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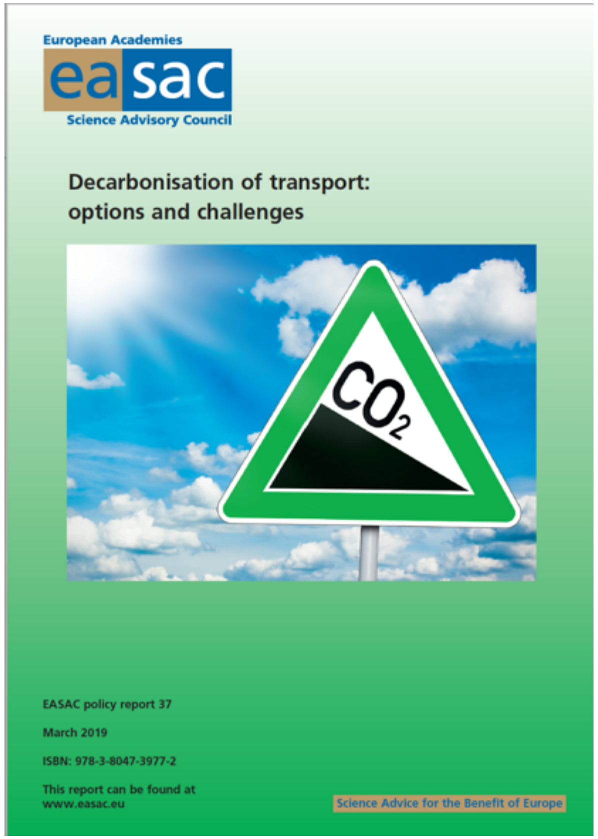

Decarbonisation of Transport: options and challenges for Europe and Switzerland

Prof. Konstantinos Boulouchos, ETH Zurich
Chairperson EASAC Working Group

Bern, 5 April 2019

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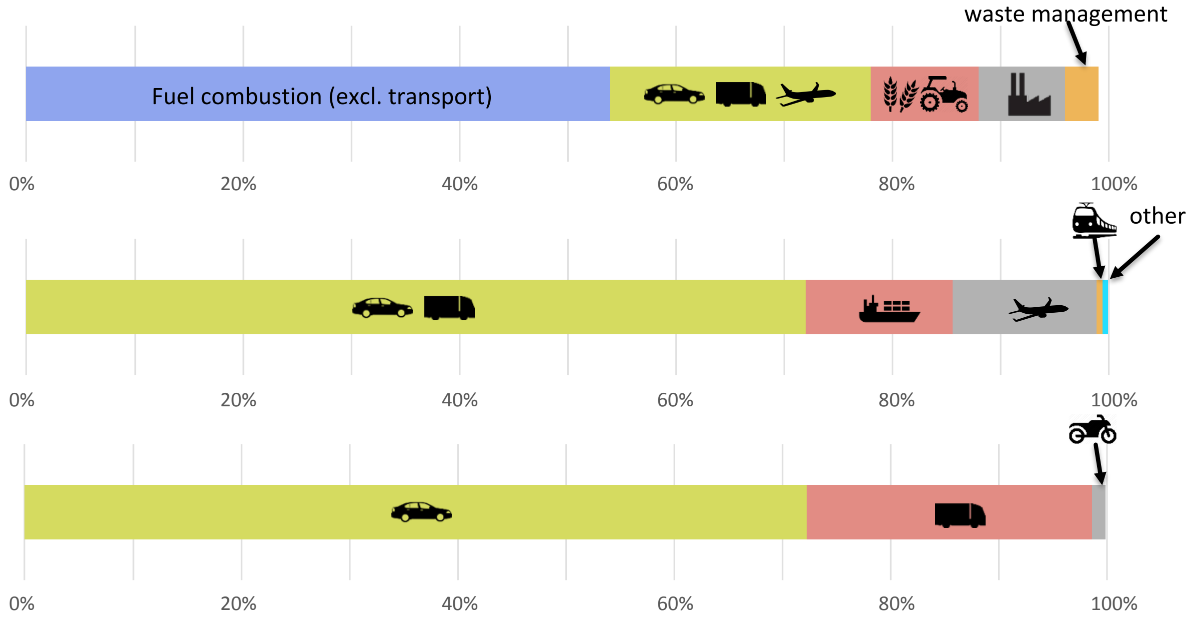
Why is transport important for EU emissions and climate goals?

Status 2016

- Transport produces 24% of total EU GHG emissions
- 72% of transport GHG emissions are produced on roads
- Of these, cars and LDVs produce 72%, while HDVs and busses produce 26%



sources: EEA 2018 & Eurostat 2018

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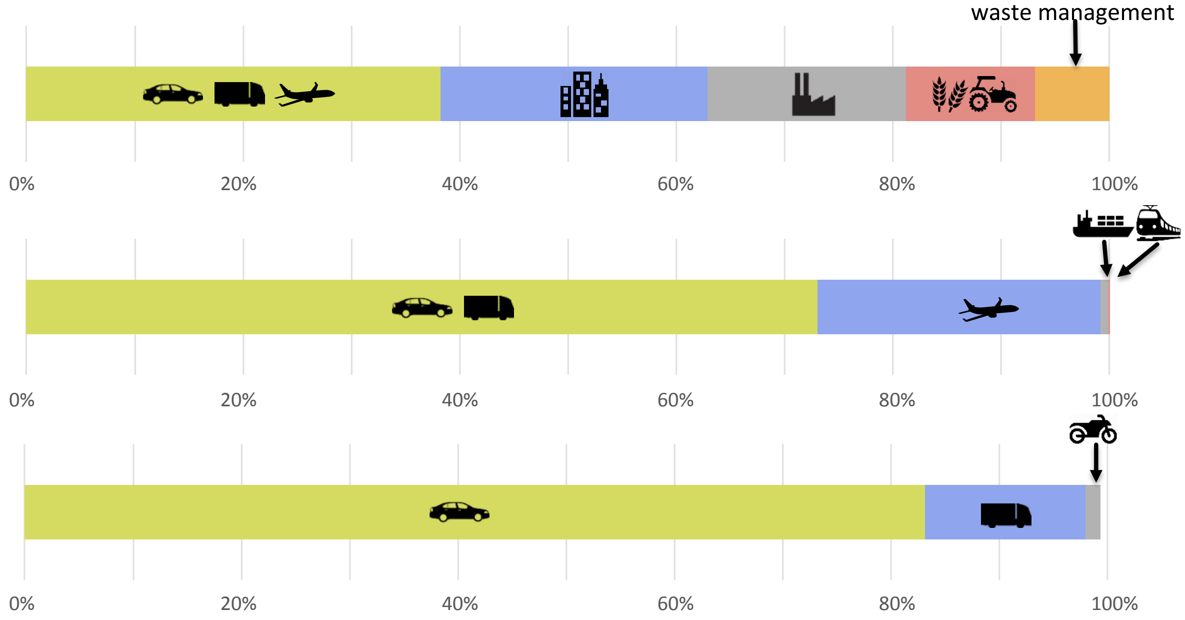
Why is transport important for Swiss emissions and climate goals?

Status 2016

- Transport produces 38% of total Swiss GHG emissions
- 73% of transport GHG emissions are produced on roads
- Of these, cars and LDVs produce 83%, while HDVs and busses produce 15%



source: BAFU 2018

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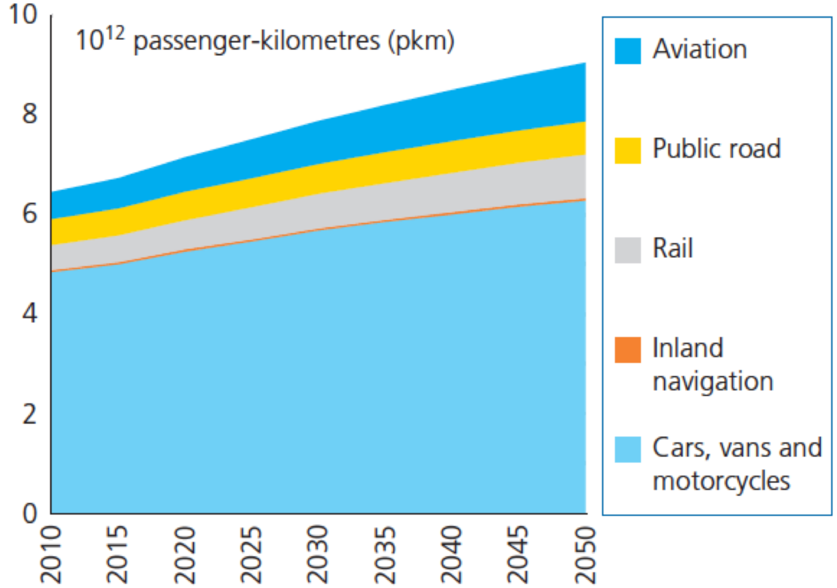
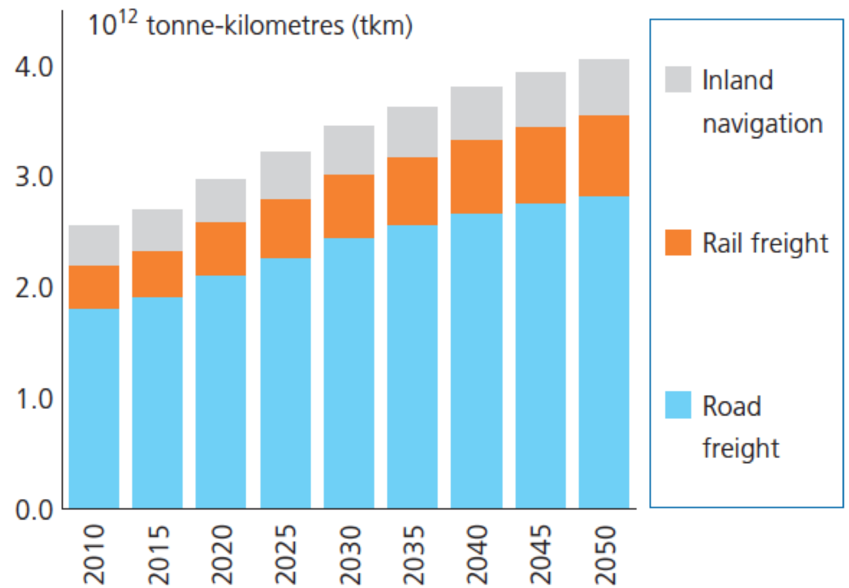
EU Reference Scenario projections (2016)

Demand for passenger and freight transport





source: EU Reference Scenario 2016

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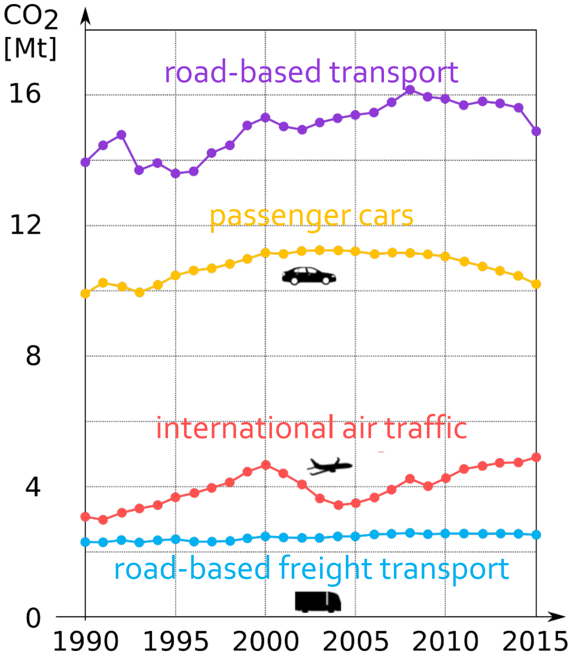
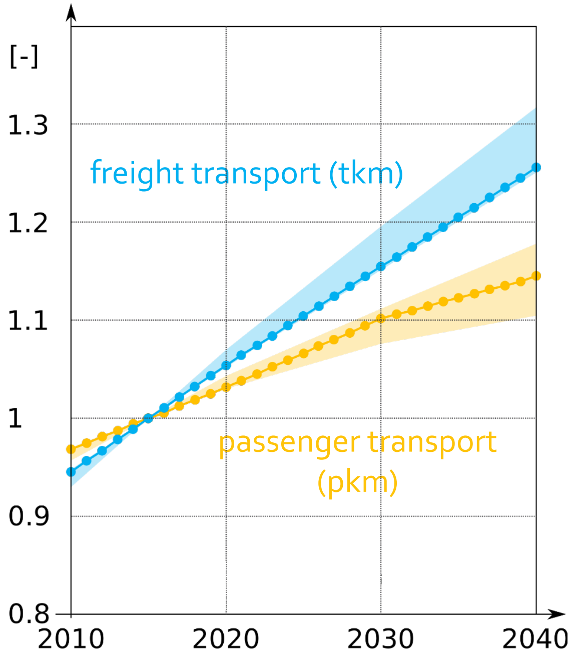
Current CO_2 emissions and future transport demand in Switzerland

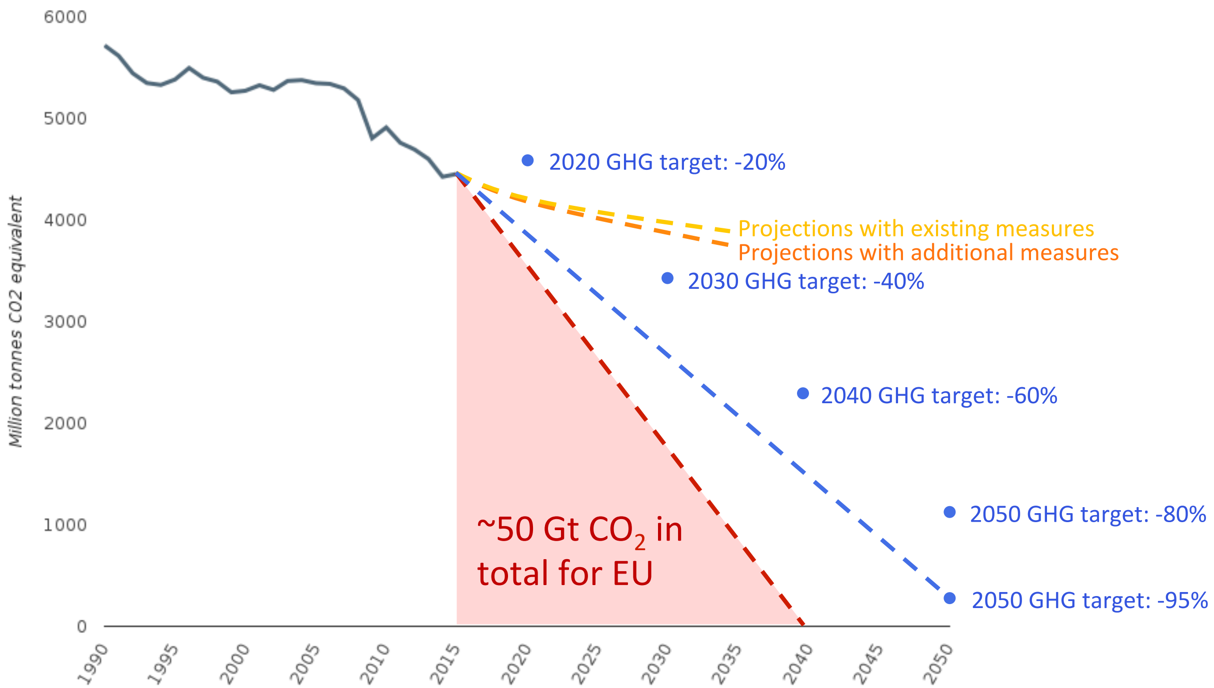


source: BAFU 2017



source: ARE 2016

EU reduction goals & commitment to Paris Agreement



source: European Environment Agency 2017

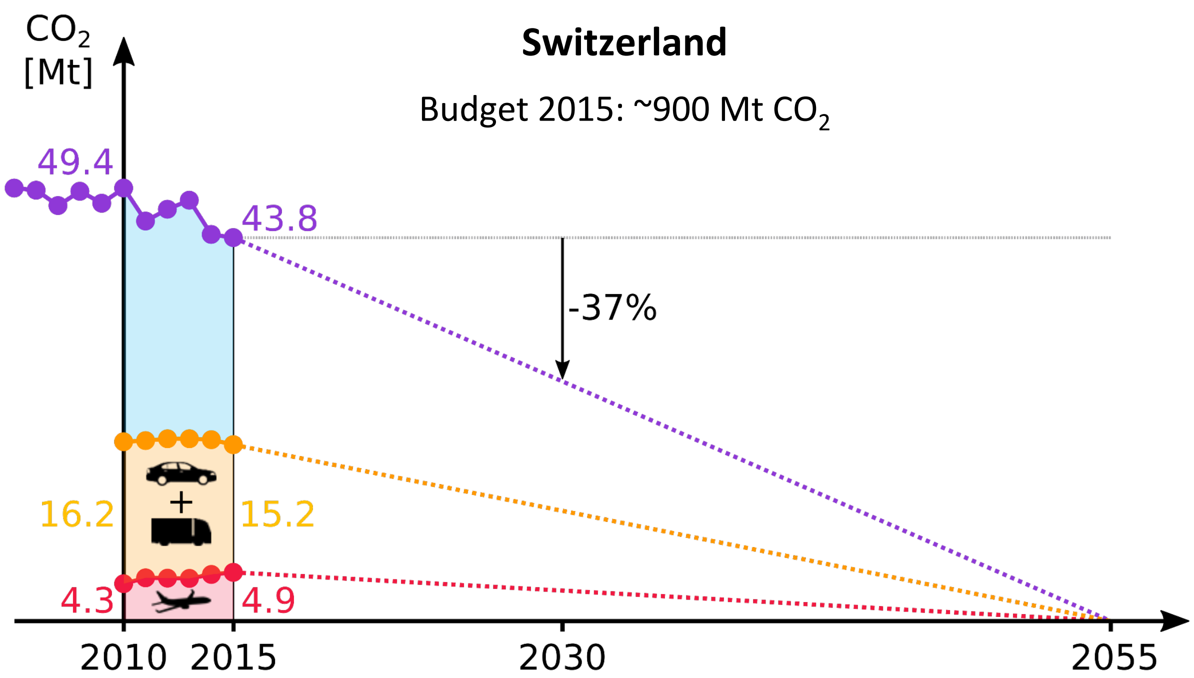
IPCC (2014) 2-degree climate goal (66% probability):

- world CO_2 budget from 2015 onward ~800 Gt
- distributed equally per capita: EU CO_2 budget ~50 Gt
- distributed equally across all energy sectors

→ Very large gap between projected greenhouse gas (GHG) emissions and what is needed to fulfill Paris Agreement commitments

→ Current EU policies are unlikely to deliver emission reductions quickly enough

Swiss commitment to Paris Agreement



IPCC (2014) 2-degree climate goal (66% probability):

- world CO_2 budget from 2015 onward ~800 Gt
- distributed equally per capita: Swiss CO_2 budget ~900 Mt
- distributed equally across all energy sectors

→ Large gap between projected greenhouse gas (GHG) emissions and what is needed to fulfill Paris Agreement commitments

→ Swiss policies need to accelerate the pace of CO_2 reduction

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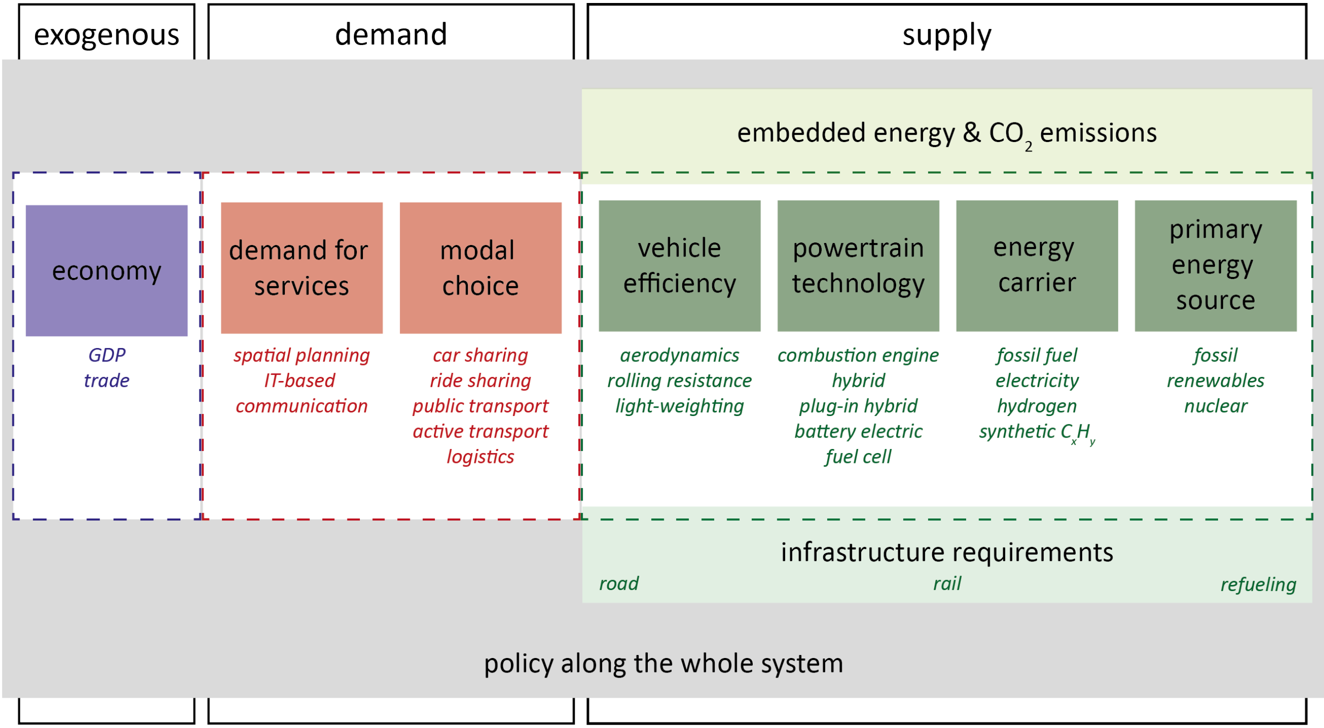
Analysis framework for decarbonisation options



- Both the demand and supply side must be included
- Information and communication technologies (ICT) can enable new business models at the interface of demand and supply but require mobility pricing policy to avoid rebound effects

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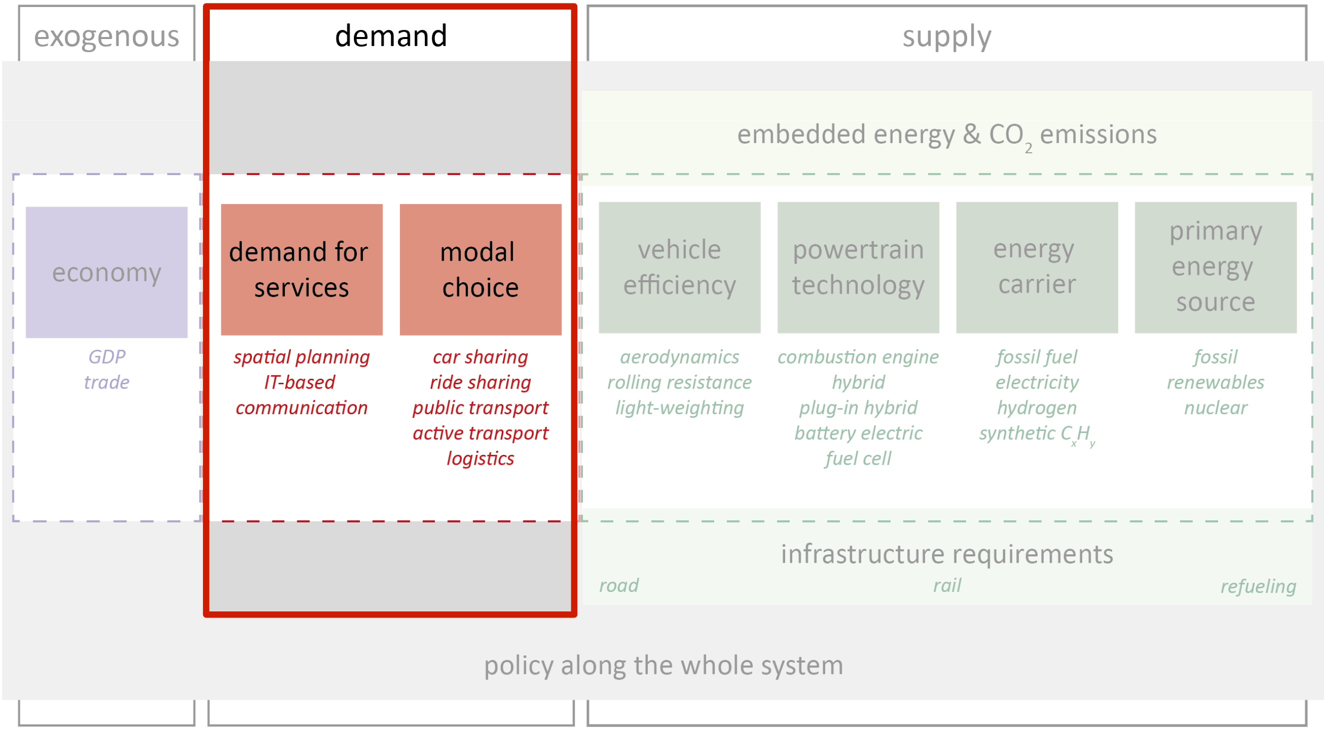

Contain (avoid excessive) demand for motorized transport

Shift to lower emission transport modes

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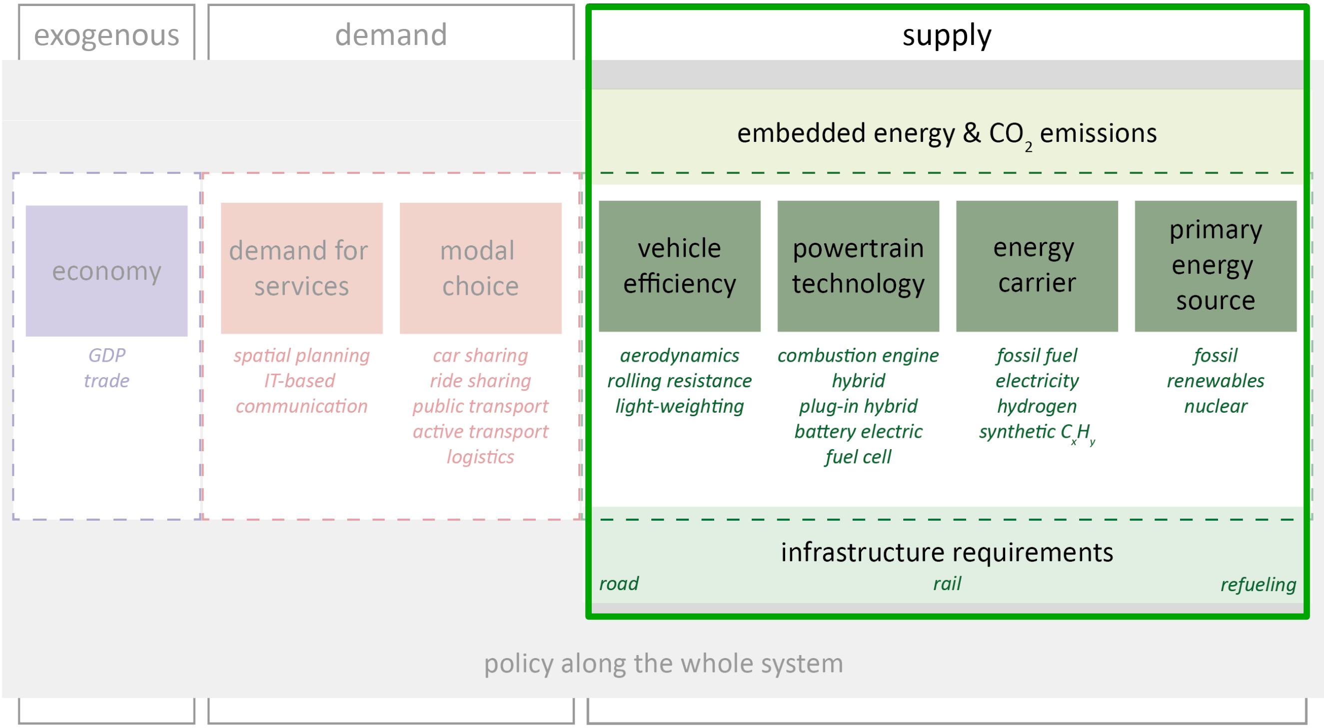

Improve vehicle design and powertrain efficiency

Substitute fossil with low-carbon energy carriers (renewable or nuclear)

Options to **contain** motorized demand for transport

Learn from best practices

- Promote cycling and walking ("micro-mobility")
- Facilitate working from home and teleconferencing
- Improve urban/spatial planning to reduce needs to commute long-term
- Implement and use ICT for identifying most efficient transport solutions

→ Be aware that ICT (incl. autonomous driving) lead to rebound effects (lower costs = more demand)

→ Therefore, mobility pricing is a must

source: metropolis.org

source: TU Delft 2019

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Options to **shift** transport demand to more efficient modes

- Shift passenger transport from cars to public transport
- Pool and share vehicles and rides
- Shift freight transport from road to rail (or waterways)
- Shift passengers from planes to high-speed trains

→ Such shifts require very large investments in new infrastructure for public transport, particularly high-speed rail

→ But: compare to worldwide subsidies for fossil fuels on the order of 300-400 billion Euros

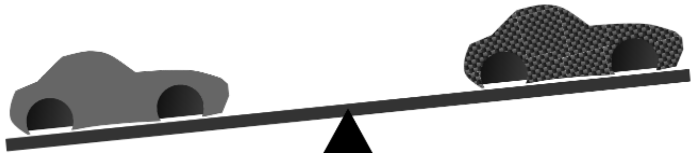
source: Wikipedia.org

source: moneyinc.com

Options to **reduce** vehicle GHG emissions
Incremental improvements (low-hanging fruits)

- Improve vehicle design (regardless of powertrain type)
  - Light weighting
  - Improved aerodynamics
  - Lower rolling resistance

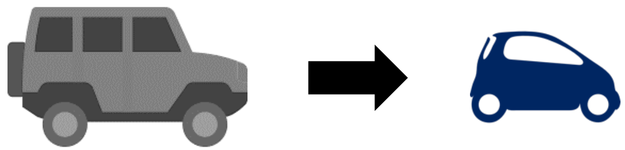
  } **~ -20%**



- Increase efficiency of powertrains
  - Hybridisation
  - Engine improvements

  } **~ -25-30%**

- Right-sizing of vehicles and engines



- Use low-carbon fuels
  - Sustainable biofuels and natural gas (if fugitive emissions of methane are limited)

  } **~ -15-25%**

Options to **substitute** fossil fuels

Long-term sustainable step-change developments

- Accelerate market penetration of battery-electric (BEV) and plug-in hybrid electric vehicles (PHEV) as well as electric road systems
- Fuel cell electric vehicles (FCEV) may be potentially important for long-range applications
- Invest in low-GHG electricity generation to meet needs of all sectors (industry, buildings and transport)
- Optimal design of future ETS will be crucial for this purpose → consequential for Switzerland
- Invest in and pave the way for the implementation of cost-efficient production of hydrogen and synthetic hydrocarbons from zero-GHG electricity
  - → particularly important for long-range heavy duty transport and long-term renewable electricity storage
  - → therefore, important for Switzerland (incl. industrial competitiveness)

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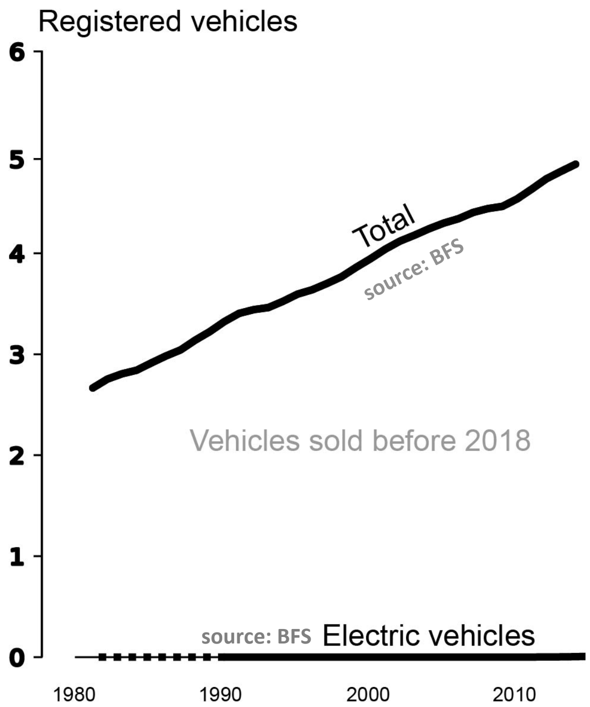
Time horizon of decarbonisation options for passenger cars (CH)



① Existing fleet
- Use low-carbon fuels

② New vehicles with higher efficiency
- Improved vehicle design
- Increased powertrain efficiency (incl. hybridisation)
- Use low-carbon fuels

③ Promote rapid electrification
- In parallel to decarbonising the electricity generation

source: Gil Georges, LAV-ETHZ

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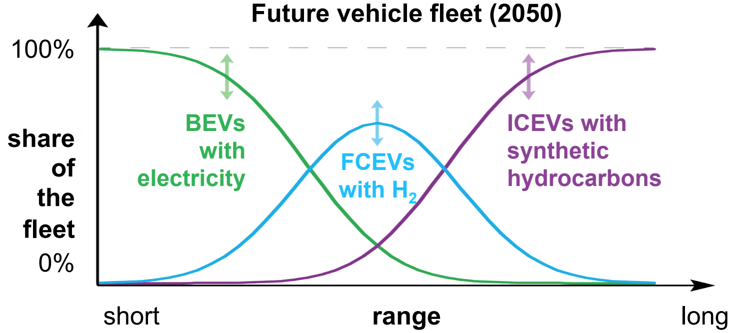
Energy conversion and efficient use of low-GHG electricity

→ Starting from zero-GHG electricity (renewable or nuclear)

Powertrain	Battery electric vehicle (BEV)	Fuel cell electric vehicle (FCEV)	Internal combustion engine vehicle (ICEV) with synthetic hydrocarbons
Efficiency at the wheel	60-70%	25-30%	13-20%

→ HOWEVER

- Long-range transport requires energy carriers with high gravimetric energy densities
- Chemical storage can help to match electricity demand with seasonally variable renewable electricity production
- Synthetic hydrocarbons could use existing distribution infrastructure and carbon from CCU (carbon capture and utilization)



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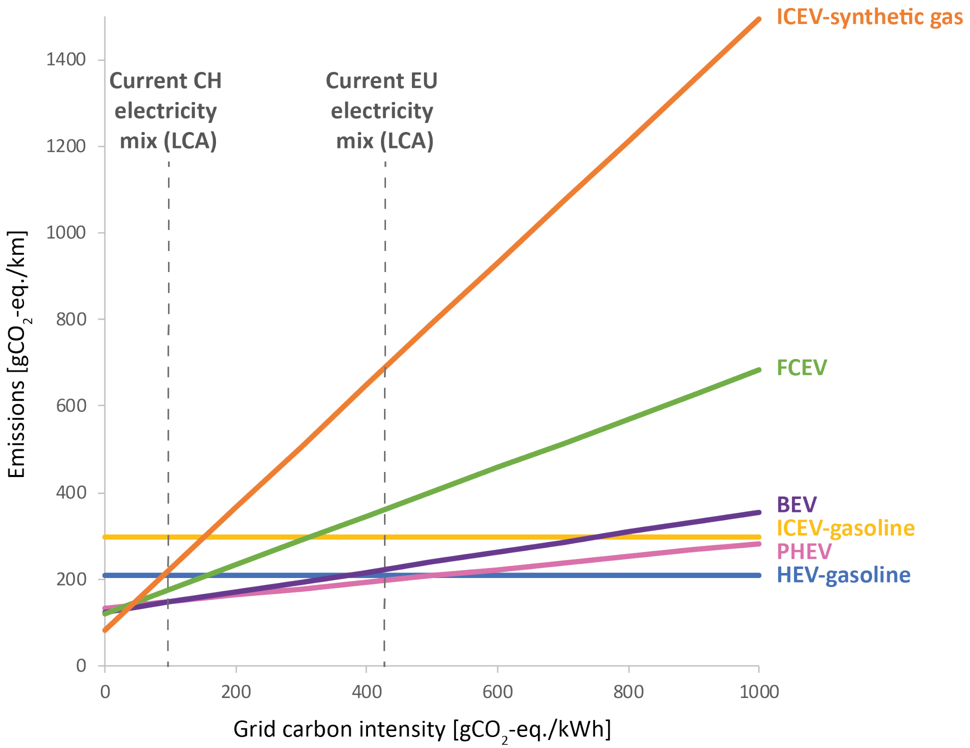
Lifecycle GHG emissions and potentials of different car technologies



source: Brian Cox 2018, PSI/ETHZ

- With the current EU electricity mix, BEVs produce less GHG emissions than ICEVs, but more than HEVs
- PHEVs with small batteries are at least as good as BEVs for all grid GHG intensities
- Hydrogen and synthetic fuels produce more GHG emissions than direct electrification (unless zero-GHG grid footprint)

→ However, it is expected that both battery and vehicle manufacturing will be less GHG-intensive and the EU grid GHG intensity will decrease substantially (with optimal ETS design)

Conclusions & recommendations

Big gap between transport demand projections and the EU's and Switzerland's commitments to the Paris Agreement. Therefore it is necessary to:

1) Strengthen policies and increase investments to contain motorized transport, shift to lower GHG-emission transport modes and increase the efficiency of vehicles and powertrains
2) Accelerate the deployment of low-GHG electricity generation in parallel to providing incentives for the electrification of road transport and reduce environmental burden of battery manufacturing
3) Strengthen international cooperation on producing, certifying, labelling and using synthetic fuels in aviation and shipping while also serving the needs for seasonal long-term storage of electricity
4) Support collaborative research and innovation activities to build skills in ICT, electricity system management, low-GHG vehicle and battery manufacturing, maintenance and recycling
5) Swiss residents are among the most frequent flyers in the world, and Switzerland hosts leading technology suppliers for the international automotive and shipping industry. Therefore, we should seize opportunities and enhance knowhow and infrastructure for the supply of renewable synthetic fuels, thus creating synergies between protecting the climate and strengthening Swiss industry.

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ETH Zurich Zukunftsblog article

“A (long) way to climate-neutral road transport”

- https://www.ethz.ch/en/news-and-events/eth-news/news/2019/04/blog-boulouchos-decarbonisation-transport.html