Implication of Transport Policies when meeting Swedish Climate Goals

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AGENDA

• Background: Why
• Background: Swedish Energy System
• HOW: Energy system optimisation modelling using TIMES-Sweden
• HOW: Transportations in TIMES-Sweden
• Scenario Analysis: Policies & Framing
• Some results: Vehicle types
• Some results: Biofuel produces
• Insights (results analysis are in progress)
A climate policy framework & a climate and clean air strategy for Sweden entered into force Jan 2018

1. **A long-term climate goal**: By 2045 - at the latest - Sweden will have no net emissions of greenhouse gases.

2. **Intermediate targets** only for emissions outside the EU Emissions Trading System (known as the non-trading sector/NETS).
   - NETS targets for year 2030 and 2040.
   - **Transport sector targets for year 2030.**

3. **A clean air strategy** with a focus on reducing air pollutants (NOX, SO2, VOC, NH4 and particles) and thereby improved air quality.

Net-zero means 15% of reduction can be offset by: i)LULUCF, ii)abroad, iii)BECCS
Net Zero GHG in 2045

Almost fossil free space heating
Low carbon electricity and DH production
Large forestry potential
High share of biofuels in the transport sector
Energy intensive industry sectors
An increasing transportation demand.
BACKGROUND: Swedish Energy System

Final use of energy per sector (TWh)
Source: Swedish Energy Agency (2017)

Final Energy Use per Energy Carrier (TWh)
Source: Swedish Energy Agency (2017)

Final Energy Consumption by sector in year 2015
BACKGROUND: Swedish Energy System

Final energy demand in Transport sector by Transport mode (TWh)

Source: The Swedish Energy Agency & Statistics Sweden
Final energy demand in Transport sector by Fuel (TWh)

Source: The Swedish Energy Agency & Statistics Sweden
**BACKGROUND: Swedish Energy System**

**Biofuel in Transport sector per Fuel type (TWh)**

- Biogas
- Biodiesel
- Bioetanol

Source: The Swedish Energy Agency & Statistics Sweden
HOW
Energy System Optimisation Modelling using TIMES-Sweden
**TIMES-Sweden** identifies how limited resources can be allocated in order to minimize the total system costs.

**TIMES-Sweden** is a comprehensive energy system model represented by seven (soon eight) main sectors: Industries, Residential, Services, Agriculture, Transports, ELC & DH and Energy supply and fuel production. The model is driven by the demand for energy-intensive goods and services.

**TIMES-Sweden** is based on the TIMES-platform (IEA-ETSAP) and share the main structure with, e.g., JRC-EU-TIMES.

- **Energy system optimisation model**
- **Comprehensive Energy System**
- Dynamic LP-model (12 per/year)
- Long-term Modelling (20-50 years)
- Bottom-up/Techno-economic model
- Cost minimisation
- Multi-Partial Equilibrium Model
- Technology Rich

**Developments:**
- Initially developed as a part of the Pan European TIMES model (PET model), within two EU funded projects (NEEDS and RES2020).
- Emissions-factors/Ancillary benefits (Krook-Riekkola et al. 2011)
- **Iron- and steel industry** (2012)
- District heating (Krook-Riekkola & Söderholm, 2013), (Pädam et al., 2013)
- **Demand** through soft-linking with EMEC (Krook-Riekkola et al. 2013a, 2013b)
- Residential sector (Boverket, 2015)
- **Biomass** (Fjänsyn project, 2015-2017)
- **Transportation** (on-going PhD project/Jonas Forsberg)
- **Industry sectors** incl CCS (on-going PhD project/Erik Sandberg)

**Documentation:** TIMES-Sweden is described in Krook-Riekkola (2015). The model is similar to the JRC-EU-TIMES model, documents by Simoes et al. (2013).
New modelling runs with improved biomass description, and included additional biofuel and industrial options.

Comparing resulting CO2-emissions from TIMES-Sweden, before (left) and after (right) implementing a more detailed description of biomass + additional fossil fuel replacement.
New modelling runs with improved biomass description, and included additional biofuel and industrial options.

→ By improving the technology representation → the CO2-emission reduction path differ significantly.
→ Fundamental new technologies is entering the arena → important to update accordingly.
TIMES-Sweden: How is transportations described?

Fuel production
- Refineries (fossil fuels),
- Integrated biofuel prod within old ref,
- Integrated biofuel prod within industries,
- Stand alone biofuel plants.
- Combination of biofuel, district heating and electricity production.
- Electricity generation. (Don’t have hydrogen in present model).

Different kinds of biofuels
- Biodiesel (TRA)
- Biogas (TRA)
- Bio DME (TRA)
- Ethanol (TRA)
- Bio FT-diesel (TRA)
- Bio methanol (TRA)
  - (H2 for transport gaseous (TRA))
  - (H2 for transport liquid (TRA))

TIMES-Sweden a national ESOM

Transportation modes
- Aviation International  PJ
- Aviation Domestic  PJ
- Road.Bus.Intercity.  Million_Pkm
- Road.Bus.Urban.  Million_Pkm
- Road.Car.Long.Distance  Million_Pkm
- Road.Car.Short.Distance  Million_Pkm
- Road.Freight.Light  Million_Tkm
- Road.Freight.Heavy  Million_Tkm
- Road.Moto.  Million_Pkm
- Navigation.Generic.  PJ
- Rail.Freight.  Million_Tkm
- Rail.Passengers.Light.  Million_Pkm
- Rail.Passengers.Heavy.  Million_Pkm

More biofuels compared with average model
Really simple, too simple?
No behaviour introduced
Scenario Analysis & Some Results
## Scenarios: Demand and Prices

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<td>Vehicle 3</td>
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**Baseline**
- REF: Transport demand in line with official projections (Swedish EPA & Energy agency, 2017)

**Extrem-WC**
- Extrem-WC: Scenario 'Basprognos' from Trafikverket (2018)
- Exogenously given for year 2030, according to BM scenario in (Algers, 2017)

**Extrem-BC**
- Exogenously given for year 2030, according to BM-techup scenario in (Algers, 2017)

**Bio 1**
- High = "Current policies" in table 4 in IEA (2017)
- Low = "Sustainable development" in table 4 in IEA (2017)

**Bio 2**
- Baseline XX X X

**Vehicle 1**
- Exogenously given for year 2030, according to BM techup scenario in (Algers, 2017)

**Vehicle 2**
- High = "Current policies" in table 4 in IEA (2017)

**Vehicle 3**
- Low (Low production/harvesting)
## Scenarios: Policies

<table>
<thead>
<tr>
<th>Scenario</th>
<th>1. Climate Targets (CO2-emission targets)</th>
<th>5. Policy: FF-Reduction obligation system (Reduktionsplikt)</th>
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<tbody>
<tr>
<td>Baseline</td>
<td>A: Meet the Overall Target (2045) and the Transport target (2030) (=restriction in the model)</td>
<td>Separat e systems for diesel and gasoline</td>
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<td>B: Not necessary meet any of the targets (= no restriction in the models)</td>
<td>Joint systems for diesel and gasoline</td>
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<td>E: Meet the Overall Target (2045) (=restriction in the model)</td>
<td>Only include biofuels in diesel- &amp; gasolin-pumps</td>
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<td>F: Meet the Transport target (2030) (=restriction in the model)</td>
<td>Include all biofuels for road transpo rations</td>
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<td>C: Not necessary meet any of the targets, NO fuel-reduction-system</td>
<td>Target in 2030 (%)</td>
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<td>D: Meet the targets, NO fuel-reduction-system</td>
<td>Biogas include d in the system</td>
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<tr>
<td>Baseline scenario</td>
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<td>Extrem - WC</td>
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Key assumption

• Assume present taxes, electric certificate system and EU-ETS

• Main biomass is forest residuals and bi-products from the industry (biomass potential derived from forest models).

• No import of biofuels after 2020 (at present >80% import, even though large resources exist, but this rely on newer technologies)

• BECCS <6.5 M ton CO₂
The car fleet in 2025 (1000s vehicles)

- BEV
- Biofuel
- Biogas
- Diesel
- Gasoline
- HEV/PHEV diesel
- HEV/PHEV gasoline
The car fleet in 2030 (1000s vehicles)
The car fleet in 2035 (1000s vehicles)
The car fleet in 2040 (1000s vehicles)
The car fleet in 2045 (1000s vehicles)
City buses in each scenario 2030 vs 2045
Final energy demand by Fuel type

Final energy demand in Transport sector by Fuel (TWh)

- Electricity
- Biofuels
- Biogas
- Natural gas
- Oil
- Diesel
- Gasoline
Takeaways

• Useful to create sets of couple-scenarios (with/without climate targets).

• Even a basic TIMES model of the comprehensive national energy system can capture vehicle-shifts in a decent way (of course not fully).

• Biofuels can be produced in many different ways, as well as it can be used for many different purposes (including exporting to other countries). Important to capture the entire biofuel route.

• Extensive interactions with the analyst at the Swedish environmental protection agency.
  - Discussed what should be analysed
  - Discussed what should be presented
  - Scrutinized the result with new eyes
  → Takes time, but provides more robust results and insights
Thank you for the attention
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