2 steps forward but 5 back in Swedish advanced biofuels
Interplay between policy & technology commercialization

BIOENERGY 2017
Sydney, 20-23 November, 2017

Why?

– Lofty Swedish goals for carbon neutrality (2050) and oil independence in transport
– Sweden can’t(!?) decarbonize 85 TWh transport sector without large scale low carbon fuel production
– Forest sector feedstocks central to future fuel plans
– Very significant sunk costs in research, pilots, and demonstration projects

– Large scale projects cancelled or ‘placed on hold’
– Policy frameworks always blamed but ....
Knowledge gaps & outcomes

- assessment of project alignment with incumbent technical & institutional systems
- stronger understanding of synergies and competitive issues between fuel platforms.
- Clearer understanding of (in)effectiveness of policy interventions

Download the report at:
http://www.f3centre.se/research/program/analys_av_systembarriarner
Yes. Policy instability was, and is, a crucial barrier to investment

But project proponents failed to recognize or deal with a raft of issues crucial to commercial viability
### Project cases & informants

#### Cases

<table>
<thead>
<tr>
<th>Cases</th>
<th>Technology, Feedstock &amp; Output</th>
<th>Plant capacity (MW capacity and approx. production)</th>
</tr>
</thead>
</table>
| Chemrec and Domsjö Fabriker, Örnsköldsvik Chemrec | Entrained flow biomass gasification, black liquor, Output: DME or methanol | 100 MW  
≈ 1000 GWh/yr |
| LTU Green Fuels, Piteå | Entrained flow biomass gasification, black liquor & pyrolysis oil, Output: DME and methanol | 3MW |
| Luleå University of Technology | Gasification, forest residues & waste, OP: methanol and/or methane | 250MW  
≈ 1800 GWh/yr |
| Bioraff (biorefinery) Norrtorp SAKAB et al., Kumla | CFB gasifier, wood chips, OP: methanol, heat | 110MW  
≈ 600 GWh/yr |
| Värmlands Metanol, Hagfors Värmlandsmetanol AB | Indirect gasification, solid biomass (pellets at first), Output: methane, heat | 20MW (≈100 GWh/yr)  
100MW (≈800-1000 GWh/yr) |
| GoBiGas, Göteborg Göteborg Energi (municipally owned energy company) | Gasification, wood chips, forest residues, Output: methanol | 325MW_{th} feedstock  
200MW biogas  
≈ 1600 GWh/yr |
| Bio2G E.ON Sverige AB (E.ON Sweden) | Catalytic conversion of lignin into lignin oil | >3000 tonnes/year  
>20 GWh/year |
| Renfuel | Diverse: HVO from bio-diesel Biooils to diesel Solid biomass to diesel (future?) | 160 000 m³/year  
≈ 1600 GWh/yr |
| Preem | Raw tall diesel separated from raw tall oil | 100 000 m³/year  
≈ 1000 GWh/yr |
| SunPine, Piteå Södra (other owners: Preem, Sveaskog, Kiram, and Lawter) | | |
De-oiling

Figure 2 Total energy supply by energy commodity 1971 – 2013, TWh

Source: Swedish Energy Agency and Statistics Sweden.
Transport – tough nut

Source: Swedish Energy Agency and Statistics Sweden.
Timing

[Graph showing the comparison of Crude oil and Natural gas prices over time, with an emphasis on timing and price movements.]
Socio-technical system: concepts

- Innovation Regime
  - Macro-level: economic and macro-political trends, significant environmental changes, demographic trends
  - Macro-level: deep structure of the system
  - Meso-level: technologies, infrastructure, institutions, practices, behavioural patterns, markets, industry structures
  - Micro-level: A small segment of a market suitable for a technological innovation

Landscape (exogenous context)
Regime
Policy
Markets
Culture
Science
Industry
Technology

Time
What sorts of projects?

A super-quick look at three on the list
**eON. Bio2G**

4-5 billion SEK
4-500 million €

<table>
<thead>
<tr>
<th>Fuel Input</th>
<th>Feedstock mass</th>
<th>Biogas production</th>
<th>Biogas annual</th>
<th>Biogas efficiency</th>
<th>Total efficiency</th>
<th>Heat</th>
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<tbody>
<tr>
<td>325 MWth</td>
<td>Circa 1Mtpa biomass (forest chips, slash)</td>
<td>200 MW  ~ 21 000 m³/h</td>
<td>Circa 1600 GWh</td>
<td>62-63% (excl. ASU)</td>
<td>70-80%</td>
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<td>Other products</td>
<td>10MW internal power potential for N₂liquid potential biorefinery setup for CO &amp; H₂</td>
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</table>
Bio2G – A large private utility

GoBiGas – ’cousin’ project

1 billion SEK
100 million €
GoBiGas – municipal utility

- Erection 20 MW plant 2010 – 2012
- Thermal fuel power - biomass 32 MWth
- Producer gas of gasification 24.5 MWth
- Thermal power gasification (district heating) 2.5 MWth
- Thermal fuel power - SNG 20 MW
- Thermal power methanation (district heating) 1.3 MWth
- District heating temperature 130°C / 75°C
Growing the vehicle gas market

Biogas is viable in a transport fuel market where tax exemptions favour biofuels.

Industrial market not viable for biogas.

PREEM + SUNPINE

Bio feedstock

Fossil feedstock
<table>
<thead>
<tr>
<th>NICHE innovations</th>
<th>Case parameter</th>
<th>Bio2G</th>
<th>GoBiGas</th>
<th>Värmlands - metanol</th>
<th>Biorefinery Norrtorp</th>
<th>Renfuel</th>
<th>SunPine</th>
<th>LTU Green Fuels</th>
<th>Chemrec - Domsjö</th>
<th>Preen</th>
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Number/Strength of protected spaces
- Core technology (e.g. a scale gasifier plant, system maturity)
- Enabling technologies (e.g. compatible 1st gen. or fossil production fuels & infrastructure)
- Distribution infrastructure, vehicle fleets, offset markets ...

<p>| Climate discourse | + | + | + | + | + | + | + | + | + | + |
| Enviro/resource eff. discourse*** | ++ | + | +/− | +/− | ++ | + | ++ | ++ | + | + |
| PROPOINTER STRATEGIES | Contribution to Cognitive &amp; Sociopolitical legitimacy | ++ | + | − | +/− | + | +++ | + | +/− | ++ |
| Organisational | + | − | +/− | +/− | ++ | ++ | + | + | + | +++ |
| Intra-industry | +++ | ++ | − | + | +/− | + | +++ | +/− | +/− | +/− |
| Inter-industry | ++ | + | +/− | + | ++ | +++ | + | − | +++ |
| Institutional | + | ++ | − | − | +/− | +/− | + | + | + | ++ |</p>
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Ambitious plans – Difficult prevailing conditions

Projects that have not moved forward

...these projects – each in their different ways – aimed to achieve a substantial substitution of incumbent technologies in the established socio-technical system for transport fuels.

Such degrees of ambition, and the strategies pursued, were not feasible under the prevailing political and institutional conditions.

Projects deemed impossible earlier than oil price fall
Stepwise reconfiguration (I)

Pursuit of more stepwise strategies (e.g. Preem/Sunpine)

- modular innovation within the biofuel supply chain replacing parts of the fossil system
- Avoid substantial change to incumbent system (e.g. production, distribution, refuelling).
- able to develop within the existing and difficult institutional conditions – lesser sensitivity to policy instability – parts of larger businesses
- coalition of strong industry actors
- Different partner goals but synergistic outcomes
Stepwise reconfiguration (II)

• significantly lower capital investment requirements in comparison to full (e.g. gasification plant, whole plant, ..)
• Market larger than supply
• Not disrupting/impacting deep sunk cost items (e.g. within a pulp mill)
• But ...
  – Limited ‘1st choice’ feedstock
  – By no means cheap or low risk
Substitution strategies – creating new systems

- Fuel market creation
- Entire plants
- Fleet/motor platform creation
- Distribution and refueling infrastructure
- Elevated technological risk
  - Too much to change, too many variables.
  - Too much dependence on long term policy support
Yes policy instability was and is a crucial barrier to investment

But project proponents failed to recognize or deal with a raft of issues that were crucial to the commercial viability (and thus investability) of projects ....
Unrealistic expectations of Swedish Policy

- Decarbonisation of transport fuel subject to SUPRAstate rule systems – state aid + restrictions on tax exemptions + …. (<3 year time horizon)
- Over-estimation of the ability of SE policy to influence EU
- Expectations of support beyond the ability or feasibility of political actors
- Sectoral actors blamed policy
- Actors now increasingly aware of systemic issues
Media & Political attention always shifting to the next ‘big thing’

- Biofuels versus electrification
- DME contra Ethanol contra methanol contra …… (!)
- Insufficient resources/resource competition
- Relative land and climate benefits
- A coordinated biofuel community?
- A clear overarching message that engages the public?
- The flavour of the day dominates …
P38116-1 Examining in-built systemic constraints and drivers for the expansion of forest-derived transport biofuels

(Analys av systembarriärer för produktion av skogsbaserade drivmedel)

Thankyou!

This project was financed by the Swedish Energy Agency and f3 – the Swedish Knowledge Centre for renewable fuels.
Niches and market creation

Examples that are often asked for ....
Hosted or protected applications (sheltered niches)

- Bus/truck fleets (biogas, ethanol, biodiesel)
- Municipal vehicle fleets (biogas)
- Preferential access to markets (taxi queues, municipal waste contract eligibility, ...)
- Forest fleets (DME)
- Asphalt (DME/LPG substitution)
Incremental growth in protected spaces and ‘learning by using’ (Swedish vehicular biogas as an example)

- Modular expansion of market then infrastructure
- Stand alone/mini-grid systems
- Piggy-backing on grid-infrastructure
- Municipal underwriting/goal alignment
- Fringe-benefit tax deductions
- Cross-border supply

- BUT …. distributed, incremental market that must be grown actively prior to investment
Co-evolution/Synergies with markets

• Biomethanol:
  – biodiesel feedstock (ILUC thresholds)
  – maritime sector (niche/protected marine bodies such as Baltic, Öresund, ...)

• DME – asphalt markets/sub-regional climate goals, ....

• DME /Biomethane metals sector ?