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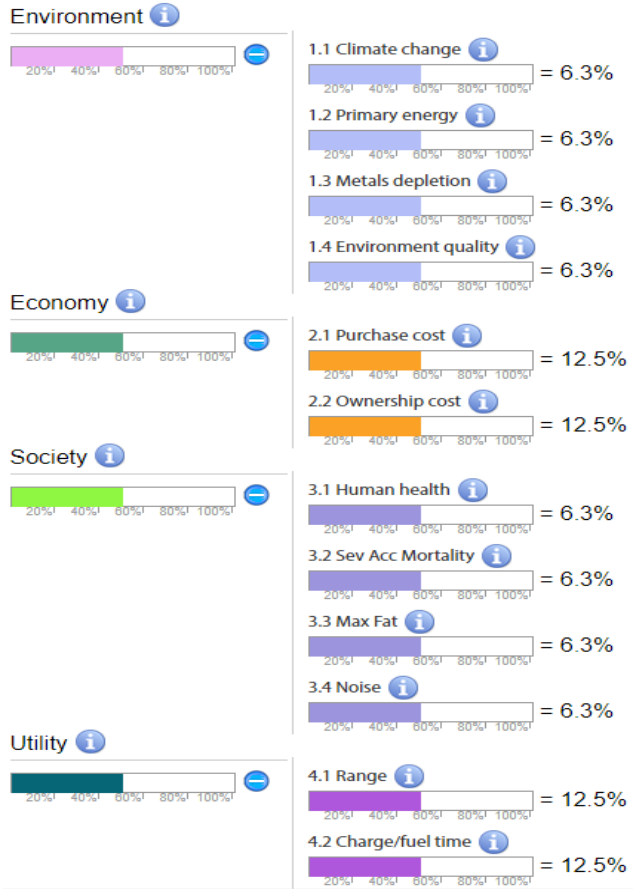
# Sustainability Assessment of Technologies and Scenarios for Passenger Transport: The Swiss Case

OR 2022 Conference, Invited Session on Integrated Assessment of Future Energy Supply Strategies, Karlsruhe, Germany, 6-9 September 2022

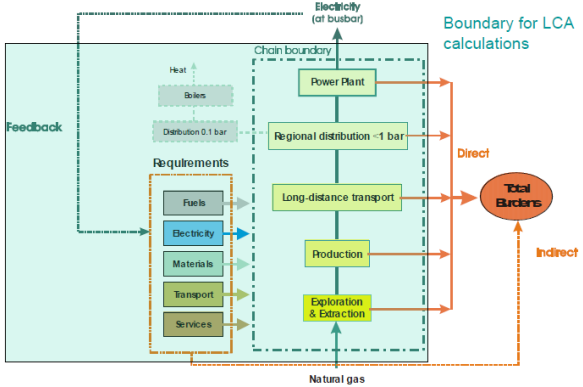
# Sustainability assessment of mobility technologies and scenarios

- Relative rather than absolute, highly quantitative
- Hierarchy of criteria based on pillars of sustainability Environment, Economy, Social (+ Utility)
- Primarily derived indicators based on state-of-the-art methods and databases
- Broad spectrum of technology options
- Detailed specification of technology performance
- Accounting for prospective technology advancements
- Aiming at transparency, consistency and balance
- Aggregation: Multi-criteria Decision Analysis (MCDA), total (internal + external) costs

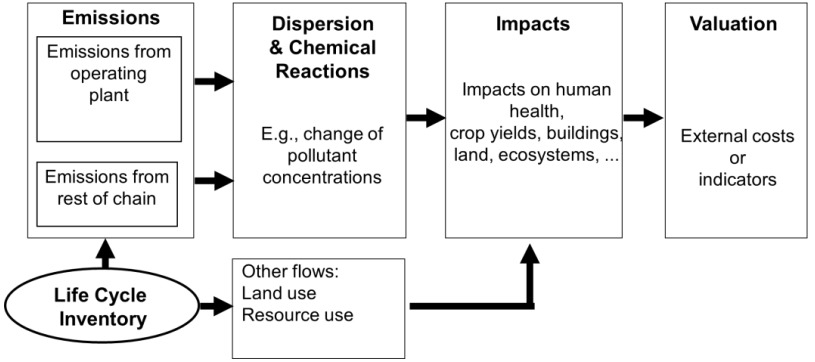


# Some methods and models used

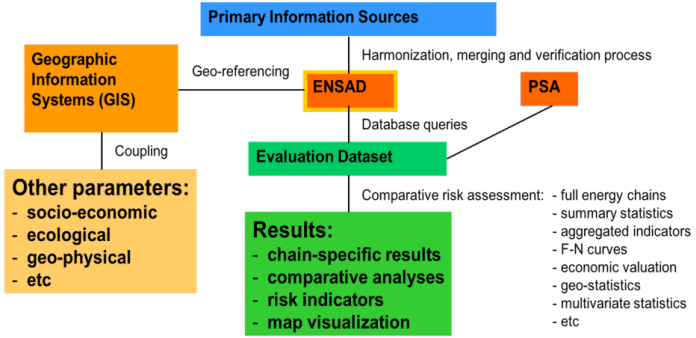
## Life Cycle Assessment (LCA)



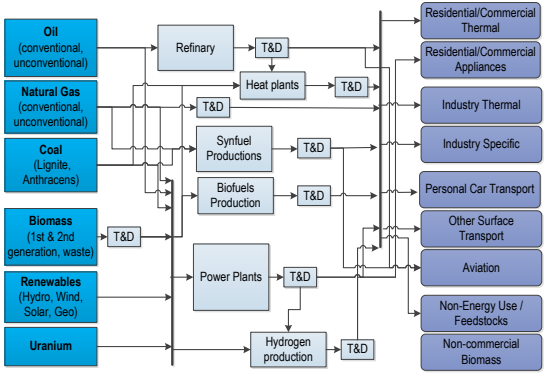

## Impact Pathway Approach (IPA)




## Accident Risks




## Bottom-up Energy System Models



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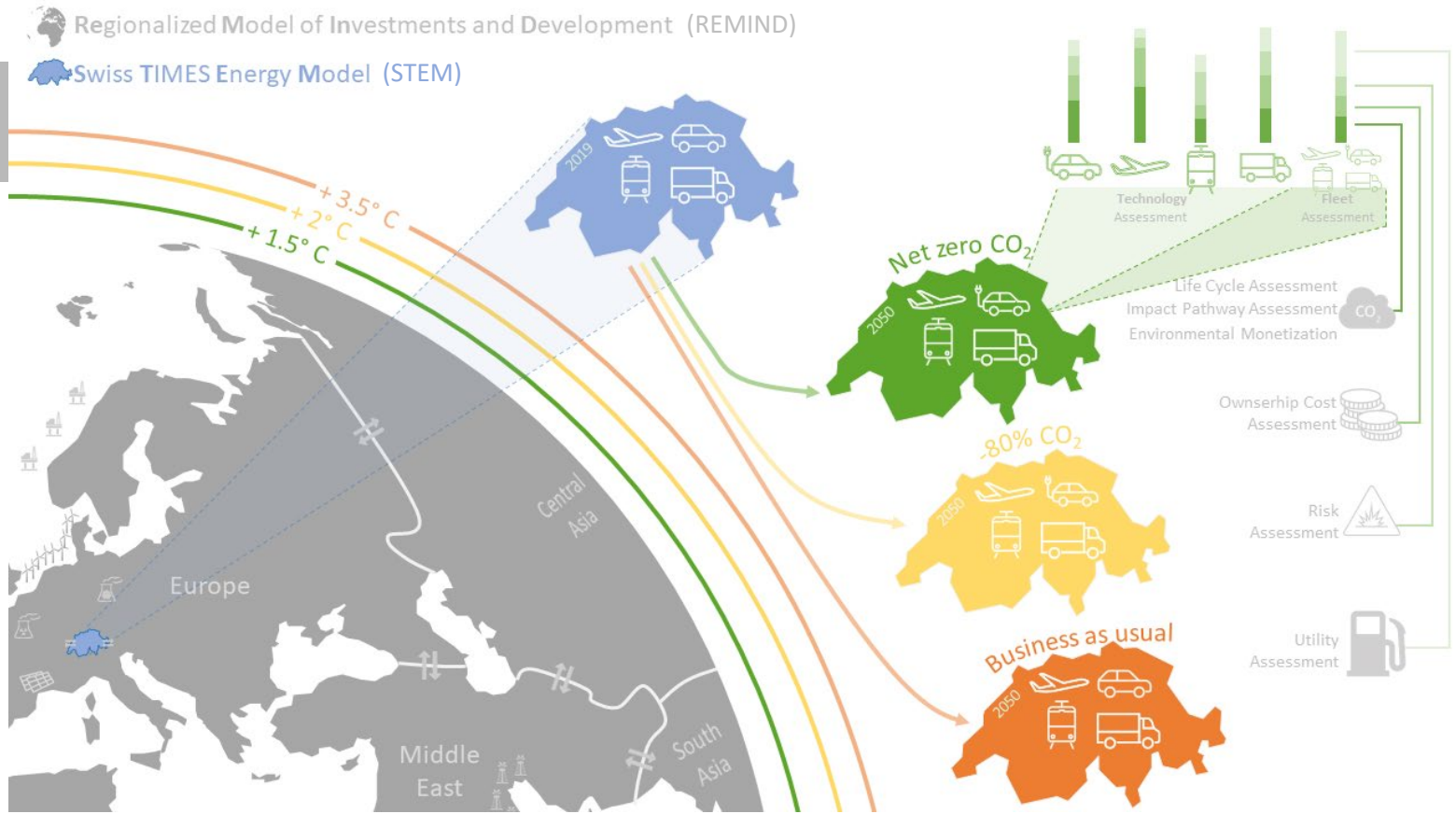
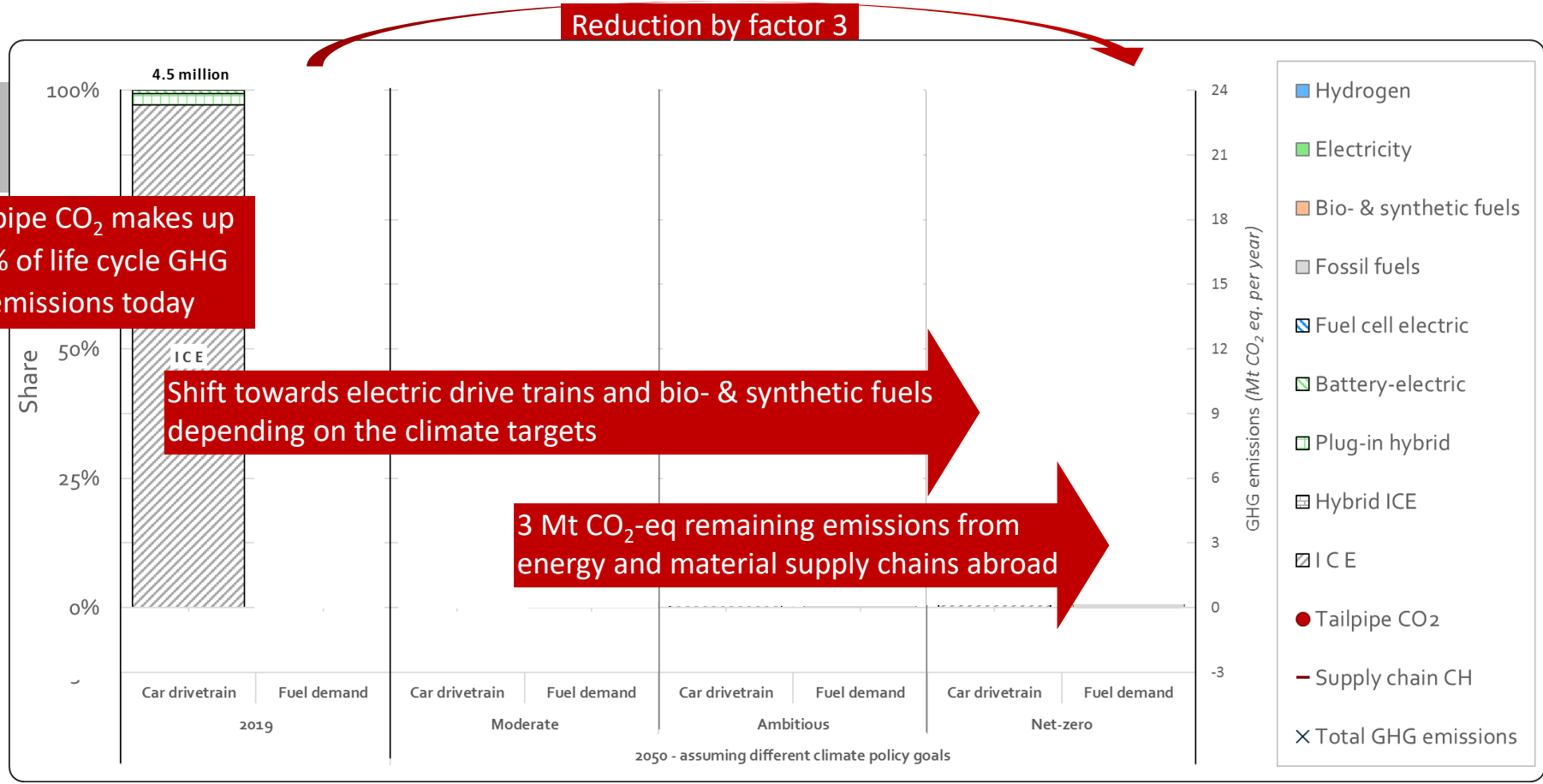
# Overall framework for integrated mobility assessment



# Car fleets in 2050 under three climate policy regimes




ICE – Internal combustion engine, GHG – Greenhouse gases

Source: Hirschberg et al., 2021

# IPA-based mortality for current (2019) lower-medium cars (YOLL per vehicle km)

IPA = Impact Pathway Approach

**Drivetrains**

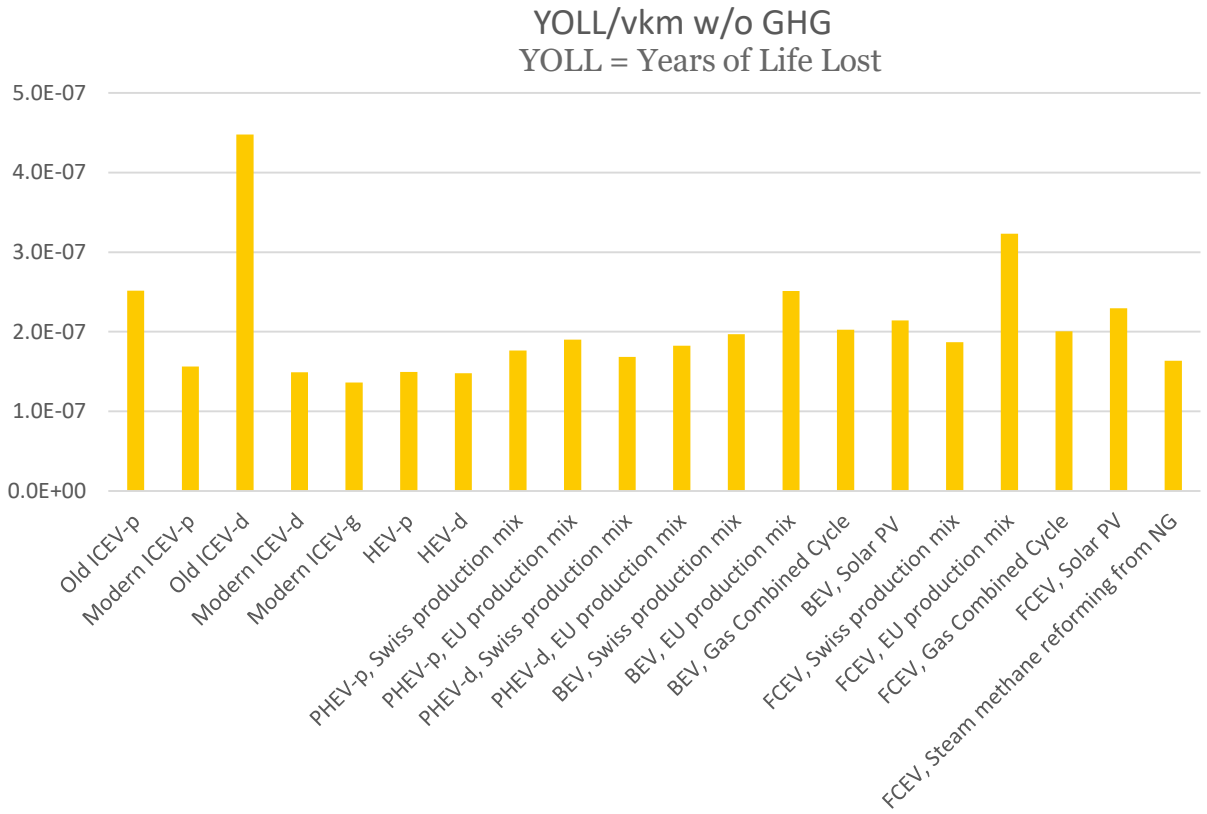
ICEV – internal combustion engine vehicle
HEV – hybrid electric vehicle
PHEV – plug-in hybrid vehicle
BEV – battery electric vehicle
FCEV – fuel cell electric vehicle

**Fuels**

p – petrol
d – diesel
g – gas

**Electricity sources**

Natural gas Combined Cycle, PV, Swiss and EU electricity mixes as shown)



# IPA-based mortality for future (2050) lower-medium cars (YOLL per vehicle km)

**Drivetrains**

ICEV – internal combustion engine vehicle
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**Fuels**

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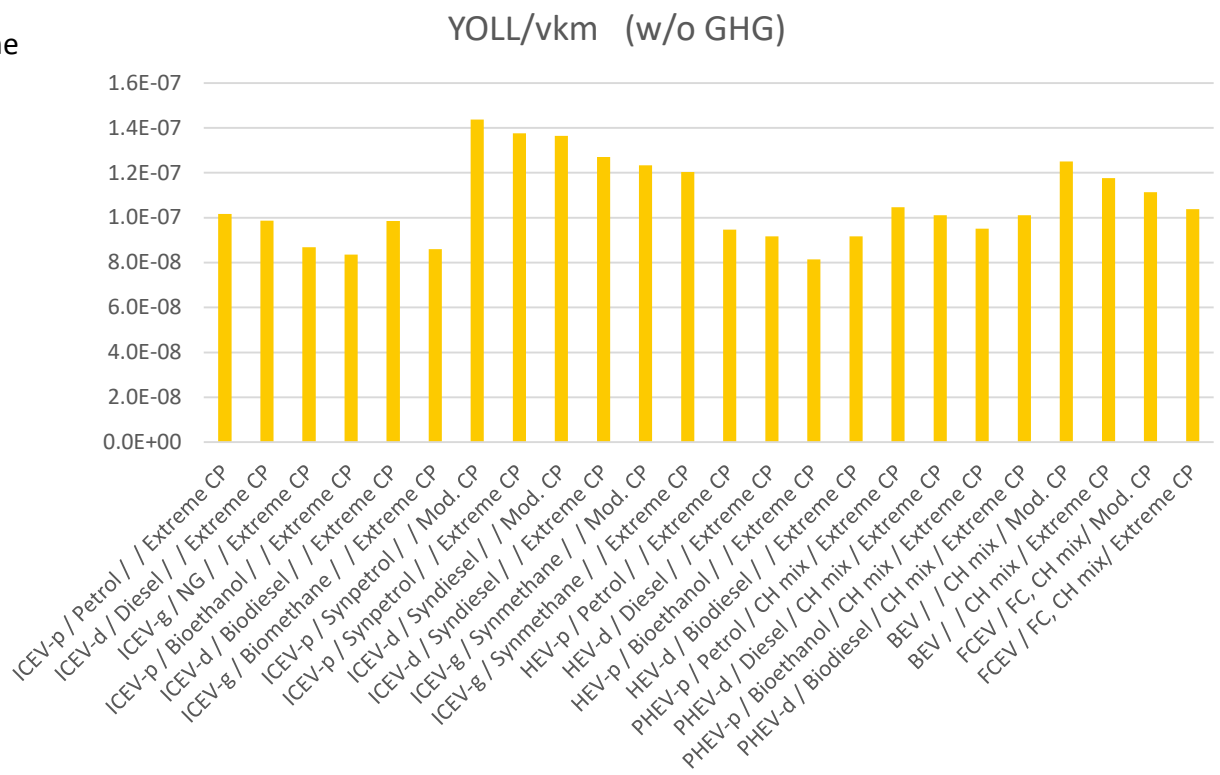
**Electricity sources**

Natural gas Combined Cycle, PV, Swiss and EU electricity mixes as shown)

**Climate policies (CP)**

Moderate and Extreme

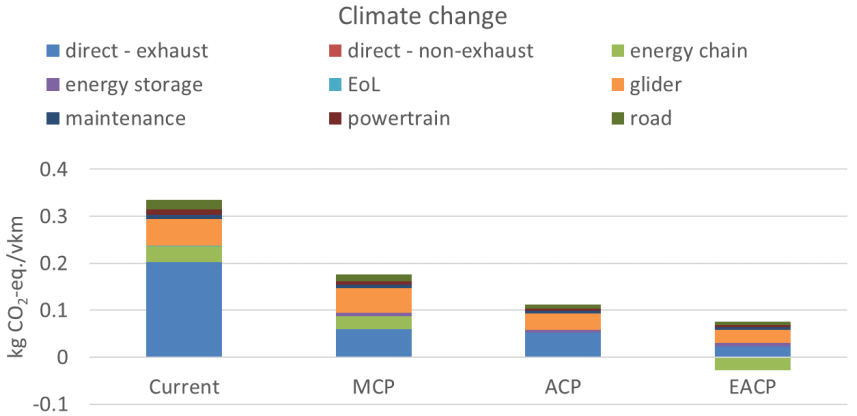


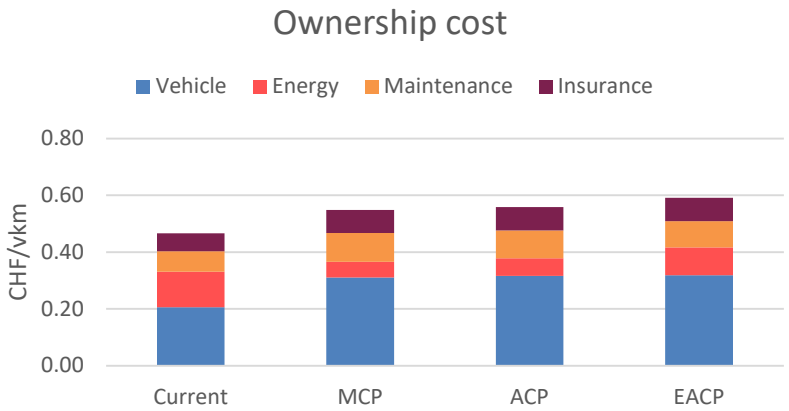
# Indicator examples for current and future future car fleets

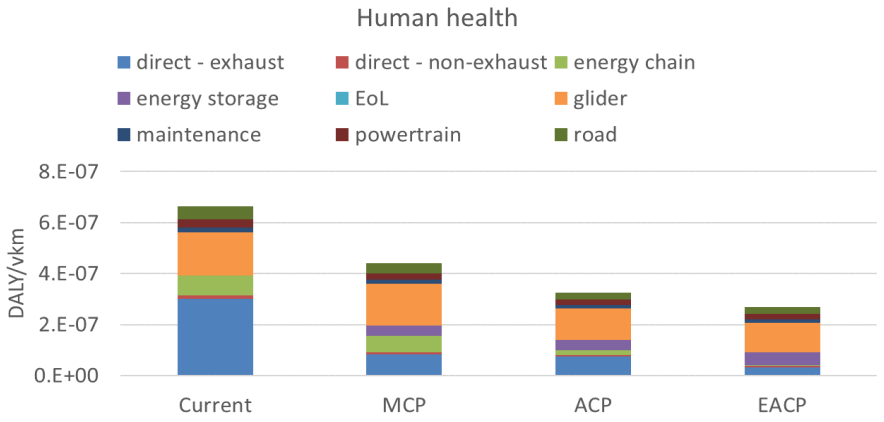
**MCP** = Moderate Climate Policy

**ACP** = Ambitious Climate Policy

**EACP** = Extremely Ambitious Climate Policy

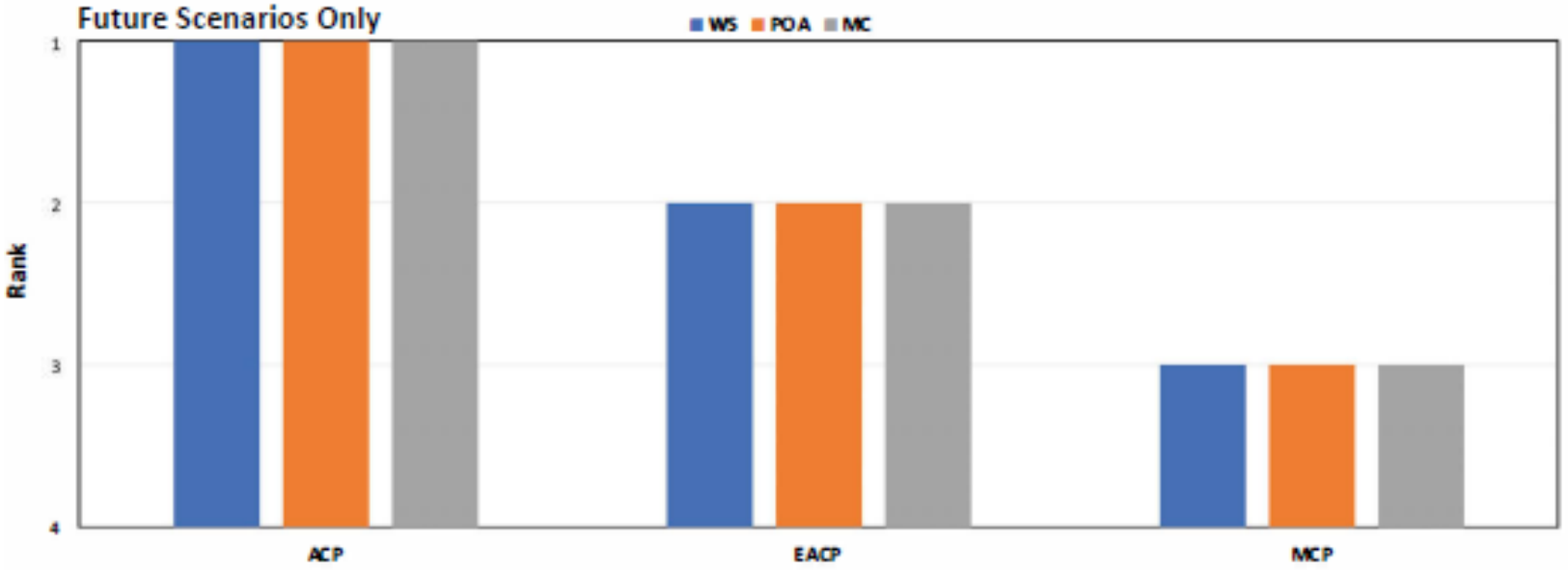



Source: Hirschberg et al., to be submitted

# MCDA-Based Sustainability Assessment of Future Car Fleets




**MCP** = Moderate Climate Policy

**ACP** = Ambitious Climate Policy

**EACP** = Extremely Ambitious Climate Policy

**WS** = Weighted Sum

**POA** = Pairwise Outperformance Aggregation

**MC** = Monte Carlo

Source: Hirschberg et al., to be submitted

# Total (internal + external) costs of car fleet in 2019 and in 2050

**Scenarios**

**MCP** = Moderate Climate Policy

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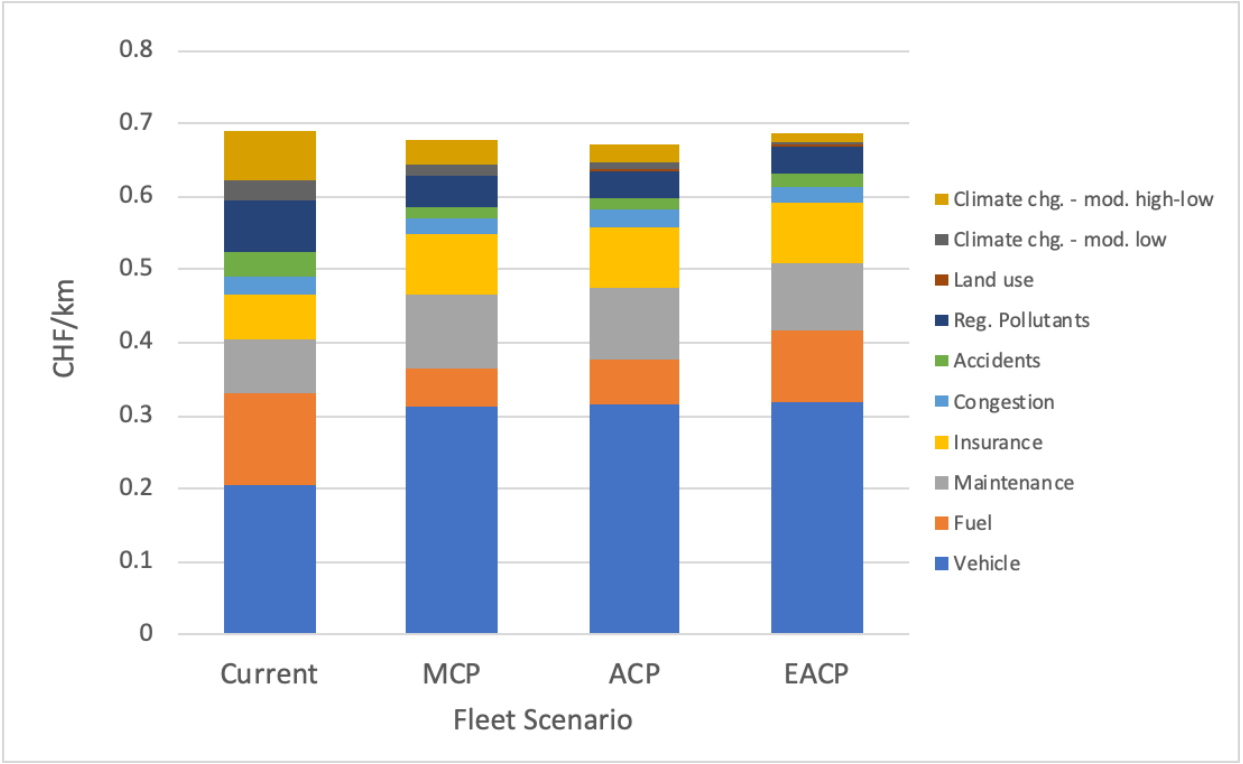
**Monetary valuation of external costs**

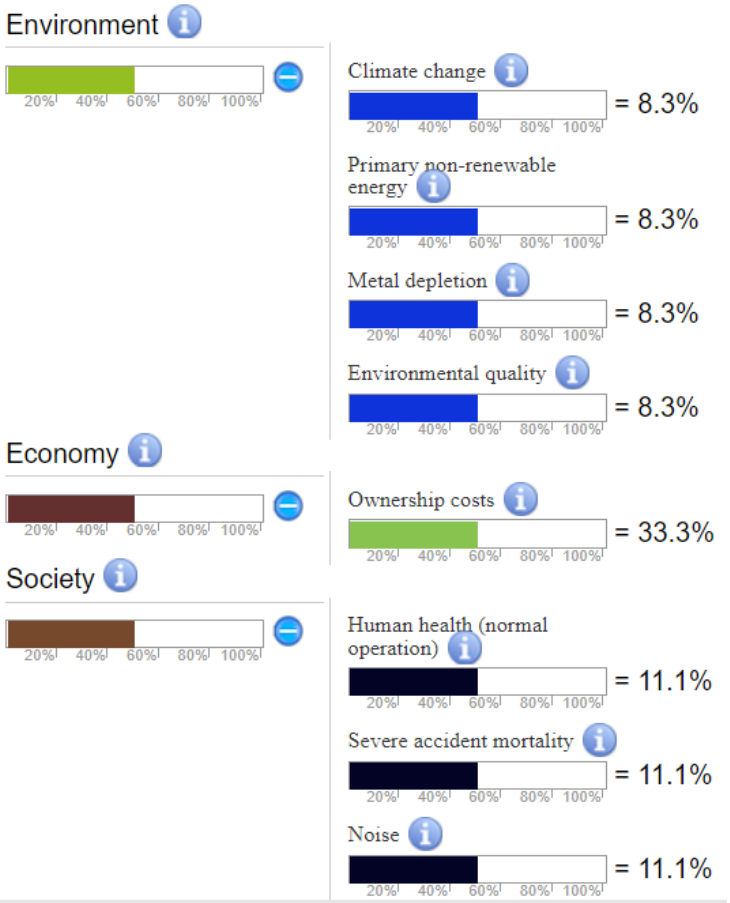
Value of Statistical Life: 6.6 MCHF

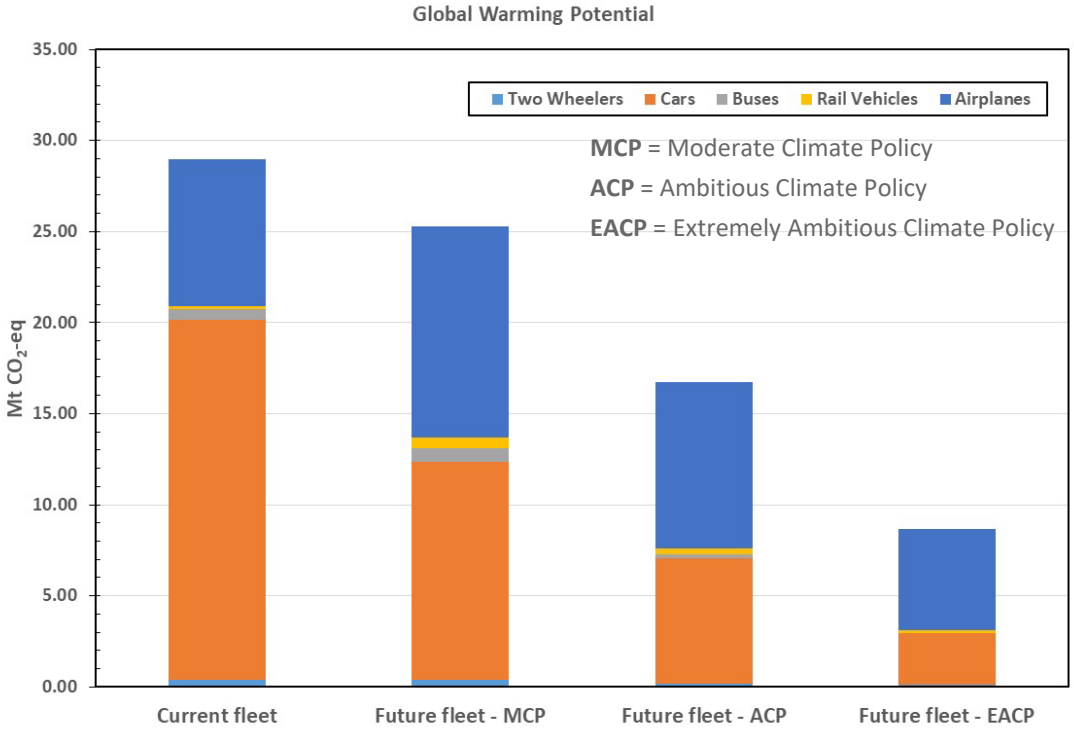
Value of Life Years Lost: 238 kCHF/YOLL




Source: Hirschberg et al., to be submitted

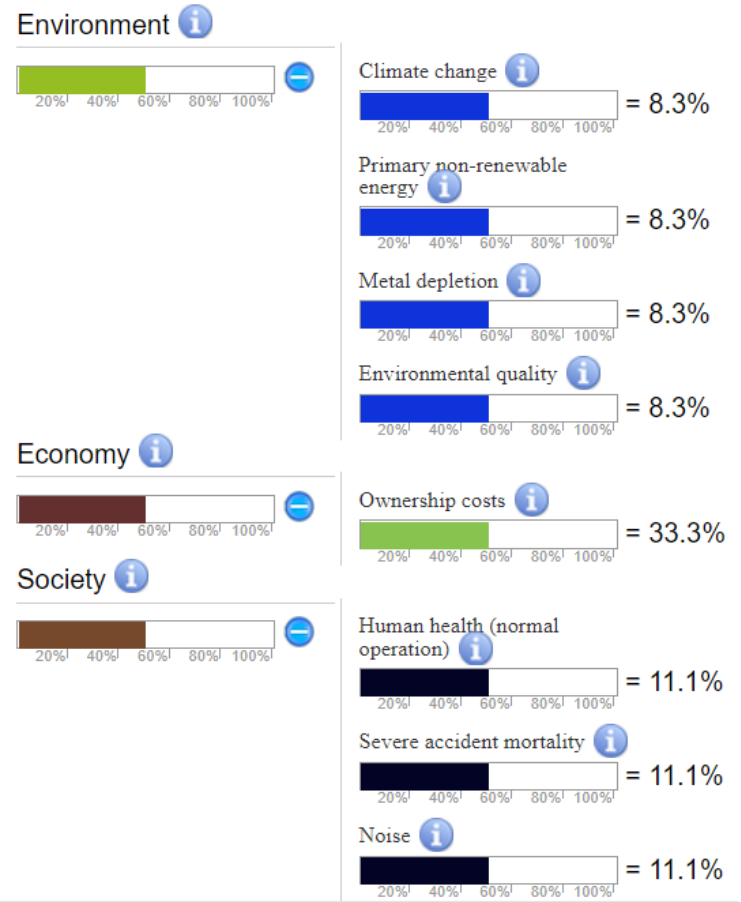
# Sustainability Assessment of Future (2050) Passenger Transport Fleets: Criteria and example of scenario-dependent indicator (GWP)

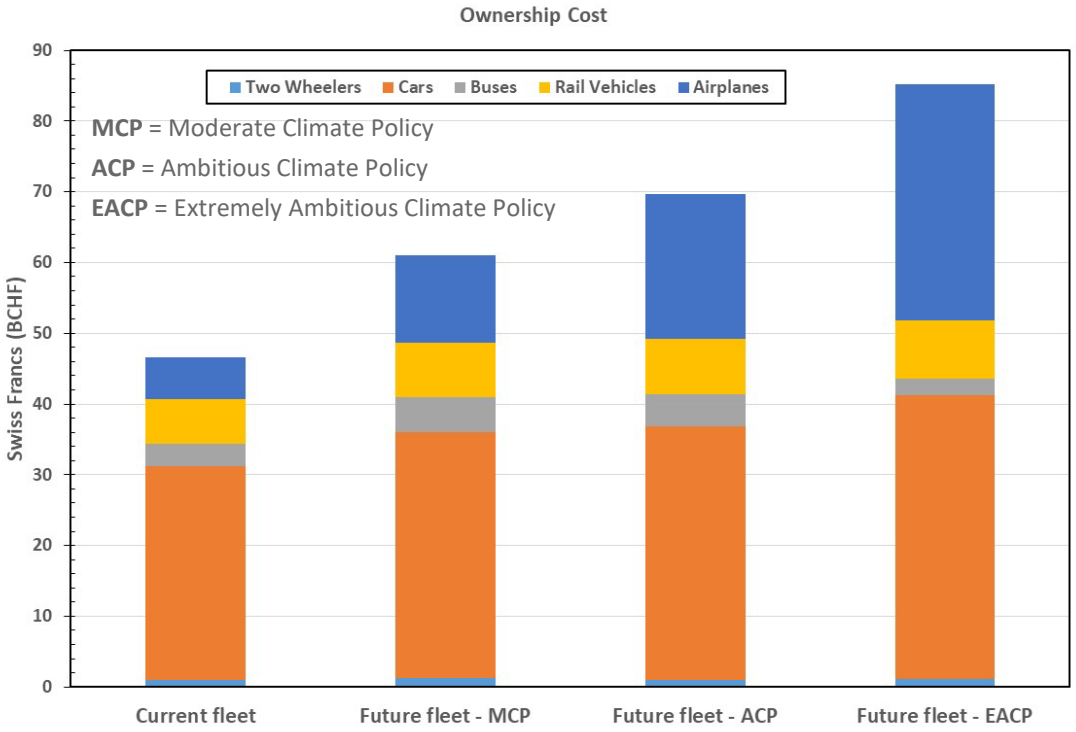



Source: Hirschberg et al., in preparation

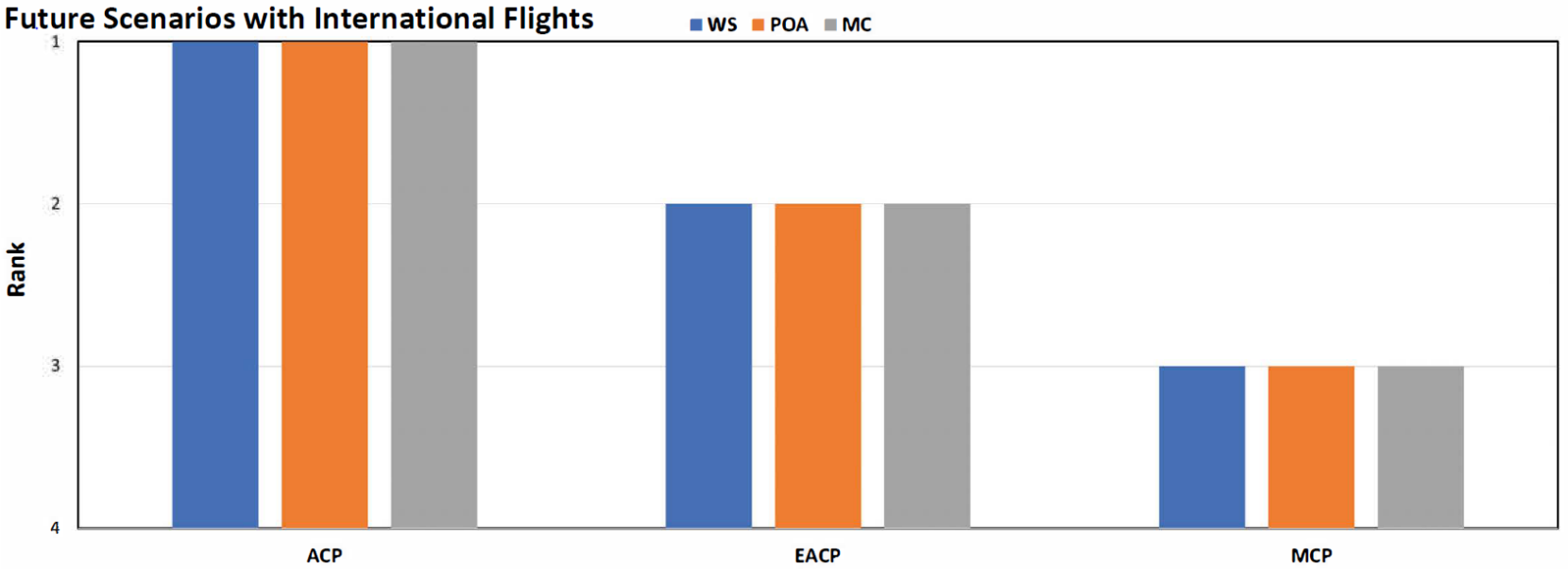
# Sustainability Assessment of Future (2050) Passenger Transport Fleets: Criteria and example of scenario-dependent indicator (Ownership costs)




Source: Hirschberg et al., in preparation

# MCDA-Based Sustainability Assessment of Future Passenger Transport Fleets

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# Selected conclusions from systemic analyses relevant for the Swiss Energy Strategy

- **Electric cars are evolving as a cost-efficient mobility option** even if climate change mitigation would not be the primary priority.
- Given **net zero emissions climate goal** the car fleet consists in 2050 of **Battery Electric Vehicles supplemented by substantial shares of Plug-in-Hybrid Vehicles and Fuel Cell Vehicles fueled by electricity, bio- & synthetic fuels and hydrogen**.
- For car fleet **the net zero emissions scenario (for CH in 2050) still results in about 3 Mt $CO_2$-eq.** emitted abroad due to supply chains external to CH. For the whole passenger transport fleet the remaining emissions increase to about **8 Mt $CO_2$-eq.** due to the remaining contributions from **international aviation**.
- **All scenarios for car fleets are superior to the current fleet with regard to six out of eight quantified sustainability indicators. The two exceptions are costs and metal depletion.**
- **The net zero scenarios for car and the whole passenger transport fleets exhibit** lowest remaining GHG-emissions and consumption of non-renewable energy. However, the costs of mitigating the last 20% of GHG emissions strongly escalate. **The 80% reduction scenario is a trade-off option.**
- While **internal costs of mobility system** increase with the stringency of climate scenario this is roughly compensated by the strong **reduction of associated external costs**.

# Thank you for your interest!

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