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Renewable Energies for Urban Mobility - Technology Paths in the future

IEA Networking Event Switzerland

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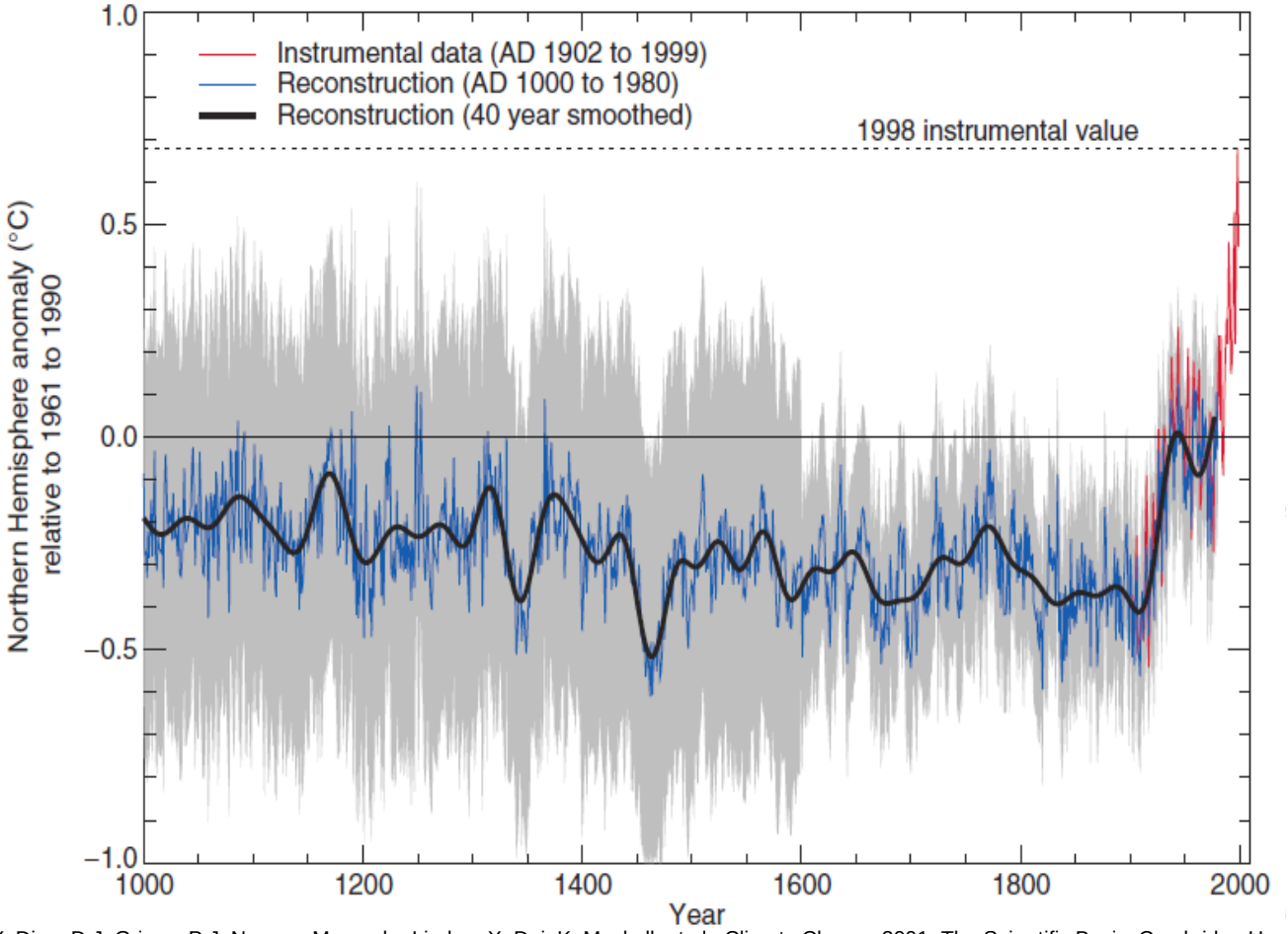
Outline

- Major challenges in the Transportation Sector:
  → Local pollution, dependence on oil, climate change (CO_2-emissions!)
- It is not all about technology → the Demand Side Development
- The Supply Side: which Powertrain Technologies and Energy Carriers for the Future?
- The SCCER on Efficient Mobility → Mission, Content and Strategic Goals
- Conclusions and Outlook

Global Warming as major threat

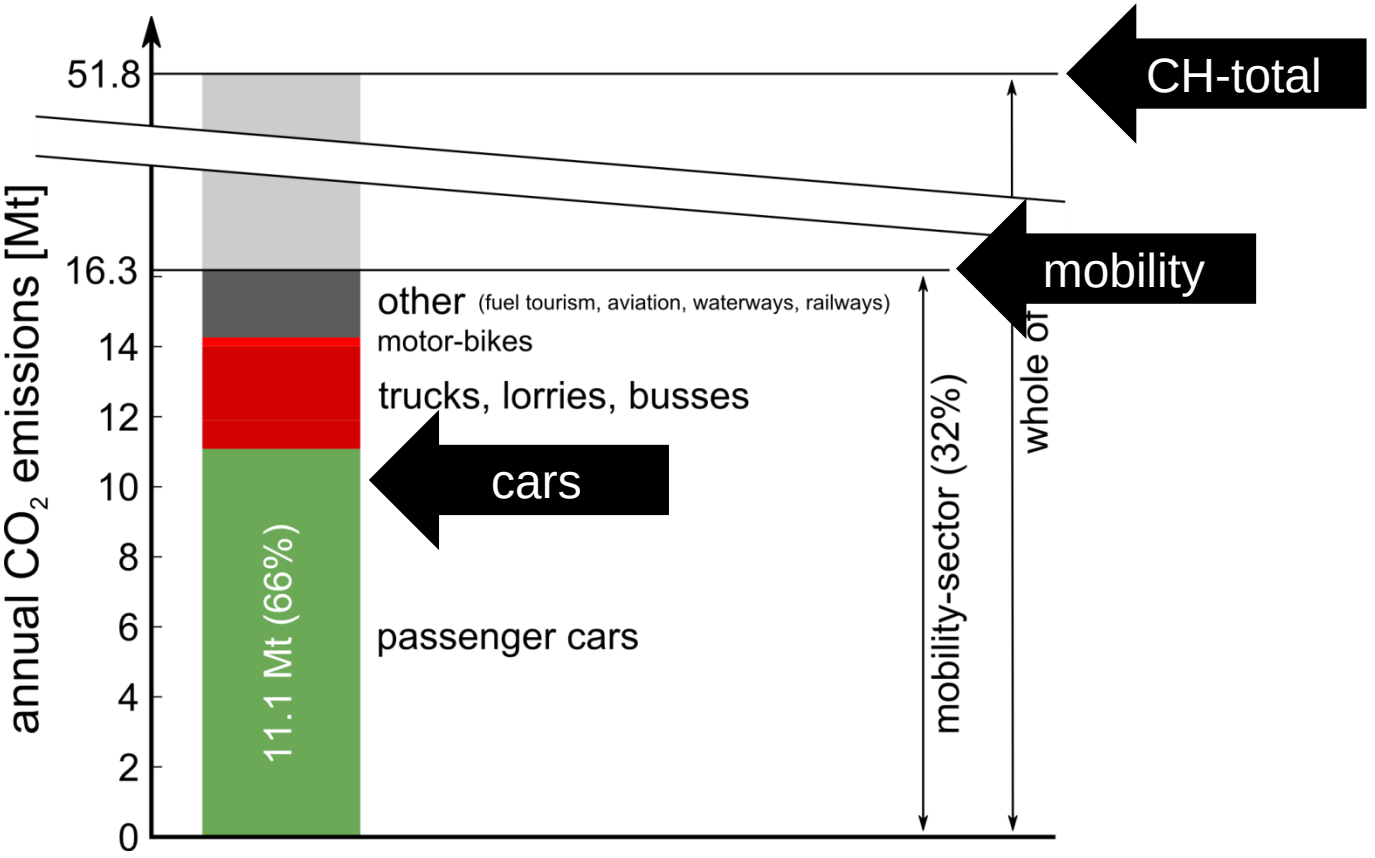
→ non-sustainable CO_2 emissions gather in the atmosphere



Source: J.T. Houghton, Y. Ding, D.J. Griggs, P.J. Noguer, M.van der Linden, X. Dai, K. Maskell, et al., Climate Change 2001: The Scientific Basis, Cambridge Unv. Press, 2001.

The Challenge → CO_2 from passenger cars

status-quo today: 11.1 Mt CO2, 98.4% conventional cars

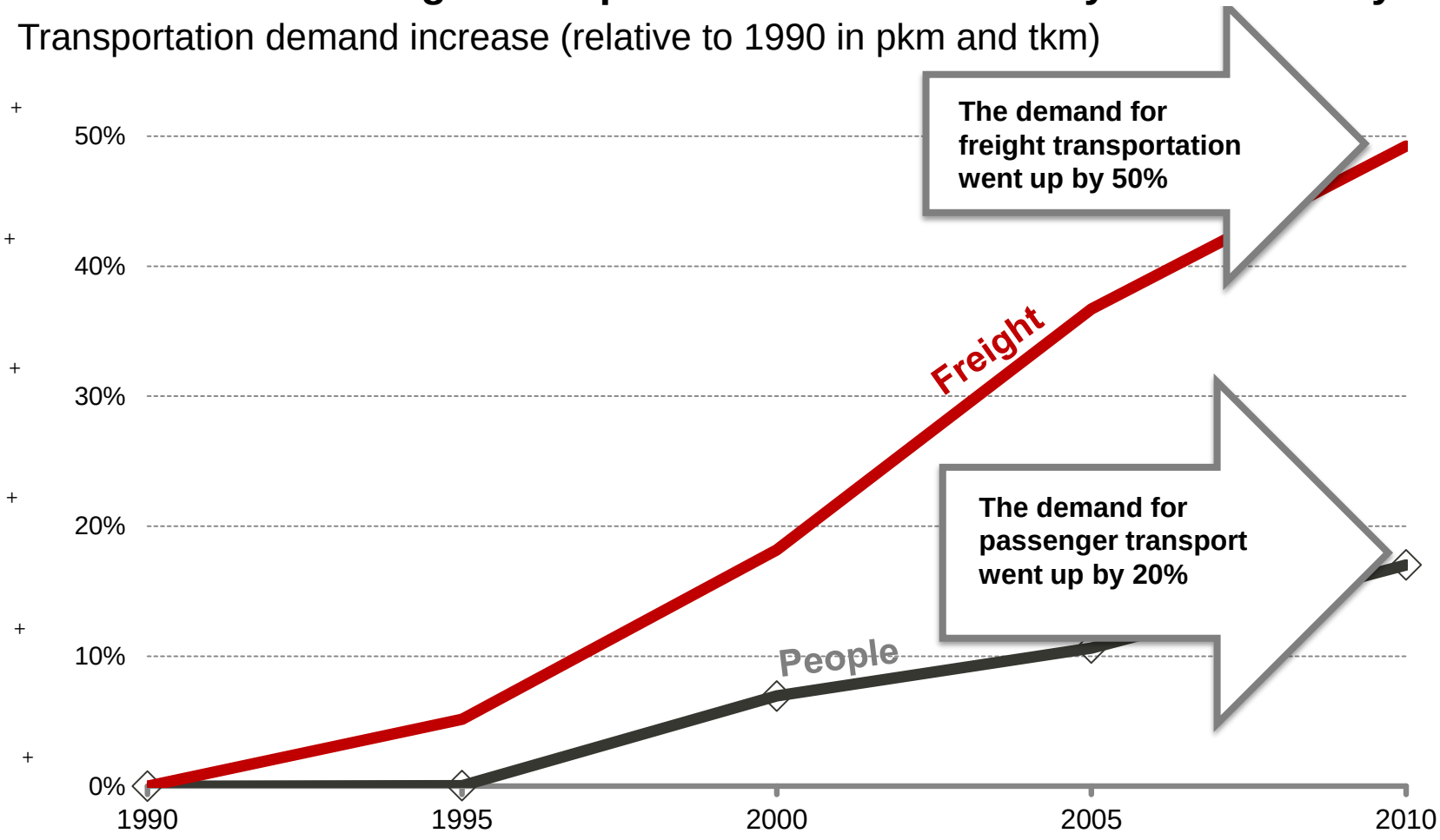


data-source: BFS/BAFU “Taschenstatistik Mobilität 2014”

Freight is growing even faster than passenger transp.

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

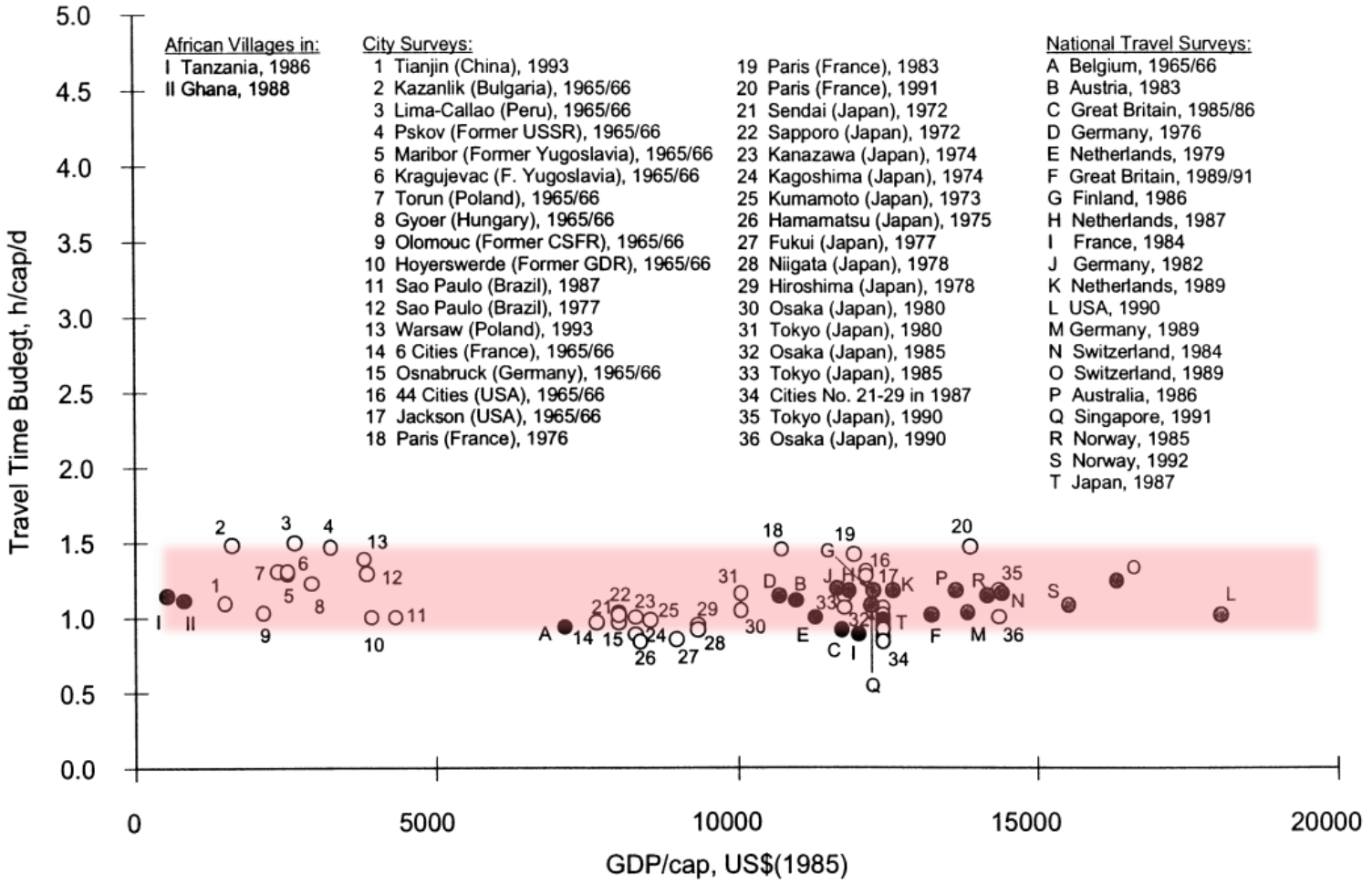
Transportation demand increase (relative to 1990 in pkm and tkm)



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

Mobility is more than mere luxury

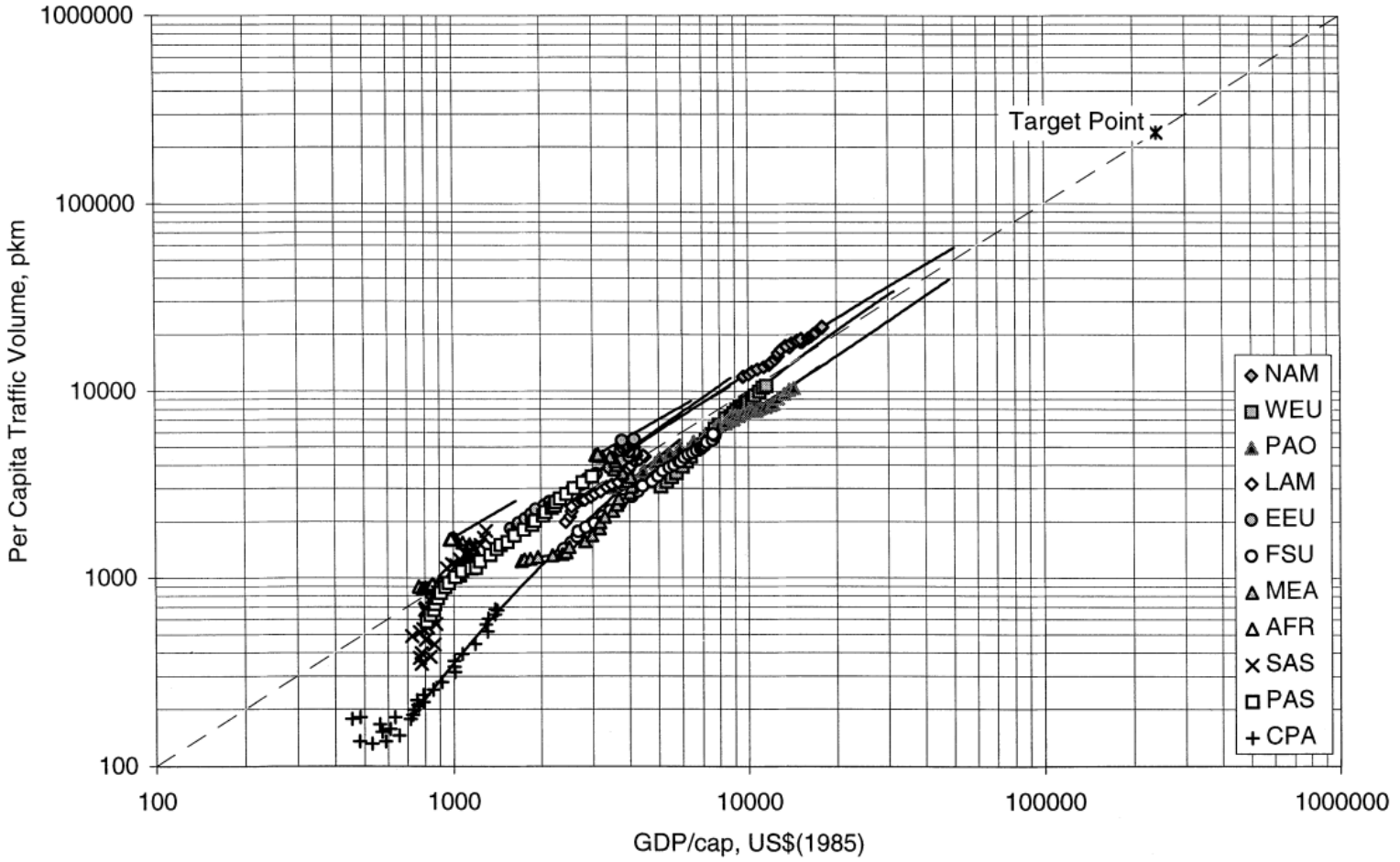
→ independently of income, people are mobile ~1h per day



Source: A. Schafer, D.G. Victor, The future mobility of the world population, Transp. Res. Part A Policy Pract. 34 (2000) 171–205.

Speed on the other hand is a commodity

→ the demand for transportation increases with wealth

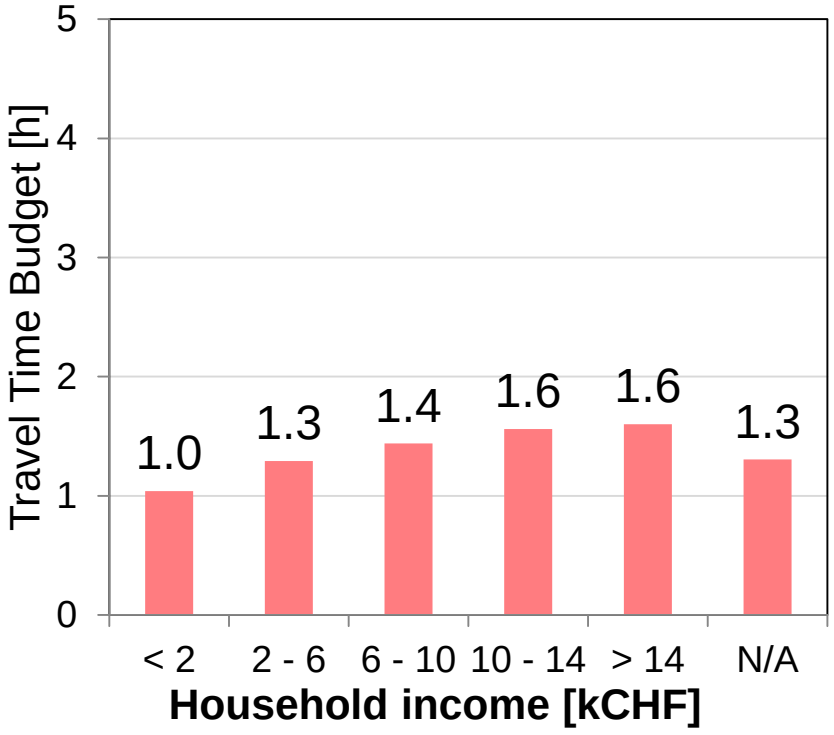


Source: A. Schafer, D.G. Victor, The future mobility of the world population, Transp. Res. Part A Policy Pract. 34 (2000) 171–205.

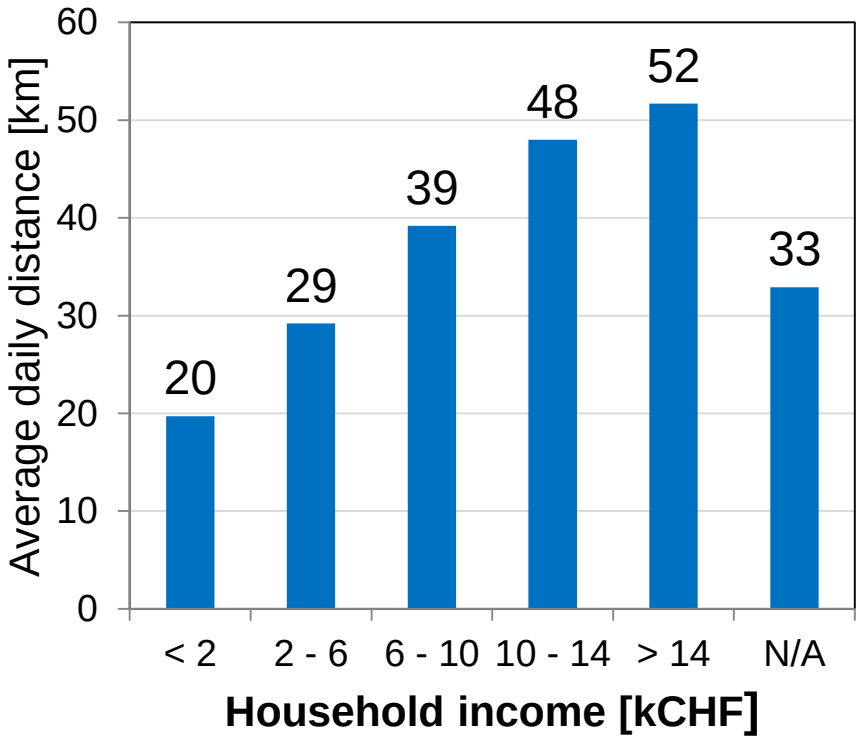
Those tendencies remain true for Switzerland

→ demographic growth leads to more mobility demand
→ economic growth leads to higher demand (and more energy intensive modeS)

Time



Distance



Source: BFS, Mobilität in der Schweiz - Ergebnisse des Mikrozensus Mobilität und Verkehr 2010, 2010.

Prospects of Autonomous Vehicles

→ Assuming the technology (together the associated legal/risk/privacy conditions) will be successful in penetrating the market, what would be PRO's and CON's?

PROS:

- Higher efficiency of infrastructure use (capacity, materials)
- People will be served best concerning their transportation needs (flexibility, convenience, …)

CONS:

- A much higher demand for transportation services will probably result
- A shift back from public to individual transportation is very liekly to happen

Energy-chains in transportation

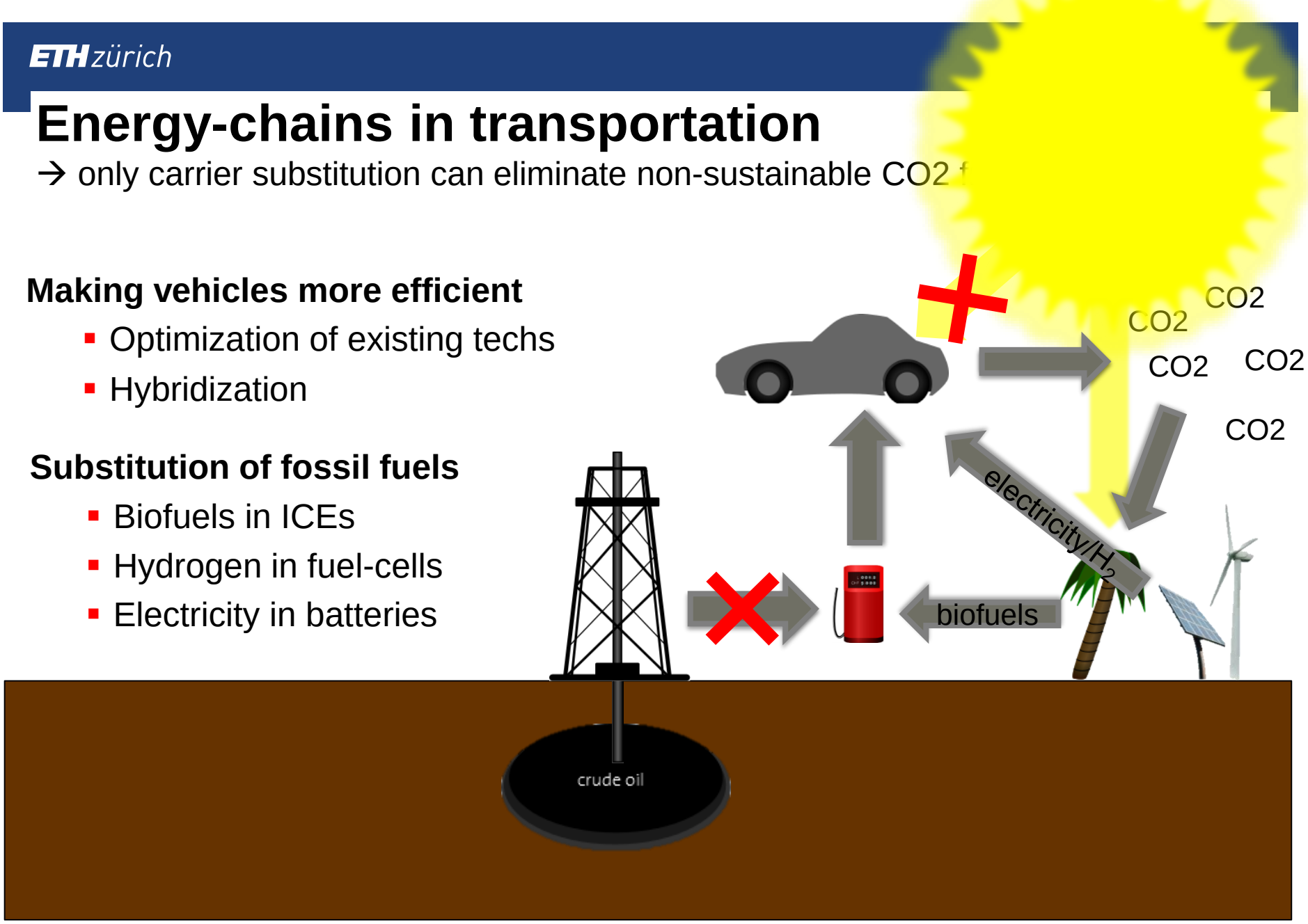
→ only carrier substitution can eliminate non-sustainable CO2 f

Making vehicles more efficient

- Optimization of existing techs
- Hybridization

Substitution of fossil fuels

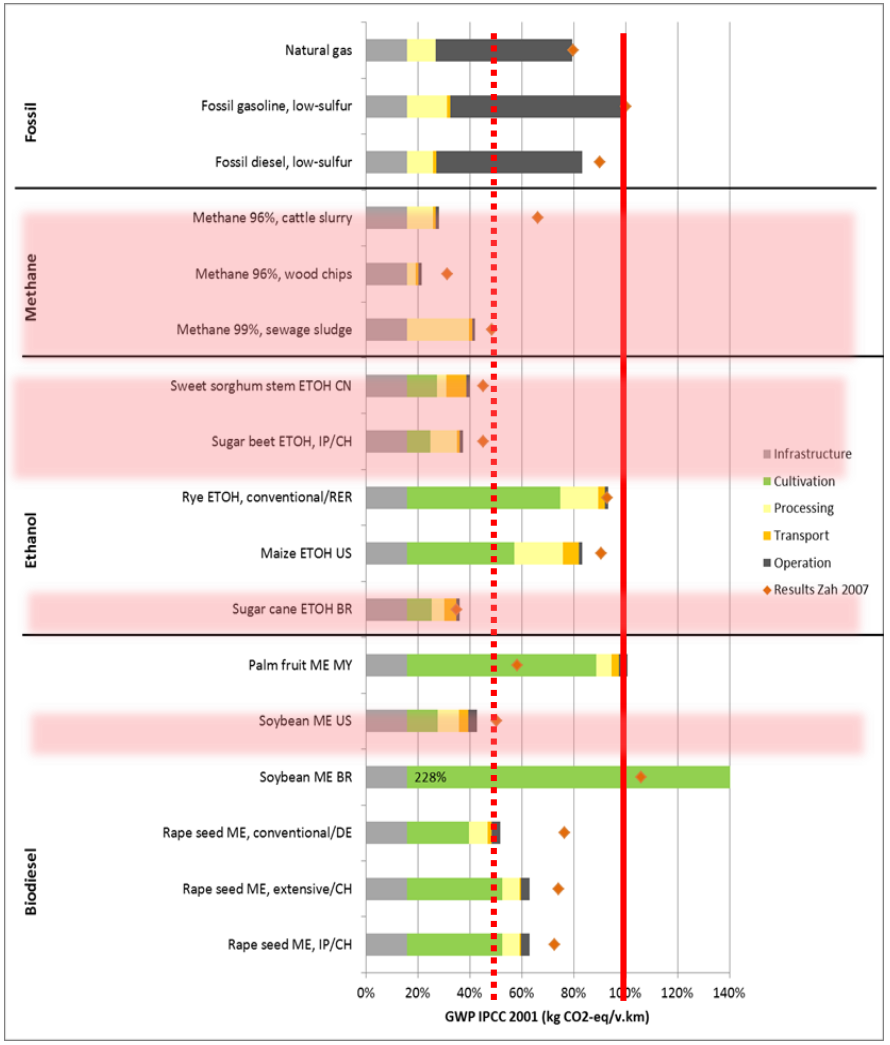
- Biofuels in ICEs
- Hydrogen in fuel-cells
- Electricity in batteries



Carrier substitution → biofuels

→ disadvantage: reduction potential depends on production method

- **Biofuel GHG emissions compared to fossil fueled gasoline ICE vehicle**
  - > 50% CO2 savings for half of the presented alternatives
  - Limited potentials for domestic production
  - Environmental impacts beyond CO2 emissions (land clearing, etc.)



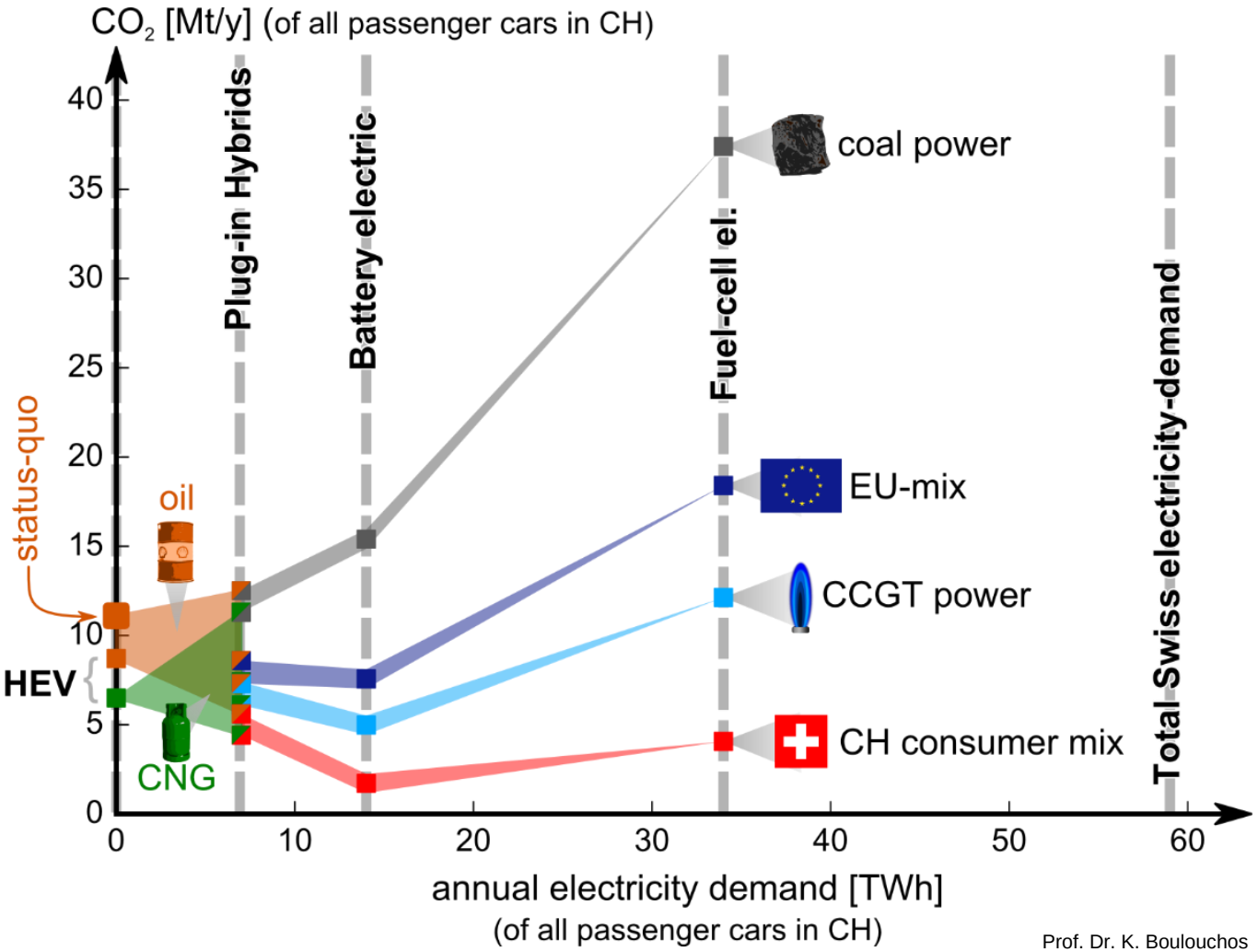
sun $\xrightarrow{\text{PV}}$ electric propulsion efficiency ~10%

sun $\xrightarrow{\text{Photosynth.}}$ biofuels $\xrightarrow{\text{Converter}}$ propulsion efficiency ~ 0.1%

Source: M.F. Emmenegger, S. Gmünder, J. Reinhard, R. Zah, T. Nemecek, J. Schnetzer, et al., Harmonisation and extension of the bioenergy inventories and assessment, 2012.

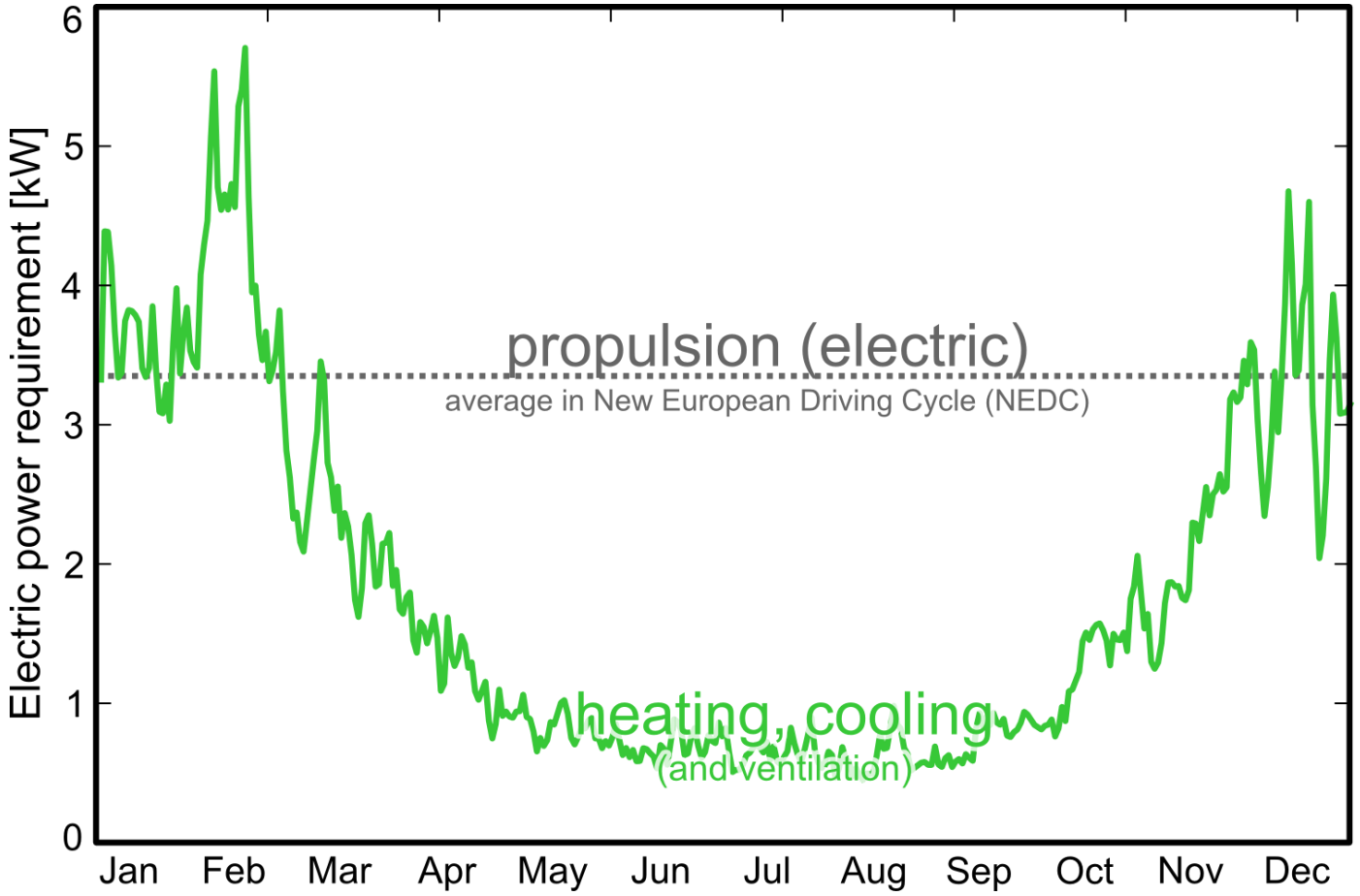
CO_2 emissions of new powertrain technologies

→ comparison of operational CO2 and electricity demand



Problematic: auxiliary demand, esp. for heating

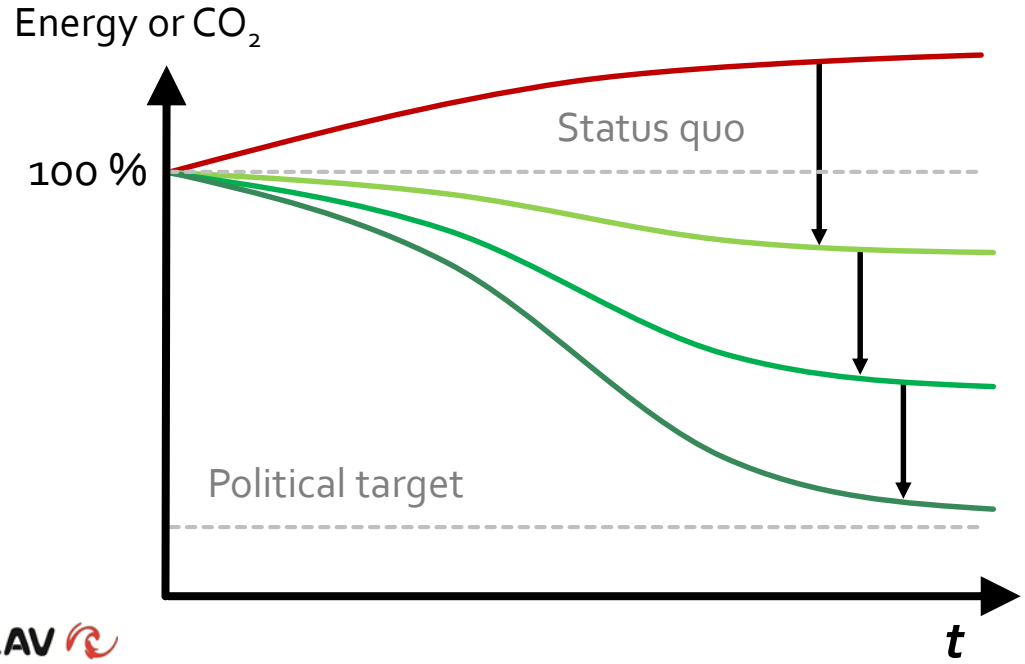
→ without an ICE → no waste heat → battery power is used for heating



Date-source: Investigation of the propulsive and non-propulsive loads in passenger cars with emphasis on electric mobility, G. Georges, ETH-Diss Nr. 22057

SCCER Mobility: Mission

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.



Business as usual scenario

Mobility and transportation demand reduction

Energy conversion processes
(efficient drivetrain, reduction of vehicular energy demand)

Energy carrier substitution
(electricity, renewable fuels, H_2)

SCCER Mobility: Capacity Areas

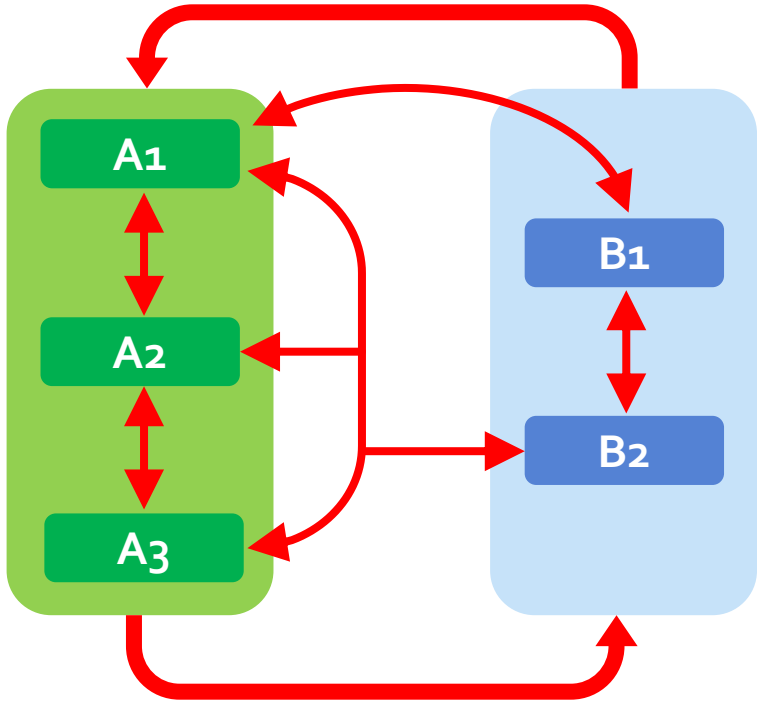
A1 **Systems and Components for E-Mobility**

A2 **Chemical Energy Converters**

A3 **Minimization of Vehicular Energy Demand**

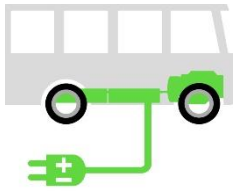
B1 **Integration, Operation and Optimization of Mobility Systems**

B2 **Integrated Assessment of Mobility Systems**



SCCER Mobility: Capacity Areas

Innovation Field A: Components, Devices and Processes

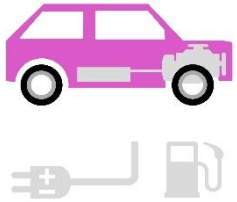


A1 Swiss Battery Research Platform (E-Mobility)

- Battery systems for rail, bus, construction, agricultural and utility vehicles

A2 Chemical Energy Converters

- Cost reduction for fuel cell systems
- Internal combustion engines: renewable fuels, efficiency increase, zero pollutants

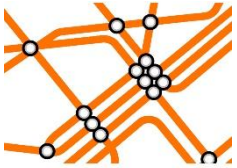


A3 Minimization of Vehicular Energy Demand

- High volume lightweight thermoplastics and bioinspired composites
- Thermal management

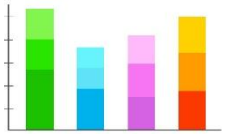
SCCER Mobility: Capacity Areas

Innovation Field B: System Aspects of Mobility



B1 Integration, Operation and Optimization of Mobility Systems

- Infrastructure and new urban transport
- Urban planning and environmental impact
- Spatio-temporal data Acquisition and analysis, monitoring devices and user communication



B2 Integrated Assessment of Mobility Systems

- Technology assessment and energy economics
- Socio-economic aspects of mobility

SCCER Mobility: Key Figures

23 Research Groups affiliated to

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ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

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SCCER mobility Project “Strategic Guidance”:

Core idea / mission

Thinking in *interventions*:

- Ways to change the system / status-quo
- Not “just” technology / policy → its application / main effects

Putting *interventions* into their systemic context

- Systemic relevancy (demand for a given mode, vehicle, …)
- How does an intervention propagate into the system?
- Technological performance (dependency on trip length, time of day, …)
- Energy supply through the energy system

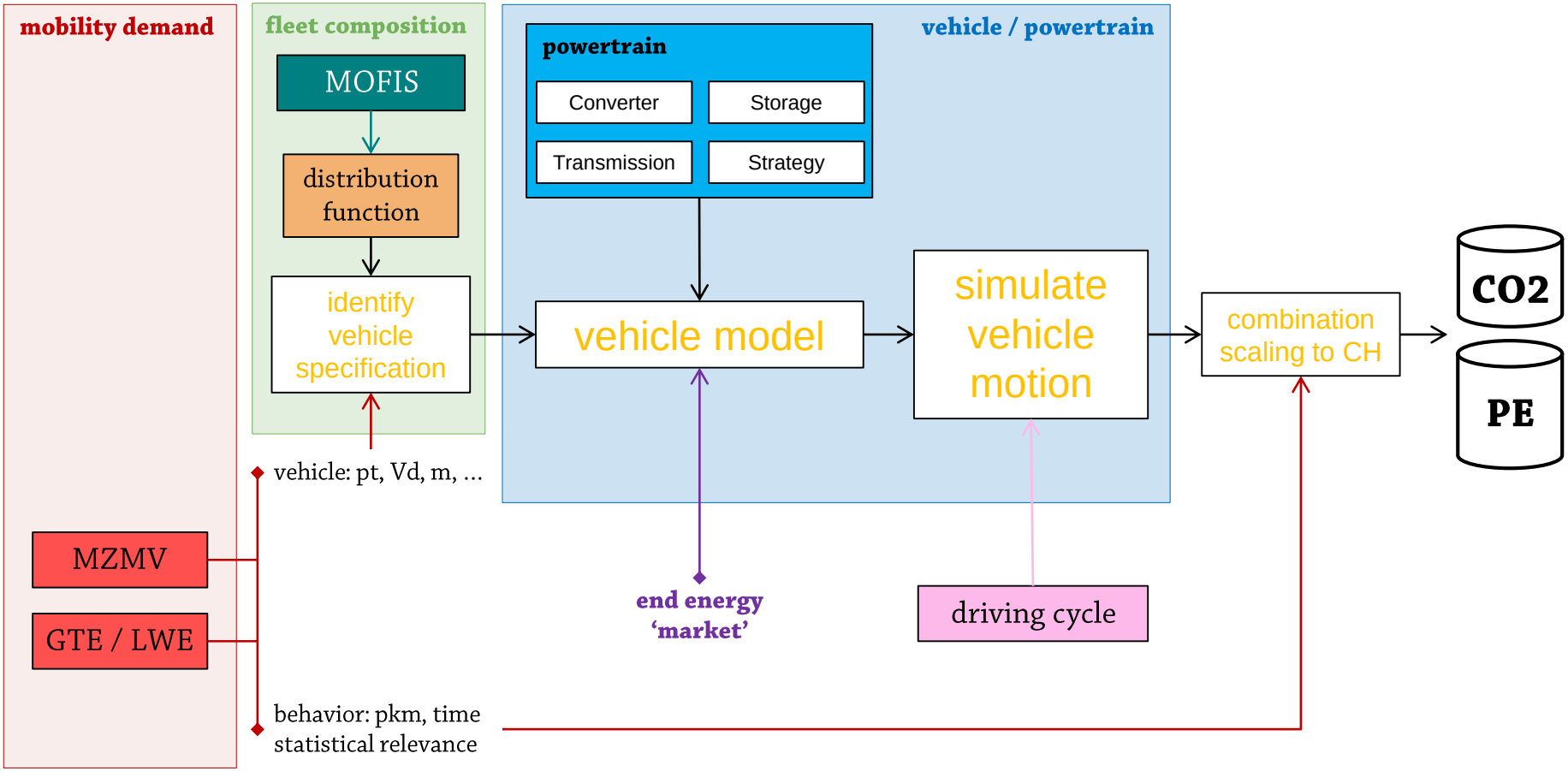
Worst-case and best-case estimates (envelope):

- CO_2 mitigation
- Primary Energy reduction

→ **“Putting a figure on the tech”**

The Strategic-Guidance model:

combining “the demand-side” with technological vehicle technology models



Conclusions and Outlook

- Climate change due to CO_2-output is THE Major Challenge for the Transportation Sector
- A coordinated strategy for the demand and the supply side is indispensable for a drastic reduction of CO_2-emissions worldwide
- The introduction of advanced IT/Communication Technologies may be a mixed blessing
- «Alternative» powertrain technologies must be assessed also with regard to their scalability for a 100 %-penetration and in view of a rapidely increasing electricity demand (non CO_2-free!)
- Switzerland has the ambition to contribute to the decarbonization of the country's transportation sector through the SCCER on Efficent Mobility

Acknowledgement

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