The potential of biogas in a 100% renewable energy system in Denmark

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Iva Ridjan Skov
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Aalborg University
DENMARK

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Innovation Fund Denmark

4DH
Applications for biogas

Power and district heat

Industry

Metan (PJ/year)

Source: GASEnergi, Danish Gas Association, June 2018

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5th International Conference on Smart Energy Systems
Copenhagen, 10-11 September 2019
#SESAAU2019
A reference model is set up for Denmark 2050

• 100% renewable
• No biogas
• Methane produced via biomass gasification and biomass hydrogenation
• Limited excess electricity
• Technical simulation
• Derived from IDA Energy Vision 2050
• EnergyPLAN use in the analysis
Biogas as a fuel and its derivatives

**Feedstock**

- Biogas
- Hydrogen

**Conversion**

- Purification
- Methanation

**End fuel**

- Biogas
- Biomethane
- E-methane

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5th International Conference on Smart Energy Systems
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#SESAAU2019
Biogas utilization scenarios

- Power plants: Replacing methane from biomass gasification
- Industry: Replacing methane from biomass hydrogenation
- Transport: Replacing liquid fuel from biomass hydrogenation
PES and biomass consumption

- 59.73 TWh PES for Ref
- 58.47 TWh PES for Power and heat
- 63.49 TWh PES for Industry
- 58.47 TWh PES for Power and heat
- 63.49 TWh PES for Industry
- 62.44 TWh PES for Transport
- 56.75 TWh PES for Power and heat
- 61.74 TWh PES for Industry
- 60.77 TWh PES for Transport

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- Fonden Energi & Miljødata
# Energy system costs

*Biomass price 6 €/GJ

<table>
<thead>
<tr>
<th>Marginal system cost difference [M€]</th>
<th>Biogas</th>
<th>Biomethane</th>
<th>E-methane</th>
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<td>Power plants</td>
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<th>Gasified biomass + H₂</th>
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## Energy system costs

*Biomass price 8 €/GJ

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Gaseous fuel costs

Liquid fuel costs in reference
Cost breakdown

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- Biogas plant
- Biogas purification
- Biogas methanation
- Electrolysis
- Wind
- Compression

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• If biogas
  – Power and heat/industry show high cost reductions
  – Power and heat/industry more appropriate if biogas is suitable
  – Fuel distribution could be an issue/imply a higher cost

• If biomethane
  – Versatility + low cost for all analyzed sectors
  – Transport seems the most suitable but high competition with electrification
  – More resilient to feedstock price changes

• If e-methane
  – Feasible in transport sector only
  – It competes with liquid fuels (cheaper) and electric vehicles
Conclusions

• More emphasis on gasification technologies
• Biogas as end-fuel is preferred independent of sector used and high biomass prices
• Biomethane should be used where biogas cannot (power and heat/industry)
• E-fuels have a role, but P2G does not present economic feasibility compared to alternatives.
• Biogas potential might suffer from change in dietary habits.
Thank you!

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