Business Models for LBG production

Presentation to Go LNG

2017.05.09 | Air Liquide Advanced Business & Technologies Europe
Biogas technologies: from waste to renewable gases

Sources of biogas:
- Organic waste
- Household waste
- Sewage sludge
- Agricultural waste
- Industrial waste

From biogas to biomethane:
- Membrane upgrading module
- Purifier 100,000 Nm³/h

Recovery of valuable methane:
- Bio-CH₄ liquefaction unit
- Cryogenic transport

Applications:
- Large energy company
- Industrial customer
- Chemical industry
- "Blue" mobility

1 ton of waste → 100 m³ of biogas → 60 m³ of biomethane

- Bio-CH₄
- Bio-CO
- Bio-H₂
- Bio-CNG, Bio-LNG, Bio-H₂

5
Neart 10 years of experience in biogas upgrading

100,000
Air Liquide, world leader in biogas purification, with a capacity of 100,000 m³/h

1,000 to 3,500 TWh
Market potential
**UK:**
- **10** biogas upgrading units (2 operated by AL)
  - 2013 – 2015
  - 1000 Nm3/h raw biogas

- **3** CNG&LNG fueling stations
  - +3 to be started during 2017

**USA:**
- **16** biogas upgrading units
  - Landfill gas
  - 2006 - 2014
  - 2350 - 20 000 Nm3/h raw biogas

**France:**
- **8** biogas upgrading units (3 operated by AL)
  - 2012 – 2015
  - 100 – 1 000 Nm3/h raw biogas

- **3** CNG&LNG fueling stations
  - +9 to be started during 2017

**Denmark:**
- **1** biogas upgrading for grid injection
  - 2015 - Denmark
  - 900 Nm3/h raw biogas

**Sweden:**
- **1** biomethane liquefaction plant operated by AL
  - 2012 - 800 Nm3/h bio-CH4

**Germany, Austria, Hungary:**
- **6** biogas upgrading units using AL membranes
  - 2007 - 2015
  - 6 – 1 500 Nm3/h

**China:**
- **2** biogas upgrading for vehicle fueling (CNG)
  - 2015 - 2016
  - 1000 – 1500 Nm3/h
Business model #1: tolling

- AL builds, owns, operates biogas upgrading & liquefaction units

- In this model, the biogas producer owns the molecule all the way: Air Liquide does not buy the raw biogas. The biogas producer has a free choice to decide how to value the bio-LNG on the market.

**Raw biogas**

**Upgrading**

**Liquefaction**

Tolling fee:
- Fix fee €/month
- variable fee €/MWh

Biogas producer

Production

Biogas

Raw biogas

Upgrading

Liquefaction

Liquid

Biomethane

In this model, the biogas producer owns the molecule all the way: Air Liquide does not buy the raw biogas. The biogas producer has a free choice to decide how to value the bio-LNG on the market.
# Tolling vs. purchase of equipment

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<th>Equipment purchase</th>
<th>Tolling offer</th>
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<td><strong>Project balance sheet</strong></td>
<td>Biogas Producer (BP) responsibility</td>
<td>Decrease of overall project risk thanks to strong guarantees</td>
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<tr>
<td><strong>Investments</strong></td>
<td>Needs for equity</td>
<td>Limited to no investment for biogas producer</td>
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<td><em>Transfer of the investment risk</em></td>
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| **Installation performances** | BP responsibility  
Guarantees at commissioning  
Limited level of liability by the equipment manufacturer | Guaranteed by AL *over 15 years*  
Start-up time  
Extraction rate / losses  
Specific energy consumption  
Replacement of faulty material  
*Transfer of the industrial risk* |
| **Operation and maintenance** | Hiring and training of operators for the biogas producer  
Support by the equipment manufacturer but no continuous monitoring! | AL operators trained and shared between several AL plants  
Distance monitoring & control  
*Transfer of the industrial risk* |
Advantages of the Air Liquide tolling solution

- Membrane and liquefaction: two AL proprietary technologies
  - Largely used in AL Group on several gases
  - Experts and R&D continuously improving technology or for troubleshooting

- Integration and cost optimization
  - Only one manufacturer for both technologies responsible for the full package ensuring optimal integration of the two units
  - Improved CAPEX through process optimization (heat recovery)
  - Improved OPEX through synergies on operation and maintenance

- Knowledge of operations
  - Membrane and liquefaction of biogas operation knowledge
  - Local knowledge on liquefier built up at Lidköping

- Transfer of the industrial risk to an experienced gas player
  - Guarantees on start-up, on upgrading extraction rate, on energy consumption
Business model #2: raw biogas purchase

- AL builds, owns, operates biogas upgrading & liquefaction units

- Air Liquide purchases the raw biogas from the producer. The biogas producer has a guaranteed revenue; Air Liquide takes the market risk.

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<th>Biogas producer</th>
<th>Raw biogas</th>
<th>Upgrading</th>
<th>Liquefaction</th>
<th>Liquid Biomethane</th>
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Tolling fee:
Fix fee €/month + variable fee €/MWh

CNG/LNG
Advantages of the purchase of raw biogas solution

■ On top of the tolling model
  ➢ Financing
  ➢ Performance guarantee

■ AL takes the **market risk**
  ➢ Capacity to value the bio-LNG on stations for trucks / industrial customer / marine market
  ➢ Providing the best value for the bio-LNG through access of
  ➢ Guaranteeing a stable revenue for the biogas producer over 15 years
  ➢ Fully interested to run the plant to its highest availability

■ Key challenge of liquefaction project
  ➢ Discrepancy between the need to invest for long period 15-20 years and ability to generate stable revenue
Thank you for your attention