IEA, IA Advanced Motor Fuels – Annex 51 Methane Emission Control

Electricity based gaseous fuels

Hydrogen enriched natural gas/biogas

Christian Bach
Head Automotive Powertrain Technologies Laboratory

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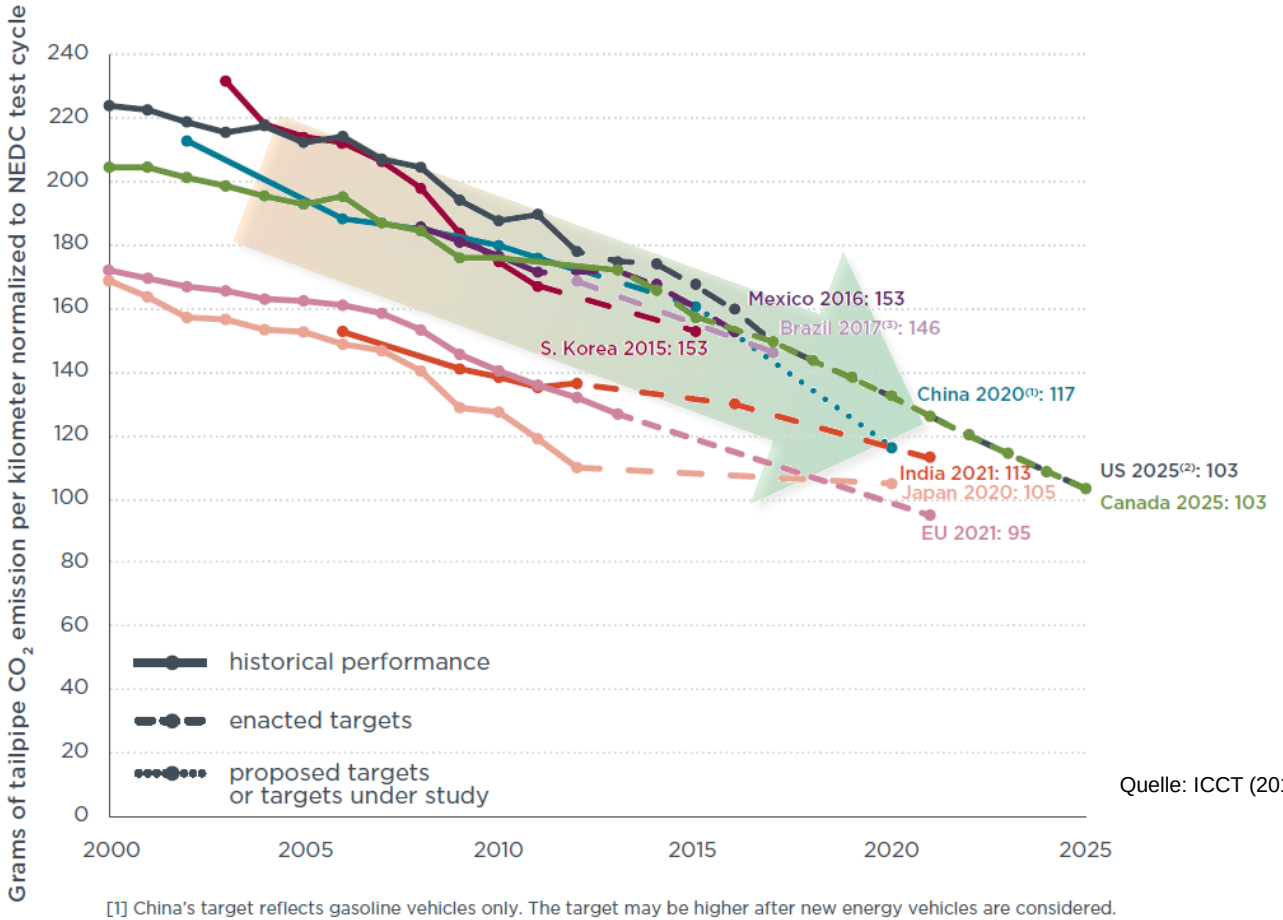
Content

- CO_2 legislation for passenger cars
- Synthetic fuels for mobility
- Hydrogen fuels
- Summary

CO_2 legislation

World wide CO_2-legislation for passenger cars



Quelle: ICCT (2014)

[1] China's target reflects gasoline vehicles only. The target may be higher after new energy vehicles are considered.
[2] US fuel economy stadards set by NHTSA reflecting tailpipe GHG emission (i.e. exclude low-GWP refrigerant credits).
[3] Gasoline in Brazil contains 22% of ethanol (E22), all data in the chart have been converted to gasoline (E00) equivalent.
[4] Supporting data can be found at: http://www.theicct.org/info-tools/global-passenger-vehicle-standards

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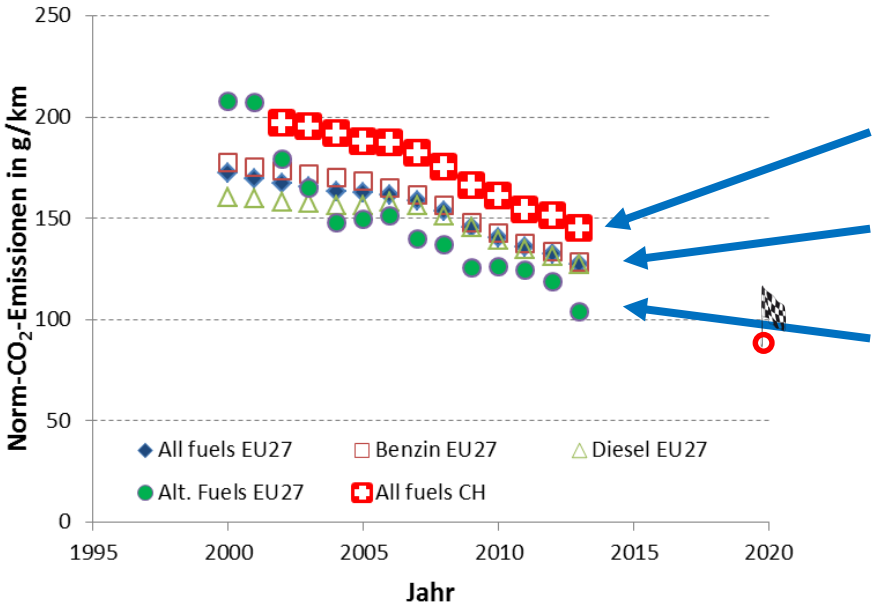
CO_2 legislation for passenger cars

Switzerland and EU – impact of alternative fuels is increasing



CH-fleet («all fuels») is 18 g/km higher than EU27-fleet

Gasoline/diesel fleet (EU27) with comparable CO_2 (standard) emissions

CO_2 emissions of alternative fuels fleet are lowest

AFV: Alternative Fueled Vehicle

Quelle: EEA (2014); Auto-Schweiz (2014)

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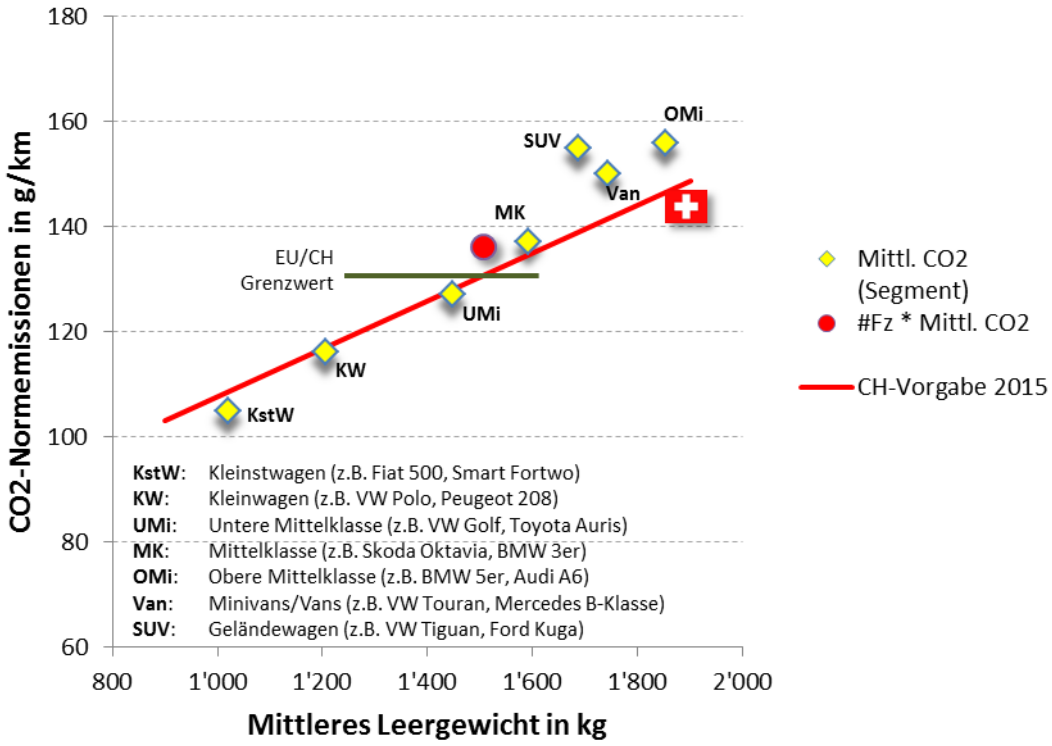
CO_2 sanctions

Example for 2015 with the assumption of 3% CO_2 reduction vs. 2014

Assumptions: Importer with 10% market share
4% KstW, 20% KW, 23% Umi, 13% MK, 3% Omi, 7% Van, 30% SUV



Mean CO_2 emissions of PC segments 2014 less 3%

- Mean CO_2: 136.1 g/km
- Target value: 130.6 g/km
- Difference: 5.5 g/km
- Rounded: 5 g/km
- **Sanction: 10 Mio CHF**

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Ind. Mob. in New Energy Politics Scenario

Passenger car mobility (acc. Prognos 2012)

Electric mobility (Plugin vehicles + FC)
Vehicles: 40%
Mileage: 46 %

ICE mobility (non-Plugin vehicles)
Vehicles: 60%
Mileage: 54 %

eF.C. total: **1 MJ/km** (3.1 $l_{Gasoline-Eq.}$/100km)

1:2

E.C. = **18 kWh/100km** (average fleet)

CO_2 = **0 g/km**

Ren. el.: 0%

F.C. = **4.1 $l_{Gasoline-Eq.}$/ /100km** (average fleet)

CO_2 = **95 g/km**

Ren. fuels = **65%**

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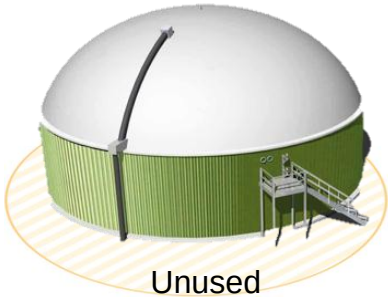
Renewable fuels

Unused sustainable biomass



Unused
sustainable biomass

Switzerland has 2 - 11 TWh/a unused, sustainable biomass that could be largely converted into biogas.
(B. Steubing et al., 2010)

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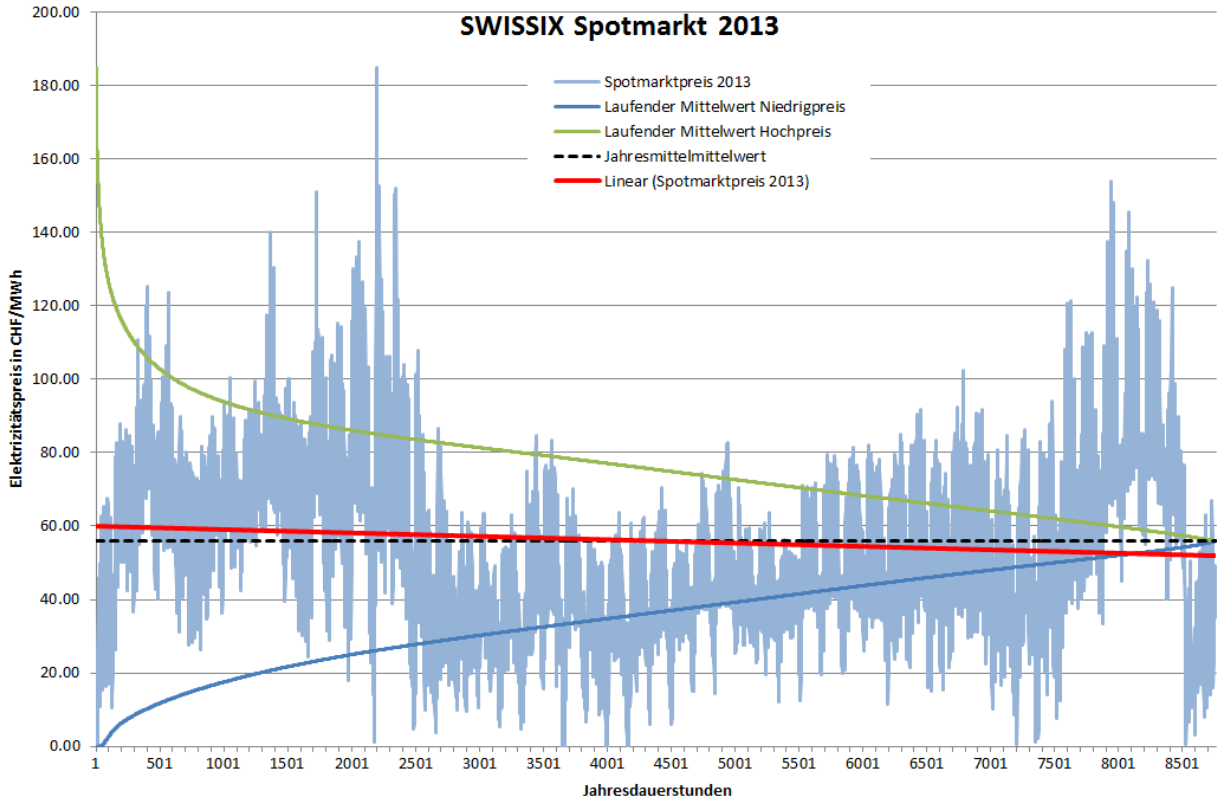
Electricity prices 2013

Summer market-price below hydro-energy production cost



Electricity market-price during 5'000 h/a below hydro-energy production cost of 70 CHF/MWh.

Quelle: PSI (2014)

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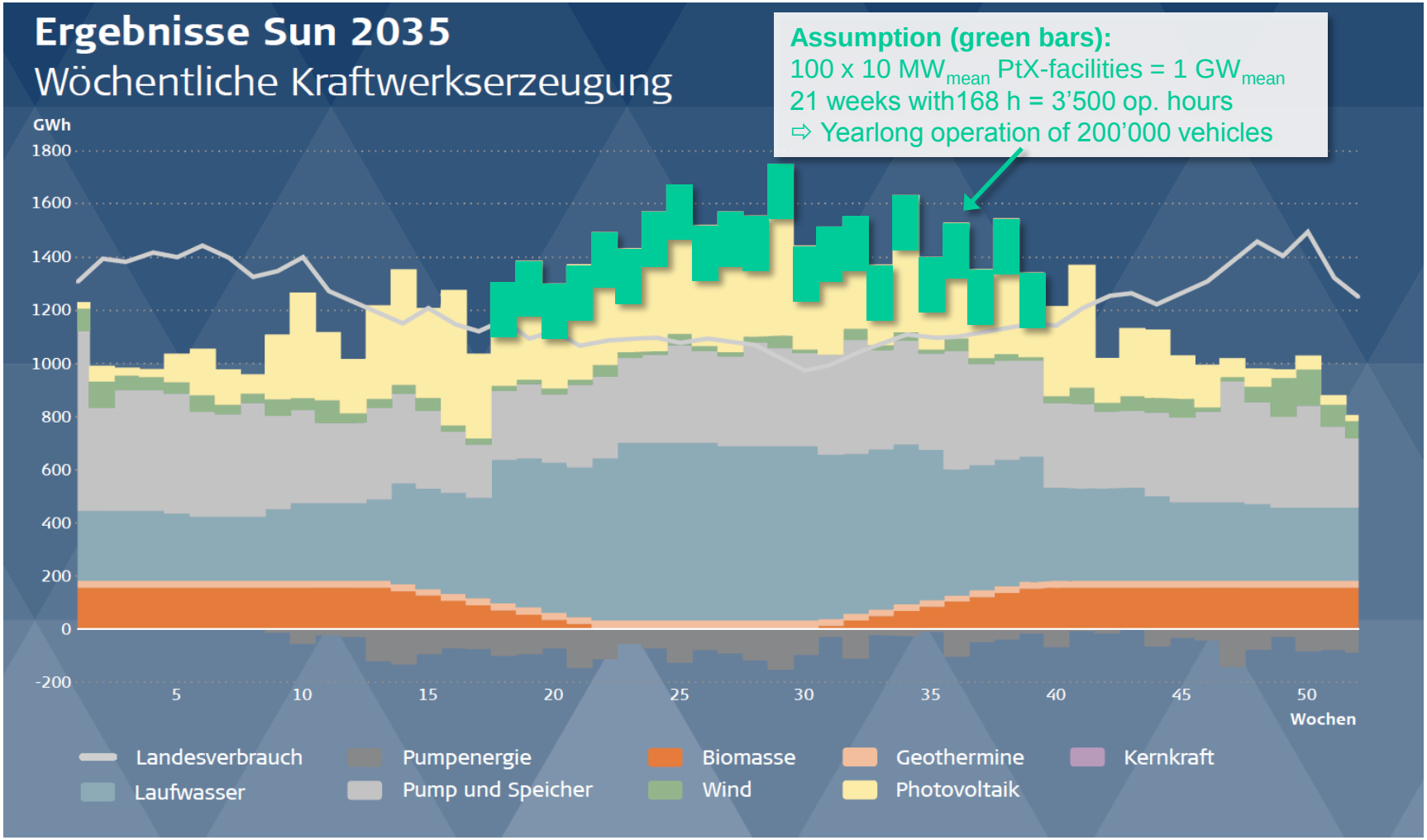
Excess electricity in summer

Simulations of Swissgrid



Quelle: Swissgrid (2015)

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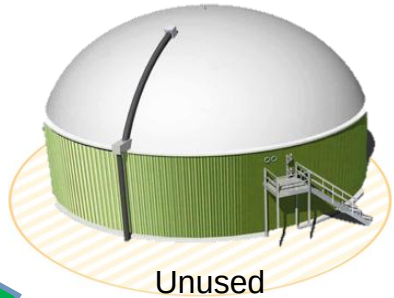
Renewable fuels

Fluctuating renewable excess electricity

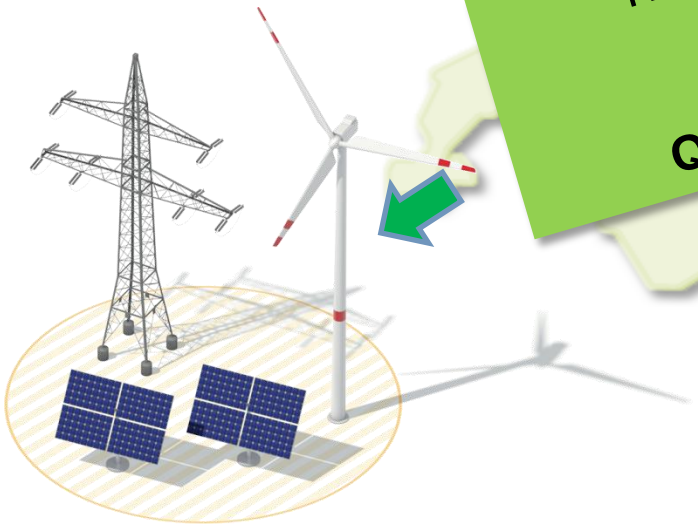
5’000
summer-h
hydro power
(today)



Unused
sustainable biomass

The only «free» domestic energy resources.

Question: How to use?



Fluctuating renewable
excess electricity
(>2035)

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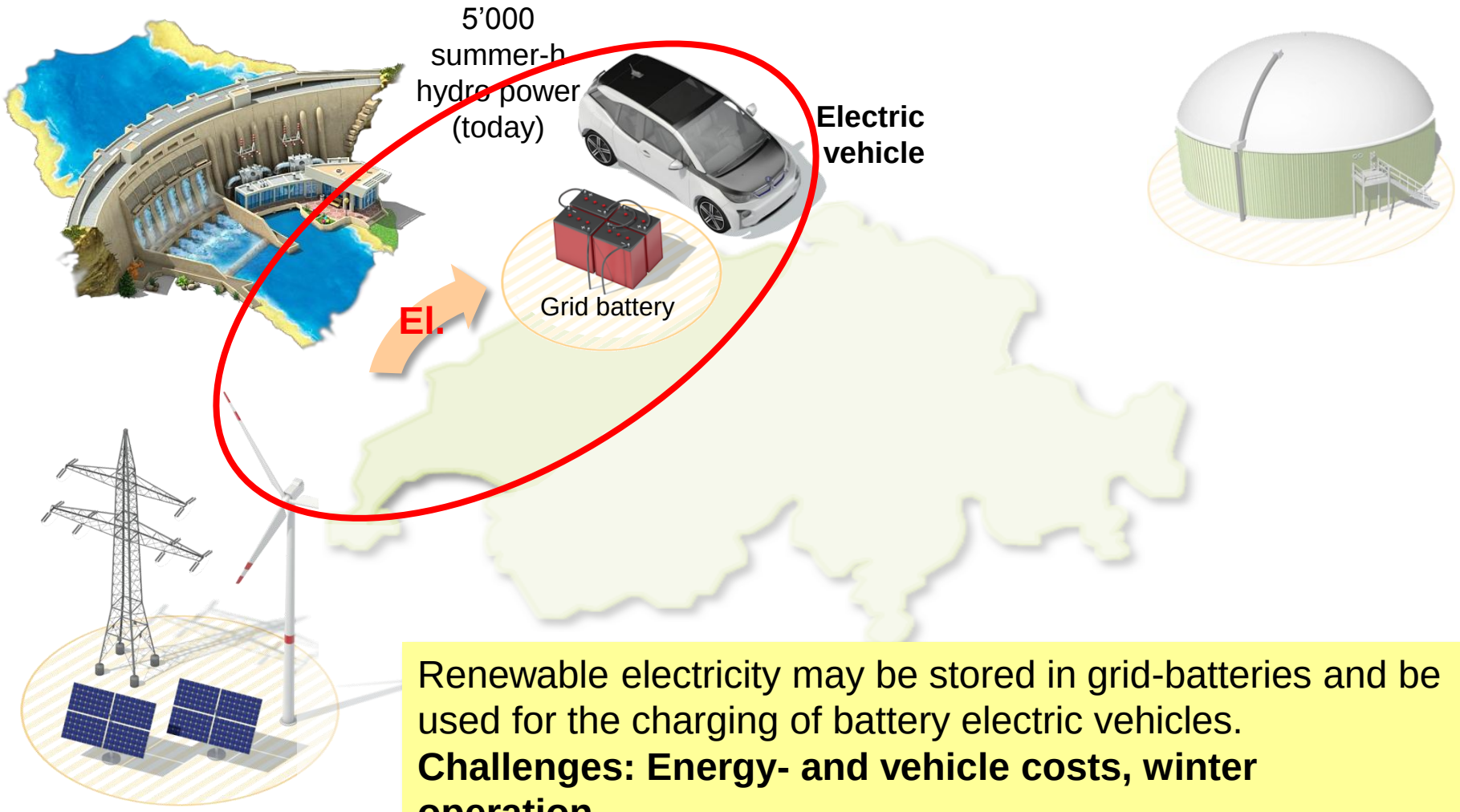
Renewable fuels

Electro-chemical storage with use in electric vehicles



Fluctuating renewable excess electricity (>2035)

Renewable electricity may be stored in grid-batteries and be used for the charging of battery electric vehicles.
Challenges: Energy- and vehicle costs, winter operation.

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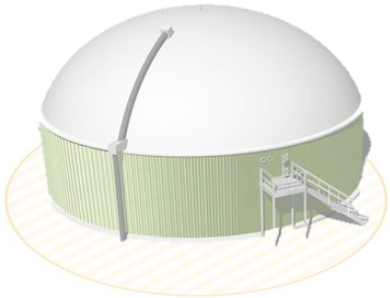
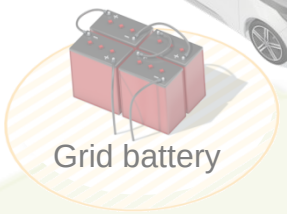
Renewable fuels

Chemical storage with use in H_2 vehicles

5'000 summer-h hydro power (today)

Electric vehicle

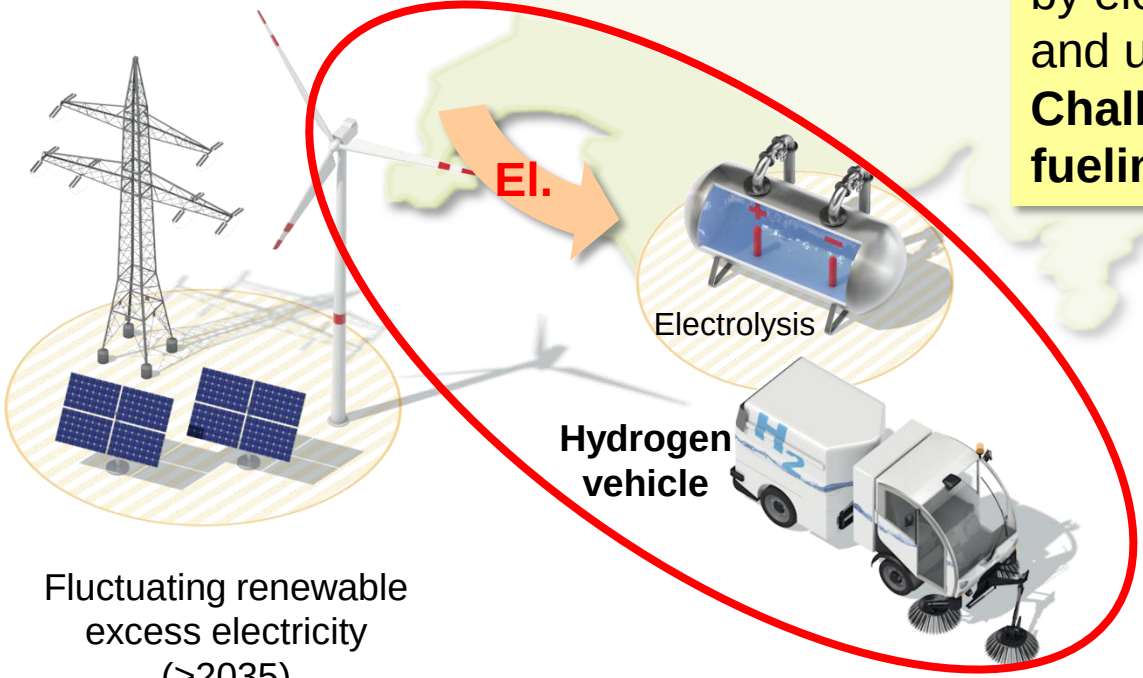




Grid battery

El.

Excess electricity may be converted by electrolysis into hydrogen (H_2) and used in fuel cell vehicles. **Challenges: direct use of H_2, fueling station and vehicle cost**.



El.

Electrolysis

Hydrogen vehicle

Fluctuating renewable excess electricity (>2035)

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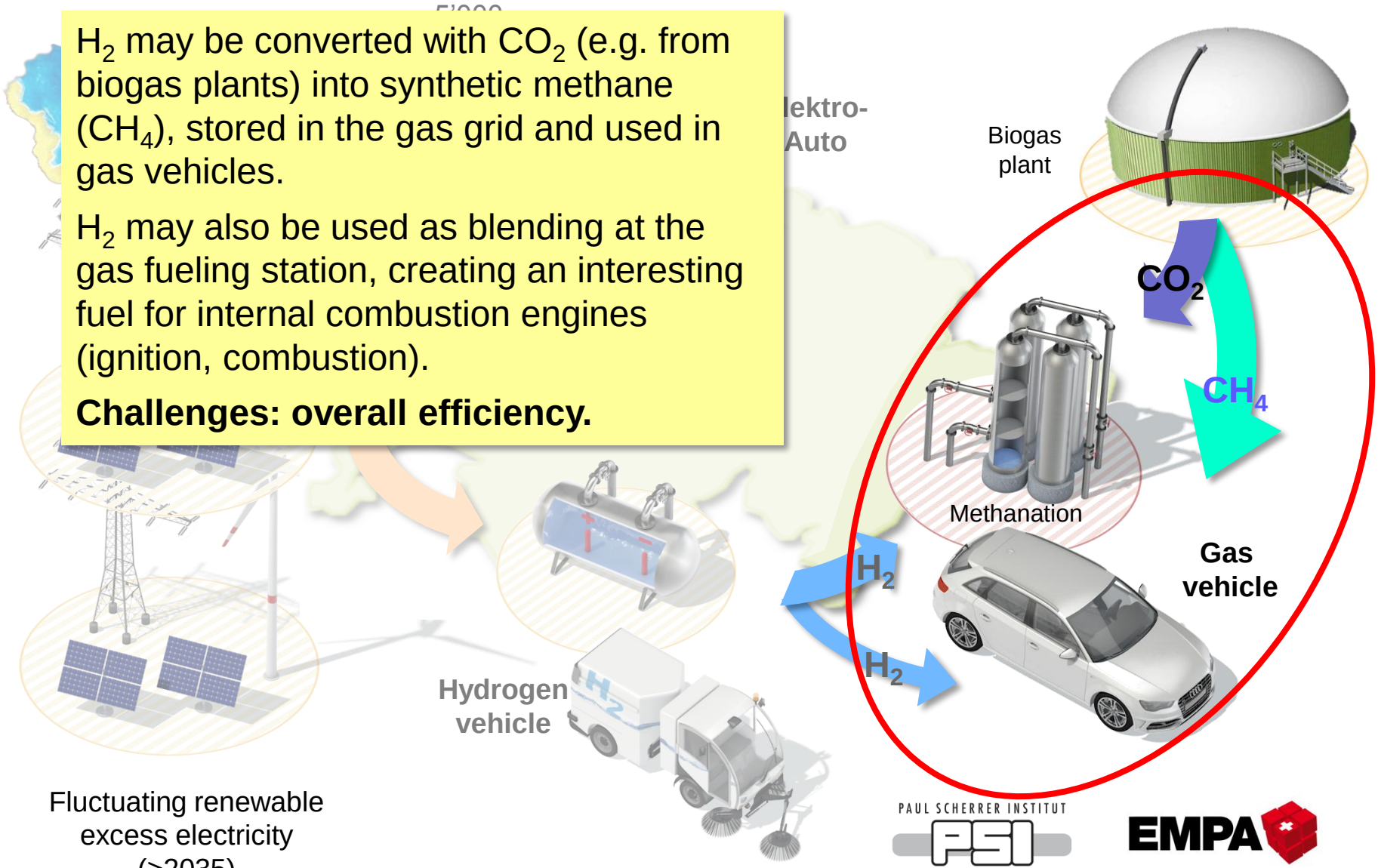
Renewable fuels

Chemical storage/methanation and use in gas vehicles

H_2 may be converted with CO_2 (e.g. from biogas plants) into synthetic methane (CH_4), stored in the gas grid and used in gas vehicles.

H_2 may also be used as blending at the gas fueling station, creating an interesting fuel for internal combustion engines (ignition, combustion).

Challenges: overall efficiency.



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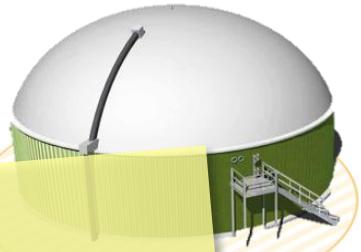
Renewable fuels

Diversification in the vehicle powertrain concepts and fuels

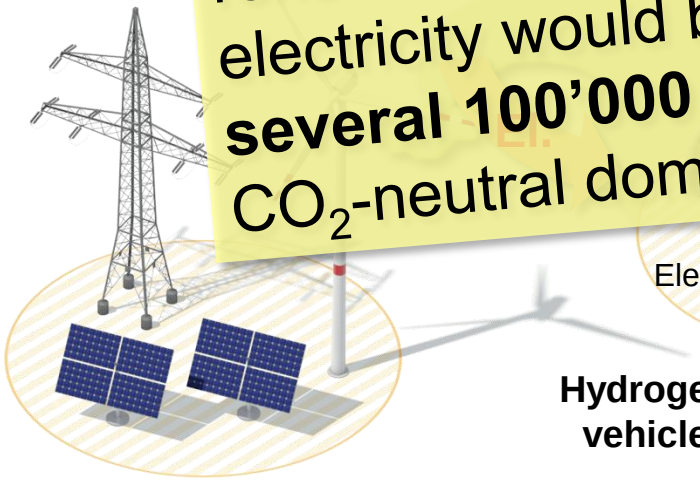
5'000 summer-h hydro power (today)

Electric vehicle

Biogas plant



Vision:
If the unused biomass potential and the expected renewable excess and non-economic water electricity would be used only to 50%, **several 100'000 vehicles** could be operated with CO_2-neutral domestic energy.



Fluctuating renewable excess electricity (>2035)

Electrolysis

H_2

H_2

Methanation

Gas vehicle

Hydrogen vehicle

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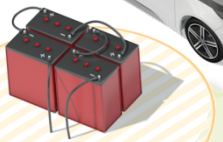
Diversification in the vehicle powertrain concepts and fuels

5'000 summer-h hydro power (today)

Electric vehicle



Grid battery

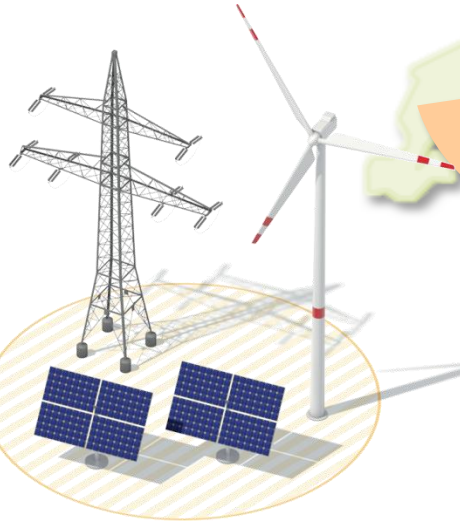
El.

Biogas plant

CO_2

CH_4

Methanation



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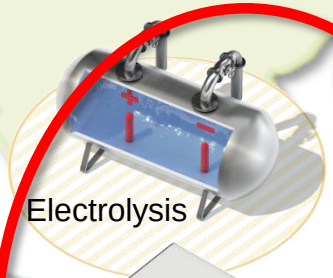

Electrolysis

H_2

H_2

Hydrogen vehicle

Gas vehicle

Fluctuating renewable excess electricity (>2035)

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Natural gas/biogas-hydrogen mixture

2 vol% H_2 blending in CNG vehicles

- Investigation on 2 vol% (0.6 E%) H_2 blending on 3 Fiat Ducato (partner: Mobility Solutions AG)
- Parcel distribution service with 200 engine starts per day
- Significant improvement of engine start time (up to -50%)
- Efficiency increase up to 1%

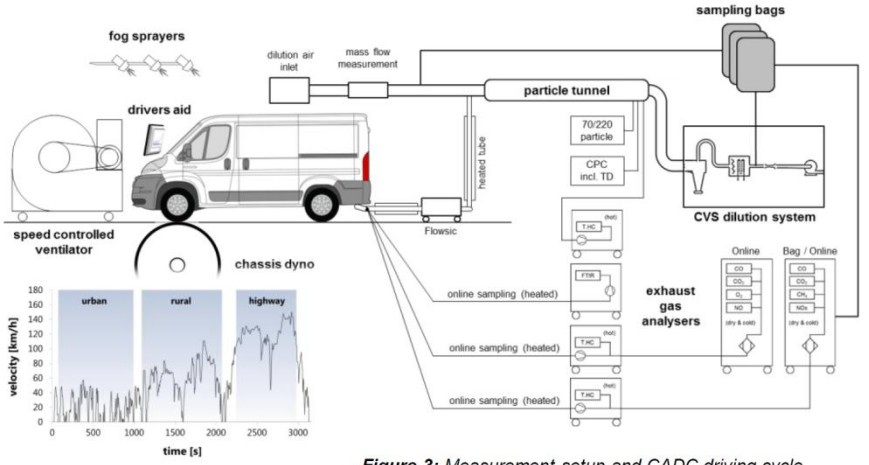
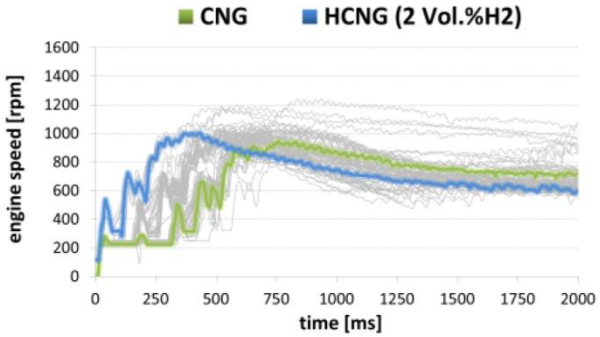
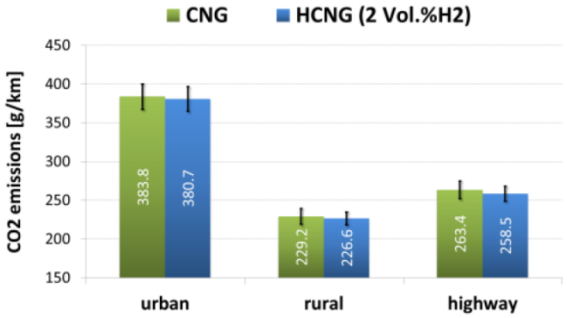
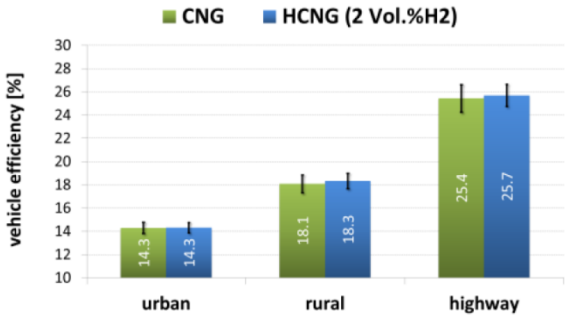


Figure 3: Measurement setup and CADC driving cycle







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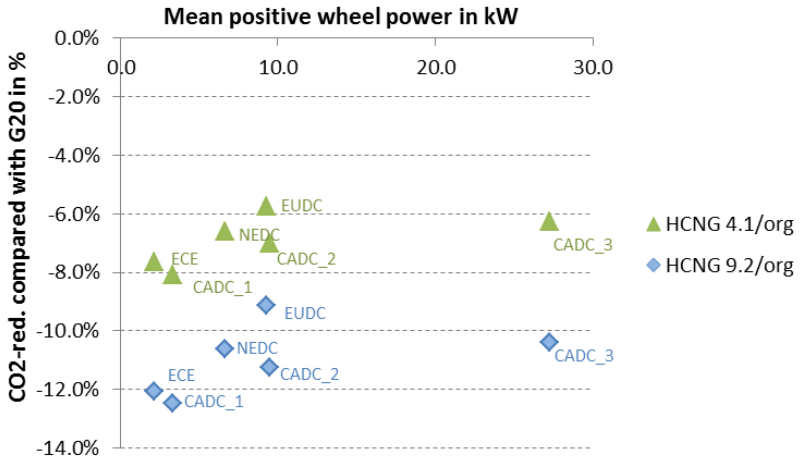
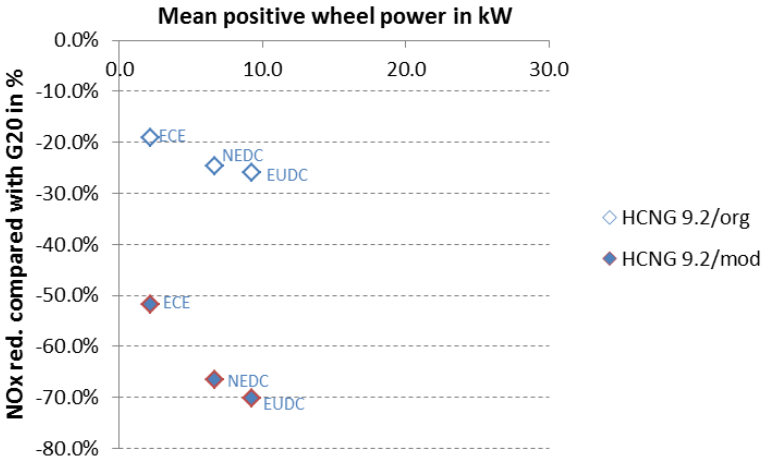
Natural gas/biogas-hydrogen mixture

25 vol% H_2 blending in CNG vehicles (annex 51 project)

- Disproportional CO_2-Reduktion (9 E% H_2 => 9-12% CO_2-Red.)
- Significant improvement of NOx- and HC emissions
- Potential for new combustion processes





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Summary

CO_2 legislation is the key driver for automotive powertrain development. Noncompliance with the target values will be sanctified with high penalties.

Energy turnaround to more fluctuating renewable electricity production will lead to increased excess electricity in summer. The glut of electricity in summer has bad economic impact on water electricity.

An increased use of renewable summer electricity would reduce the negative impact of the promotion of new renewable electricity and could help the achieve the CO_2 targets in Switzerland, without increasing the electricity demand in winter time.

On a long term basis, synthetic gaseous (H_2, CH_4) and liquid (methanol, OME, synthetic diesel) fuels would allow to decouple individual mobility from fossil energy resources.

Thank you for your attention!

Thanks to colleagues:

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Dr. Patrik Soltic
Urs Cabalzar
Thomas Bütler

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