ETH zürich

Wenn Batterien nicht genug sind

Waserstoff zur Dekarbonisierung des Schwerverkehrs

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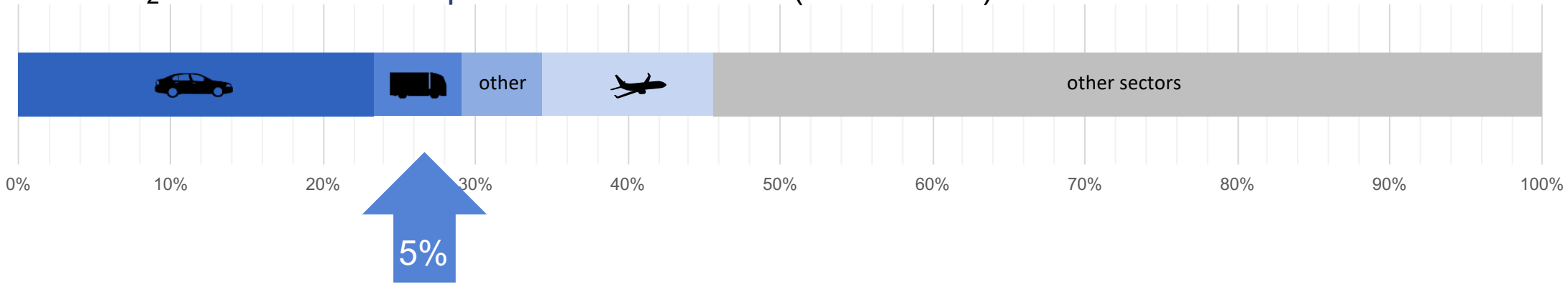
Motivation

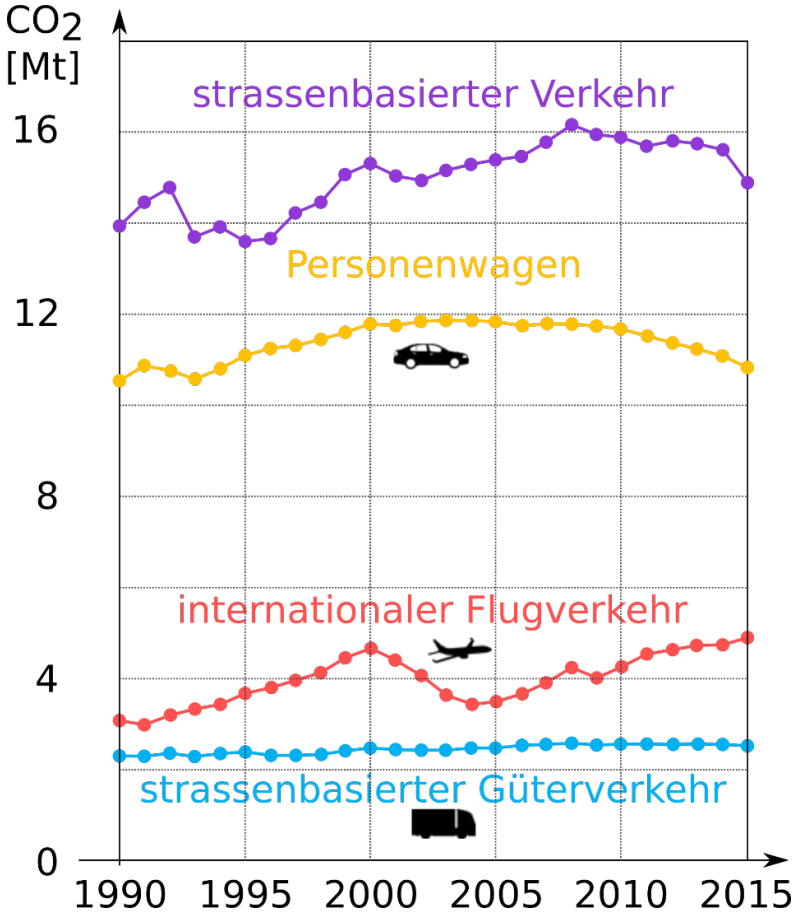
Anteil LKW an nationalen CO_2 Emissionsen → vernachlässigbar?

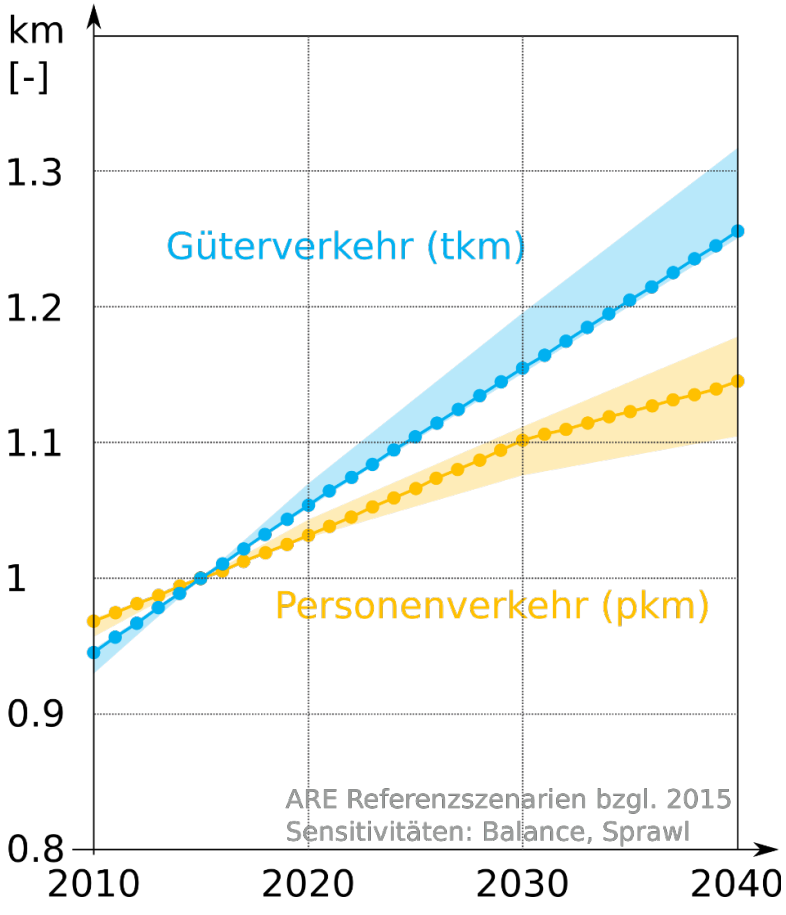
Direct CO_2 emissions of transport and other sectors (BAFU 2015)



CO_2 Emissionen von LKW: warum sie uns beschäftigen

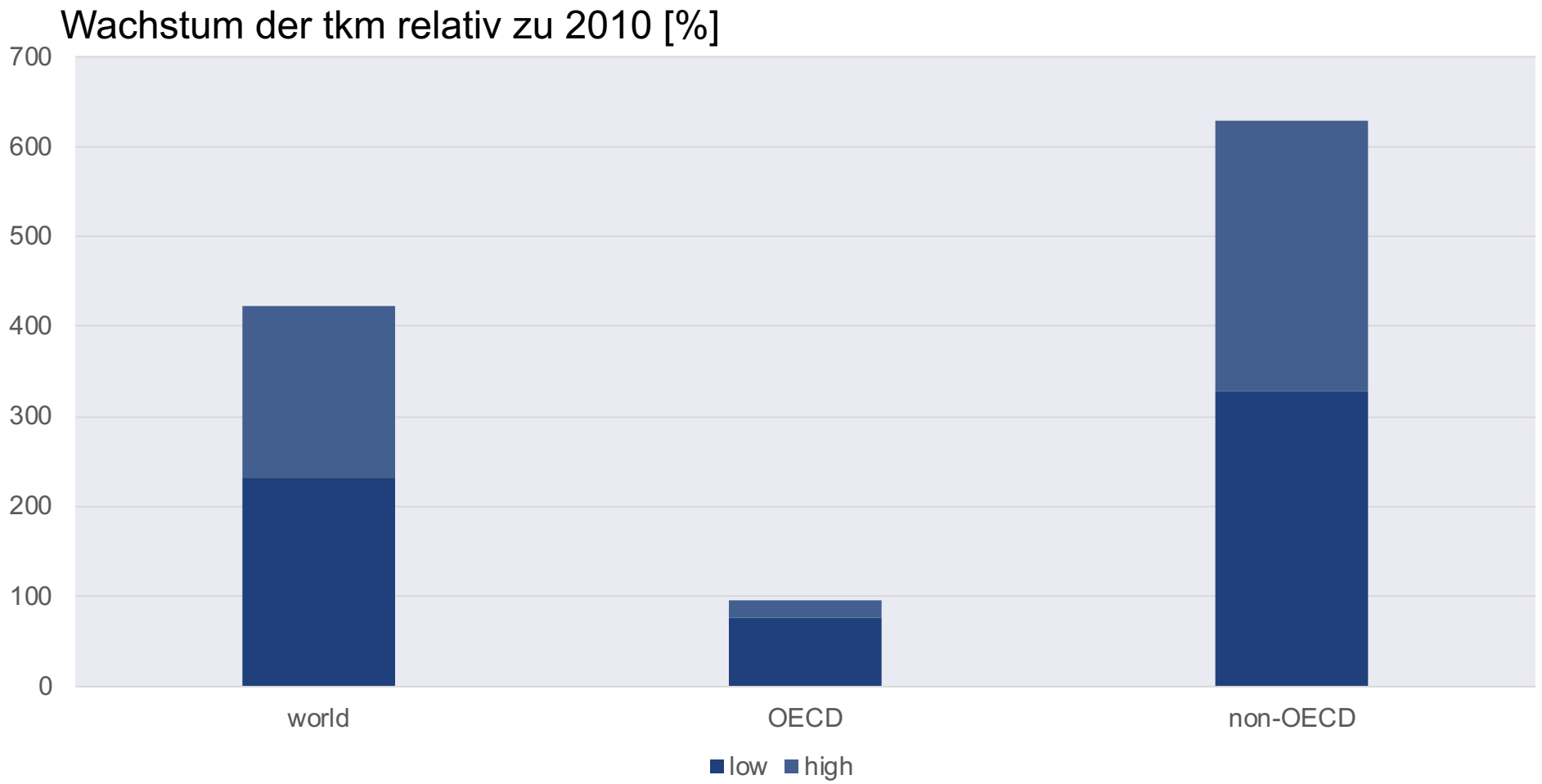
Wenn PW dekarbonisieren, bleiben LKW und Flugverkehr übrig; beide stark am Wachsen





Internationaler Verlgeich: massives Wachstum

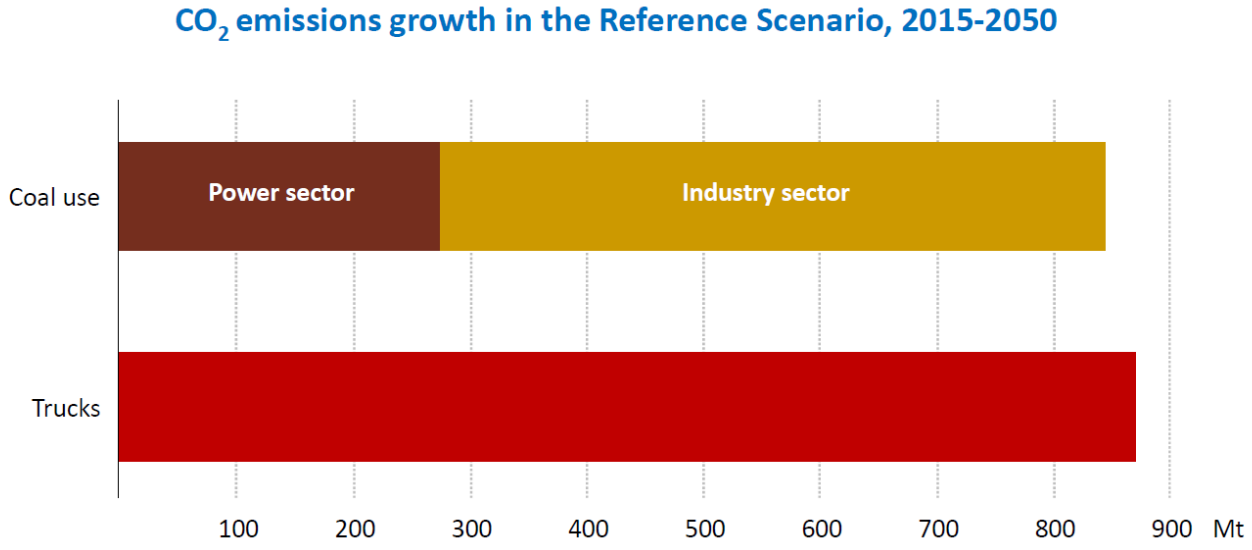
Wachstum in der Schweiz ist vergleichsweise klein *(ITF Transport Outlook 2015)*



Konsequenz: starke Zunahme der LKW-CO_2 Emissionen

IEA ETP 2017 Szenarien: international, CO_2-Zunahme = die aus zusätzlicher Kohleverbrennung

A modern truck sector is still a long haul away



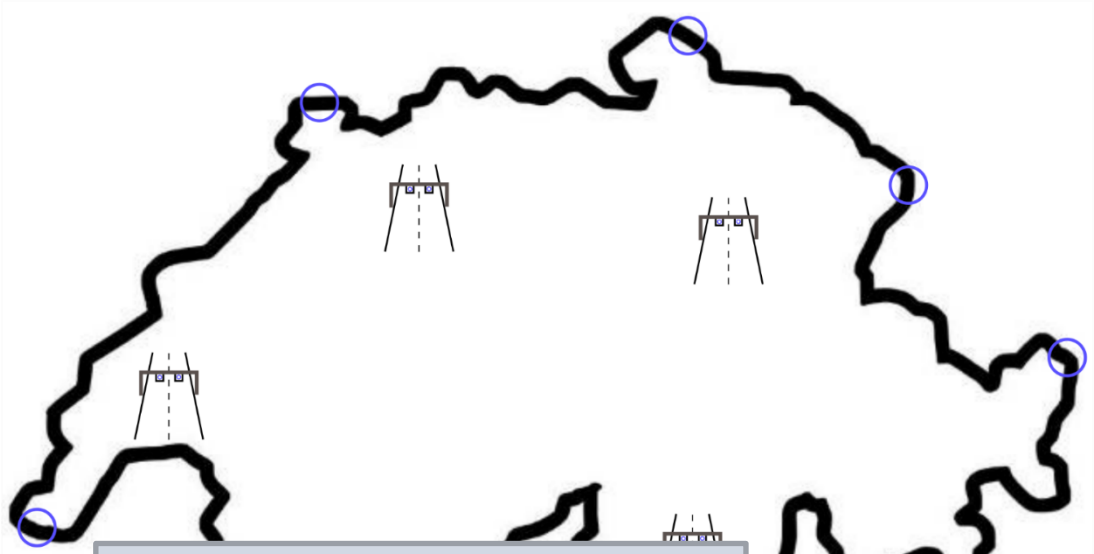
Nearly 40 countries have fuel efficiency standards for cars;
Only Canada, China, Japan and the United States have standards for trucks

© OECD/IEA 2017

Vorgehen

Grundlage: LSVA Monitoring System

Leistungsabhängige Schwer-Verkehrs-Abgabe → EZV beobachtet Leistung aller* LKW



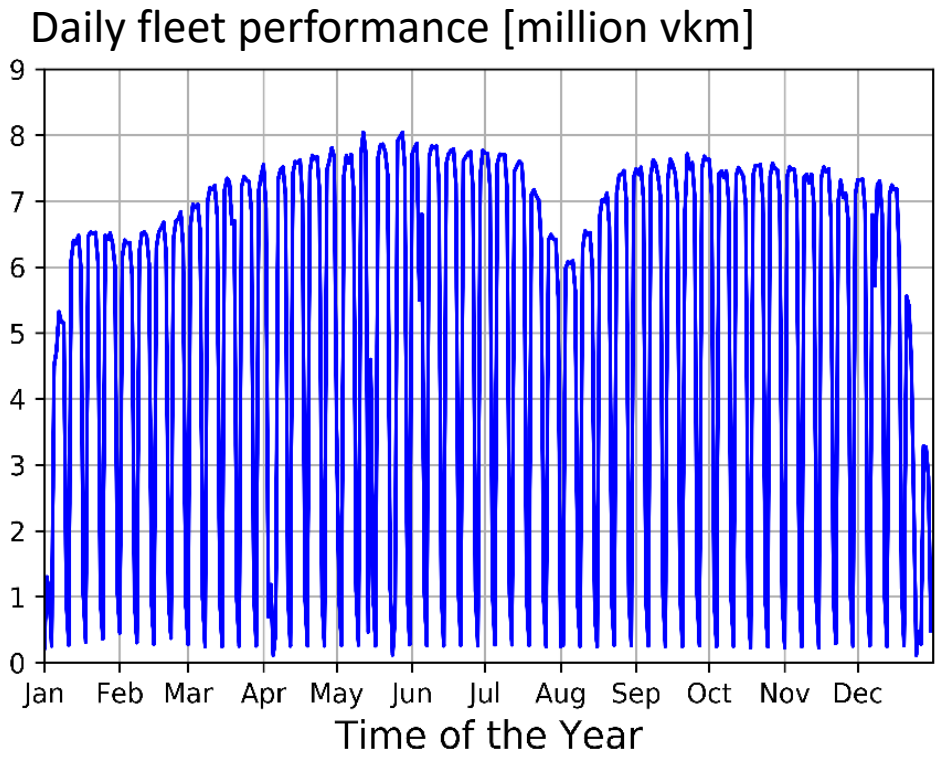
- → 52’800 vehicles subject to LSVA
- → 99% powered by Diesel
- → 35’000 vkm / yr
- → 233’266 tkm / yr (= 6.5 t)

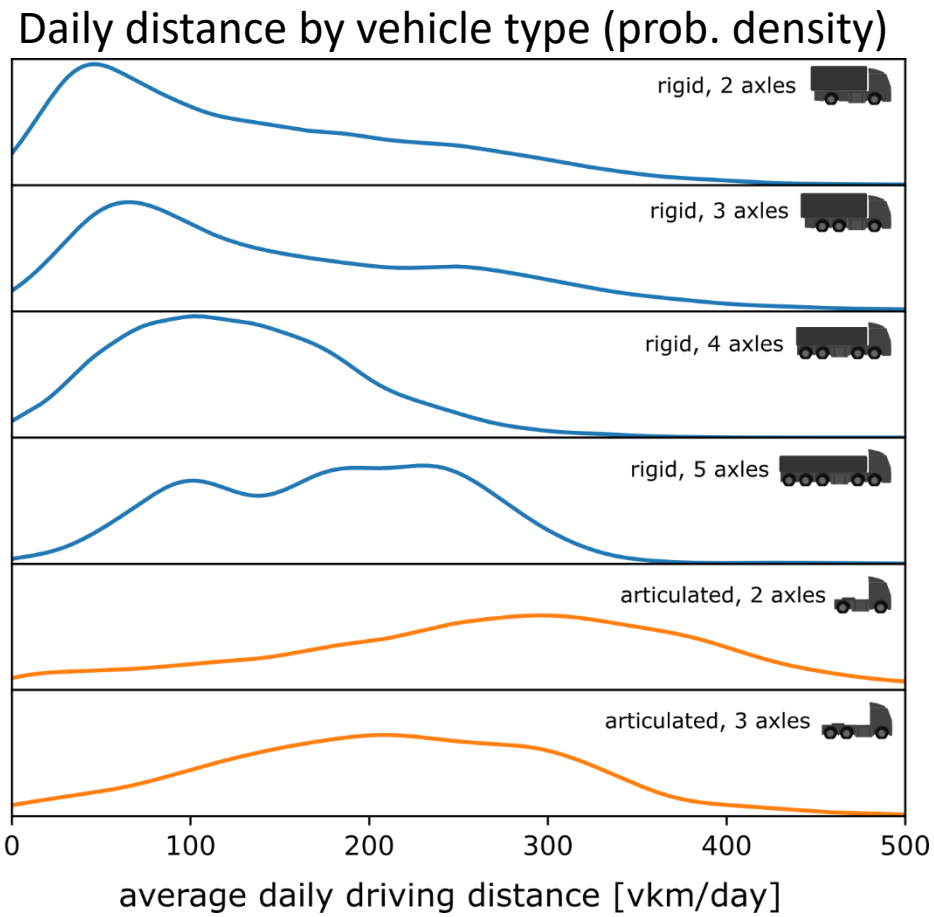
Image sources: Eidgenössische Zollverwaltung, blick.ch

*) Fahrzeuge über 3.5t die für den Gütertransport bestimmt sind

LSVA → tägliche zurückgelegte Strecke jedes LKW in der Flotte

an jedem Tag des Jahres (und ob und welcher Anhänger angehängt war)

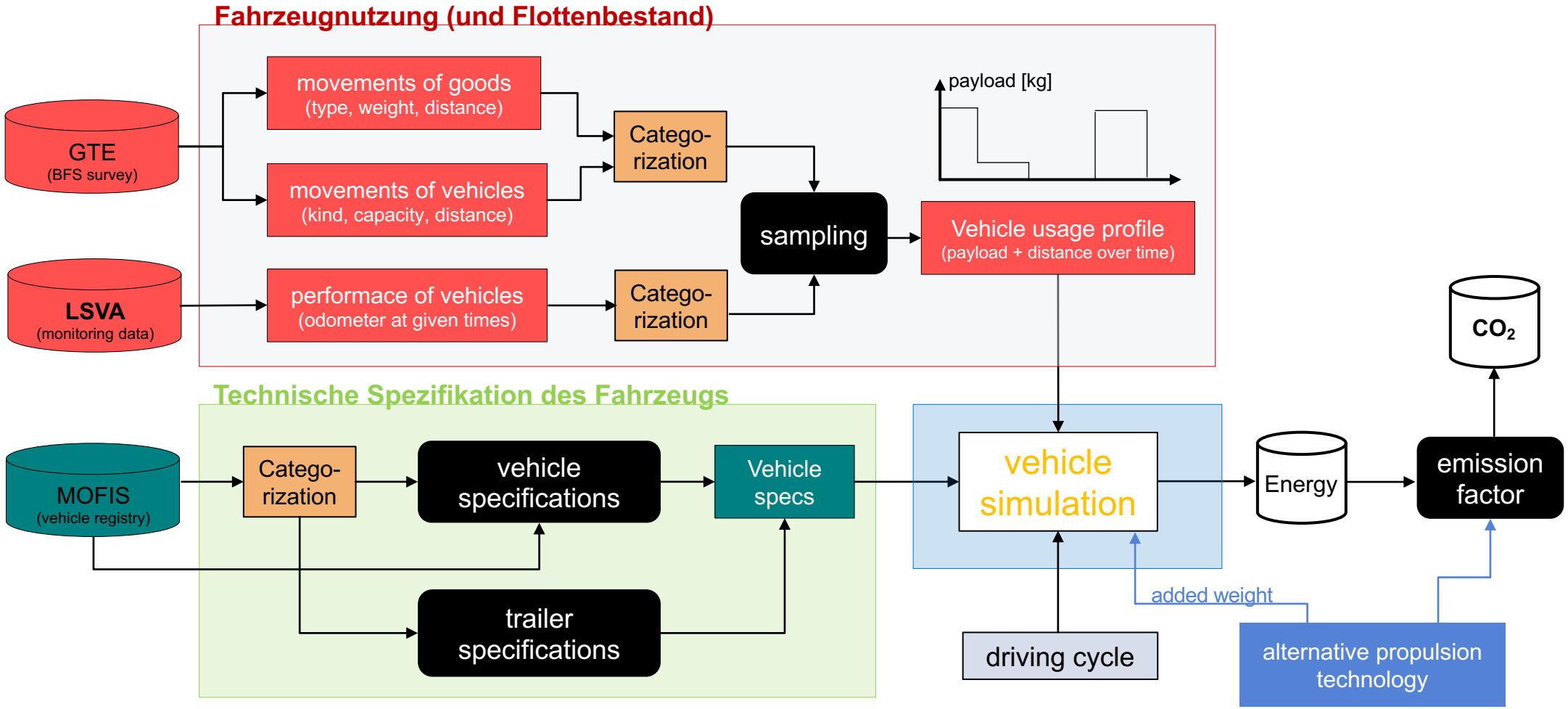




Adapted from: E. Cabukoglu, G. Georges, L. Küng, G. Pareschi, K. Boulouchos (2017). Battery electric propulsion: an option for heavy-duty vehicles? Results from a Swiss case-study. Transport Research Part C: Emerging Technologies, https://doi.org/10.1016/j.trc.2018.01.013

Simulationskette → Energie und CO2 Emissionen der Flotte

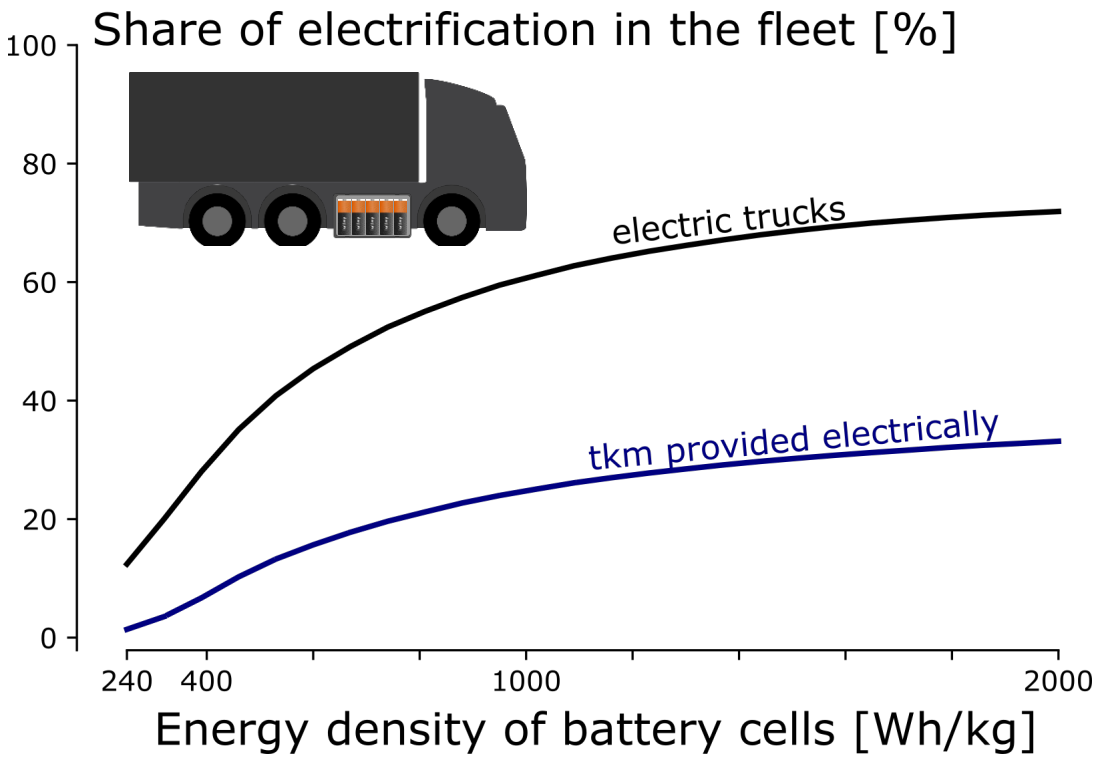
→ Fahrphysikalsche Simulation jedes Fahrzeugs in der LSVA

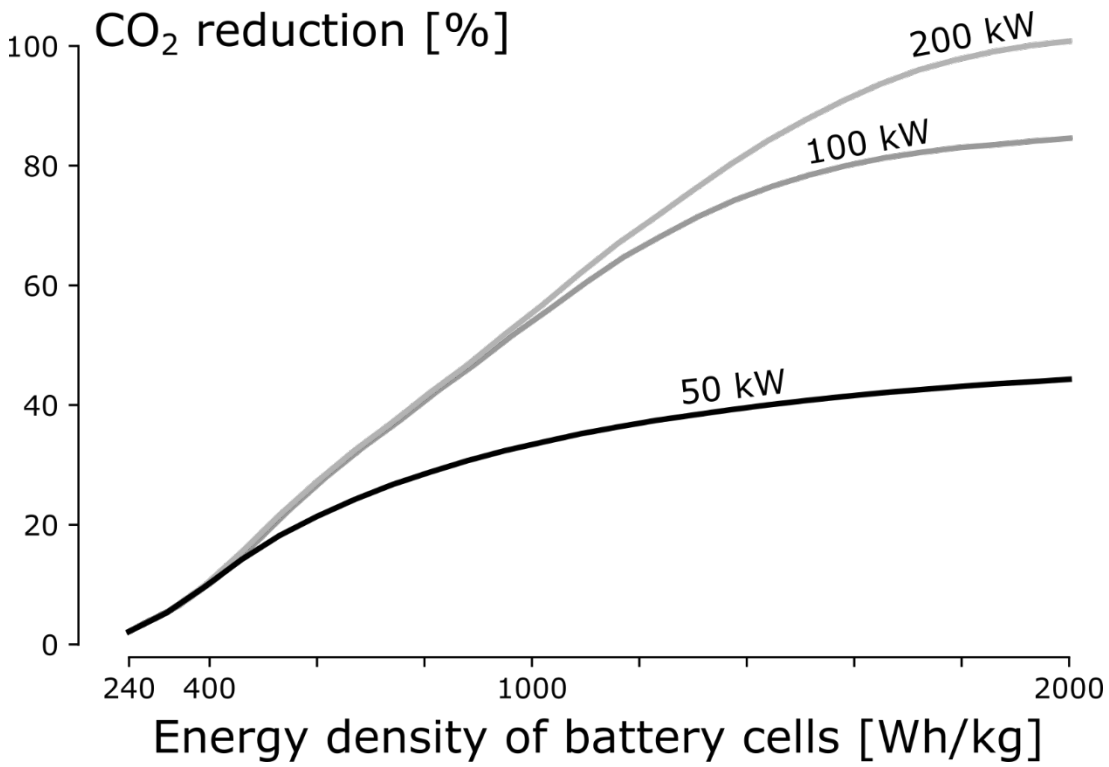


Batterie-elektrsiche LKW

Elektrifizierung → Batterien: Energiedichte = limitierender Faktor?

Elektrifizierungspotential bei reinem “Nachtladen”





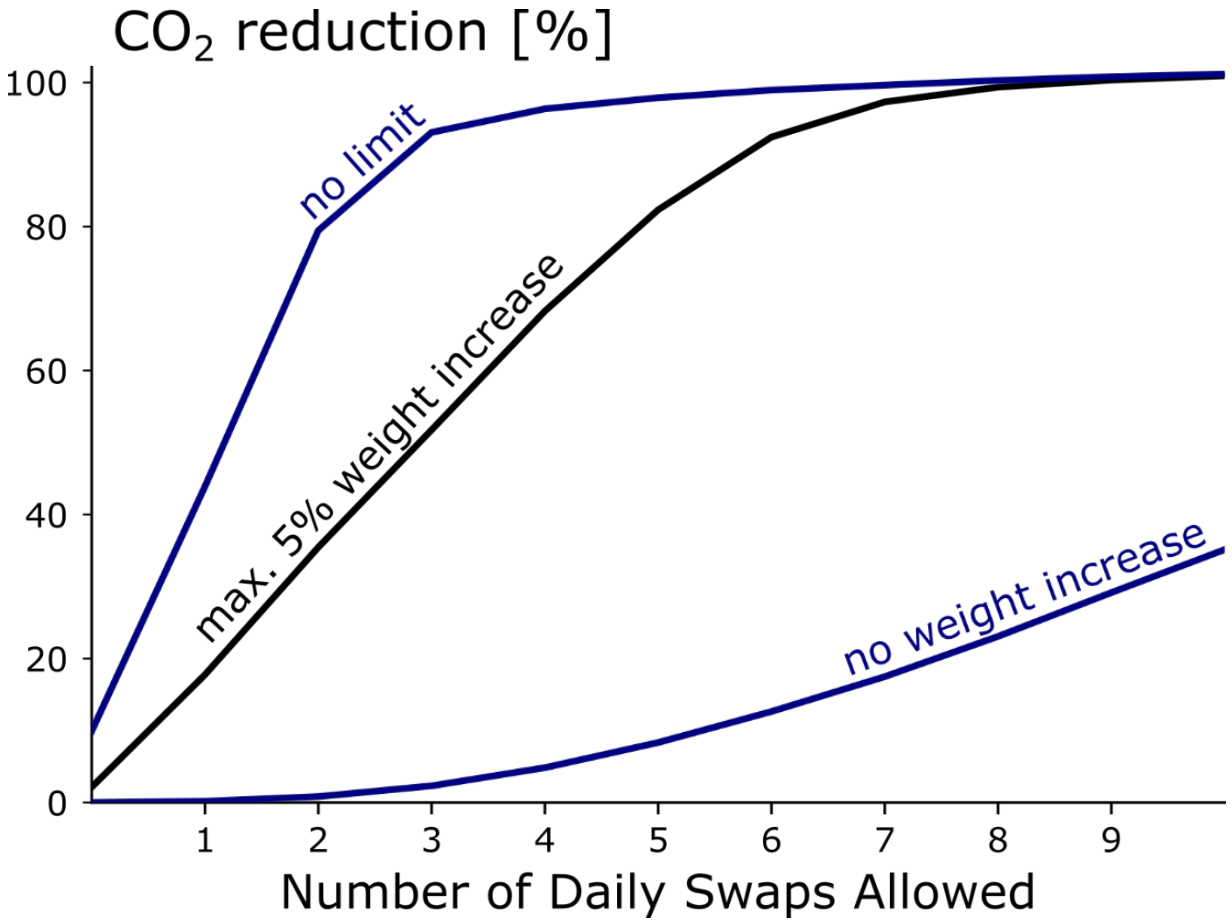
With improving battery densities, most vehicles cannot be fully charged in a night with 50 kW.

Adapted from: E. Cabukoglu, G. Georges, L. Küng, G. Pareschi, K. Boulouchos (2017). Battery electric propulsion: an option for heavy-duty vehicles? Results from a Swiss case-study. Transport Research Part C: Emerging Technologies, https://doi.org/10.1016/j.trc.2018.01.013

Ausweg: Energie unter dem Tag ins Fahrzeug bringen

Wenn keine höhere Energiedichte → Batteriewechsel

Battery swapping technology developed for Mercedes LE 206 Buses - 1972[2]



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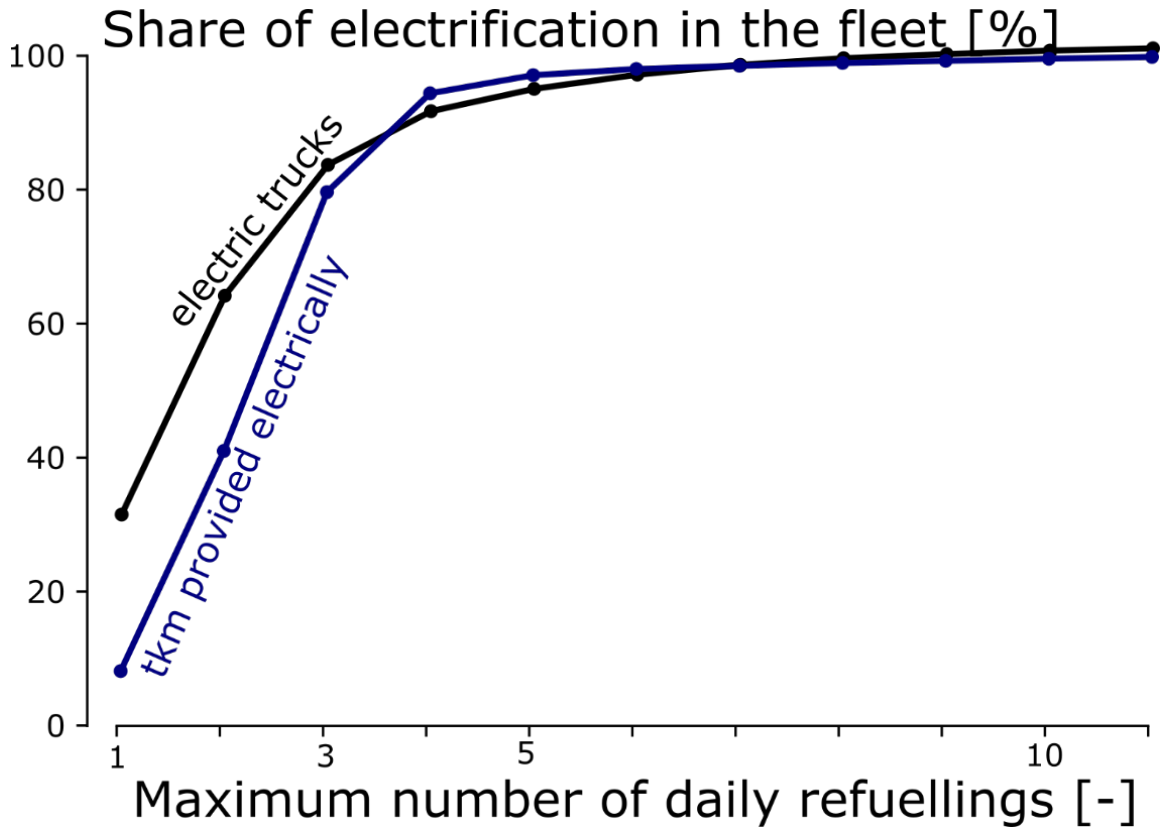
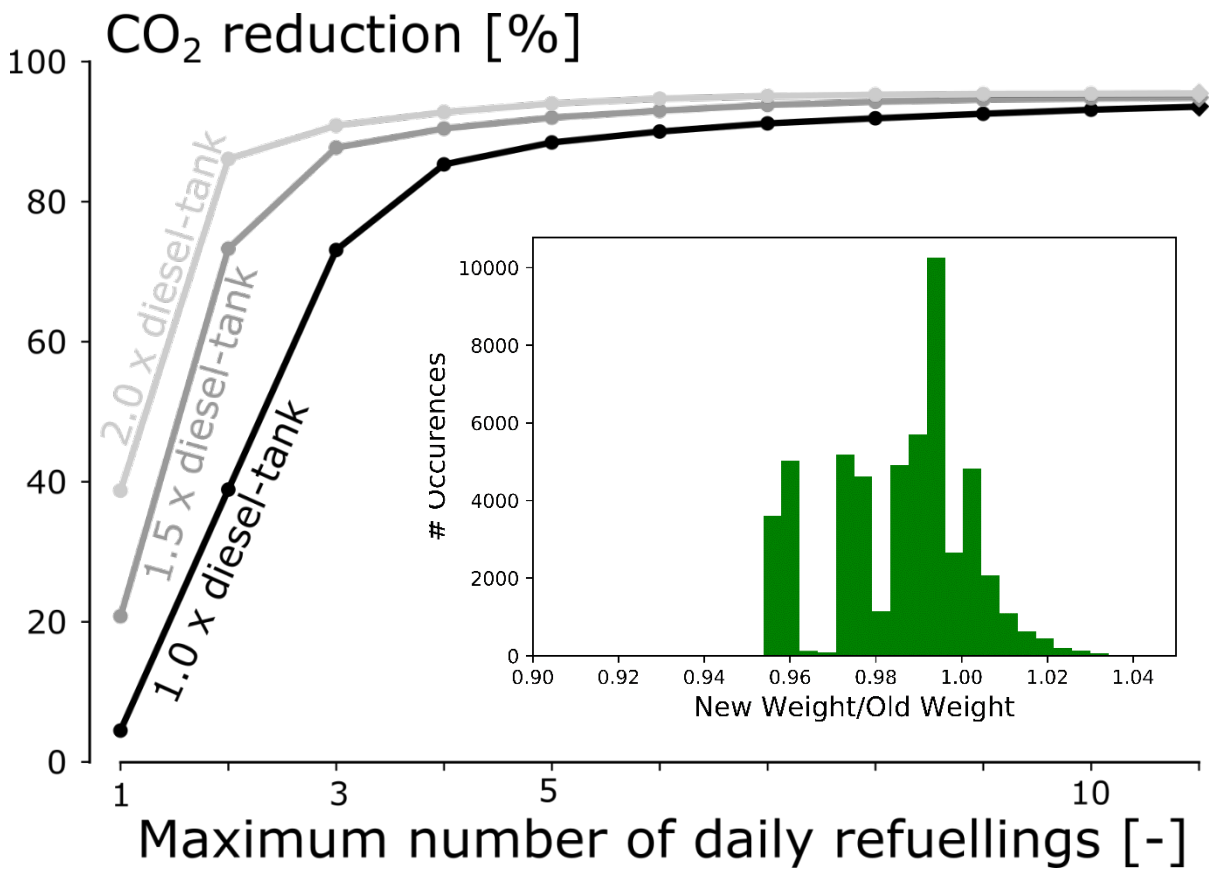
H_2-LKW

Elektrifizierung → Wasserstoff-LKW

Limitierender Faktor: Volumen und Tankstelleninfrastruktur; vernachlässigbare Gewichtszunahme





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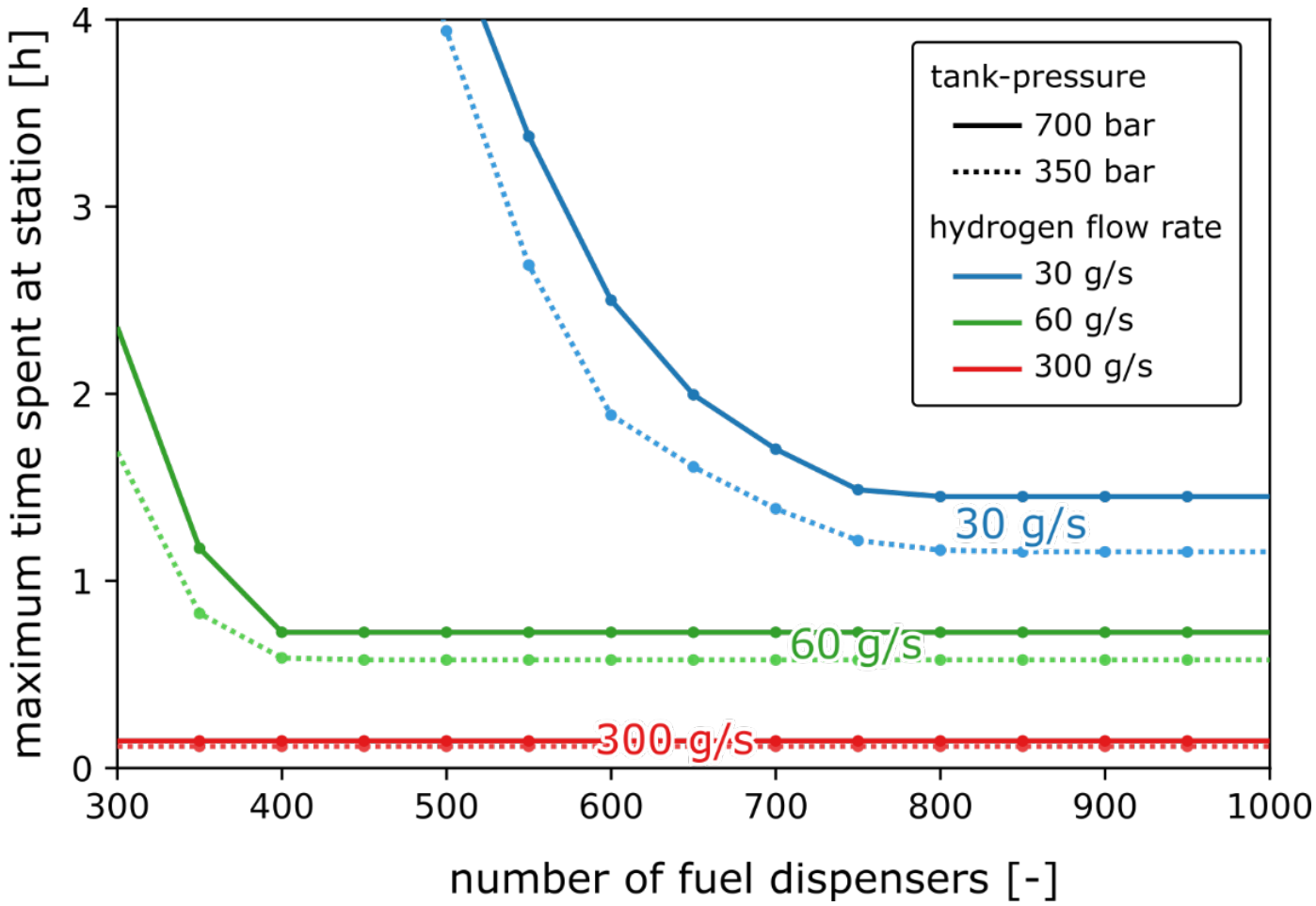
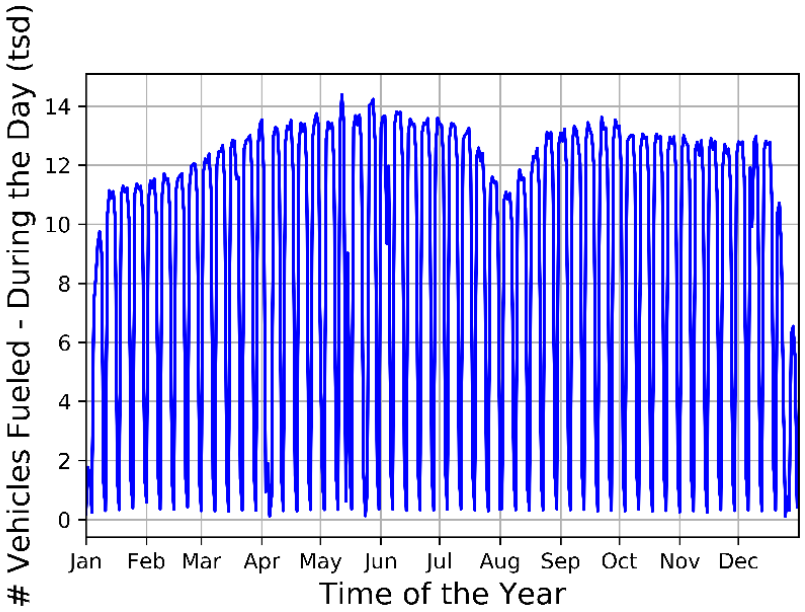
Tankstellen-Infrastruktur → zeitliche Auslastung

Je nach Flussgeschwindigkeit ergibt sich eine kritische Mindestanzahl

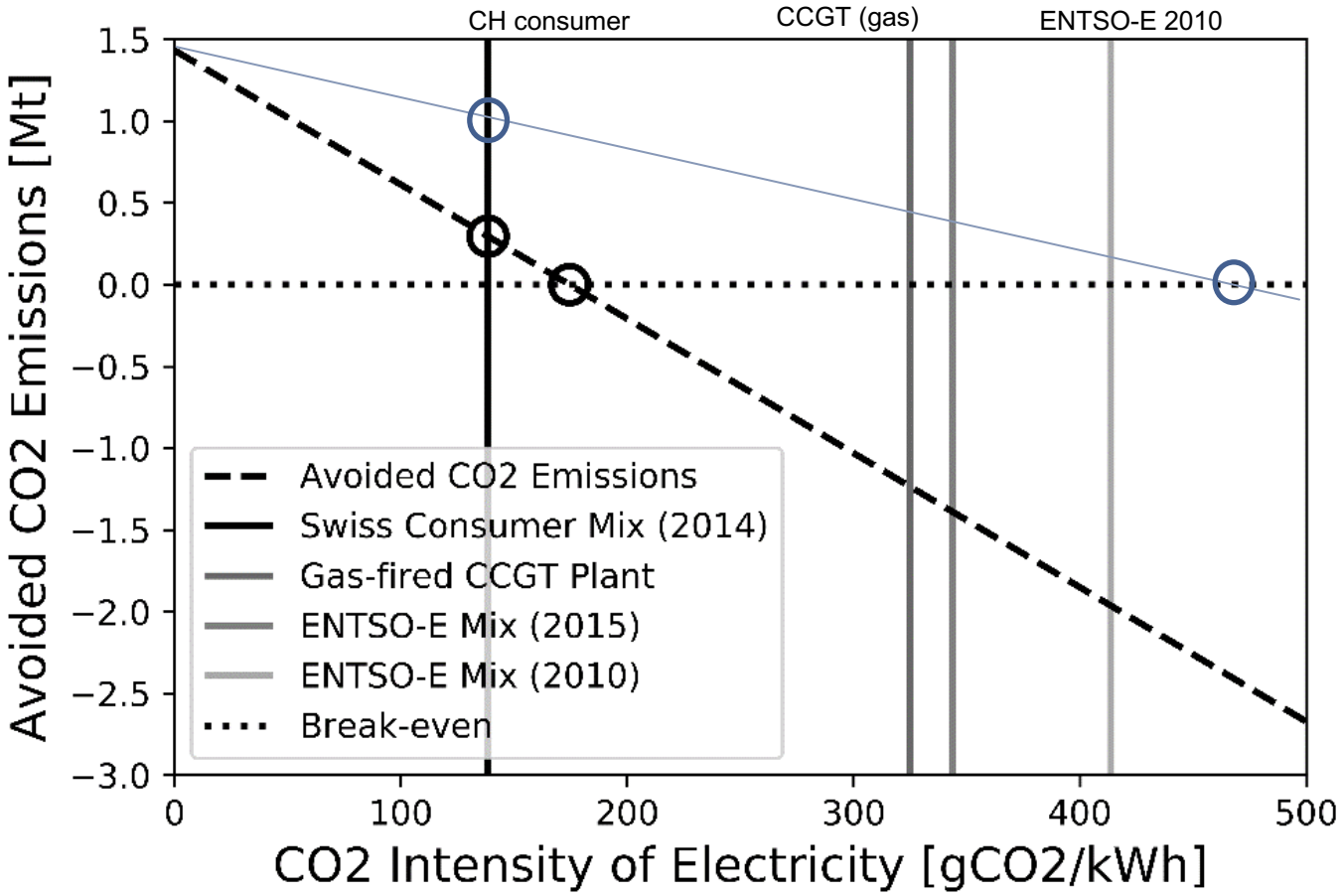


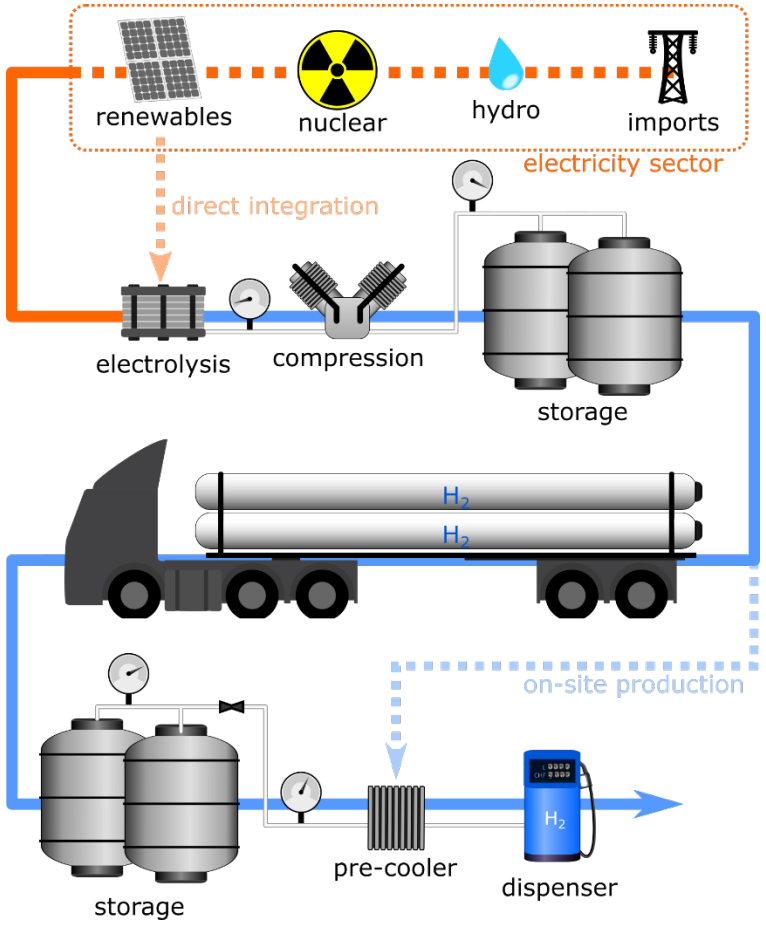


Ausblick

Herausforderung: Wasserstofflogistik & Energieintegration

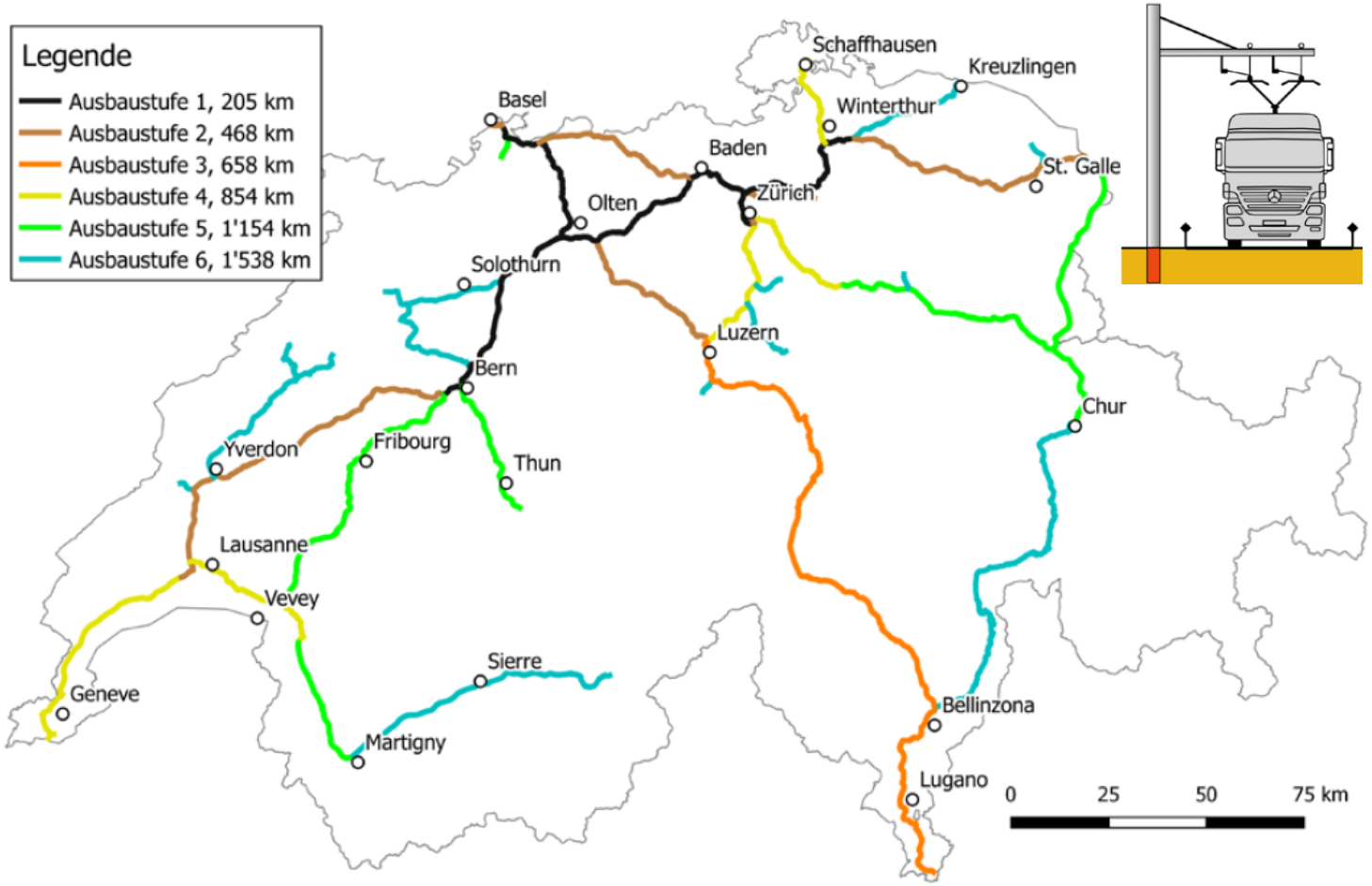
Reduktionspotential sehr sensibel auf Energieproduktion





Herausforderung: konkurrierende Systeme

Source: IB Times UK



MAS Efficient Mobility – Masterarbeit Wolfgang Kling

Herausforderung: Veränderungen im Güterverkehr

Source: Daimler

Conclusions

Our contribution: energy carrier substitution → technical feasibility

- Contrary to aviation & navigation → electrification technically feasible
- Several options, all of which require supporting energy infrastructures
- CO_2 reduction potential limited by:
  - severity of specific use cases (range, power, time)
  - technological constraints (e.g. battery cell energy density)
  - regulatory constraints (maximal permissible weight)
  - energy infrastructure constraints (e.g. charging power)
  - gray emissions in energy chain (electricity mix) and production (battery)

The core issue: should we do it?

- Chicken & egg → who finances what infrastructure / technology and why?
- Many alternatives → substitute e.g. to rail (electrification already complete, at least in CH)
- Relevance → international perspective (larger growth, international players, …)