EXPLOITING POTENTIAL FOR ECONOMIES OF SCALE IN BIOGAS PURIFICATION INFRASTRUCTURE

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Framework

- Current business model: combined on-site heat and power generation
- Changes in regulation in Germany and coupling of sectors → new business models required
- Approach: biogas purification and injection into the natural gas grid

Business model of biogas plants in Germany

- 8500; 98%
- 200; 2%

Source: Daniel-Gromke et al. (2017)
Advantages of biomethane

• New business models for existing biogas plants
• Greenhouse gas savings
• Flexible and universal applicability
  o Off-site CHP generation
  o Fuel replacement in mobility sector
  o Heat market
• Use of an existing infrastructure

Synergy effects

• Degression in investment costs for purification plants
• Smallest size (250 m$_N^3$) exceeds average production of biogas plants in Germany (180 m$_N^3$) and the research region (150 m$_N^3$)

Source: Beil et al. (2019)
Approach

- Purification and distribution infrastructure is needed
- Different impurities
  - desulphurization and dewatering
  - removal of carbon dioxide
- Minimize system costs for biogas purification by cooperation
  - Costs for upgrading plants (investment costs and annual expenditure)
  - Costs for pipelines (investment costs)

Research hypothesis:
Construction of a joint purification plant including biogas pipelines is economically advantageous compared to individual on-site purification infrastructure
Biogas
Methane concentration: ~ 54 %

Model

Biomethane
Methane concentration: ~ 95 %

Feedstock
Digester
Biogas pipelines
Central purification plant
Gas grid
Utilization

Power & heat (CHP)
Heat
Mobility

Methane concentration:

Biogas
Methane concentration: ~ 54 %

Biomethane
Methane concentration: ~ 95 %
Clusters are created by K-means algorithm

Solution:
• Pipeline
• Purification plants
Case study

- Reference region: administrative district of Osnabrück county
- 90 biogas plants in the region
- Average biogas plant size
  - Raw biogas volume: 150 $\text{m}_N^3$/h
  - Installed capacity: 560 $\text{kW}_{\text{el}}$
- No existing biogas purification to biomethane
Results

- Individual purification:
  - Annual system costs: 39.87 million euros
  - Even the smallest purification plants are significantly overdimensioned
- Joint purification:
  - 14 clusters (3 - 12 biogas plants)
  - Annual system costs: 22.82 million euros
  - Cost savings: 43 %
Results

• Purification costs in individual facilities significantly higher
• Pipeline costs for fewer clusters higher
• Make use of spatial proximity of biogas plants
  o Cooperation
  o Exploitation of cost degression
Cluster 1: 250 mₙ³ biogas

Cluster 2: 500 mₙ³ biogas
- 500 mₙ³ capacity for purification plant

Cluster 3: 250 mₙ³ biogas

3 Clusters:
System costs: 261,113 € per year
Capacity optimally used

Cluster 1: 350 mₙ³ biogas
- 500 mₙ³ capacity for purification plant

Cluster 2: 550 mₙ³ biogas
- 1000 mₙ³ capacity for purification plant

2 Clusters:
System costs: 275,425 € per year
Worse utilization of capacity leads to higher costs
Variation of upgrading plant location

- NP-hard optimization problem
- Two possible locations for purification plants are provided

- First approach: purification plant is placed at the center of the cluster
- Second approach: purification plant is placed next to the biogas plant closest to the gas grid
- Cost-optimal option is selected by model
Conclusions and policy recommendation

- System costs are almost reduced by 50 % using joint purification
- Economics depend on
  - Availability of gas infrastructure
  - Options of cooperation
- Verified with real data
  - Highly relevant for further infrastructure development
  - Flexible adaptation to local requirements of other regions
- Next steps
  - Examination of the economic efficiency in detail
  - Feasibility depends on various framework conditions (e.g. acceptance of biogas plant operators)
Thank you for your attention!

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