KTH ROYAL INSTITUTE
OF TECHNOLOGY

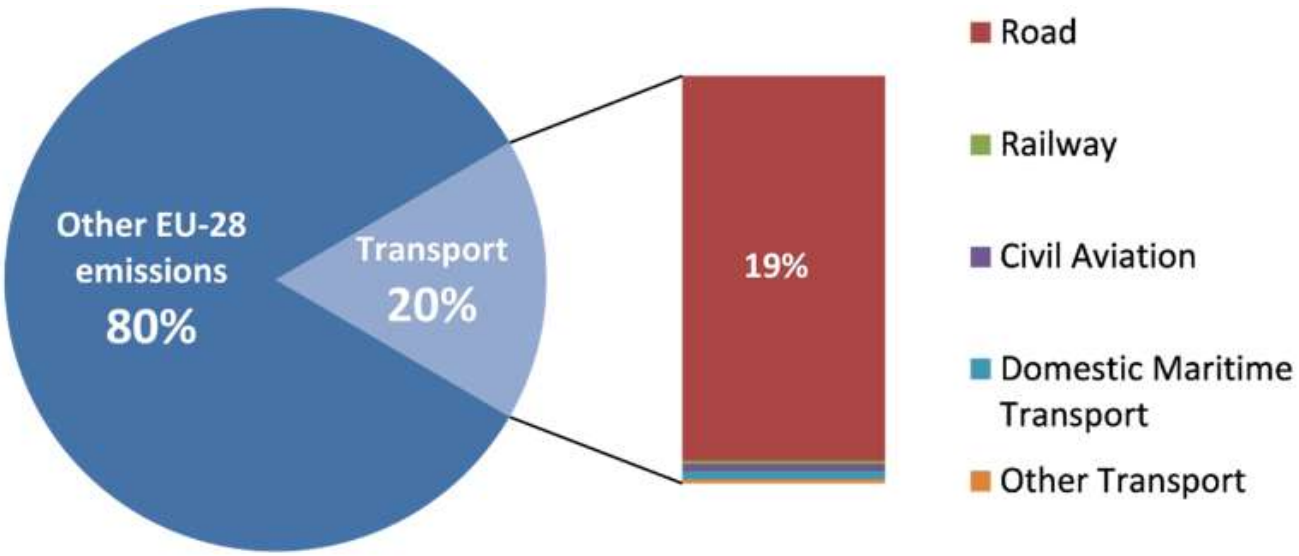
Improving urban mobility in Stockholm

Semida Silveira, Professor in Energy Systems Planning,
Head of Energy and Climate Studies (ECS),
KTH Royal Institute of Technology, Sweden

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



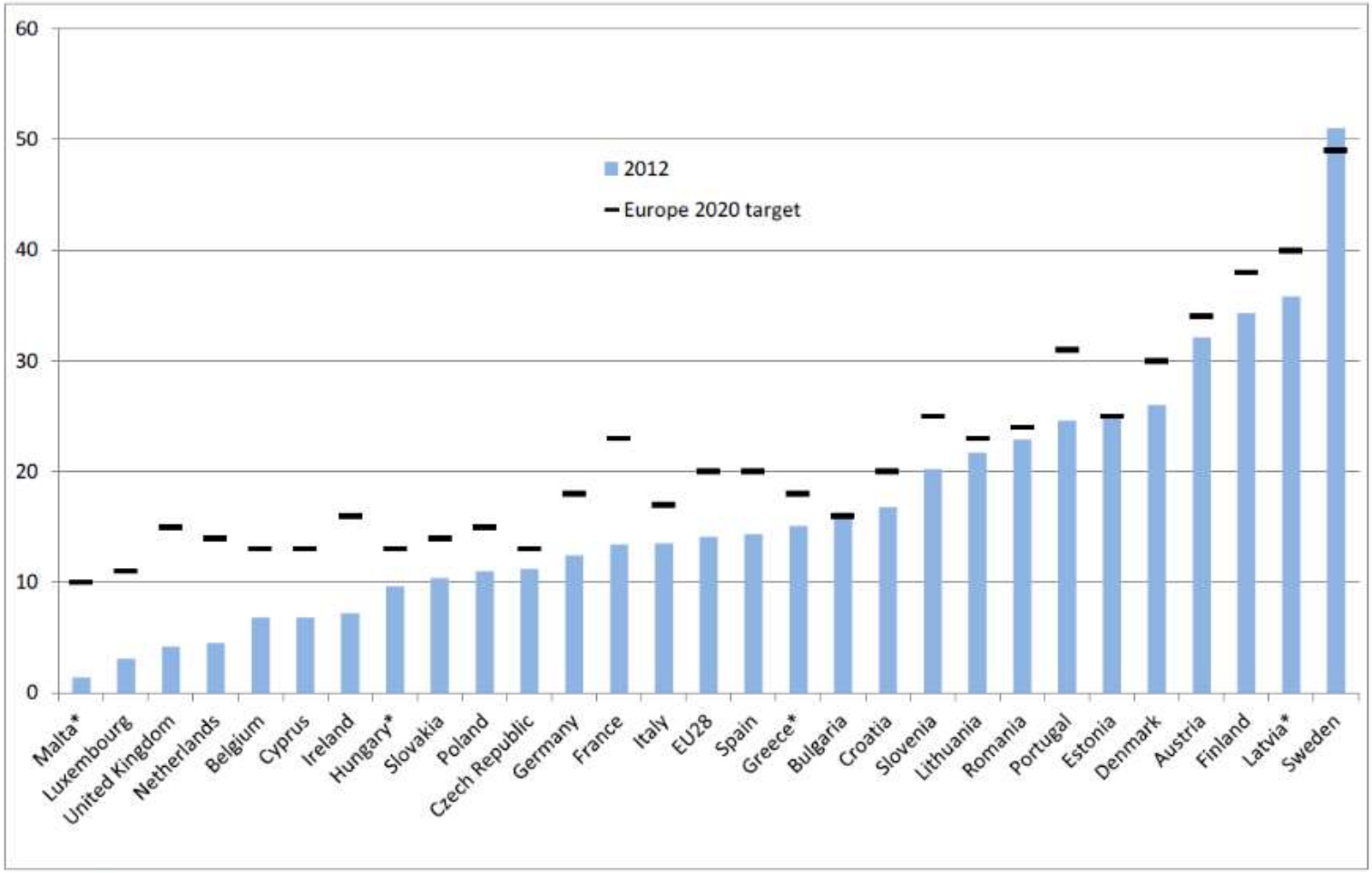
Urban transport accounts for 70 % of the pollutants and

40 % of the greenhouse gas emissions from EU road transport.

Cities emit 69% of Europe's CO_2

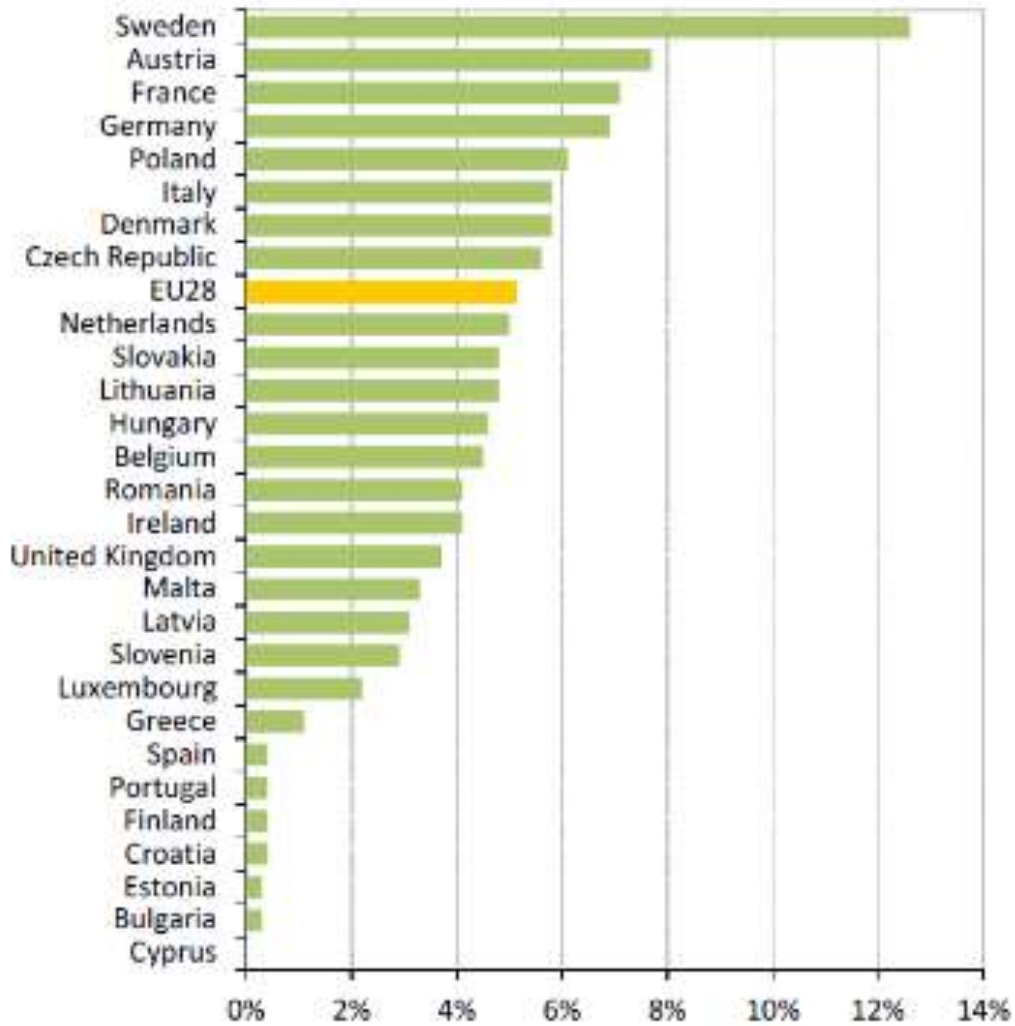
Share of energy from renewable sources

in percentage of final energy consumption



* estimated

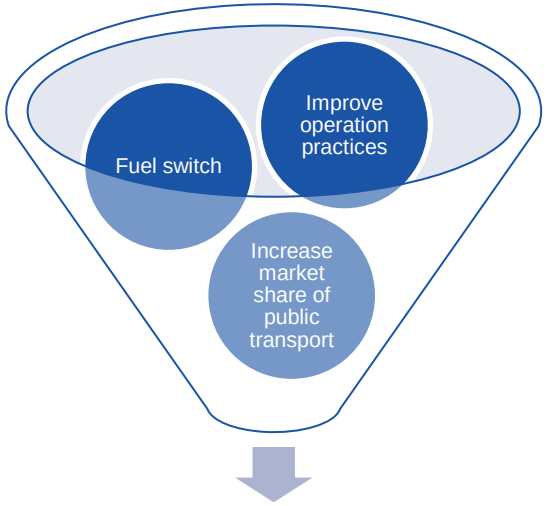
Share of renewable fuels in transport, EU 28, 2012



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

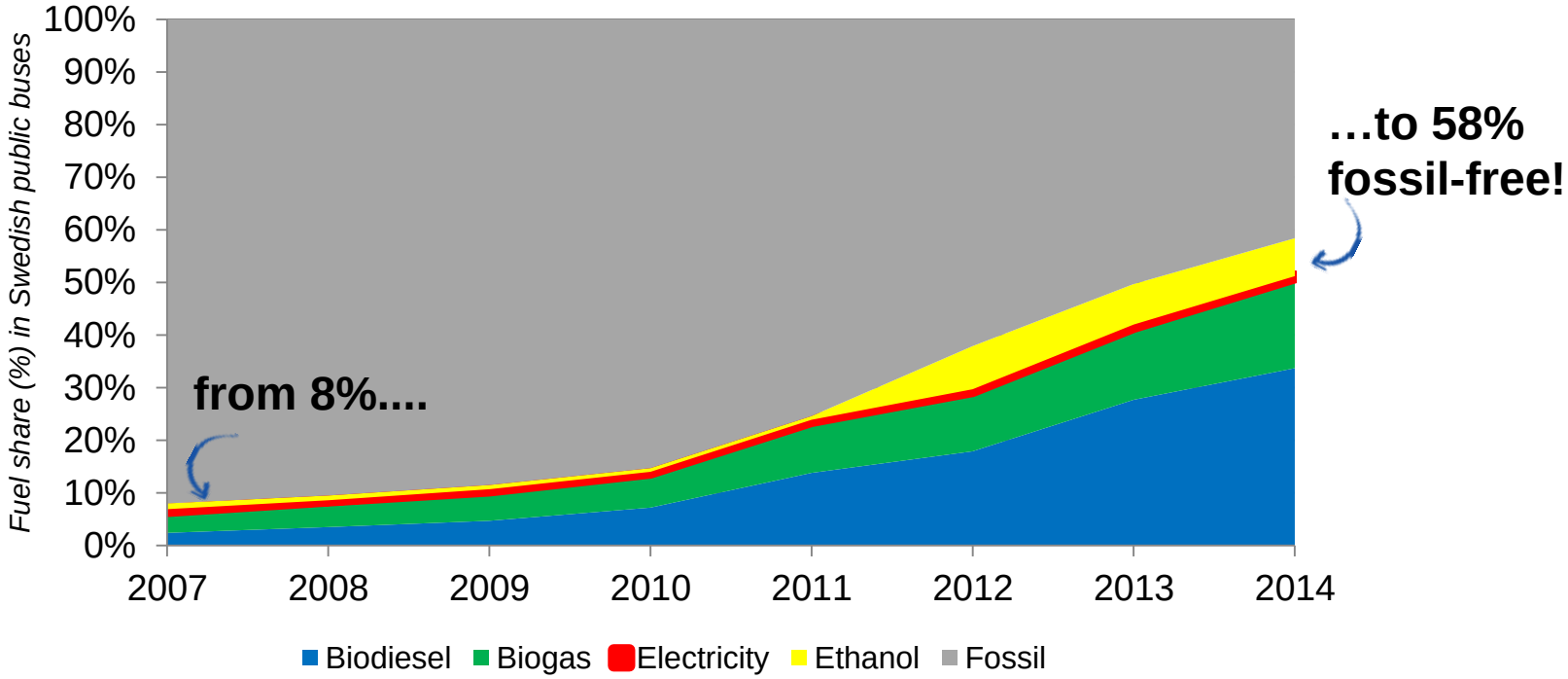


Sustainable urban mobility

Swedish public transport: goals & achievements

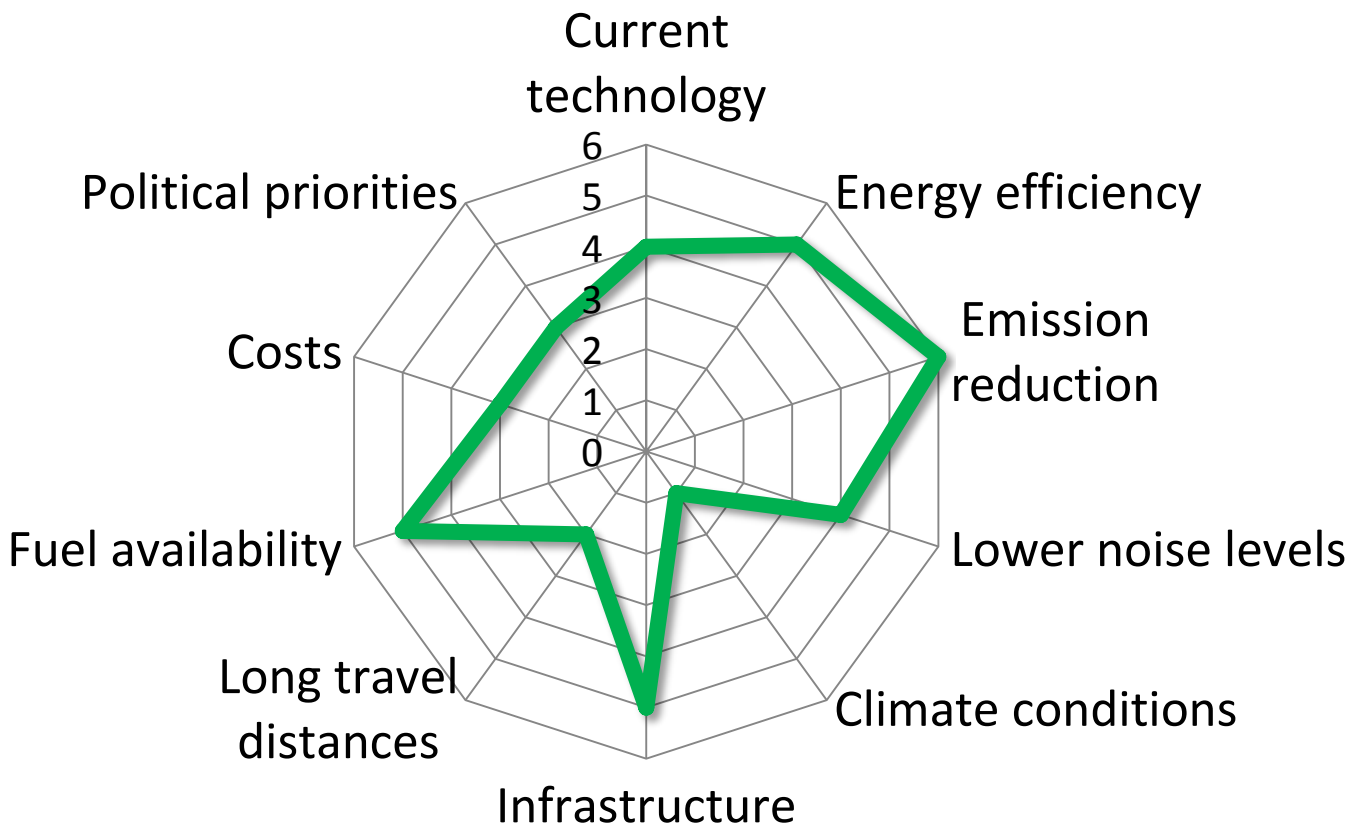
Goals for 2020

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



Source: Xylia and Silveira, 2016

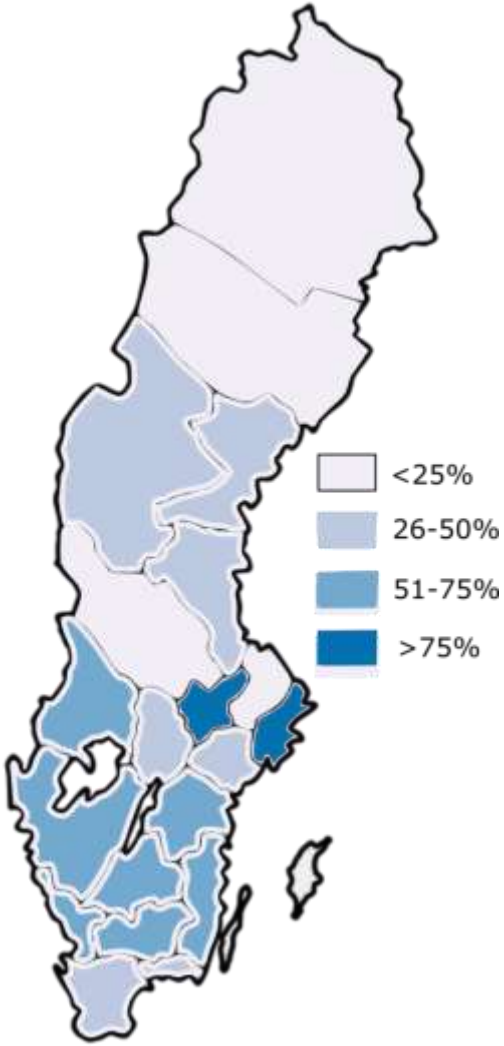
What are the factors affecting fuel choices?



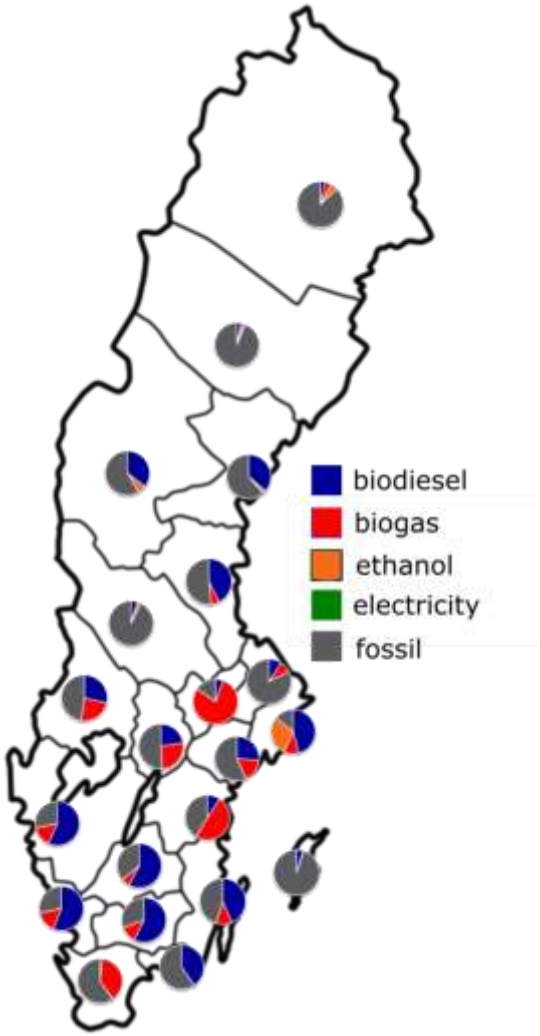
** from survey carried out among managers at public transport authorities*

Source: Xylia and Silveira, 2016

Biofuel share



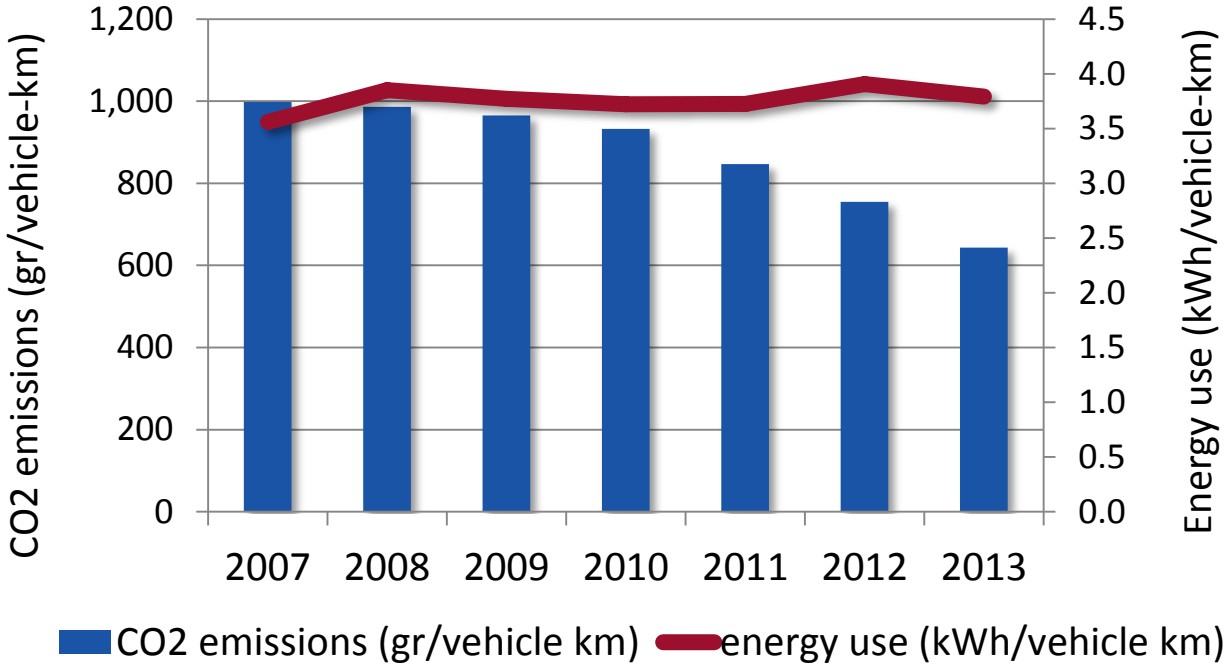
Fuel mix



renewable fuel deployment tends to be higher in the South!

Source: Xylia and Silveira, 2016

CO_2 emissions and energy efficiency

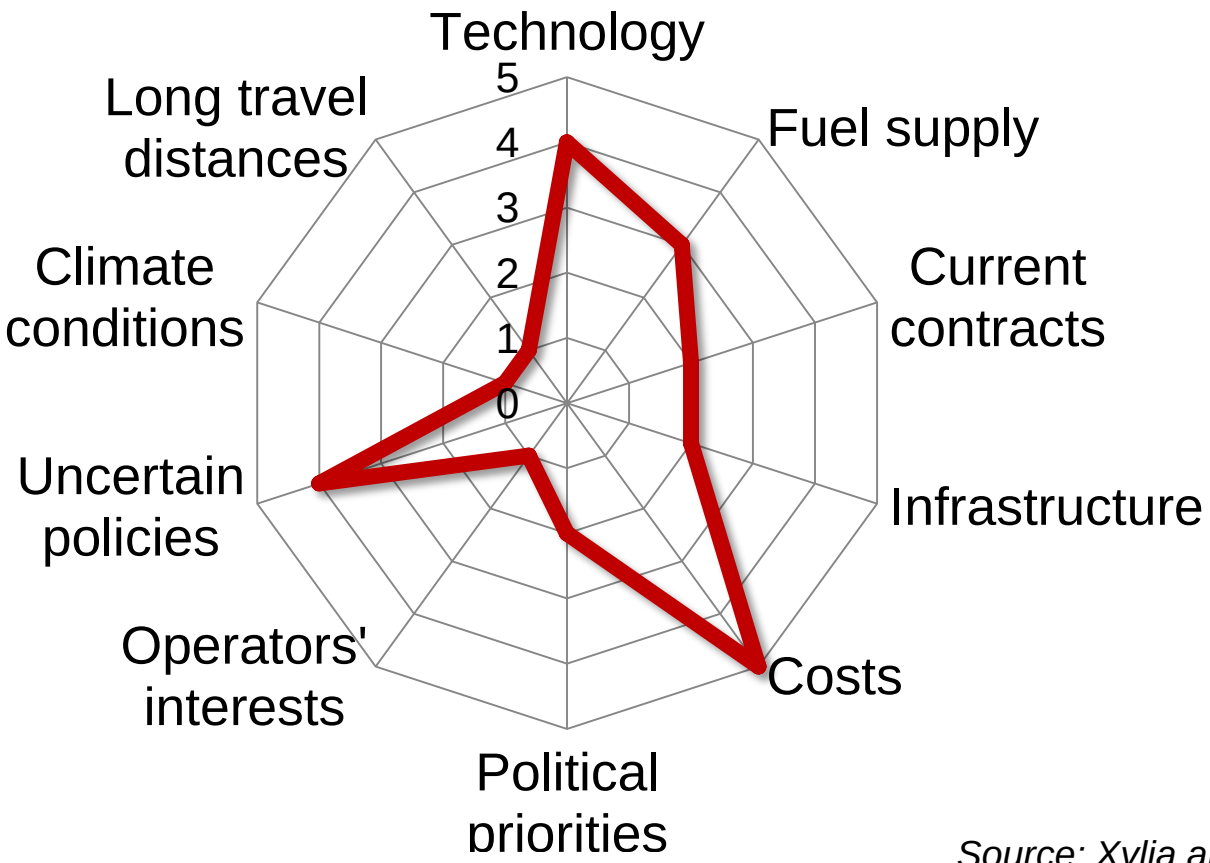


emissions per vehicle-km is decreasing, but not necessarily energy efficiency!

is electrification the solution?

Source: Xylia and Silveira, 2016

What are the barriers to renewable fuel deployment in bus fleets?



Source: Xylia and Silveira, 2016

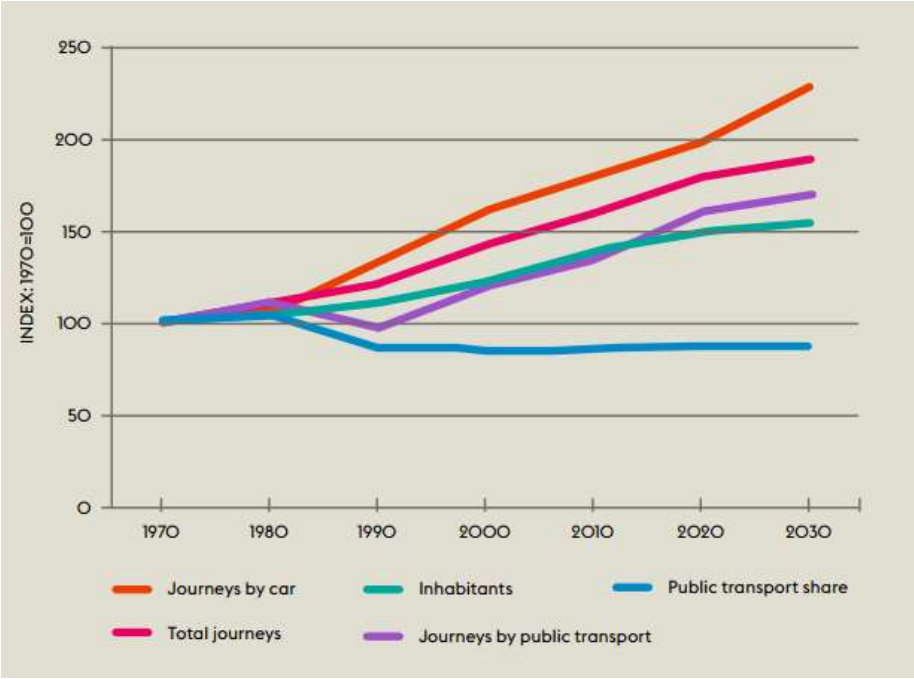
** from survey carried out among managers at public transport authorities*

Stockholm – capital of Sweden

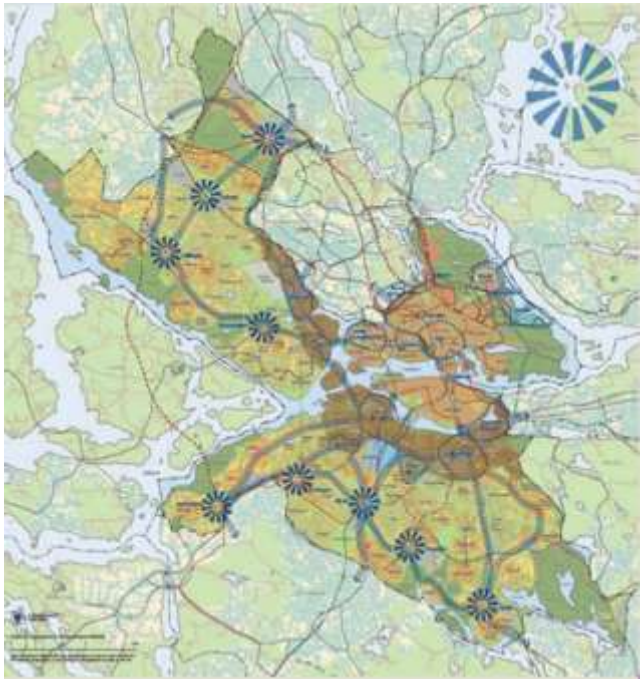
- 900 000/2 million inhabitants
- 280 000/850 000 cars
- Built on 14 islands connected with 54 bridges
- 50 % public transport (80 % in peak hours)
- Congestion charging zone
- Environmental zone for heavy vehicles
- Improved air quality but problems with NOx and PM
- Green Capital of Europe 2010
- Fossil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

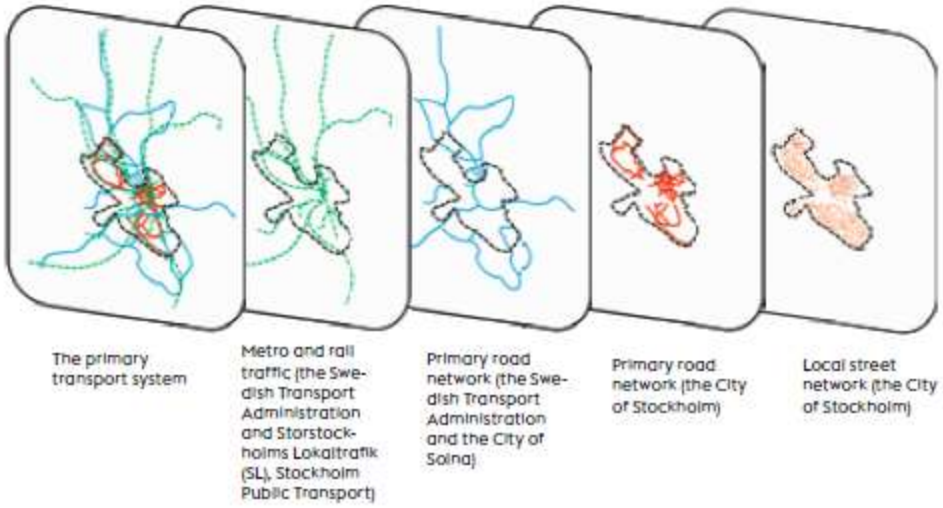
Increasing market share of public transport

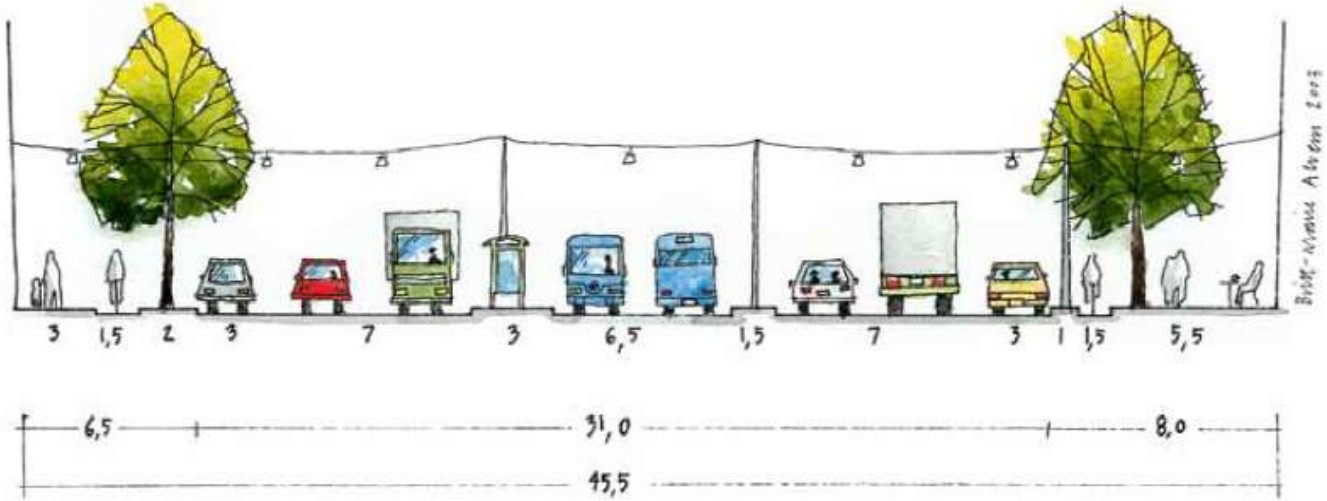
Projections for travel and public transport in Stockholm County



Source: Stockholm Stad, 2015




The primary transport system
Metro and rail traffic (the Swedish Transport Administration and Storstockholms Lokaltrafik (SL), Stockholm Public Transport)
Primary road network (the Swedish Transport Administration and the City of Solna)
Primary road network (the City of Stockholm)
Local street network (the City of Stockholm)


3
1,5
2
3
7
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3
1
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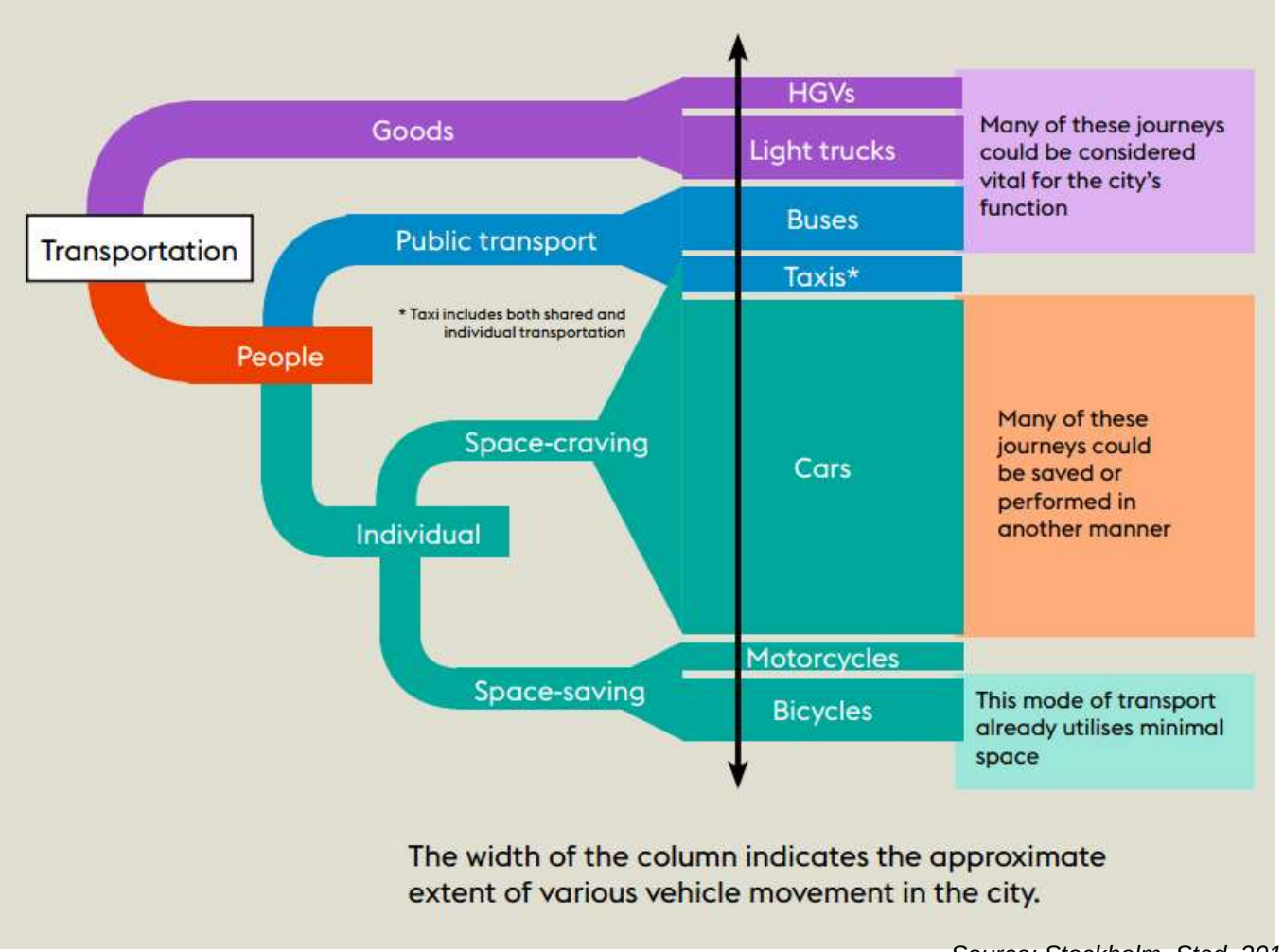
8,0
45,5

Stockholm - the walkable city

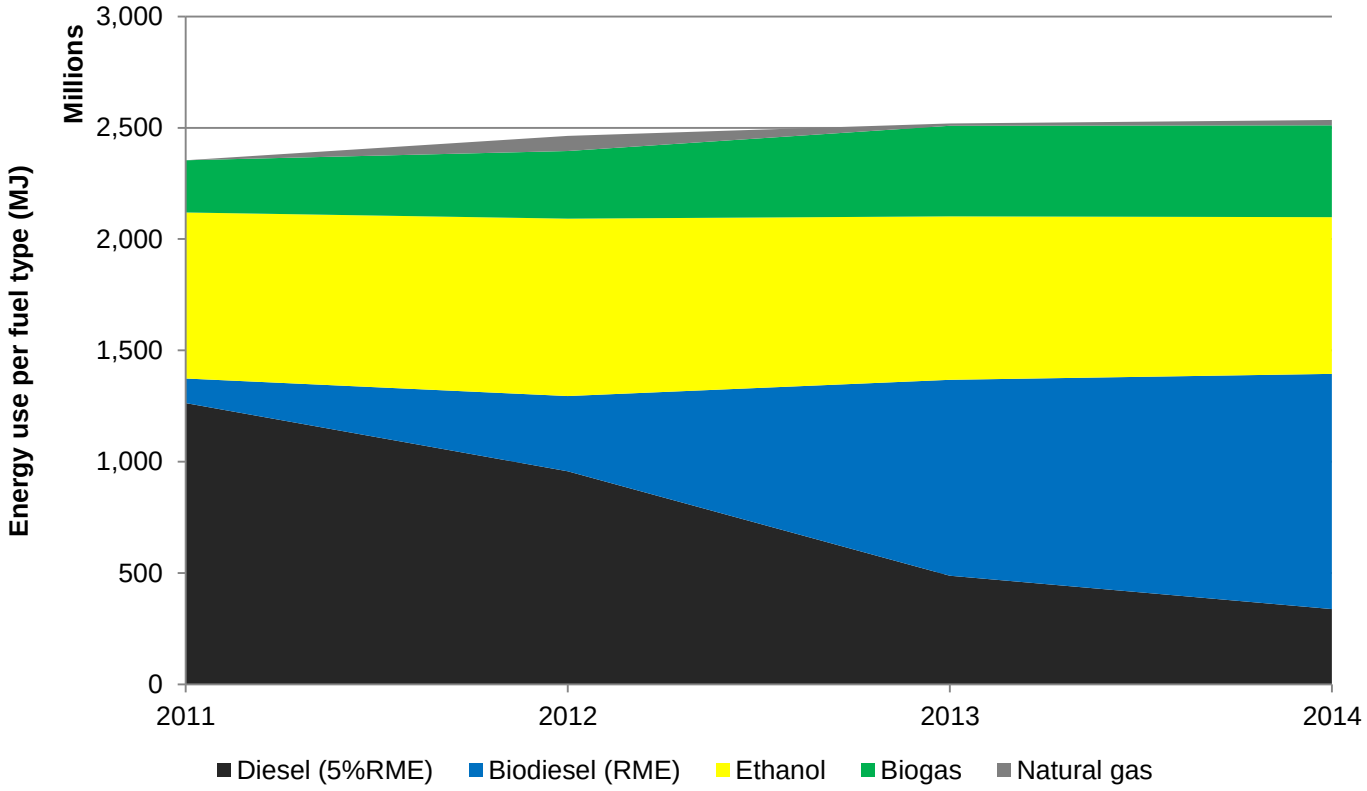
Source: Stockholm Stad, 2015

Stockholm's urban mobility plan for 2030



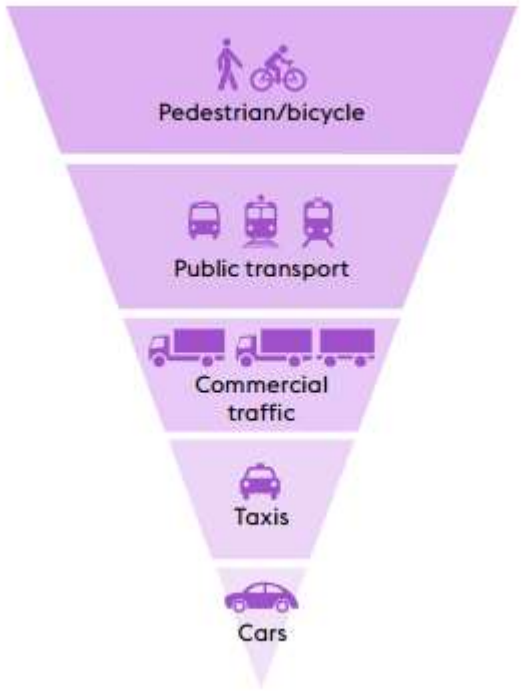
Source: Stockholm Stad, 2015

Total energy use per fuel type for Stockholm county buses

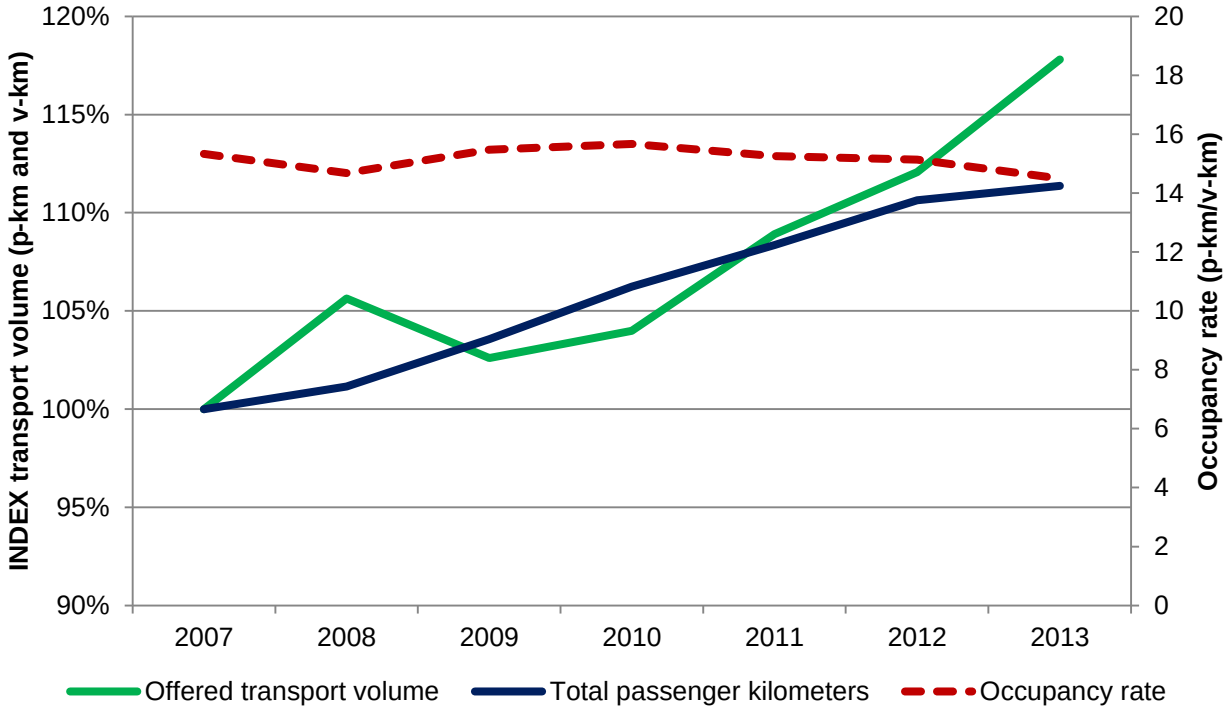


Source: SLL, 2015

Public transport needs to attract more passengers



data for Stockholm buses



Source: Trafikanalys, 2015

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

Exploiting the bus electrification potential: how to ensure gradual development?

range/route applicability

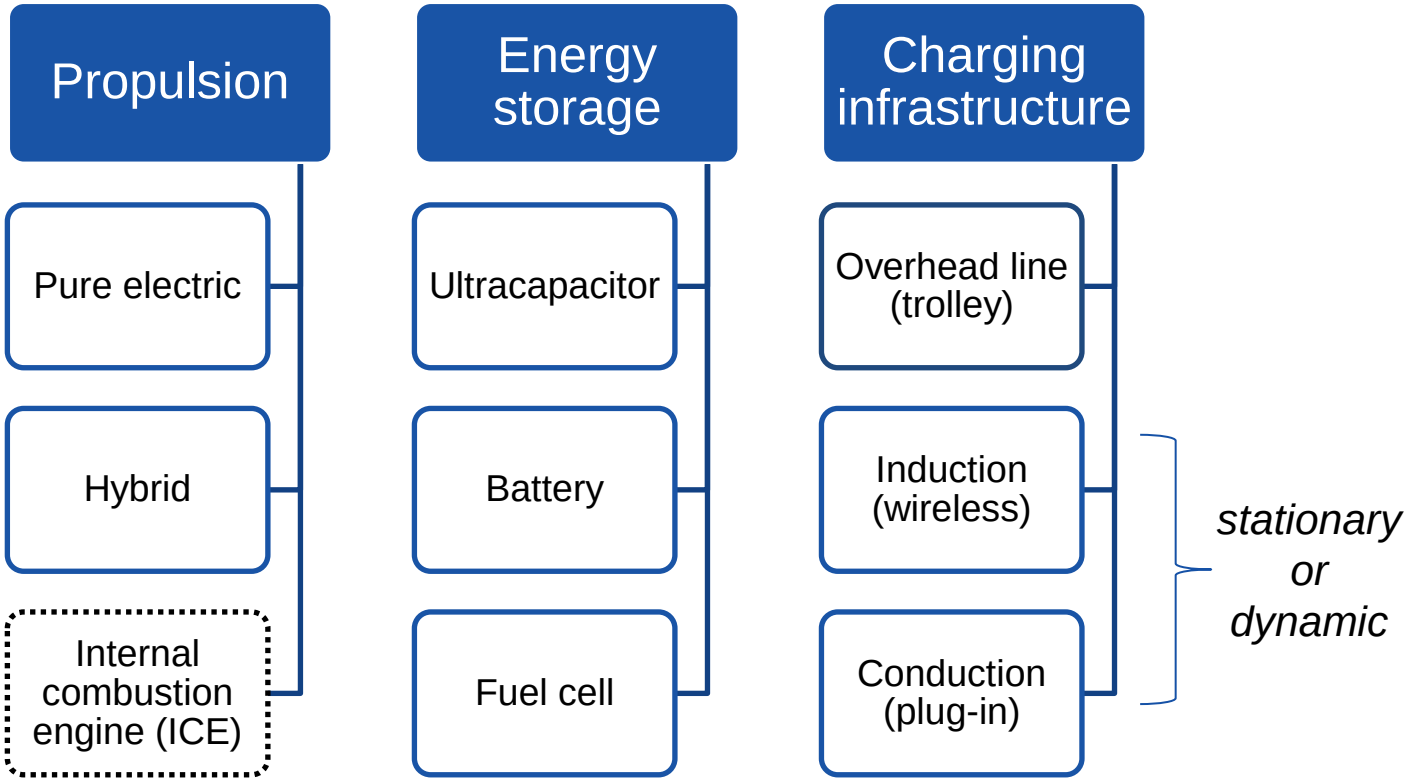
Full-electric	inner city (zero-emission, zero-noise zones)
Electric hybrid	inner city (longer distances)
Hybrid biogas (or biodiesel/HVO)	suburban routes
Hybrid biodiesel/HVO (or biogas)	inter-city (longer routes)

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

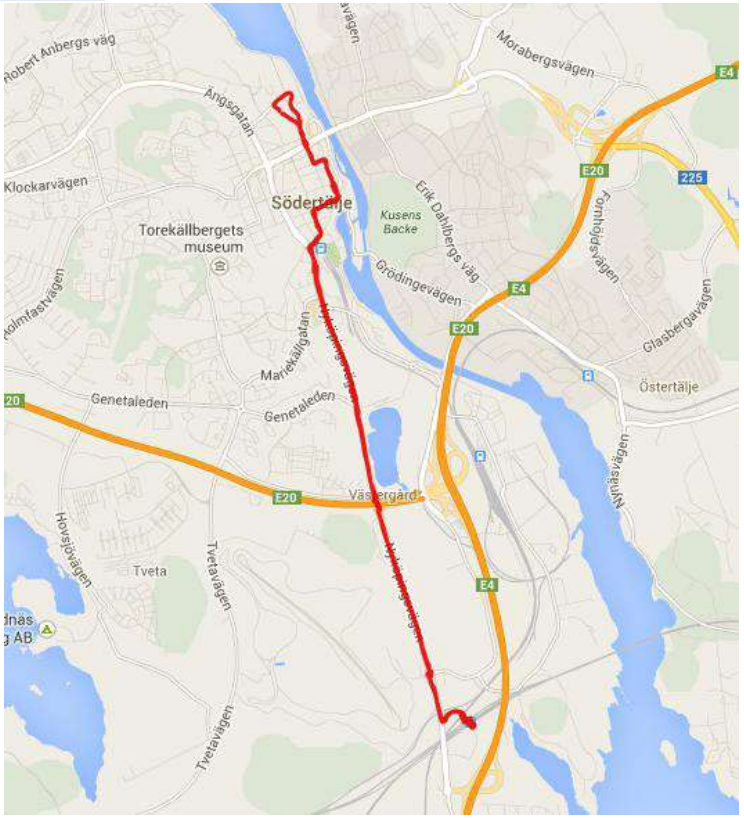
Powertrain, storage and charging

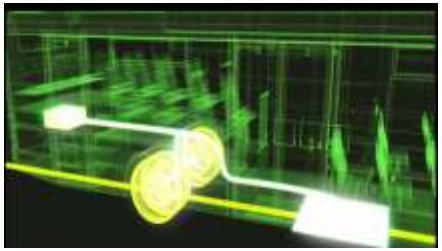


When to charge?

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



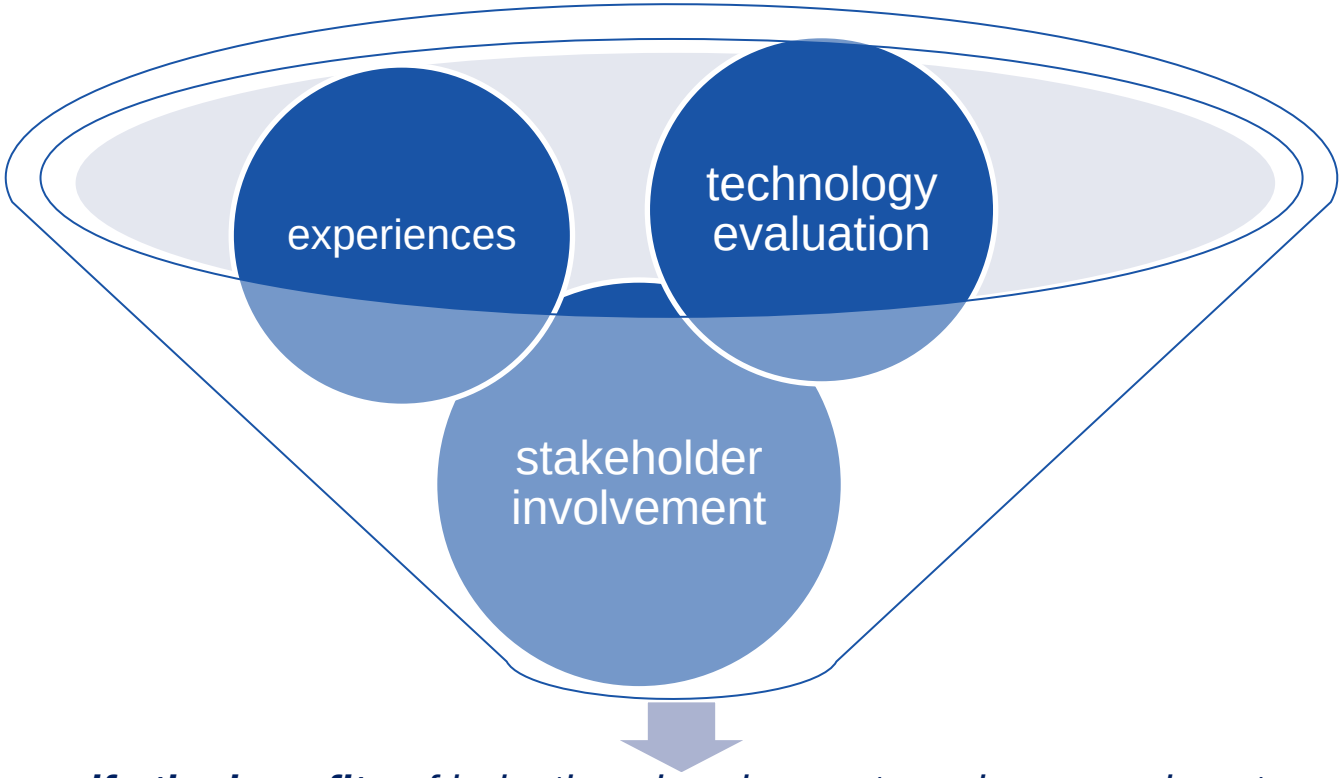


Aim: *to* ***implement, test and evaluate*** *the potential of wireless charging for buses in city traffic to* ***reduce emissions, improve energy efficiency and reduce fossil-fuel dependence through electrification****.*

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…)

Benefits	Drawbacks
Decarbonization	Battery lifecycle/compatibility
Security of fuel supply	Passenger capacity
Noise reduction	Salary costs/contract terms
Passenger comfort	Schedule adjustments
New mobility opportunities	Infrastructure installation
Synergies in transport system	Climate & heating requirements

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 busses 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