Modeling energy system impacts of shared mobility in the Nordic context

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Sustainable Horizons in Future Transport

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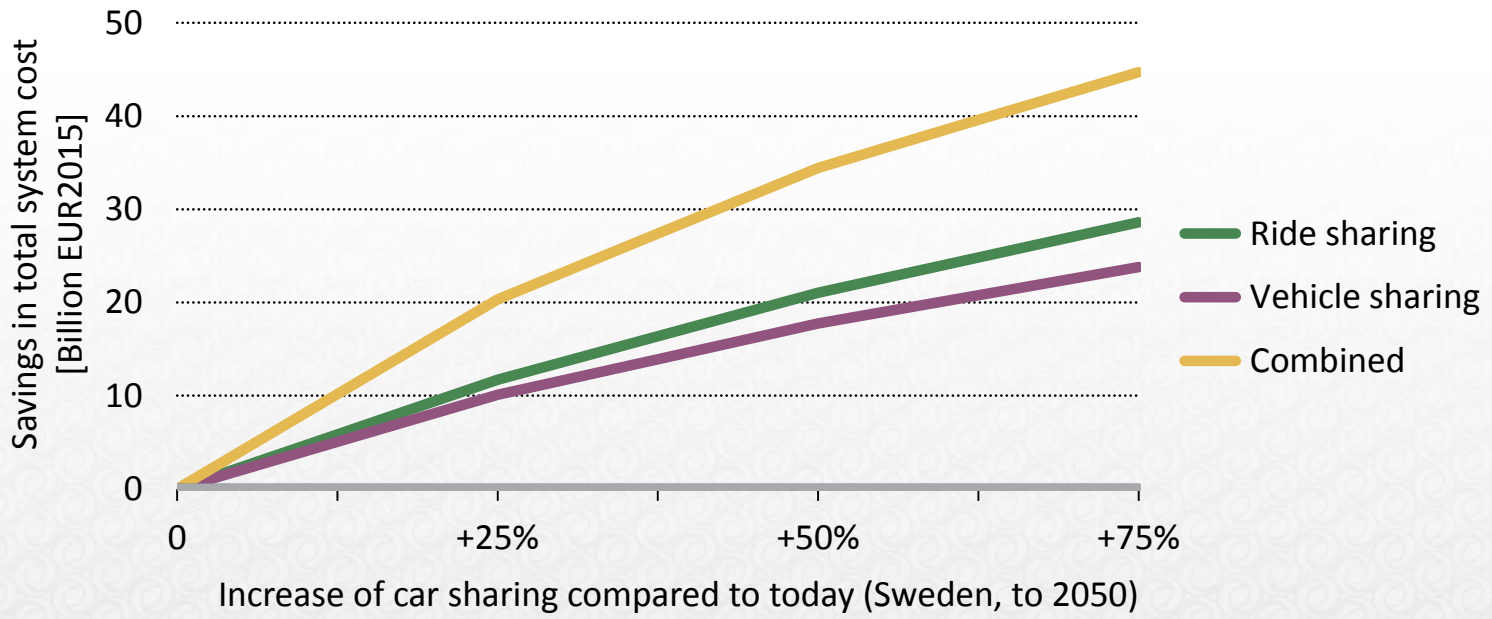
Why shared mobility?

- The average car is unused more than 90% of the time
- System cost saving potential from increased capacity utilization in transport is substantial



Questions & scope

- *How can shared and autonomous vehicles be represented in a bottom-up optimization energy system model (TIMES)?*
- *How do the addition of shared and autonomous vehicles impact the cost-optimal development of the system?*

  – Passenger car sector

  – Sweden as a case study

Newly developed Swedish TIMES model

- Bottom-up, optimization (cost minimization) energy system model
- Comprehensive coverage of the national energy system
  - Power and heat sector, transport sector, industry and service sector, residential sector
- Time period: 2010-2050
- Part of new Nordic TIMES model
  - cooperation with Danish Technical University (DTU)

Model options for car transport sector

Base model		New additions
Fuels	Technologies	
Gasoline Diesel Natural gas Biodiesel Ethanol Methanol Biogas DME Hydrogen Electricity	Internal combustion (SI and CI) Flexifuel Electric Hybrids Fuel cell	• **Shared electric vehicle** • **Autonomous electric vehicle (private)** • **Shared Autonomous Electric Vehicle (SAEV)**

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How to distinguish and characterize shared/autonomous vehicle options in the model ?

- Mileage (vehicle driving distance per year and per vehicle lifetime)
  - Vehicle-sharing increase the potential mileage
- Vehicle occupancy
  - Ride-sharing increase occupancy per vehicle
  - Shared autonomous vehicles increase ride-sharing possibilities
- Vehicle cost
  - Autonomous vehicle technologies involve extra costs
- Constraint based on population density
  - Vehicle-sharing is primarily an option in towns/cities rather than rural areas
- Cost of travel time
  - Autonomous vehicles make it possible to do other things when traveling than driving (e.g., relaxing, working, …) → the “cost” of travel time decreases

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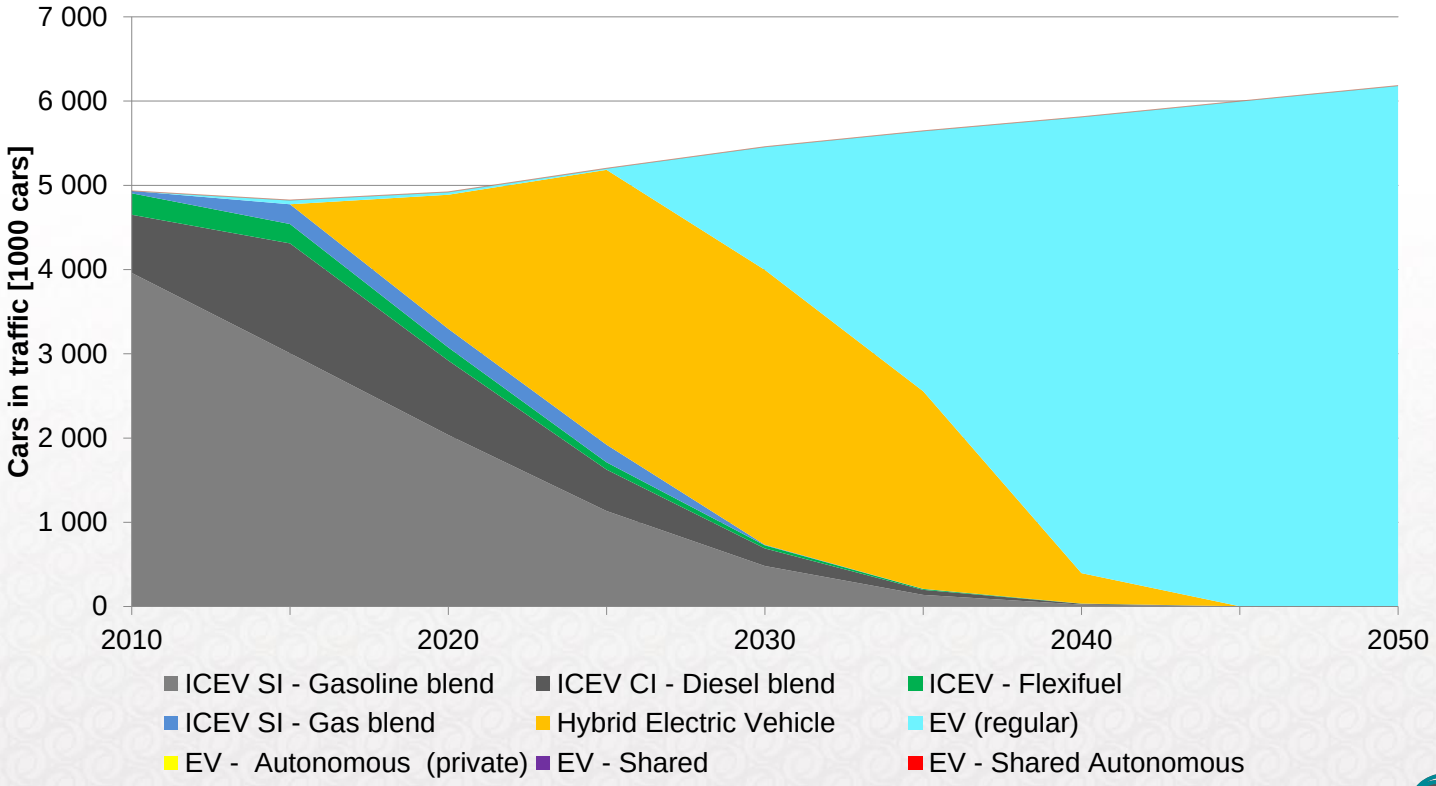
Technology characterization for new technology additions

Model Parameter	EV (regular)	Auto-nomous EV (private)	Shared EV	Shared auto-nomous EV
Mileage	Reference	-	↑	↑
Occupancy (ride-sharing)	Reference	-	-	↑
Vehicle cost	Reference	↑	-	↑
Potential related to population density	Reference	-	↓	↓
Cost of travel time	Reference	↓	-	↓

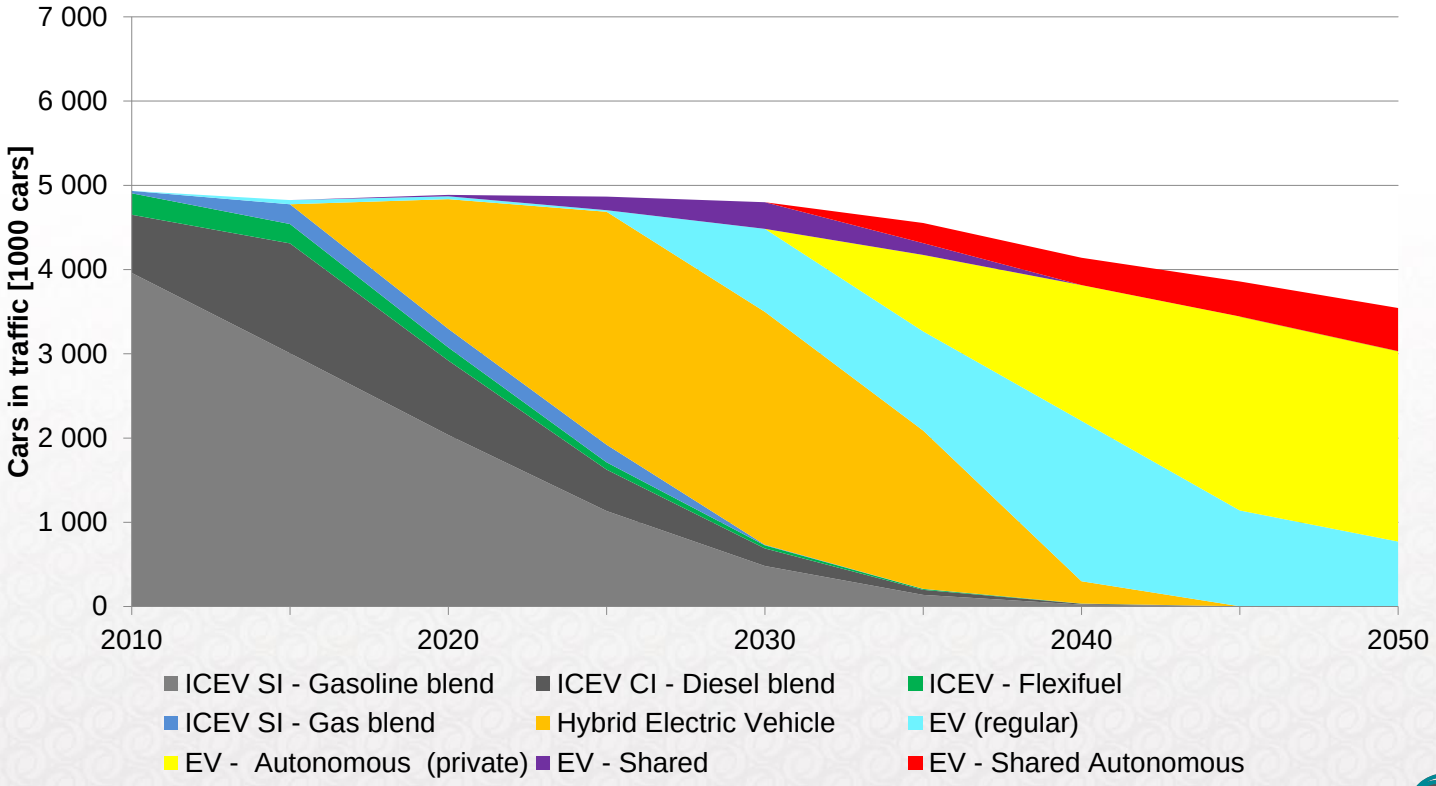
Technology characterization for new technology additions

Model Parameter	EV (regular)	Auto-nomous EV (private)	Shared EV	Shared auto-nomous EV
Mileage	Reference	-	Per year: + 200% Per lifetime: + 50%	Per year: + 400% Per lifetime: + 100%
Occupancy (ride-sharing)	Reference (1.7 persons/car)			+ 20 % (2.0 p/car)
Vehicle cost	Reference	+ 10 kUSD		+ 10 kUSD
Potential related to population density	Reference		Max 50% of total pkm in 2050	
Cost of travel time	Reference (9-14 Eur/h)	- 15% to -30% (8-10 Eur/h)		- 15% to -30% (8-10 Eur/h)

Model results: Car stock development Scenario: “Standard car technologies” (stringent CO_2 constraint)

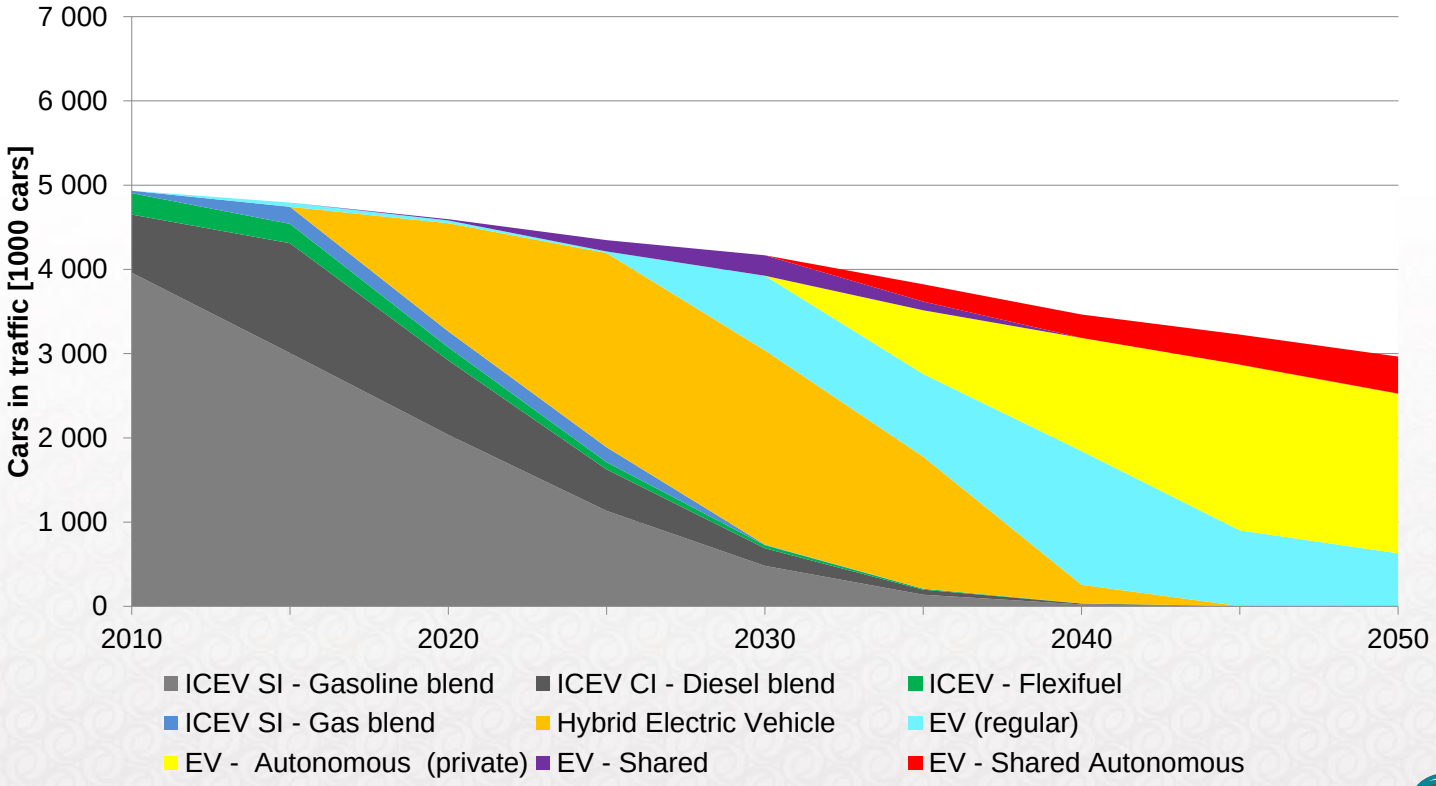


Model results: Car stock development
Scenario: “All car technologies”
(shared & autonomous EVs available)

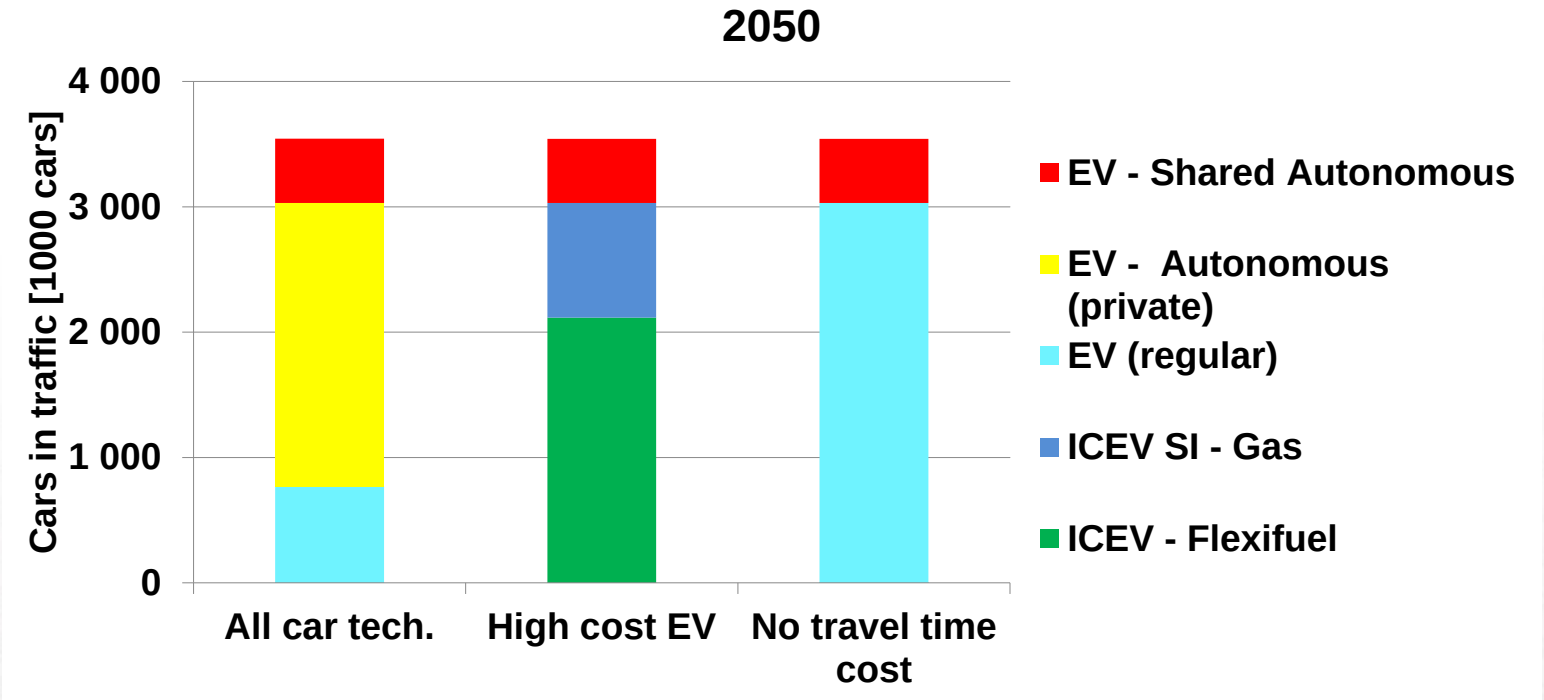


Model results: Car stock development

Scenario: “High ride-sharing”

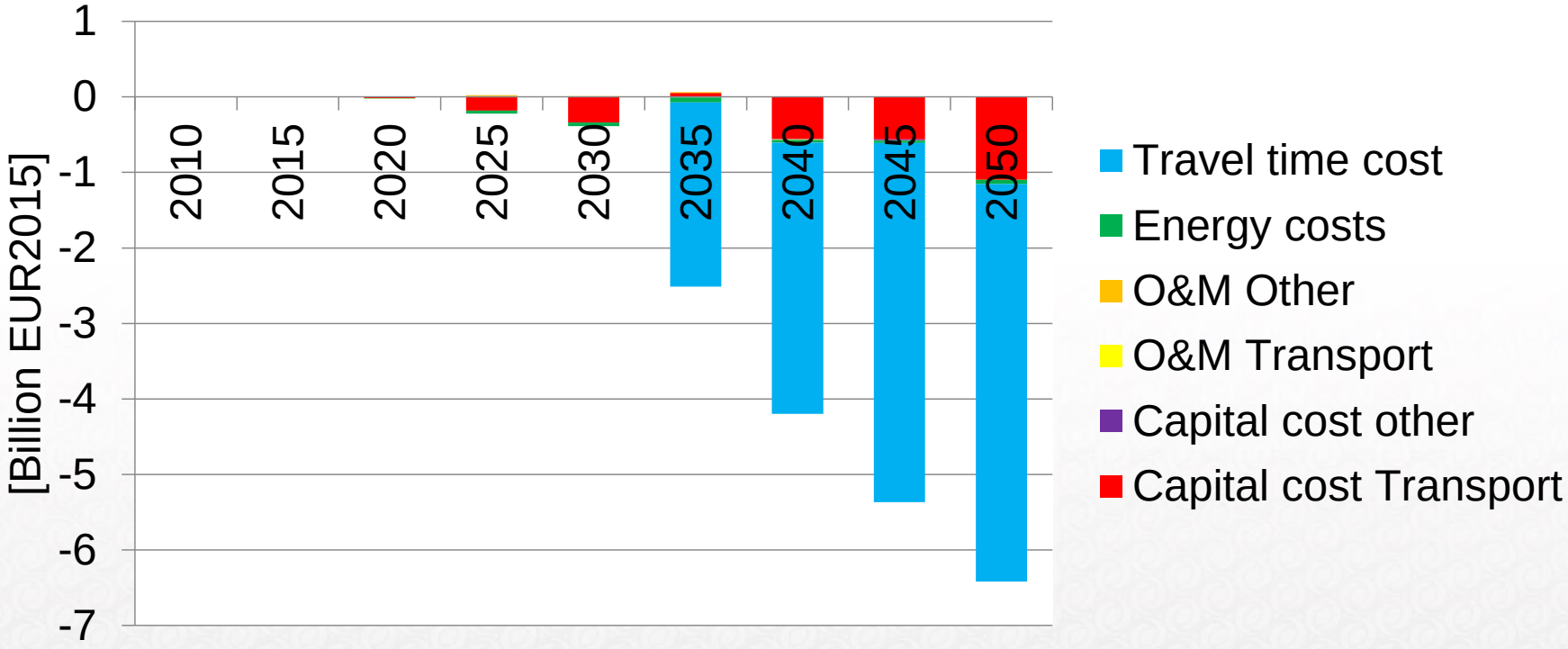


Car stock in 2050, alternative assumptions



→ Results for SAEV are robust for several alternative assumptions

Impact on annual system cost
from including shared & autonomous EVs



→ Change in system cost is dominated by reductions in transport sector capital costs and in travel time cost

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Summary and insights

- Shared and autonomous electric vehicles can have large impacts on the development of the transport system
  - Vehicle sharing reduces required car capacity
  - Ride-sharing reduces required car capacity and vehicle km traveled
  - Autonomous vehicles reduce “travel time cost” (through increased “comfort”)

- SAEV is an attractive option from a system perspective
  - High mileage leads to low cost per pkm

- Important to include options for shared and autonomous vehicles in energy system modeling studies
  - May require including “unconventional” model parameters such as travel time cost

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Thank you!

Questions/comments?

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