The prospects of biomethane as biofuel for the transportation sector in Europe

Dr. Mattias Svensson, Energiforsk – Swedish Energy Research Centre
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Why biomethane in transports?

• Full utilization of energy with solutions available now
  – Inevitable heat losses in CHP utilization, wind & sun better alternatives
  – Commercially available solutions for oil dependent transports of all types (LDV, MDV, HDV, short, medium and long-distant), with performance on par with diesel soon to come!
  – Natural gas and biomethane: freely intermixed and interchangeable
  – Evident co-distribution and backup synergies (backup for market fluctuations, process failure) allow for 100 % utilization of your biomethane and earlier market buildup

• Promotional value compensates for added costs
  – Steadily increasing the renewable share gives true greening
Biomethane powered transport in Europe

- At the most 1% market share
- 2015: Sweden forerunner (1,124 GWh) followed by Germany (580 GWh)
- …but USA is now no.1 (at least double compared to Sweden)

Biomethane sales 2013 (GWh) / share of total

Sources: European Biogas Assoc., NGVA Europe, newsletters
Lots of opportunities for growth!

• Large biomethane potential, AD + gasification
• Commercially mature market
  – Biogas production, lots of vehicle offers in all different segments, expanding refuelling network
• Dieselgate + The promise of future gas powertrains
  – Real emissions are lower (NO2) and less unhealthy (particles)
  – Dedicated gas engines on par with diesel, 2nd gen dual fuel (methane diesel)
• Key technology of the circular economy and the future sustainable agricultural sector
... but also challenges

- Production capital intensive with low profit margins
- Electric powertrain preferences, e.g. city bus segment
- Market actor inadequacies
  - Complex and heterogenous value chain
  - Marginal segment for both gas industry and vehicle manufacturers
  - Lack of commercial competence
- Public perception and acceptance
- Bioenergy credibility is suffering (energy crops, forestry)
- The need for long-term policy environments
Biomethane as a transport fuel

Not only lower emissions of CO₂ but also particles and SOₓ and NOₓ

<table>
<thead>
<tr>
<th>Vehicle type</th>
<th>Present fuel</th>
<th>Liquid bio fuels</th>
<th>Electric</th>
<th>Hybrids</th>
<th>Biogas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cars</td>
<td>Petrol/Diesel</td>
<td>Yes (%)</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes (CBG)</td>
</tr>
<tr>
<td>Delivery trucks</td>
<td>Diesel</td>
<td>Yes (%)</td>
<td>No</td>
<td>Yes</td>
<td>Yes (CBG)</td>
</tr>
<tr>
<td>Urban busses</td>
<td>Diesel</td>
<td>Yes (%)</td>
<td>Yes (wired)</td>
<td>Yes</td>
<td>Yes (CBG)</td>
</tr>
<tr>
<td>Heavy trucks</td>
<td>Diesel</td>
<td>Yes (%)</td>
<td>No</td>
<td>No</td>
<td>Yes (LBG)</td>
</tr>
<tr>
<td>Train</td>
<td>Diesel/Electric</td>
<td>Yes (%)</td>
<td>Yes (wired)</td>
<td>No</td>
<td>Yes (LBG)</td>
</tr>
<tr>
<td>Ships</td>
<td>Diesel</td>
<td>Yes (%)</td>
<td>No</td>
<td>No</td>
<td>Yes (LBG)</td>
</tr>
</tbody>
</table>
Biomethane potential
Waste, residual products and energy crops

Cities (urban)
- Sewage sludge
- Household organic waste
- Industrial organic waste
- Landfill gas

Agriculture
- Manure
- Residual products
- Energy crops

Forestry
- Residual products from forests and industry

The natural scavenger in all biorefinery schemes; dedicated biogas production show high substrate flexibility with best in class conversion and area efficiency

Interreg
Öresund-Kattegat-Skagerrak
European Regional Development Fund

BioGas2020
Energiforsk
EU-27 Biomethane potential from waste

- Waste water treatment sludge – 68TWh/yr
- Urban biowaste – 180TWh/yr
- Food related waste + park and garden waste, 138 mill. tons
- 40% currently landfilled – may add 40-60TWh/yr* for many years
- Manure – 205TWh/yr
- Waste total 500TWh – Energy crops potential 1,500TWh!
- Current more conservative (with technical constraints) estimate of manure + crop residues potential: 194TWh/yr**

*90% recovery of conservative estimate of 4 mill. ton CH4/yr emitted per year (H Scharff 2008: Untapped potential – Achieving adequate control of landfill gas in Europe)

**f3 2015:07 - ESTIMATING THE EU BIOGAS POTENTIAL FROM MANURE AND CROP RESIDUES — A SPATIAL ANALYSIS
Source for all other data: M Svensson 2010: NGVAE Position Paper – Biomethane, the renewable natural gas
Biogas potential in Europe close to the grid

**EU-28 potential** on par with current road transport needs

2005: 3000 TWh
2020: 5000 TWh

**EU27 2005, road transport: 3,457TWh (296.9 Mtoe)**

*AD and gasification combined; Thrän et al, IE Leipzig 2007, Möglichkeiten einer europäischen Biogaseinspeisungsstrategie

*Abschätzung*
Sustainability of bioenergy questioned

- ILUC – Indirect land use change, the reason behind the 7% cap food based biofuels in EU
- The “carbon debt” issue (gasification!)
  - Long pay-back time for forest-based bioenergy
  - But: Intensified forest management show that BOTH forest growth and increased gross fellings are possible, inclusive of solid biofuels outtake
- Current state of mind:
  - Policies disappearing
  - Lack of trust – is this really the solution for the future?
- Crucial to turn this around in time for post 2020 regulations of biofuels and renewable energy!
Drivers spelled out: Biomethane positive externalities

- Considering the wider picture is important in order for biomethane production to be worthwhile

**Energy value**
- Biomethane

**Socioeconomic:**
- Lesser air pollution
- Closing nutrient cycles
  - Climate mitigation
- Domestic production
  - Job creation
- Agricultural development.
- Securing soil fertility
  (double cropping and catch crops: more micronutrients and soil carbon, alleviate compaction)

**Promotional:**
- Customer demand
- Creating a greener image

**Regulatory:**
- Quota systems
- Feed in Tariffs, premiums
  - CO2 taxation
- Tax exemptions
- Procurements
- National goals

**Interreg Öresund-Kattegat-Skagerrak**

**BioGas2020**

**Energiforsk**
GHG performance biofuels (SWE)

Source: Börjesson, Lundgren, Ahlgren, Nyström (2013)
GHG performance biofuels (SWE)

Source: Swedish Energy Agency 2015: “Hållbara biodrivmedel och flytande biobränslen”
“Low indirect impact biofuels”
(minimizing risks of indirect land use changes - iLUC)

A. Increased productivity  **GO!**

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**NO GO!**

C. Expansion of cropland

Land of high competition and carbon stock & biodiv.

**GO!**

C. Expansion of cultivated land

Land of low competition and carbon stock & biodiv.

B. Increased utilisation of wastes and residues  **GO!**

Source: Pål Börjesson
Goal of IEA Bioenergy: Secure the role of bioenergy in the future biobased economy

• Improved outreach through cooperation with other international bodies

• Support from newly appointed director Faith Birol
  • **FAO**
    Bioenergy & Food Security
  • **GBEP**
    Sustainability assessment
  • **IRENA**
    Policies to stimulate Renewable Energy and bioenergy
  • **SE4ALL**
    High Impact Opportunity Bioenergy to realise jointly market introduction
IEA workshop on iLUC

- Indirect land use change can be prevented!
  - Good agricultural practices
    - Growth Intensification
    - Improved crop yields
    - Nutrient/Water efficiency improvement
  - Holistic Approach
    - Integrate solutions for demand for food, fibres, fuels
    - Reduce waste of resources

Source: Kees Kwant IEA Bioenergy Conference 2015
How to use the future emission space?

• Some of the emission space up to the 2 degree goal could be used to develop a bioenergy industry to provide renewable and climate friendly energy services for the world

Source: Anette Cowie
The future gas engine with diesel-like performance

- Current commercial trends:
  - Scania Euro VI dedicated otto gas engine 340 hp: Sweet spot 40% efficiency, only 7% fuel penalty mixed driving. Rumours about >400hp version!
  - Westport HPDI 2.0: dual-fuel direct injection with diesel-like performance, launch in Europe late 2017? e.g. Volvo
The future gas engine with diesel-like performance

- Ongoing research:
  - Improved low load performance and increased max. power close to the dilution limit through high turbulence pistons, EGR, turbocharging, higher compression and model based control
  - Increasing dilution limit further: Fuelled prechamber tech delivered 47.5% efficiency at 10 bar IMEPg at first go (no optimization)

- But: It all hinges upon the gas quality delivered!
Gas quality challenge when considering CNG/biomethane powered transport

• A growing but still emerging market situation where peripheral market segments of two major business actors (grid owners and OEM’s) interact
  – Challenge: Reach low emissions and high fuel efficiency in heavy duty gas engines without risking the gas core business
  – Cost optimisation across two businesses: trust and cooperation needed, despite complexity
  – New conditions: Euro VI Certification on real market fuels with durability testing included (after 700,000 km or 7 years on the road)
Why not cooperate to secure future NGV market growth?

• Joint market ventures, e.g. non-grid based distribution of MN 70+ gas for heavy-duty sector
• Joint research a way ahead? (Horizon 2020)
  – Sulfur free odorization
  – Fit for purpose gas quality sensor development (e.g. onboard) to change engine ignition timing cycle-to-cycle
  – Gas engine research
  – (R&D cheap online biogas analysis equipment)
Final remarks

• The complex research showing the environmental and socioeconomic sustainability benefits of bioenergy need to be disseminated AND demonstrated!
• Public-private partnerships and long-term policies are key in building a biomethane powered NGV market!
  – Medium but long-term policy environment, preferrably % market size!
  – The whole value-chain need to be involved from the beginning!
  – Future efficient gas powertrains calls for cooperation between gas industry and vehicle manufacturers!
• More commercial competence building needed!
• Customer oriented approach, making gas powered transport more “sexy”
• In the background: Reduction of OPEX and CAPEX through continued technology improvement and increased understanding of the AD biology regarding the technology of the process
Prospects biomethane as biofuel in Europe

Thank you for the opportunity!
Questions?

Welcome to meet up at any of our conferences!
Gasakademin sommarinternat (summer school) 8-12 Aug 2016 in Hallsberg, www.gasakademin.se

mattias.svensson@energiforsk.se
www.energiforsk.se (www.sgc.se)
Biomethane: USA now no. 1

- Reliable stats only for California, but according to source roughly 90% of available biomethane finds its end-use here because of better frame conditions
- Stats from 2014, The Swedish total gas volume corresponds to 159 million m3
- So more than double the consumption in California

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<thead>
<tr>
<th></th>
<th>Sweden</th>
<th>California</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual Traditional NG Use (BCF)</td>
<td>2,174,403,982</td>
<td>8,401,702,738</td>
</tr>
<tr>
<td>Annual RNG Use (BCF)</td>
<td>3,244,879,788</td>
<td>7,976,973,875</td>
</tr>
<tr>
<td>Total Annual NGV Use (BCF)</td>
<td>5,419,283,770</td>
<td>16,378,676,613</td>
</tr>
<tr>
<td>Percent Traditional NG Use</td>
<td>40.1%</td>
<td>51.3%</td>
</tr>
<tr>
<td>Percent RNG Use</td>
<td>59.9%</td>
<td>48.7%</td>
</tr>
</tbody>
</table>

Source Data (tack till Erik Neandross för dataframtagningen)

http://www.arb.ca.gov/fuels/lcfs/media_request_092215.xlsx
Examples US incentives for biomethane

- **Renewable Fuel Standard (FS2 – federal)**
  - Conventional fuel suppliers need to purchase RINs (Renewable Identification Numbers) to fulfil their RVO (Renewable Volume Obligations)*
  - RVO target 2013: 16.55 billion gallons, total 9.63%, including special quotas for cellulosic, advanced and biomass based diesel (conventional share = 6.9%); 2022 goal: 36 billion gallons
  - Blend wall (10% EtOH) effects, cellulosic biofuels waiver credits
  - Biogas from landfill, WWTP or manure digesters = advanced; landfill eligible to fulfil cellulosic advanced biofuel obligation! 3-12 USD/mmBTU (2014)

- **Low Carbon Fuel Standard (LCFS, California)**
  - Similar market based cap and trade system used in California
  - Demands reduction of carbon intensity, from 0.25% (2011) to 10% (2020), also natural gas and electricity eligible
  - 20-80 USD/ton CO2 (Source: Harrison Clay, CERF, 2014)

- **Late 2015:** 6-13 USD/mmBTU for RINs, 2-4 USD/mmBTU for LCFS → 0.25-0.5 SEK/kWh .... (293kWh/mmBTU, 8.50 SEK/USD)

* "RINs and RVOs are used to implement the Renewable Fuel Standard" [http://www.eia.gov/todayinenergy/detail.cfm?id=11511](http://www.eia.gov/todayinenergy/detail.cfm?id=11511)
Illustration landscape scale: Berndes 2011
Balancing objectives: Switchgrass crop as cellulosic bioenergy source

- Design of crop plantings may both improve water quality and increase profits while achieving a feedstock-production goal