sccer mobility
Swiss Competence Center for Energy Research
Efficient Technologies and Systems for Mobility

Supported by:
Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra
Swiss Confederation
Innosuisse – Swiss Innovation Agency

Life cycle environmental burdens of Swiss passenger transport sector

We calculate the total life cycle environmental burdens caused by current (2017) and future (2050) Swiss passenger transport. Two national energy scenarios are considered for the production of electricity and hydrogen, while two global energy scenarios are included in the life cycle database used to calculate the upstream burdens due to infrastructure and energy chains. We compare the potential of battery (BEV), fuel cell (FCEV), and fossil hybrid powertrains using three simple scenarios.

BEV could reduce national passenger transport related life cycle GHG emissions by 47 – 72 %, depending on development of the electricity sector. International air transport is likely to be the major hurdle to overcome in terms of future climate change impacts of passenger transport as aviation related climate change is expected to surpass those of all other passenger transport modes combined, regardless of powertrain and energy chain scenario.

Brian Cox, Paul Scherrer Institute
brian.cox@psi.ch

Chris Mutel, Paul Scherrer Institute
christopher.mutel@psi.ch

Passenger transport demand

We use the ARE national passenger transport demand scenarios [1] for future transport demand and modal distribution, with further information from [2]. International air transport demand is according to the low growth scenario from Cox et. al. [3].

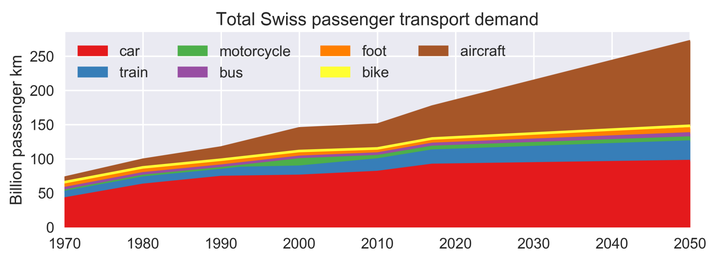
Three simple vehicle powertrain mixes are selected:

BEV – all road vehicles are battery electric;

FCEV – all road vehicles are fuel cell electric;

Fossil – All road vehicles are fossil fueled hybrids.

Aircraft are fossil fueled and trains are electric in all scenarios.



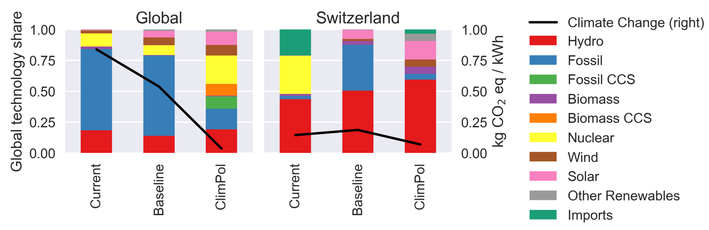
Simple transport supply scenarios

Transport mode	Passenger transport mode share 2017	Passenger transport mode share 2050	Powertrain share per mode: Powertrain	2017	2050 Scenario BEV	2050 Scenario FCEV	2050 Scenario Fossil
Aircraft	26.4%	45.4%	Swiss average	100%	100%	100%	100%
Car	51.6%	35.6%	ICEV-p	58.3%			
			ICEV-d	36.2%			
			ICEV-g	0.2%			
			HEV-p	3.8%			100%
			BEV	1.5%	100%		
			FCEV	0.0%		100%	
Motorcycle	3.1%	2.1%	ICEV	98.8%			100%
			BEV	1.2%	100%		
			FCEV	0.0%		100%	
Bus	2.5%	2.2%	Diesel	94.1%			
			CNG	0.0%			
			Hybrid	4.7%			100%
			Battery-LR	0.6%	50.0%		
			Battery-SR	0.6%	50.0%		
			Fuel Cell	0.0%		100%	
Train	11.8%	10.5%	Long distance	65.0%	65.0%	65.0%	65.0%
			Regional	24.1%	24.1%	24.1%	24.1%
			Urban	10.9%	10.9%	10.9%	10.9%
Bike	1.3%	1.4%	Bike	100%	100%	100%	100%
Foot	3.3%	2.7%	Foot	100%	100%	100%	100%

Energy Scenarios

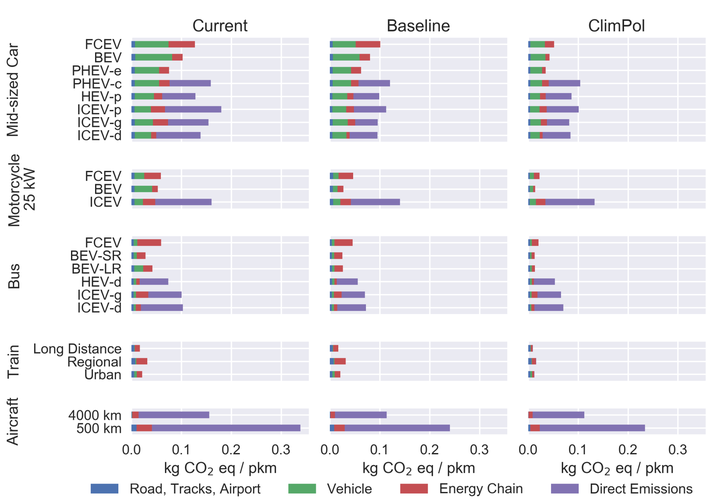
We integrate future global electricity scenarios into the LCA database using results from the IMAGE integrated assessment model [4]. The **Baseline** scenario represents a business as usual scenario, while **ClimPol** is an aggressive 450 ppm climate policy scenario.

Future Swiss electricity mixes are taken from the Swiss energy perspectives [5]. Baseline is matched with BAU-C (future demand met by new gas power plants) and ClimPol is matched to NEP-E (future demand reduction and expansion of renewables).



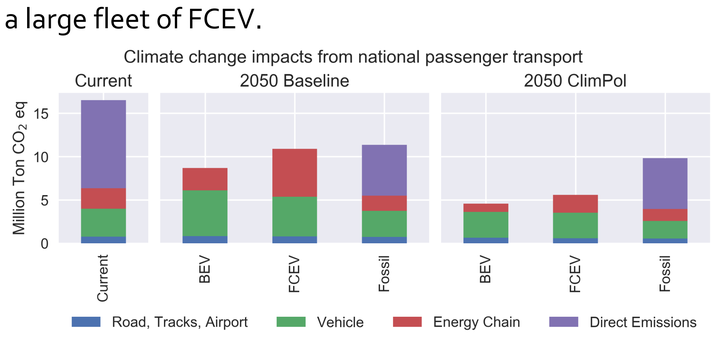
Technology results

Here we show climate change results for individual passenger transport technologies per passenger kilometer (pkm). Electricity and hydrogen are produced using the Swiss average electricity mix for each scenario. BEV are found to provide climate benefits for all vehicle types, though the greatest improvements are found when switching from cars and aircraft to buses and trains.



National passenger transport impacts

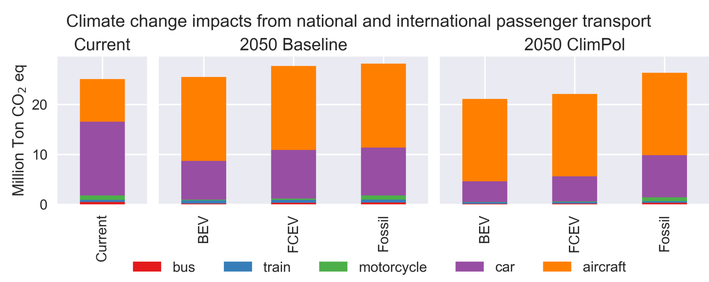
Significant greenhouse gas emission reductions are expected for the future scenarios, with the greatest potential improvements coming from the scenario where all powertrains are battery electric. Especially for this BEV scenario, the total greenhouse gas emission savings are strongly dependent on the global energy transition, as much of the total climate impacts due to Swiss passenger transport occur outside of the country. Caution must be used when interpreting results for the FCEV scenario as it would result in huge increases in electricity demand that were not considered in the original study. It is possible that the NEP-E scenario would not be possible with such a large fleet of FCEV.



Total passenger transport impacts

When international air transport is also included in the total passenger transport demand, the results look much less promising. The large expected growth in air transport demand could nearly nullify all gains made in ground passenger transport, despite significant expected improvements to aircraft design.

This will likely remain one of the most difficult sectors in terms of greenhouse gas emission reductions in coming decades. With no obvious technical solution to reduce the climate impacts of international air transport in sight, focus will have to be placed on demand reduction and, where possible, modal shift.



References

[1] Federal Office for Spatial Development, *Transport Outlook 2040: Development of passenger and freight transport in Switzerland*. 2016.

[2] Swiss Federal Statistical Office, *Mobility and Transport Pocket Statistics 2017*. 2017

[3] Cox, B., W. Jemioło, and C. Mutel, *Life cycle assessment of air transportation and the Swiss commercial air transport fleet.* Transportation Research Part D: Transport and Environment, 2018. **58**: p. 1-13.

[4] Cox, B., et al., *Uncertain Environmental Footprint of Current and Future Battery Electric Vehicles.* Environ Sci Technol, 2018. **52**(8): p. 4989-4995.

[5] Prognos, *Die Energieperspektiven für die Schweiz bis 2050*. 2012

PAUL SCHERRER INSTITUT