Critical challenges for future biorefineries and biofuels: Lessons from Sweden

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Examples of key feedbacks

Innovation System

Research & Education

Development

Demonstration

Market formation

Diffusion

Contextual factors: e.g., industry, country, climate, crises

Actors

Networks

Institutions
Restructuring of production and consumption systems
Diffusion in mass markets
Diffusion in niche markets
Demonstration projects
Research and Development

Diffusion of the technical system

Concept development phase
Demonstration phase
Niche market phase
Commercial growth phase
Maturity phase

Time
Figure 1: Actors, networks, and technological trajectories of the Swedish Advanced Biorefinery Technological Innovation System (AB-TIS). See also Energimyndigheten (2014b).
System strengths

• Significant existing biorefinery related activities: Domsjö, Preem/Sunpine, Lantmännen. Perstorp..
• Considerable research infrastructure: Övik, Piteå, GoBiGas / Chalmers, Bäckhammar, Umeå / Holmsund etc.
• Products such as ethanol, DME/methanol, biodiesel, and biogas has been tested in practice.
• Most prominent research actors and entrepreneurial companies
• The actors are linked in a strong network of international connections
• Long-term research funding
• The processing of biomass into high value products are considered legitimate
• Key competences and industrial structures in the example process and chemical industry, oil industry and district heating sector.

• Clear vision around a fossil-fuel independent vehicle fleet
The challenge for the future of biorefineries: shift the area into a new phase!

From demo:
Ö-vik, Piteå, Gobigas etc.

8-12 Commercial plants
~20TWh
System weaknesses

W1: Lack of policy instruments in niche market and commercial growth phase

W2: Weak coordination between ministries, agencies, and regional actors

W3: Weak industrial participation and industrial absorptive capability

W4: Weak collaborations over knowledge and organizational boundaries

W5: Unclear roles, collaborations, ownership, and financing of research infrastructure

TIS-INTERNAL

W6: Competition from fossil fuels and alternative use of raw materials

INTERNATIONAL
Increased competitiveness against incumbent alternatives

Neutral incentives: CO₂ taxes, Emission Trading Systems, etc.

Type II: Verification
$: Public R&D

Type I: High Profile
$: Private

Type III: Deployment
$: Investment support and market schemes

Type IV: Permanent
$: Public and Private R&D

Maturity of a Technological Innovation System (TIS)

Demonstration Phase
Niche market
Growth Phase

(a) important overlaps in policy
(b) important overlaps in policy
(c) important overlaps in policy
(d) important overlaps in policy
Current biofuel situation in Sweden

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Share of biofuels in the Swedish road transport sector

Target in EU Renewable Energy Directive to 2020
Biofuels in the Swedish road transport sector

• Low-blend fuels:  
  - Ethanol (in petrol)
  - FAME (in diesel)

• High-blend fuels:  
  - Ethanol (E85 & E95)
  - FAME (100)
  - Biogas (CBG & LBG)
  - HVO diesel (drop-in)
The rise and fall of E85

Volume E85

Flexi-fuel cars

SPBI 2015; Bil Sweden 2015
Bi-fuel (methane) cars & Electric cars

Gasbilar - Methane cars
Elbilar - Electric cars

Bil Sweden 2015
Tall oil-based HVO as drop-in fuel in diesel

Forest company

“Innovation” company

Oil company

Photo: Magnus Wikman, SunPine

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>Idea</td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td>Commercial plant</td>
<td></td>
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<tr>
<td>2015</td>
<td>100,000 m³ biodiesel</td>
<td></td>
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Feedstock for the HVO used in Sweden

Approx. 19% domestic feedstock (64% Europe and 16% S.E. Asia)
Grain-based ethanol production systems

- Grain
- Cellulosic feedstock
- Process energy
- Forest residues
- Ethanol
- Protein feed
- Compressed carbon dioxide

Photo: Agroetanol
Feedstock for other biofuels

**Ethanol**: 19 % domestic (55 % Europe, 16 % Ukraine, 10% US & Brazil)

**FAME**: 7 % domestic (61 % Europe, 17 % Australia, 15 % Ukraine & Russia)

**Biogas**: 94 % domestic (6 % Europe)

**EU RED**: Maximum 7 % crop-based biofuels!

Swedish Energy Agency 2015

(12 % biofuels in Sweden x 58 % crop-based = 7 %)
Conclusions

• The use of biofuels is continuously increasing in Sweden and the EU RED 2020 target (10 %) has been reached 7 years in advance

• The use of biofuels consist of a mix of different types of biofuels, as well as low- and high-blend fuels, and the composition changes over time

• Less than 20 % is based on domestic feedstock and less than 10 % on lignocellulosic feedstock (but this is domestic)

• The two main trends during the last two to three years are the significant reduction in E85 and the rapid increase in HVO as drop-in fuel

• The revised Renewable Energy Directive (after 2020) will not have any new biofuel targets on a EU level - rely on new domestic targets instead?