation of process - operating characteristics optimised by advanced control algorithms, designed to minimise gas compression, chilling and liquid pumping energy requirements.



Energy in : Energy out

- **CSFR Micro**, 80 Nm³/hr raw gas processing.

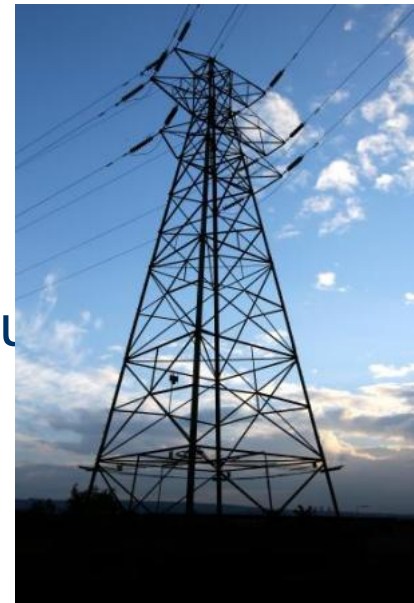
$$\underline{1 \text{ kWe} : 19.8 \text{ kW}}$$

Electrical energy input \approx 5% of energy output

- **CSFR 2000**, 2000 Nm³/hr raw gas processing.

$$\underline{1 \text{ kWe} : 25.6 \text{ kW}}$$

Electrical energy input \approx 4% of energy output



Energy in : Energy out

- **CSFR Micro**, 80 Nm³/hr raw gas processing.

1 kWe : 19.8 kW

Electrical energy input to energy output

- **Ethanol distillation – Corn ethanol**

1 kWe : 3.84 kW

Electrical energy input to energy output*

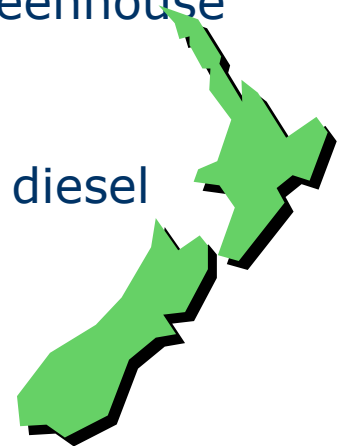
*Lorenz, Morris “How much energy does it take to make a gallon of ethanol” August 1995, Institute for local self reliance (IISR).





How did it begin? New Zealand's first Biogas Plant

- Initiative taken by Christchurch City Council, New Zealand in the 1970's
- Produced upgraded biogas for a vehicle fleet of 70 vehicles operated by the Christchurch City Council
- Carbon dioxide (CO²) produced as by-product from gas upgrading plant was recovered and used to boost greenhouse production
- Biogas as a fuel became uncompetitive compared to diesel prices and the plant was closed in 1994.





Market developments of last 16 years

- Prior to 1990's biogas was only used commercially as raw fuel, for heating and power generation
- 1992 IANGV conference in Gothenburg, Sweden; Flotech was first to introduce the concept of biogas upgrading technology
- 1994 Swedish municipal and national governments instigate funding and tax structure to commercialise biogas for vehicle fuel
- Swedish program resulted in successful large scale projects, such as the Linköping city bus fleet which operates 100% on biogas



Market developments of last 16 years

Commercial Biogas plants are operating in:

- France
- Sweden
- Japan

Commercial plants will be soon opened in:

- Spain
- Germany

Greenlane Biogas has sold $<200\text{Nm}^3/\text{hr}$ plants to:

- Korea (trial to proceed commercial plant)
- Iceland

What does it cost?

0.95€/ ltr = ~ NZ\$1.90



Biogas fuel is cheaper at the fuel station

The price of biogas (not taxed) is very competitive with petrol.

The price is presented in Nm³ (normal cubic meter). In December 2006 the price of biogas in Linköping, Sweden, was:

Biogas price at the fuel station:

9.25 SEK/Nm³ (1.03 €)

Petrol equivalent biogas price:

8.57 SEK/l (0.95 €)

Petrol price: 10.45 SEK/l (1.16 €)

The driver of a biogas vehicle saves 1.50 SEK/l (0.16 €).

Birath, "Non-polluting and energy efficient vehicles, Biogas in captive fleets", December 2006, [ONLINE] www.niches-transport.org. accessed 15 July, 2008



Future of Biogas



- Most Japanese car makers have already produced, or plan to develop a fuel cell vehicle.
- CBG is an attractive feedstock for hydrogen production by reformer, for fuel cell powered engines!
- Limited numbers of the Honda FCX fuel cell powered car became available for lease from July 2008





How could it work in NZ?

- Government support is key
 - Road tax exemption, low interest loans for CAPEX, grants etc
- Identify waste streams for raw gas source
 - Meat works, sewage treatment plants, dairy factories etc
- Supply to captive fleets
 - Buses, refuse trucks, depot based trucks, milk trucks
- Emphasis on high quality equipment
 - OEM Biogas/CNG vehicles
- Do not focus on private vehicles until established



Why use Biogas in New Zealand?

- Improves balance of trade
- Valuable for emissions trading schemes – carbon neutral
- Independence from energy price/supply instability – oil & gas
- 100% renewable
- Could provide reticulated and vehicle gas for the South Island
- Valuable point of difference for marketing – Negate food miles argument, tour buses and snow groomers on ski fields operating on Biogas!



Thank you for your interest !