ETH zürich

On the Future of Transport – an Energy Systems Perspective

Joint Symposium

MIT Energy Initiative and ETH Zürich ESC

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Outline

- Driver(s) for the future development of the Transportation System
- Decarbonization as overarching goal → 3 pillars of a transformation path towards Sustainable Transport
- Interfaces between the Transportation and Electricity Sectors
- Where should we best invest a **«1kWh renewable electricity»**? – A comparative view on different energy sectors
- Targeted interventions for CO2-reduction in Transportation – some examples from the SCCER Strategic Guidance Project

Drivers for the future Transportation System

- Higher income → more demand for transportation services of «higher quality» (comfort safety, vehicle performance)
- Urbanization and worldwide integration of trade streams
- IT/C/ «Digital revolution» (Energy, Mobility 4.0)
- Minimization of atmospheric pollution
- Security of supply → Efficiency and Diversification
- Climate change Mitigation

CO_2 Emissions of Transport

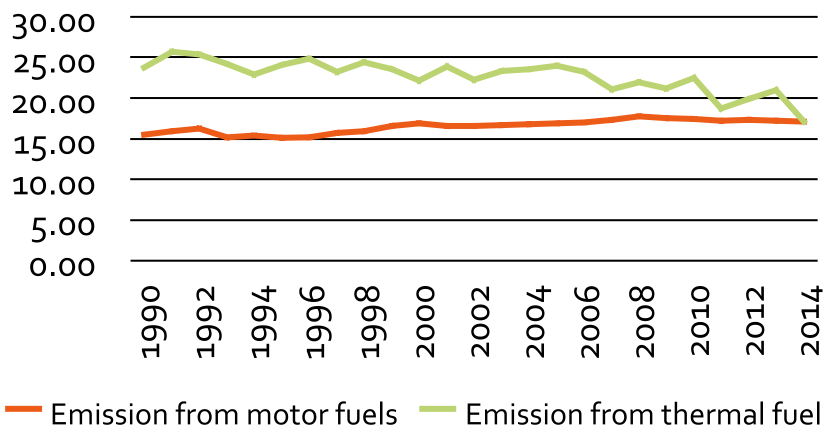
Direct CO_2eq emission

Sector	Worldwide	Switzerland (w/o air travel)
Transport	18 %	**39 %**
Electricity supply	33 %	5 %
Buildings	8 %	37 %
Industry	28 %	13%
Total per capita	5t/y	5t/y

(Source BAFU)

Emission from motor and thermal fuels

(Million tons CO_2 in Switzerland)

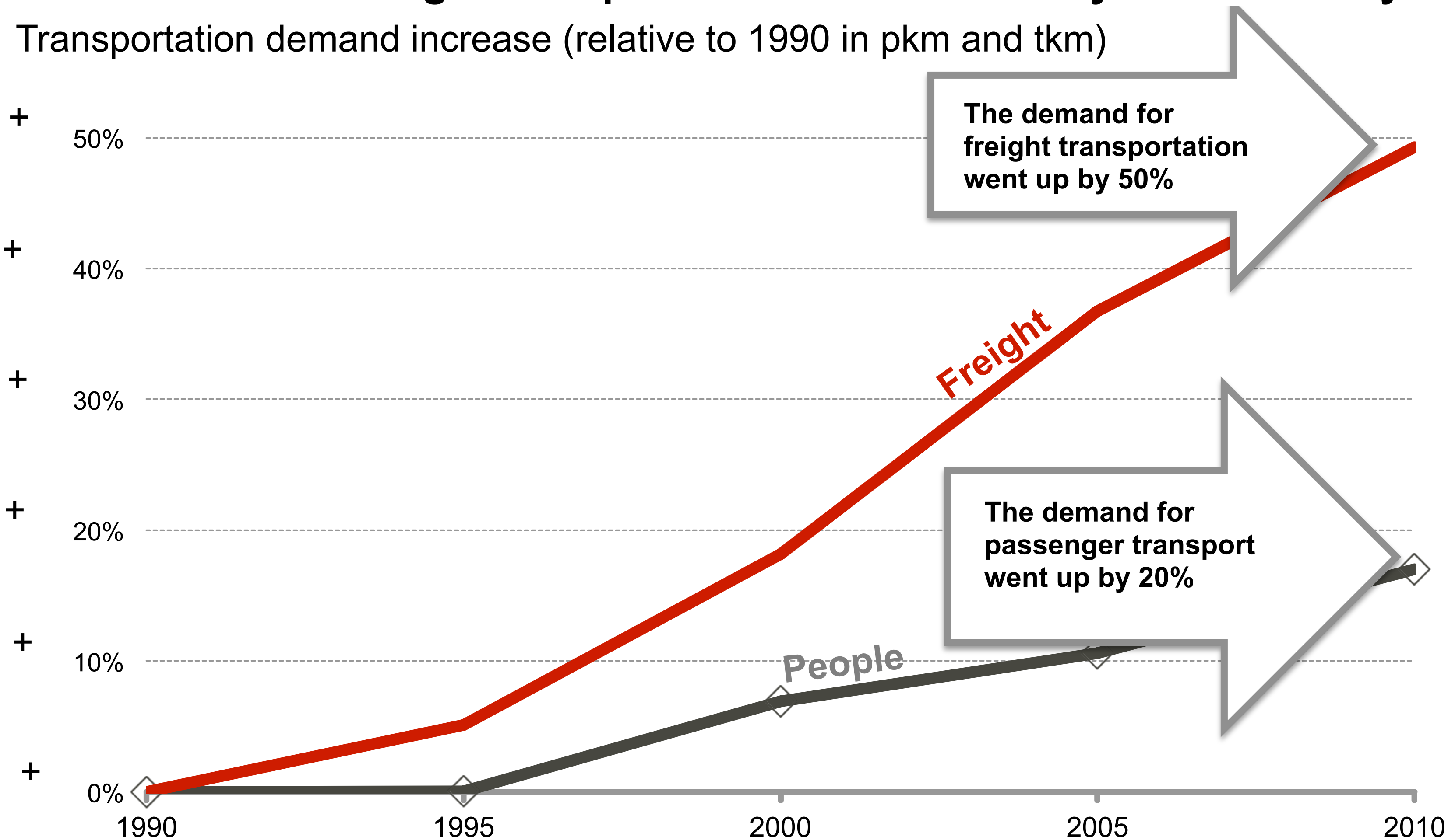


- Share of transport-related GHG emission very high in Switzerland
- Relative importance likely to increase in the future also worldwide

Freight is growing even faster than passenger transp.

→ the demand for freight transp. in CH has increased by 50% over 20 years

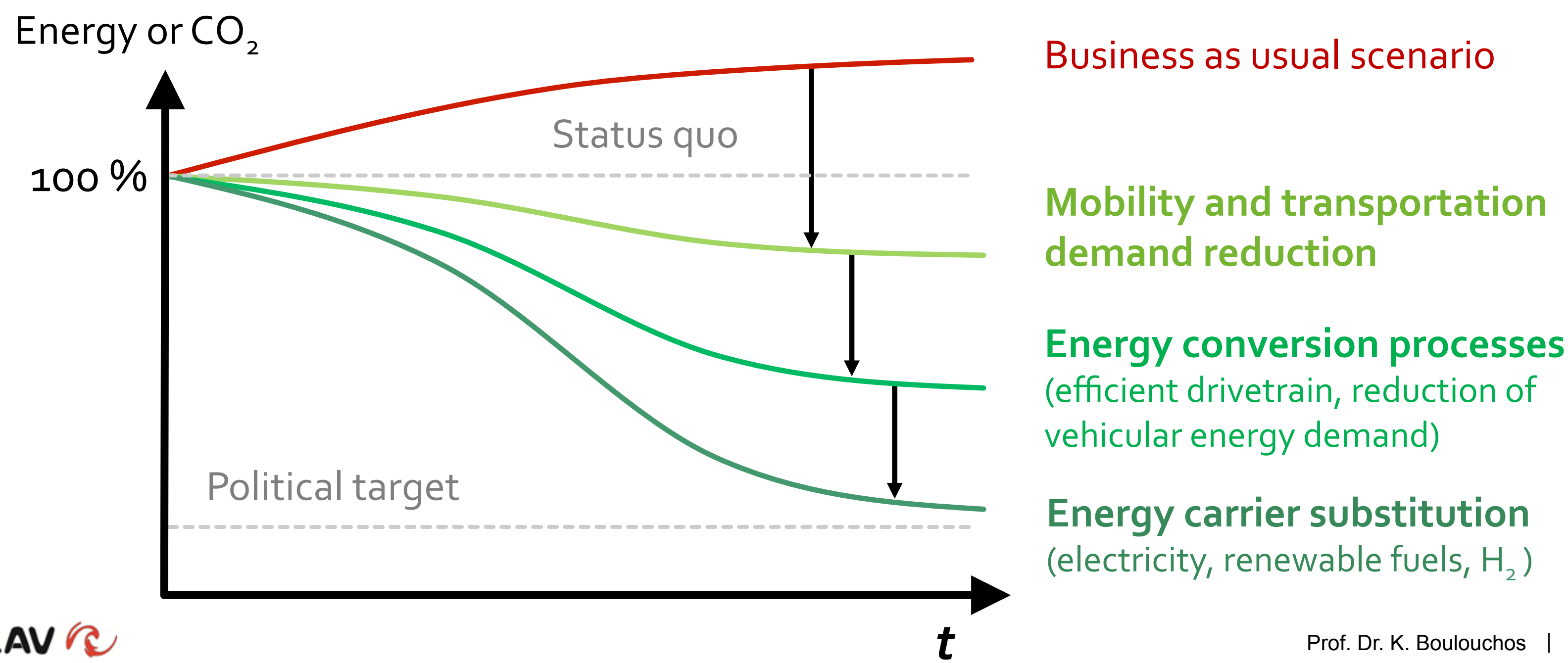
Transportation demand increase (relative to 1990 in pkm and tkm)



Sources: BAFU (2011), strassenschweiz FRS (2011), BFS (2012)

SCCER Mobility: A 3-pillars Strategic Approach

Developing the knowledge and technologies essential for the **transition of the current fossil fuel based transportation system to a sustainable one**, featuring minimal CO2-output and primary energy demand as well as virtually zero-pollutant emissions.



SCCER Mobility: Capacity Areas

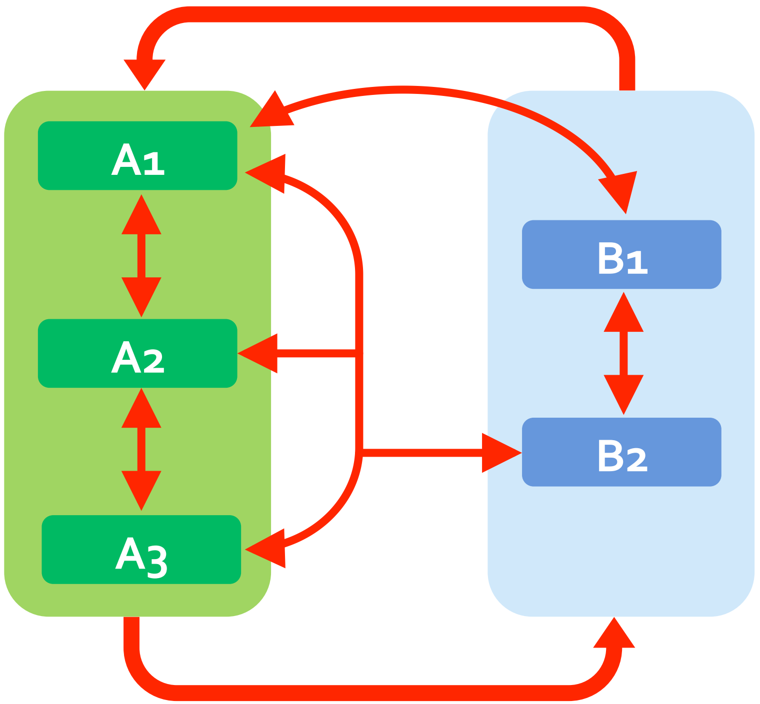
A1 **Systems and Components for E-Mobility**

A2 **Chemical Energy Converters**

A3 **Minimization of Vehicular Energy Demand**

B1 **Integration, Operation and Optimization of Mobility Systems**

B2 **Integrated Assessment of Mobility Systems**

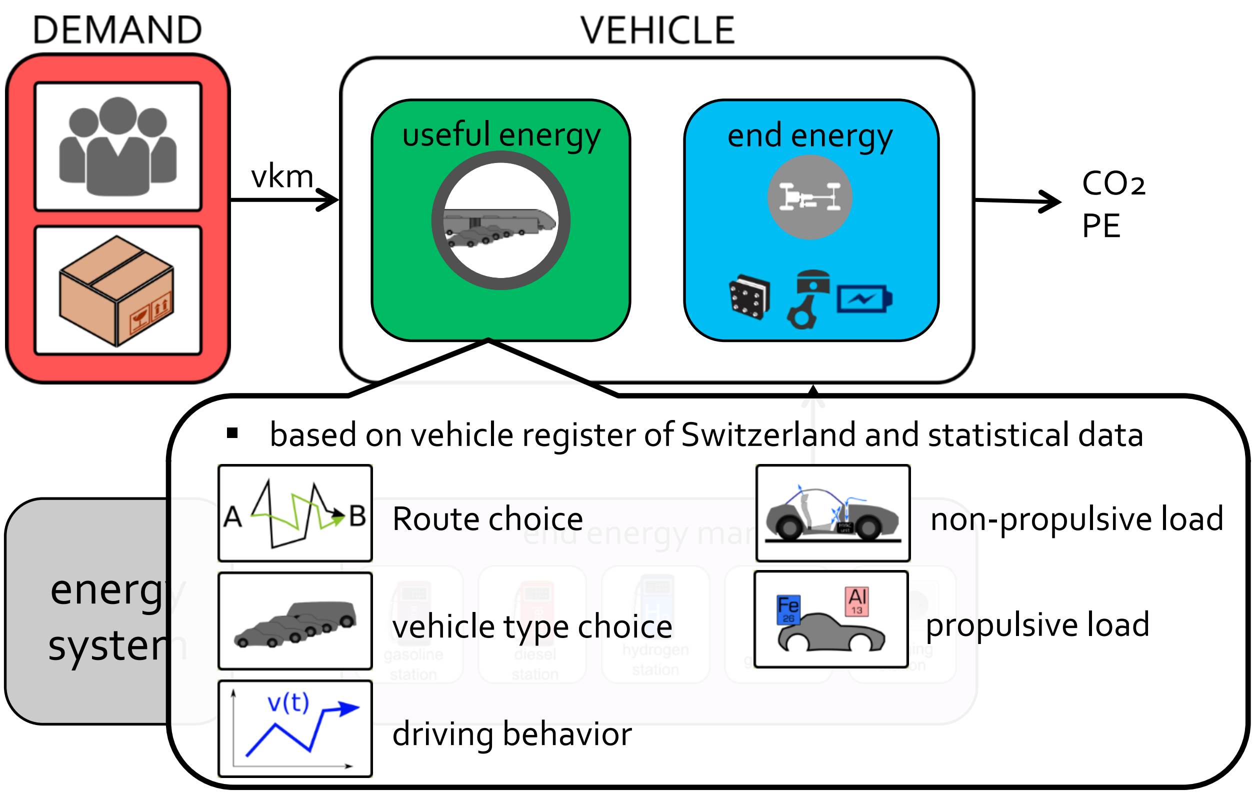


Innovation Field A
Components and Technologies

Innovation Field B
Mobility Systems

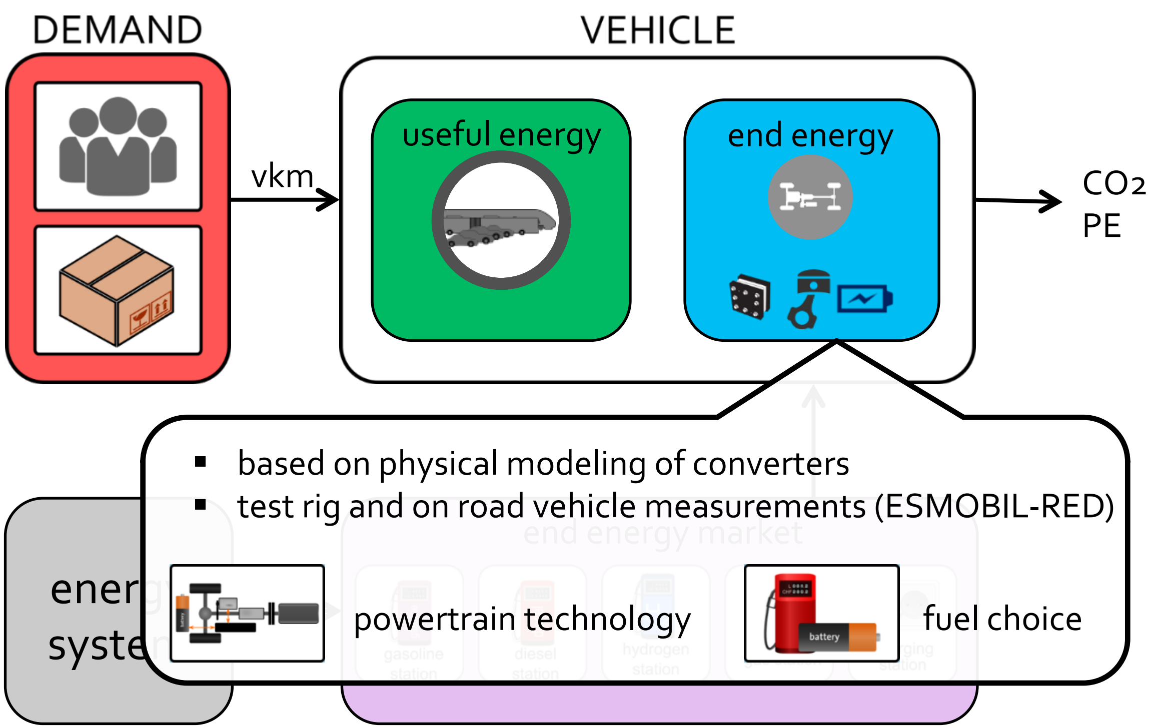
Energy-systemic model of the mobility sector (ESMOBIL-RED)

translate “vkm” to real-world energy demand; propulsive & non-propulsive energy demand



Energy-systemic model of the mobility sector (ESMOBIL-RED)

translate “vkm” to real-world energy demand; powertrain technology and energy carriers

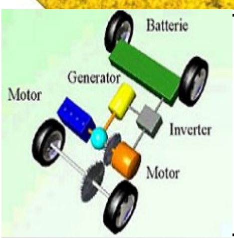


Technical paths for future cars powertrains

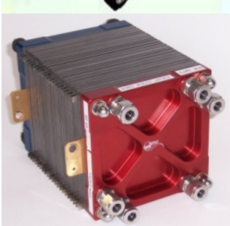
Evolution of the **Otto engine**
Evolution of the **Diesel engine**

Downsizing, direct injection with high variability, flexible high charging, variable valves, flexible geometries, combined exhaust gas after treatment

Evolution of the IC-motor (Diesel, Otto) **PLUS**
new fuels (biogenous, gas/liquid, synthetic/H_2-enriched reformates)



Increasing **hybridization** (mild, full,...) on IC-engines as „Range Extender“ and finally extensive **electric operation**

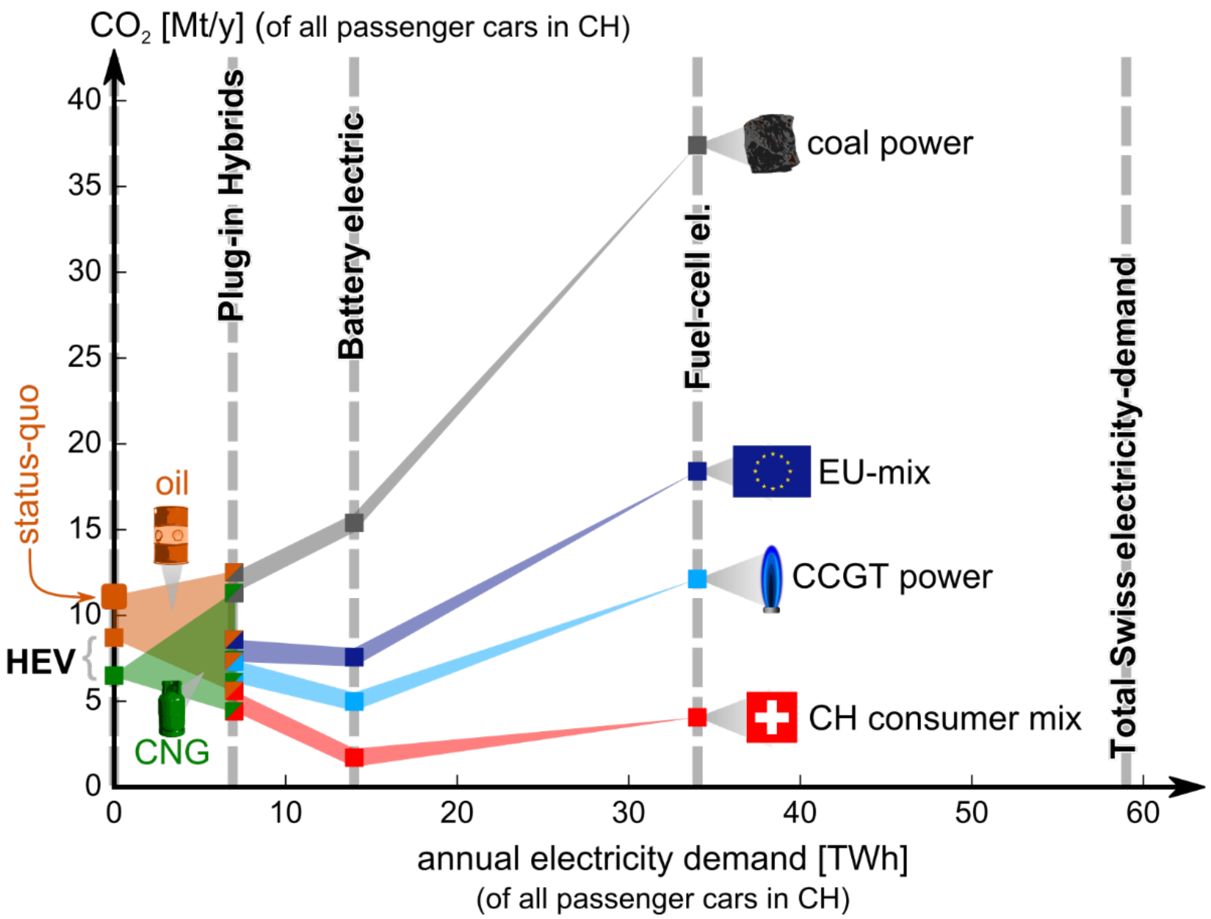


Conversion to hydrogen and fuel cells

2000 → **2050**

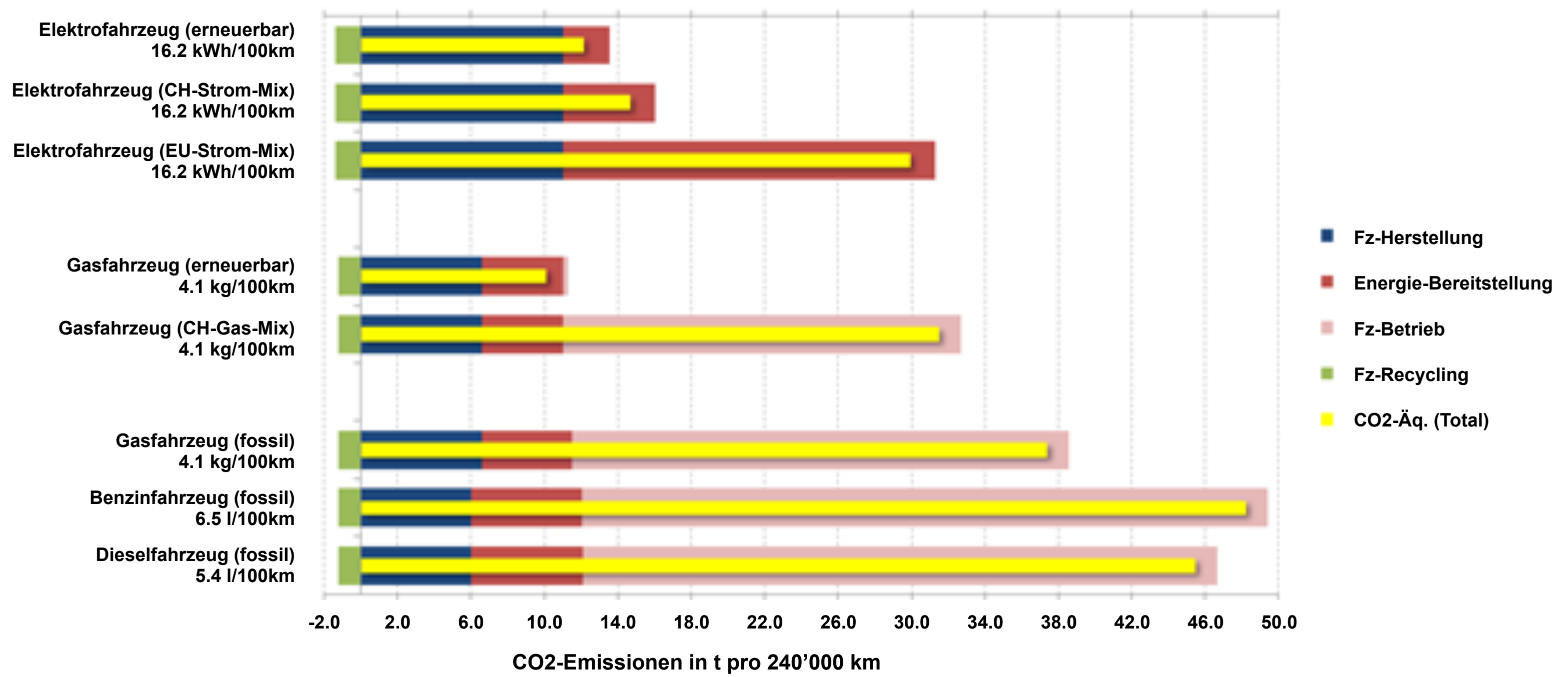
CO_2-reduction potential

of individual Transportation CH and associated Electricity Demand



Comparison of CO_2 for renewable fuels and renewable electricity

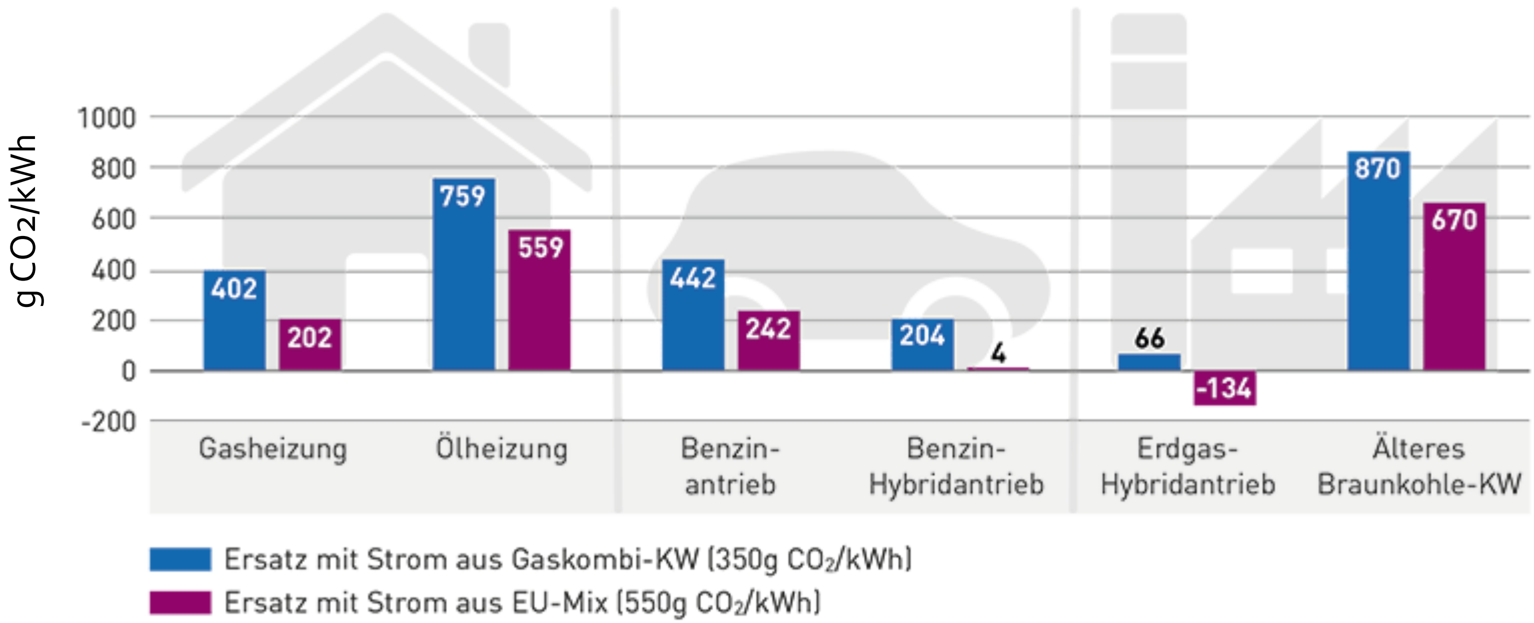
based on Life Cycle Analysis



Source: Bauer et al, Applied Energy (2015), Fuchs et al. ATZ (2014), Audi (2015), fuel consumption from Spritmonitor.de for VW Golf 81-85 kW (MJ 2014/2015). Biogas according to LCA-Study Empa-PSI-Agroscope-Doka (2012); EU-Strom-Mix: 522 g CO_2/kWh, CH-Strom-Mix: 130 g CO_2/kWh, renewable Electricity: 65 g CO_2/kWh

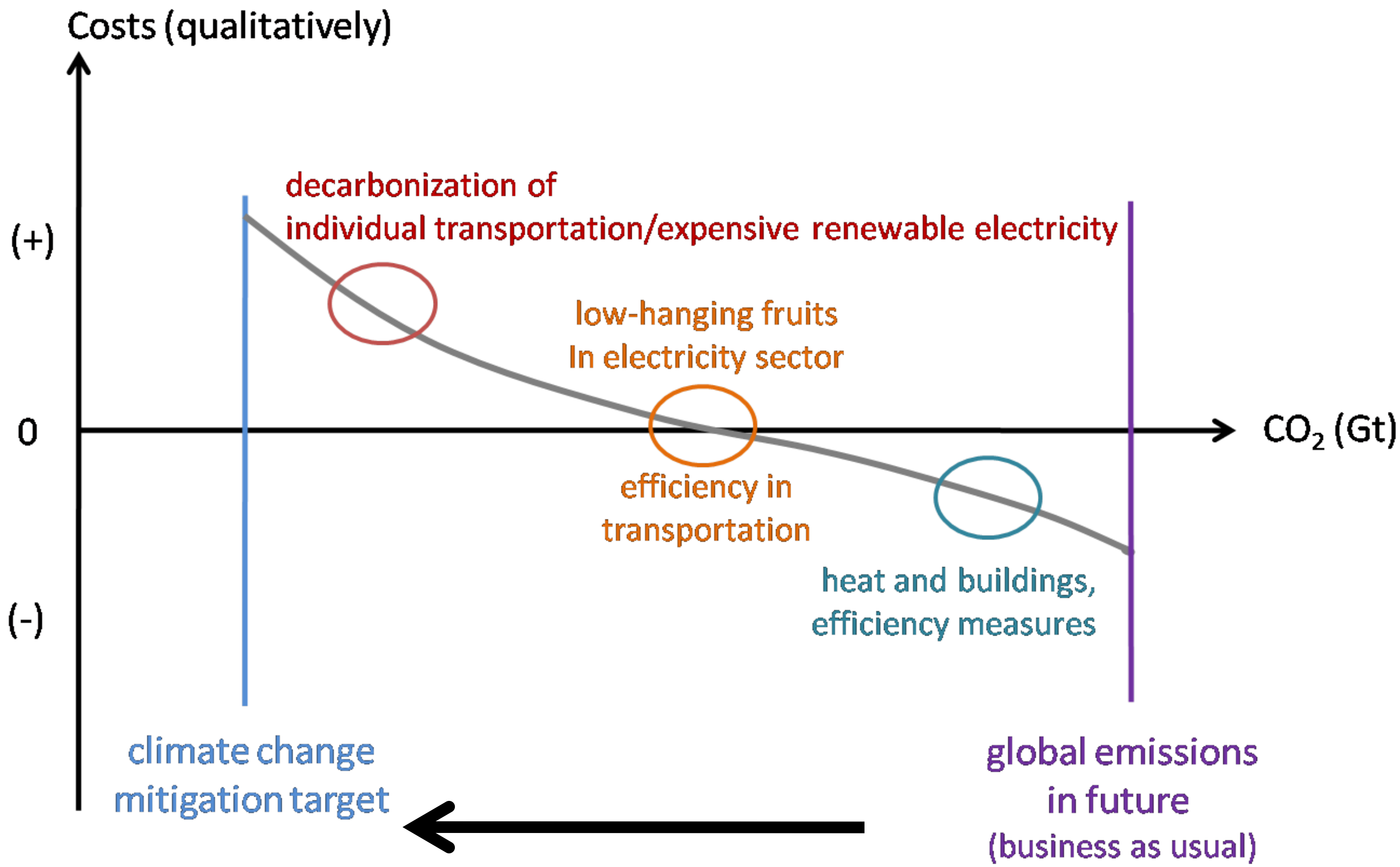
CO_2-reduction through substitution of existing assets

→ **what can we achieve with 1 kWh of electricity?**



Source: K. Boulouchos, ETHZ Zukunftsblog, «Weg zu CO2-armen Energiesystem»

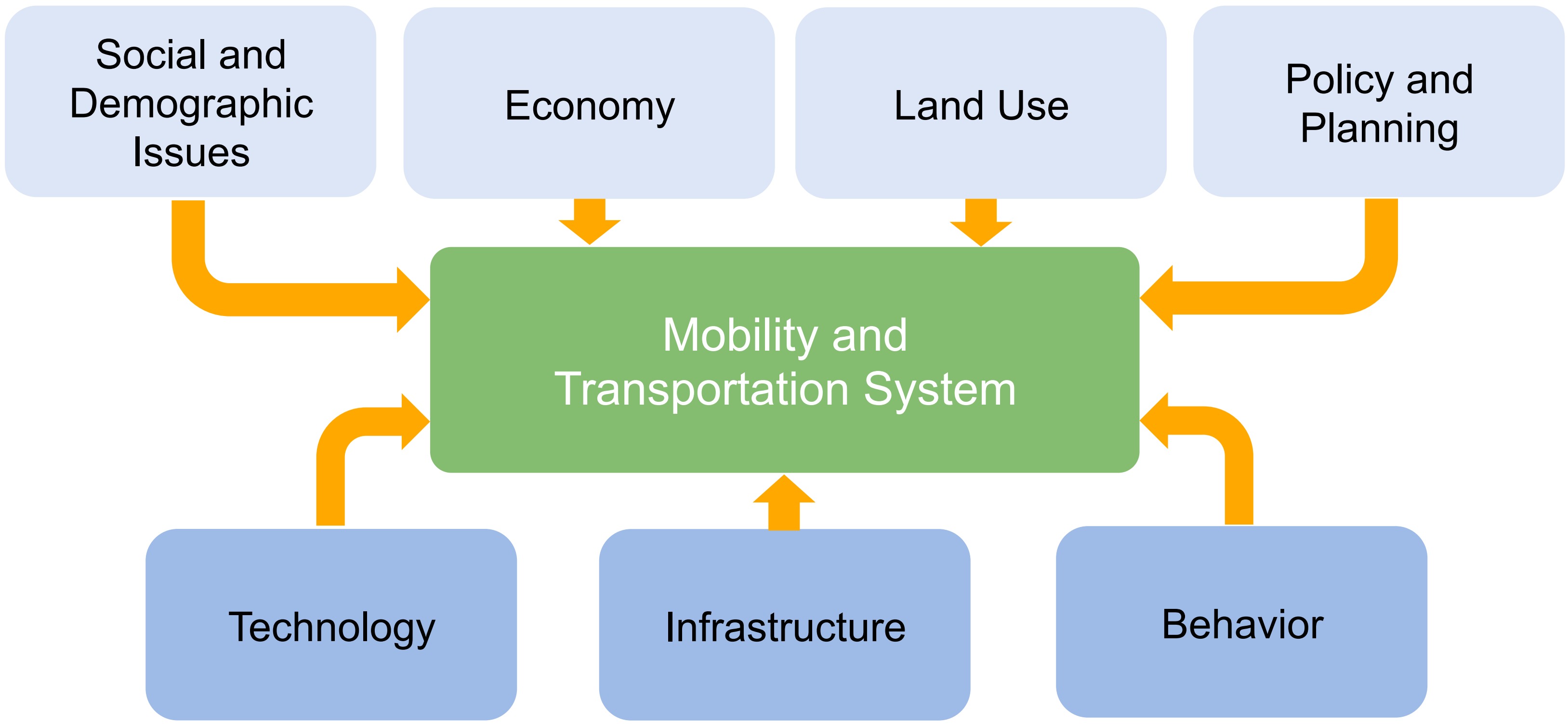
CO_2 mitigation (qualitatively)
Costs for different sectors and technologies



Source: K. Boulouchos, ETHZ

… but it is not only about technology and costs…

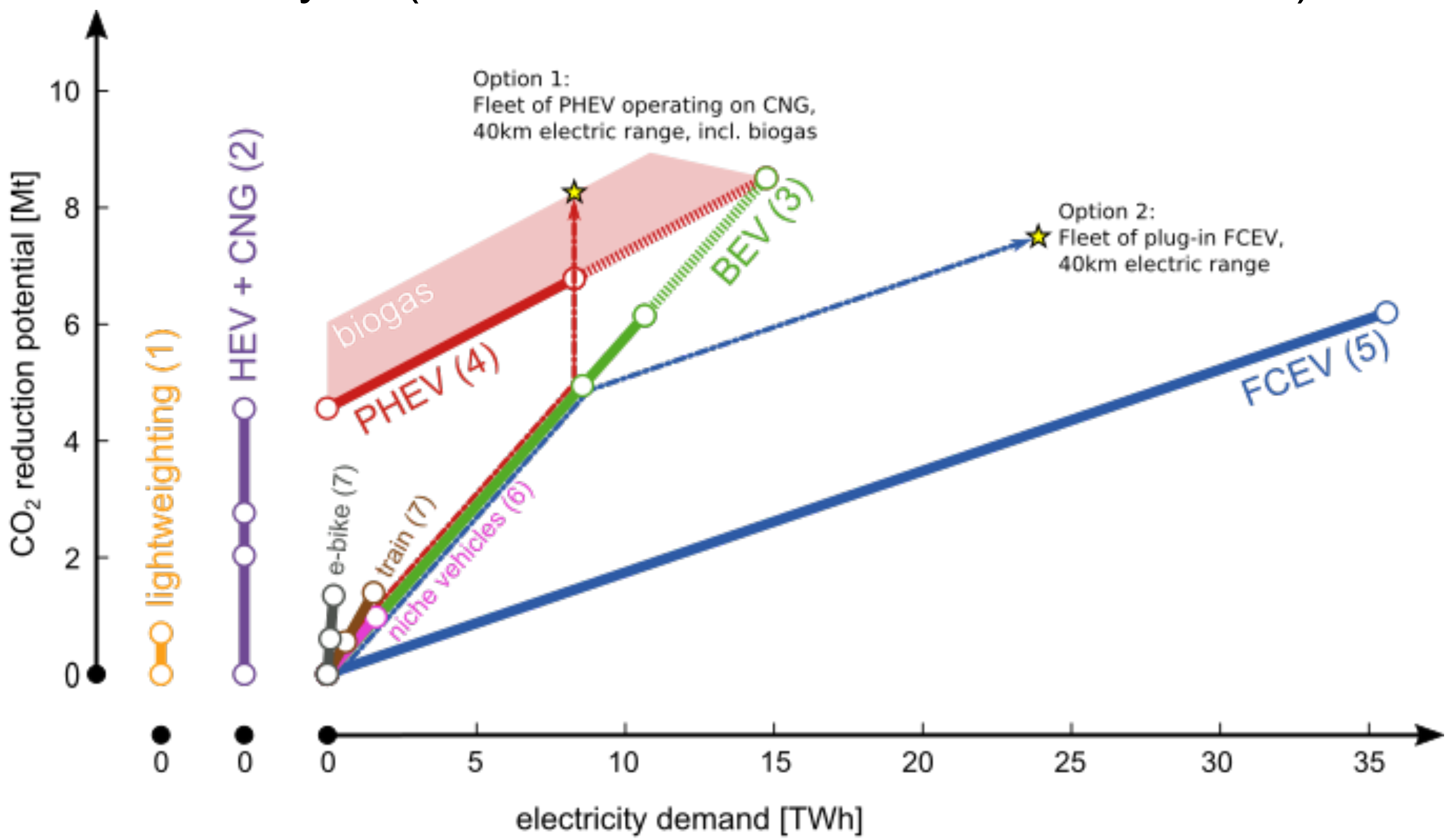
Key Factors and Drivers Influencing the Mobility System



CO_2 Mitigation Potential vs. Electricity Demand

(SCCER Strategic Guidance Project)

Portfolio analysis (calculations for selected interventions)



Why consider FCEV?

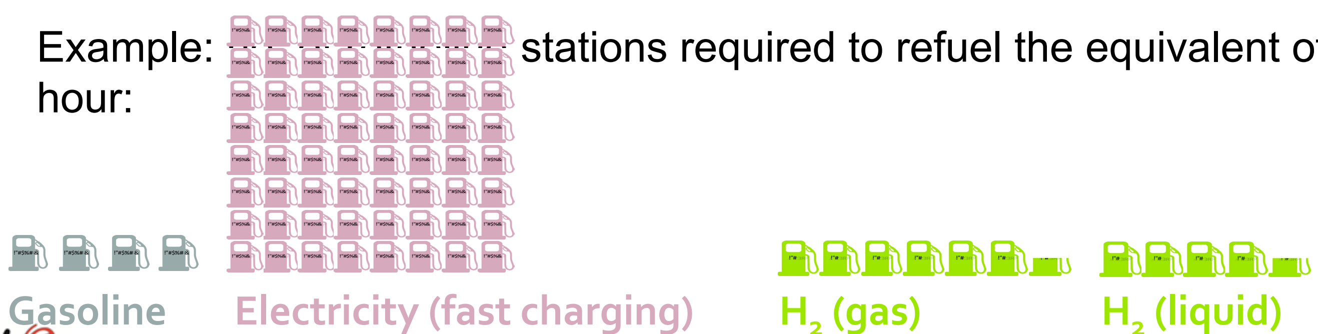
Undisputedly,

- electricity demand of FCEV is much higher than for BEV
- additional infrastructure for H_2 generation and distribution is expensive

But,

- larger **driving range for same weight**
- H_2 production important option for **storing excess electricity**
- shorter **recharging times** and **less charging stations**

Example: stations required to refuel the equivalent of 40'000 km in 1 hour:



Conclusions and Outlook

1. Climate change mitigation and consequently CO_2-minimization will affect dramatically the shape of the Transportation Sector future (together with digitalization)
2. Transportation refers not only to passenger cars → long-range (particularly intercontinental) freight and individual transport demand increases faster than short range individual mobility
3. We are certainly going to experience a fierce competition among powertrain technologies and energy carriers with different possible winners for distinct sectors
4. Overall, there cannot be any doubt that an increasing electrification of the transportation sector will happen
5. However, the extent to which such substitution is meaningful in terms of the trade-off between CO_2-mitigation and overall costs will ultimately depend on the CO_2-footprint of the electricity sector in the next decades

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23 Research Groups affiliated to

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SCCER Mobility Overview

n|w Fachhochschule Nordwestschweiz

SUPSI Scuola Universitaria Professionale della Svizzera Italiana

zh aw

Leading House: ETH Zurich

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Further information: **www.sccer-mobility.ch**

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sccer mobility

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Efficient Technologies and Systems for Mobility

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In cooperation with the CTI

Energy funding programme
Swiss Competence Centers for Energy Research

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SCCER Mobility

The **Swiss Competence Center for Energy Research - Efficient Technologies and Systems for Mobility (SCCER Mobility)** aims at developing the knowledge and technologies essential for the transition of the current fossil fuel based transportation system to a sustainable one, featuring minimal CO_2 output and Primary Energy Demand as well as virtually zero-pollutant emissions.

Innovation Field A deals with components and devices: Capacity Area CA A1 aims at new battery technologies, CA A2 at optimal use of renewable chemical energy carriers for fuel cells and combustion engines and CA A3 at the minimization of vehicular energy demand (lightweighting and thermal management). Innovation Field B composes of CA B1 targeting infrastructure, logistics and ICT-systems and CA B2 covers the assessment of the transportation system.

The program aims at creating synergies at the interfaces of these five Capacity Areas serving as virtual research teams, composed of new and rededicated key research positions from ETH-Domain and the Universities of Applied Sciences. Many relevant Swiss and foreign companies are actively involved in various SCCER Mobility research projects.

Events

System Models in Life Cycle Assessment

September 5, 2016

Summer school on system models in life cycle assessment, - September 5-9, ...

Energy Storage in Batteries: Materials, Systems and Manufacturing

July 11, 2016

Summer School 11-15 July 2016 in Möschberg, Switzerland organized by SCCER ...

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