Improving urban mobility in Stockholm

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Sustainable mobility

- accessibility
- financial outlay required of users
- travel time
- reliability
- safety
- security
- impact on public revenues and expenditures
- prospective rate of return to private business
- greenhouse gas emissions
- impact on the environment and public well-being
- resource use
Greenhouse gas emissions in the EU

Urban transport accounts for 70 \% of the pollutants and 40 \% of the greenhouse gas emissions from EU road transport. Cities emit 69\% of Europe’s CO$_2$
Share of energy from renewable sources in percentage of final energy consumption
Share of renewable fuels in transport, EU 28, 2012

Data source: Eurostat 2012
Energy efficiency and reduced emissions for improving sustainability in transport

- promote fuel substitution
- create synergies with energy sector and information technologies – system integration
- improve energy efficiency (e.g. less energy for the same amount of services)
- reduce energy intensity
Swedish public transport: goals & achievements

Goals for 2020
- 90% of vehicle-kilometers on renewable fuels (biodiesel, biogas, ethanol and “green” electricity); and
- double market share and volume of travel on public transport

...to 58% fossil-free!

Source: Xylia and Silveira, 2016
What are the factors affecting fuel choices?

* from survey carried out among managers at public transport authorities

Source: Xylia and Silveira, 2016
renewable fuel deployment tends to be higher in the South!

Source: Xylia and Silveira, 2016
CO\textsubscript{2} emissions and energy efficiency

emissions per vehicle-km is decreasing, but not necessarily energy efficiency!

is electrification the solution?

Source: Xylia and Silveira, 2016
What are the barriers to renewable fuel deployment in bus fleets?

* from survey carried out among managers at public transport authorities

Source: Xylia and Silveira, 2016
Stockholm – capital of Sweden

- 900 000/2 million inhabitants
- 280 000/850 000 cars
- Built on 14 islands connected with 54 bridges
- 50% public transport (80% in peak hours)
- Congestion charging zone
- Environmental zone for heavy vehicles
- Improved air quality but problems with NOx and PM
- Green Capital of Europe 2010
- Fossil Fuel Free City by 2040
Increasing market share of public transport

Projections for travel and public transport in Stockholm County

Source: Stockholm Stad, 2015
Stockholm - the walkable city

THE CITY PLAN
A planning aim to achieve the vision

THE URBAN MOBILITY STRATEGY

Main network strategy
Road safety
Bicycle plan
Parking
Goods traffic
Pedestrian traffic
Traffic and the environment

Source: Stockholm Stad, 2015
Stockholm’s urban mobility plan for 2030

The width of the column indicates the approximate extent of various vehicle movement in the city.

Source: Stockholm Stad, 2015
Total energy use per fuel type for Stockholm county buses

Source: SLL, 2015
Public transport needs to attract more passengers

The higher the occupancy rate, the more environmental benefits achieved from modal shift!

Source: Trafikanalys, 2015
Exploiting the bus electrification potential: how to ensure gradual development?

range/route applicability

- Full-electric
  - Inner city (zero-emission, zero-noise zones)
- Electric hybrid
  - Inner city (longer distances)
- Hybrid biogas (or biodiesel/HVO)
  - Suburban routes
- Hybrid biodiesel/HVO (or biogas)
  - Inter-city (longer routes)
Stockholm exploring innovation in bus fleets

- 8 plug-in hybrid buses in Stockholm (*line 73*) under the EU program ZeEUS (Zero Emission Urban Bus System)
- Operation started 2015, project to be completed end of 2016
- Two charging points (pantograph/Siemens) at end-stations, 8 km

*Electric Hybrid bus. Source: Vattenfall, 2015*
Powertrain, storage and charging

**Propulsion**
- Pure electric
- Hybrid
  - Internal combustion engine (ICE)

**Energy storage**
- Ultracapacitor
- Battery
- Fuel cell

**Charging infrastructure**
- Overhead line (trolley)
- Induction (wireless)
- Conduction (plug-in)

*When to charge?*
- opportunity (e.g. electric road system (ERS))
- primary charging (e.g. overnight at the depot)
- fast charging (e.g. at end-stations)
Inductive bus charging project: Line 755 Södertälje

**Aim:** to implement, test and evaluate the potential of wireless charging for buses in city traffic to reduce emissions, improve energy efficiency and reduce fossil-fuel dependence through electrification.
Technology option: inductive bus charging

• magnetic AC fields generation from coils buried underground
• AC fields captured by pick-up on the vehicle
• can be combined with electric road systems (ERS) for increased charging efficiency
• **benefits:** almost invisible, insensitive to weather, better battery performance than conductive
• **drawbacks:** charging installation expensive, electric bus purchase more expensive than liquid or gas bus, battery life and costs, grid connection
What will be done?

- verify the benefits of inductive-charging systems in comparison to other charging options, as well as alternative engine technologies
- explore how to take advantage of wireless charging but also ways for gradual development of the infrastructure
Benefits and drawbacks of bus electrification (in a Nordic context...)

<table>
<thead>
<tr>
<th>Benefits</th>
<th>Drawbacks</th>
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<tbody>
<tr>
<td>Decarbonization</td>
<td>Battery lifecycle/compatibility</td>
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<td>Security of fuel supply</td>
<td>Passenger capacity</td>
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<td>Noise reduction</td>
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<td>New mobility opportunities</td>
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<td>Synergies in transport system</td>
<td>Climate &amp; heating requirements</td>
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</tbody>
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A future for electric buses?

- How shall electric buses be introduced?
- What synergies exist with other options and transport modes?
- What routes are attractive for electrification?
- What contracts and business models are needed?
- Who undertakes the investments?
- How can electric buses be made more competitive? (e.g. noise and pollution reduction, accessibility)
- What infrastructure is needed?
- What incentives are required to promote electrification?
Challenges for electrification in urban context

• more space for charging stations in low-density suburbs, but higher benefits for electrification in inner city (noise reduction, decreased local emissions etc.)

• choice of technology and its integration with existing modes of transport

• unclear business models (who owns infrastructure? who invests in bus purchase?)

• electric grid connection, building permits, construction work disturbing dense urban environments etc.
Conclusions

• important role for public transport in Stockholm’s urban mobility strategy (key component in the ”walkable city” concept)
• the public transport sector has shown impressive achievements regarding emission reduction & fossil-free fuels
• need to improve attractiveness and energy efficiency for achieving full environmental benefits
• geospatial factors influencing bus transport strategies include climate conditions, bus range and route applicability, traffic and population density, available space and local fuel availability
• large potential for buses to improve urban environments, but still many complexities to be addressed for future upscaling