

## List of References

### Completed Biogas Upgrading Plants

**Hashøj Biogas plant, Hashøj DK**Capacity 250 m<sup>3</sup>/h @ 33 % CO<sub>2</sub>

Commissioned in 2012

This plant is heated with a biogas-fired boiler, and waste heat will eventually be sent to Dalmore's district heating network.

The immediate reason for building this upgrading plant was curiously to achieve increased energy transported through an existing pipeline from the plant to the district heating plant in Dalmore.

As CO<sub>2</sub> is twice as heavy as methane, the same compressor and pipeline can transport twice as much energy forward when the CO<sub>2</sub> is removed.

DGC has measured this plant, also for a number of siloxanes. The report for this project is available on request.

**Frevar, Frederikstad NO**Capacity: 600 m<sup>3</sup>/h @ 33 % CO<sub>2</sub>

Commissioned in 2013

The gas is produced mainly from what a municipality can collect of 'wet' waste from citizens, incl. sewage sludge. This project, which was won in an open tender, with Hashøj as reference plant, provides the upgraded compressed biogas to 100 buses throughout the whole of Southern Norway.

In addition to the CO<sub>2</sub> separation, there is a low-pressure compressor station (7 bar), with redundancy compressor, adsorption dryer, and gas analysis.

[www.frevar.no](http://www.frevar.no)**Madsen Bioenergi, Skive DK**Capacity: 1,200 m<sup>3</sup>/h @ 33 % CO<sub>2</sub>

Commissioned in 2014

Commercial plant. In addition to the CO<sub>2</sub> separation, there is a low-pressure compressor station (4.5 bar), with redundancy compressor, adsorption dryer, and gas analysis. The plant delivers gas to the Danish natural gas grid (HMN). The gas is produced from pig manure, deep litter, diverse types of straw and maize.

Drying: Alternating adsorption, which can dry down to a dew point of - 70 °C

Electricity consumption at 883 m<sup>3</sup>/h: 77 kW

Heat: Madsen Bioenergi has their own automatic straw furnaces. This uses approximately 200 g straw net/m<sup>2</sup> upgraded gas for the upgrading process. However, the waste heat covers the heat demand for the reactors.

Hydrogen sulfide: At the inlet, the gas contains around 1,000 ppm H<sub>2</sub>S. It is sorted out by the upgrading process to CO<sub>2</sub> stream, so the pure biomethane contains only 0.0 ppm H<sub>2</sub>S.

[www.madsenbioenergi.dk](http://www.madsenbioenergi.dk)**Hias, Hamar NO**Capacity: 300 m<sup>3</sup>/h @ 33 % CO<sub>2</sub>

Commissioned in 2015

Commercial plant. Ammongas scope of supply is limited to the CO<sub>2</sub> separation part and gas analysis. The plant is built on a single stainless-steel frame, suitable for on-road transport.

The upgraded gas is stored in +220 bar vessels for easier distribution and for use for automotive transport.

[www.hias.no](http://www.hias.no)

## **Horsens Bioenergi, Horsens DK**

Capacity: 3,000 m<sup>3</sup>/h @ 33 % CO<sub>2</sub>

Commissioned in 2015

Commercial plant. In addition to the CO<sub>2</sub> separation, there is a low-pressure compressor station (4.5 bar), with redundancy compressor, adsorption dryer, and gas analysis. The plant delivers gas to the Danish natural gas grid (Dong).

## **Ivar, Stavanger NO**

Capacity: 1,300 m<sup>3</sup>/h @ 33 % CO<sub>2</sub>, Prepared for 1500m<sup>3</sup>/h @ 33 % CO<sub>2</sub>

Commissioned in 2016

Commercial plant. In addition to the CO<sub>2</sub> separation, there is a low-pressure compressor station (4.5 bar), with redundancy compressor, adsorption dryer and gas analysis. The plant delivers gas to the local natural gas grid (LYSE).

[www.ivar.no](http://www.ivar.no)

## **Stormossen, Finland**

Capacity: 300 m<sup>3</sup>/h @ 33 % CO<sub>2</sub>

Commissioned: 2016

Placed in Stormossen, Finland at a regional waste management facility. The gas is produced from biodegradable household waste from the municipality and is used upgraded as CBG (Compressed Biogas/bio-methane) for the municipalities garbage trucks in a "closed-loop" system.

## **Biofos Water Treatment Plant, Avedøre DK**

Capacity: 500 m<sup>3</sup>/h @ 33 % CO<sub>2</sub>

Commissioned: 2016

Built as part of the Biogas Park Project, the plant was ordered by HMN-gasnet in cooperation with Biofos who deliver the gas from their waste water treatment. The upgraded gas is grid-injected and was, by opening, the first and only biogas upgrading plant on Zealand.

However, not only the upgraded gas is used. The CO<sub>2</sub> is also separated clean and is used for further upgrading as part of the Biogas Park Project.

## **BB Biogas, Vrå DK**

Capacity: 3,000 m<sup>3</sup>/h @ 33 % CO<sub>2</sub>

Commissioned: 2017

Commercial plant. In addition to the CO<sub>2</sub> separation, there is a low-pressure compressor station (4.5 bar), with redundancy compressor, adsorption dryer, and gas analysis. The plant delivers gas to the Danish natural gas grid.

## **Grønhøj Biogas, Grønhøj DK**

Capacity: 1500 m<sup>3</sup>/h @ 33 % CO<sub>2</sub>

Commissioned: 2017

Commercial plant. In addition to the CO<sub>2</sub> separation, there is a low-pressure compressor station (5.5 bar), adsorption dryer, and gas analysis. The plant delivers gas to the Danish natural gas grid.

## **Nature Energy Månsson, Brande DK**

Capacity: 1,500 m<sup>3</sup>/h @ 33 % CO<sub>2</sub>

Commissioned: 2017

Commercial plant. In addition to the CO<sub>2</sub> separation, there is a low-pressure compressor station (5.5 bar), adsorption dryer, and gas analysis. The plant delivers gas to the Danish natural gas grid.

**Iglsø Agro og Bioenergi,**

Capacity: 2,200 m<sup>3</sup>/h @ 33 % CO<sub>2</sub>

Commissioned: 2018

Commercial plant. In addition to the CO<sub>2</sub> separation, there is a low-pressure compressor station (5.5 bar), adsorption dryer, and gas analysis. The plant delivers gas to the Danish natural gas grid.

## Ongoing Projects

**Ribe Biogas, Ribe DK**

Capacity: 3,000 m<sup>3</sup>/h @ 33 % CO<sub>2</sub>

Commissioned: 2016, expected medio 2018

**Storde Biogas,**

Capacity: 2,200 m<sup>3</sup>/h @ 33 % CO<sub>2</sub>

Commissioned: 2017, expected medio 2018