Modelling urban transports in a city energy system model – Applying TIMES on Malmö

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A climate policy framework & a climate and clean air strategy for Sweden

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 (70% reduction).

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

AIM: Support smart city level integration of policies and measures towards a low carbon energy system including mobility services

Part delivery: A generic TIMES-City model

• EU ERA-NET project, 2016-2018
• Partners in Austria, Portugal and Sweden

PhD PROJECT

TIMES-Sweden

AIM: To improve transport sector representation within and around TIMES

• Identifying how the Swedish transport sector could be sufficiently described in an energy system optimisation model with the overall aim to improve the analysis of the transition to a Net-Zero GHG in Sweden.

• Consider both recourse, technical, economic, environmental and behavioural (e.g. choice of transport mode) factors

• NOT necessary include everything in TIMES, i.e. consider developing complementary methods/models
Modelling urban transports in a city energy system model – Applying TIMES on Malmö

- What is the system CHARACTERISTICS?
- What can we LEARN from Transport models?
- Which DEMAND should DRIVE the model?
- An illustrative results

Ongoing Study
SYSTEM CHARACTERISTICS & MANAGEMENT

- Urban transport characteristics:
  - High frequency of movements
  - Low average speeds
  - Short distances

- Urban built environment creates lock-in patterns; affects energy-use for decades

- Mobility is key to the functioning of all cities

- Needs of local policy-makers:
  - Explore and analyse different long-term targets and policies, to...
  - ...identify cost-efficient actions for improving overall system efficiency
CITIES ACCOUNT FOR
- 2/3 of global final energy use
- 75% of GHG emissions

AIR POLLUTION are a pressing problem in many cities; affects health, natural and built environments

URBAN TRANSPORTATION is a major source of local and global emissions
- >20-40% of urban GHGs
- Leading local contributor to e.g. NO\textsubscript{x}, PM, CO

EU LEVEL INITIATIVES TARGETING CITY-LEVEL
- Urban Mobility Package, SUMP
- Covenant of Mayors, SECAP
- Air Quality Directive (2008/50/EC)

COMPLEX POLICY LANDSCAPE
- Mobility of people and goods
- Energy system management
- Health and environment
**AIM & APPROACH**

**Aim:** Investigate the impact on cost-efficient low-carbon options for urban transportation when also considering ambitious air quality targets.

**Philosophy:** Mathematical models powerful tools for ‘mental experiments’ on complex systems development over longer time perspectives.

- Based on the TIMES framework
- Differ between activities ‘in control’ by the municipality and activities not in control by the municipality.
- **Transportation, Residential & Commercial buildings,** Industry, Agriculture, Electricity & DH and Energy supply.
What is the Transport System?

Infrastructure: capacity, land-use, costs, etc.

- **Transport policy**
- **'Behavior'**

**Technology options**

- **Passenger**
- **Freight**

**Modes**

- **ROAD**
- **RAIL**
- **SEA**
- **AIR**

**Energy policy**

**Climate policy**

**Air quality policy**

**Fuels/energy carriers:** feedstock, ‘footprint’, supply infrastructure, etc.
WHAT CAN WE LEARN FROM OTHER MODELS

TRANSPORT MODELS

Modal split: important determining factor for both energy-use and emissions

→ Trip purposes and commodity group characteristics: important factors for frequency and mode choice of transportation

Typical base-year calibration:
- Travel surveys → passenger transportation disaggregated by trip purpose
- Goods flow surveys → freight transportation disaggregated by commodity groups

ESOM

Disaggregating transport demand input to ESOMs can improve:
- Representation of different choices/behaviour
- Understanding of mode shift potentials
- The ability to test effects of specific mode shift measures (targeting e.g. all commuting car-trips)

Drawbacks?
Further data and understanding of the transportation system is needed
TRANSPORT SECTOR IN TIMES-CITY

- **Passenger & Freight**

- **All conventional modes and technologies, with addition of:**
  - ‘No physical travel’ (e-meetings etc)
  - Walking
  - Bicycle (conventional + electric)
  - Light electric vehicles (pass, freight)
  - Taxi
  - Car-pools
  - Public transport city ferry

- **Conventional and emerging drivetrain and fuel options**

Demand disaggregated by:

1) **Mode**
2) **City organisation/Other**
3) **Intra-city/Long-distance**

Mode shares exogenously determined, but... Input demands derived from 'scenario generator' using **trip purpose** and **commodity groups** → indirect representation of behaviour/choices
Generating Data Input

City Interface

**Passenger (pkm)**
- Commuting trips
- Business trips
- Shopping trips
- Personal business trips
- Leisure trips
- Etc.

**Freight (tkm)**
- Construction mtrl.
- Manufactured goods
- Mining products
- Products of forestry
- Products of agri.
- Etc.

**External models and surveys**
- Travel surveys
- Transport models
- Goods-flow surveys

**TIMES Vehicle Technology database**
- Bus.Intercity.DST.Base-year.
- Bus.Intercity.GAS.Base-year.
- Bus.Urban.DST.Base-year.
- Car.DST.Base-year.
- Car.ELC.Base-year.
- Car.ETH.Base-year.
- Car.GAS.Base-year.
- Truck.Heavy.DST.Base-year.
- Truck.Heavy.HEV.DST.Base-year.
- Train (pass./freight)
- Aviation (domest./int'l.)
- Bicycle (electric/conv.)
- Etc. etc.

**TIMES input Demand projection**
- Bus (urban/intercity)
- Car (urban/long-dist.)
- Truck (light/heavy)
- Etc. etc.

**City Interface**

**External models and surveys**

**TIMES Vehicle Technology database**

**TIMES input Demand projection**

- Car (urban/long-dist.)
- Truck (light/heavy)
- Bicycle (electric/conv.)
- Etc. etc.
Transport demand

**Passenger**
- Official statistics on vehicles:
  - Driving range
- Base-year demand derived from travel survey (2014)
  - All trips by city residents within and to/from Malmö
  - Work, education, business, shopping, personal business, leisure, other
  - By mode and distance
- Future demand driven by population growth (SCB)

**Freight**
- Official statistics on vehicles:
  - Driving range
- No quantifiable base-year data → Alternative approach:
  - National ‘Material footprint’ approach determine freight demand (ton of goods per capita and GDP) * Malmö population
  - Intra-city freight: 100% by road
  - Long-distance freight: mode shares, distance by commodity groups based on national statistics
- Future demand driven by population growth (SCB) and GDP/capita (OECD)
### Mode share assumption

→ Generate Demand projections

<table>
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<tr>
<th>Sub-sector</th>
<th>Technology</th>
<th>Base-year</th>
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<th>REF_B: 2050</th>
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<td>Walking</td>
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<td>33%</td>
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<td>Car</td>
<td>44%</td>
<td>44%</td>
<td>22%</td>
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<tr>
<td>Passenger – LongDistance</td>
<td>Bus</td>
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<td></td>
<td>Car</td>
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<td>Train (high-speed)</td>
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<td></td>
<td>Aviation</td>
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<td></td>
<td>Light electric vehicle (LEV)</td>
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<td>5%</td>
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<td>Truck, heavy</td>
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Mode share assumption → Demand projections

**Intracity travel demand (Mpkm)**

- **Car**
- **Bus**
- **Walking**
- **Bicycle**
- **E-Bicycle**

**Long-distance travel demand (Mpkm)**

- **Car**
- **Bus**
- **Train**
- **Train (h-s)**
- **Aviation**

**Intracity freight transport demand (Mtkm)**

- **Light truck**
- **Heavy truck**
- **LEV**
- **E-bicycle**

**Long-dist. freight transport demand (Mtkm)**

- **Heavy truck**
- **Light truck**
- **Navigation**
- **Train**
MODELLING LOW-EMISSION SCENARIOS

CO₂

- Explore cost-efficient low-carbon pathways
- Mitigation targets based on Swedish national policy:
  - 70% CO₂ in 2030
  - 95% CO₂ in 2050
- Model generated CO₂ emission level for 2015 used as baseline

Air quality

- Explore cost-efficient low-pollution pathways (NOₓ, PM, CO)
- Mitigation targets based on own assumptions:
- Model generated emission levels for 2015 used as baseline
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<th>Climate Target</th>
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<tbody>
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<td>Air quality Target</td>
<td>Climate &amp; Air quality Target</td>
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ILLUSTRATING RESULTS

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<th>NOX</th>
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No Target:
- CO2: -100%
- PMN: -80%
- NOX: -60%
- COX: -40%

Climate Target:
- CO2: -80%
- PMN: -60%
- NOX: -40%
- COX: -20%

Air quality Target:
- CO2: -60%
- PMN: -40%
- NOX: -20%
- COX: 0%

Climate & Air quality Target:
- CO2: -40%
- PMN: -20%
- NOX: 0%
- COX: 0%
ILLUSTRATING RESULTS

No Target

Air quality Target (NOX)

Climate Target

Climate & Air quality Target

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ILLUSTRATING RESULTS

No Target

Air quality Target (NOX)

Climate Target

Climate & NOX Target
FINAL REMARKS

When developing a city model: Important to consider what the municipality can impact directly, indirectly or not at all.

By adding a City-interface (generates the demand inputs)
- The underlying assumptions behind becomes ‘visible’, and
- easier communicated with the city/municipality

There are not necessary co-benefits between CO2 and Air quality target → important to also optimize for both!