Synthetic Power-to-Gas Methane as Fuel for Transportation

Life Cycle Environmental Impacts of the PtG Methane Supply Chain Powered by Renewable Electricity

Source: Frank Brüderli

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LCM 2017: LCM for transport and mobility
4 September 2017, European Convention Center Luxembourg

Hegemony of diesel finally crumbling?

Mainstream natural gas Volkswagens are still a ways away.

VW looks to natural gas as it pivots away from diesel

NATURAL GAS VW COULD HELP KEEP FLEET EMISSIONS LOW, BUT NO WORD YET ON TIMING

MAY 4, 2017

Stuttgart judge demands diesel bans from 2018, ruling retrofits will not tackle pollution

31/07/2017 in Manufacturer News

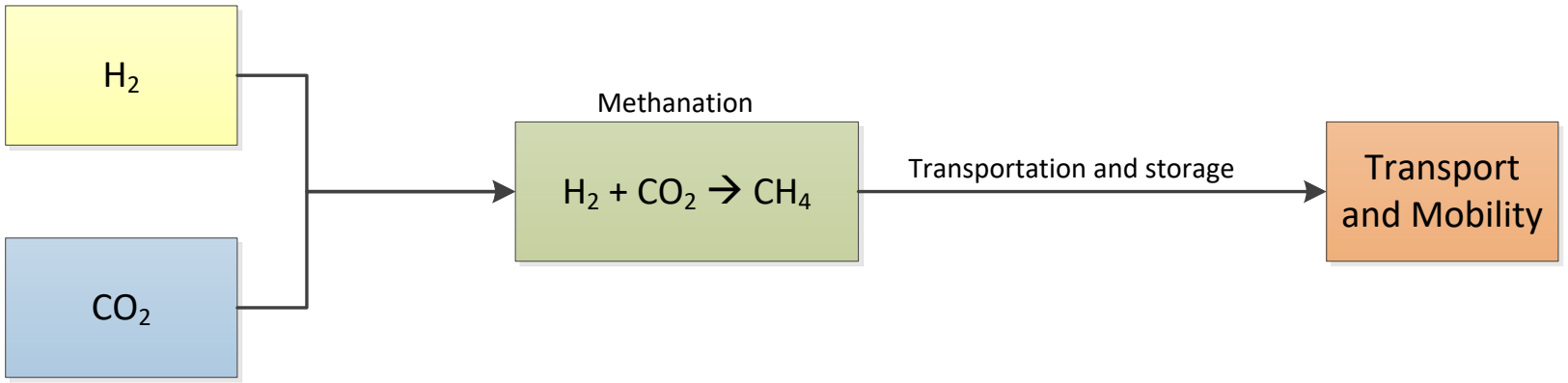
A Stuttgart judge has ruled that retrofitting illegally polluting diesel vehicles will not solve the German region's air quality crisis and demanded a diesel ban be implemented in the city from January 2018.

The ruling means Stuttgart's government must rewrite its Air Quality Plan (AQP), as the current version is inadequate and will not protect people's health in the shortest time possible.

Air quality in the region is illegally poor, regularly breaching limits for toxic gas nitrogen dioxide (NO_2) and dangerous coarse particles (PM_{10}). The levels are some of the worst in Germany.

Production of Power-to-Gas methane

Power-to-Gas (PtG) process uses excess power from renewable sources to produce hydrogen (H_2). H_2 is then converted to **methane**, which can be used to power vehicles.



NRP 70 «Energy Turnaround»: Sustainability assessment of the CO_2 methanation value chain: environmental impacts and socio-economic drivers and barriers
Project: **Renewable Methane for Transport and Mobility (RMTM)**

Goal and scope of the project

Quantification of the environmental impacts of **vehicles powered by PtG methane** in comparison with conventional vehicles.

4 different vehicle types

- Petrol powered car
- Diesel powered car
- Natural gas powered car / PtG methane powered car
- Electric car

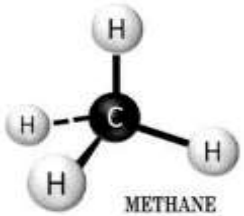
Framework

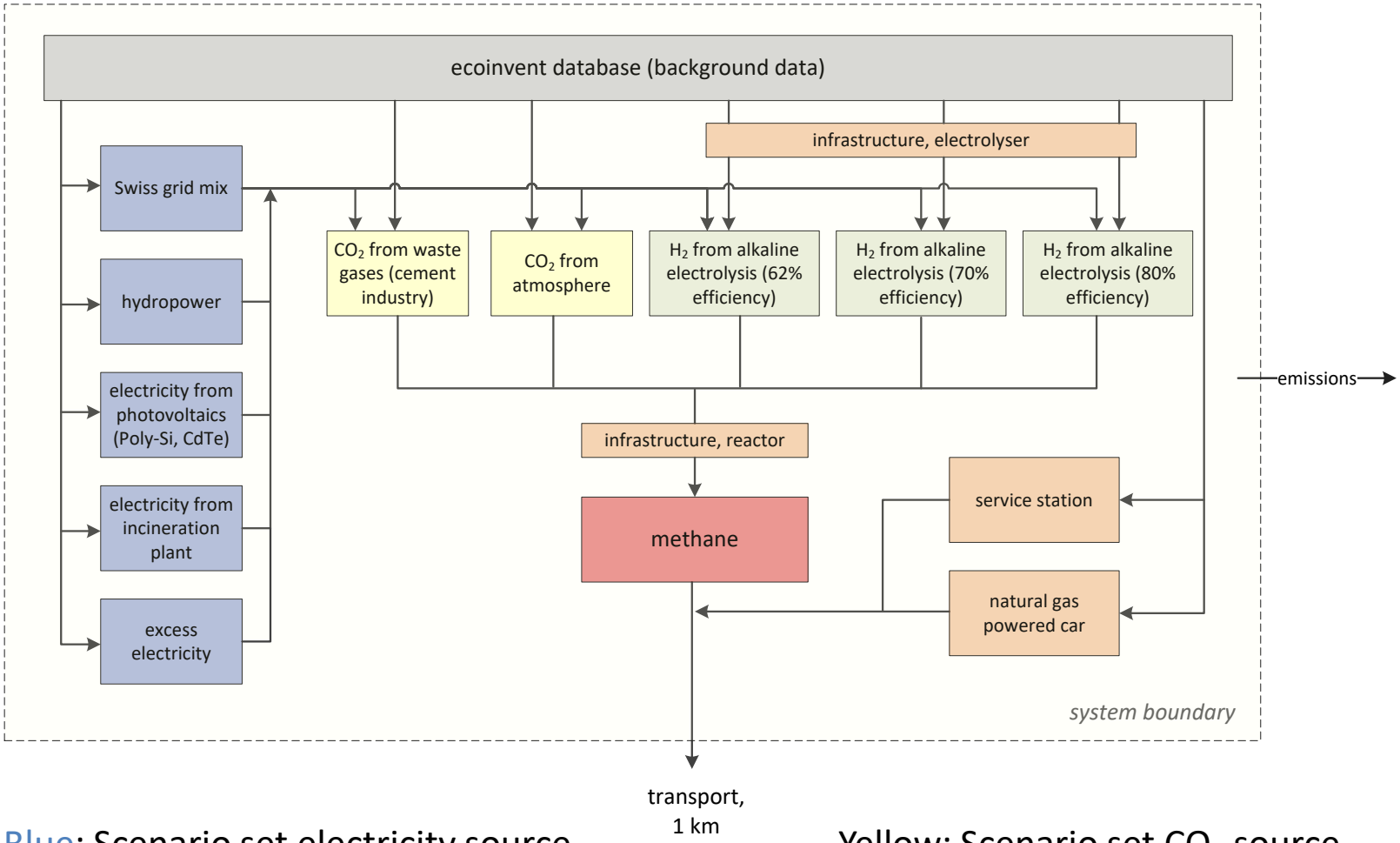
- Geographic: Switzerland
- Temporal: Current state of research, 2015

Functional Unit

- 1 kilometre driven by passenger car (1 vehicle kilometre) based on VW Golf 2015-2016 with 110 - 130 HP

Schematic represenation and scenarios of the production system





Blue: Scenario set electricity source
Green: Scenario set electrolysis efficiency
Grey: Background data

Yellow: Scenario set CO_2 source
Orange: Infrastructure and vehicle

Scenario electricity source: Greenhouse gas emissions per vehicle kilometre

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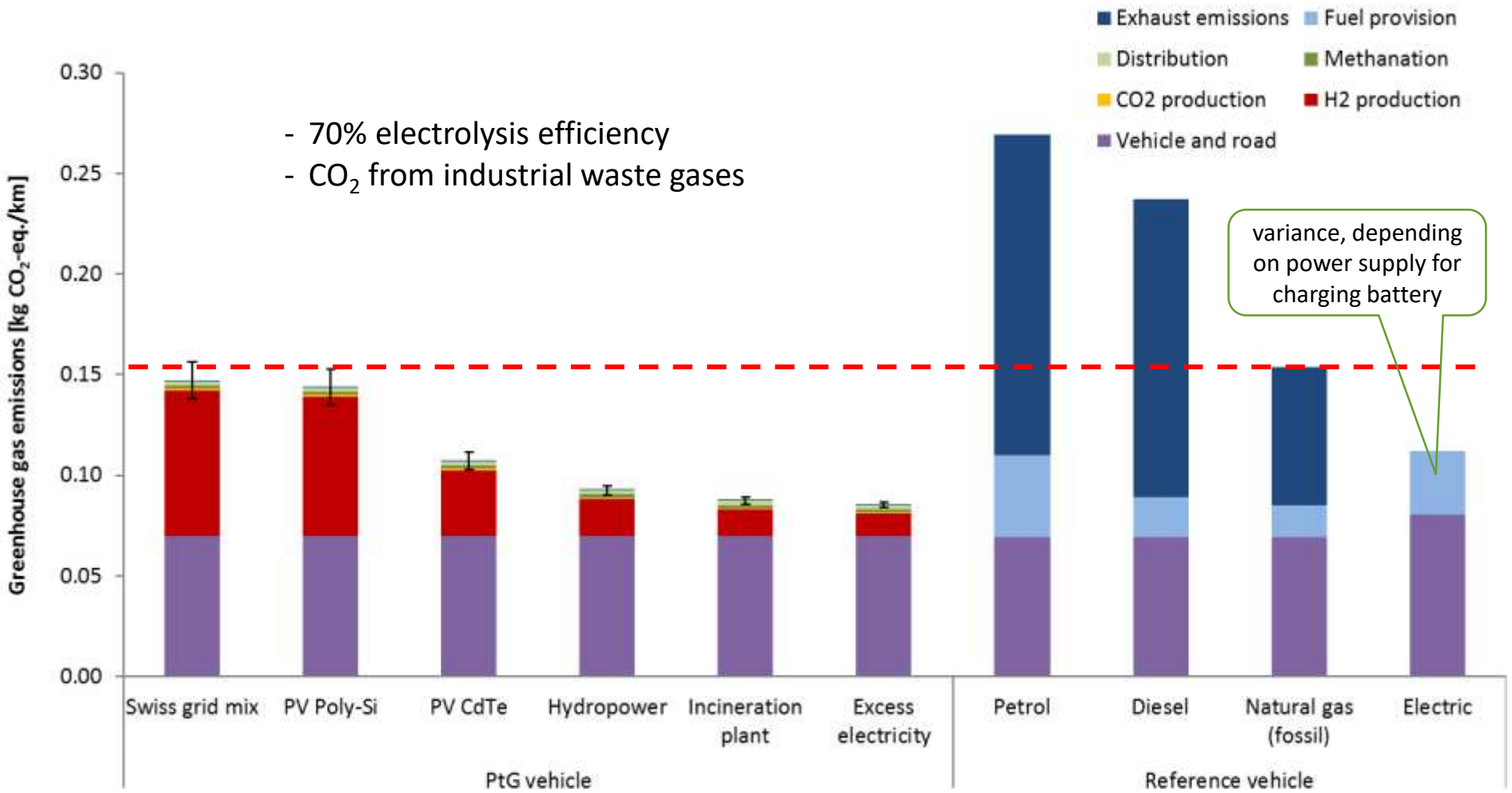

Error bars indicate the variance due to change in electrolysis efficiency from 70% to 62% and 80%.

Scenario electricity source: Total environmental impacts according to ecological scarcity 2013

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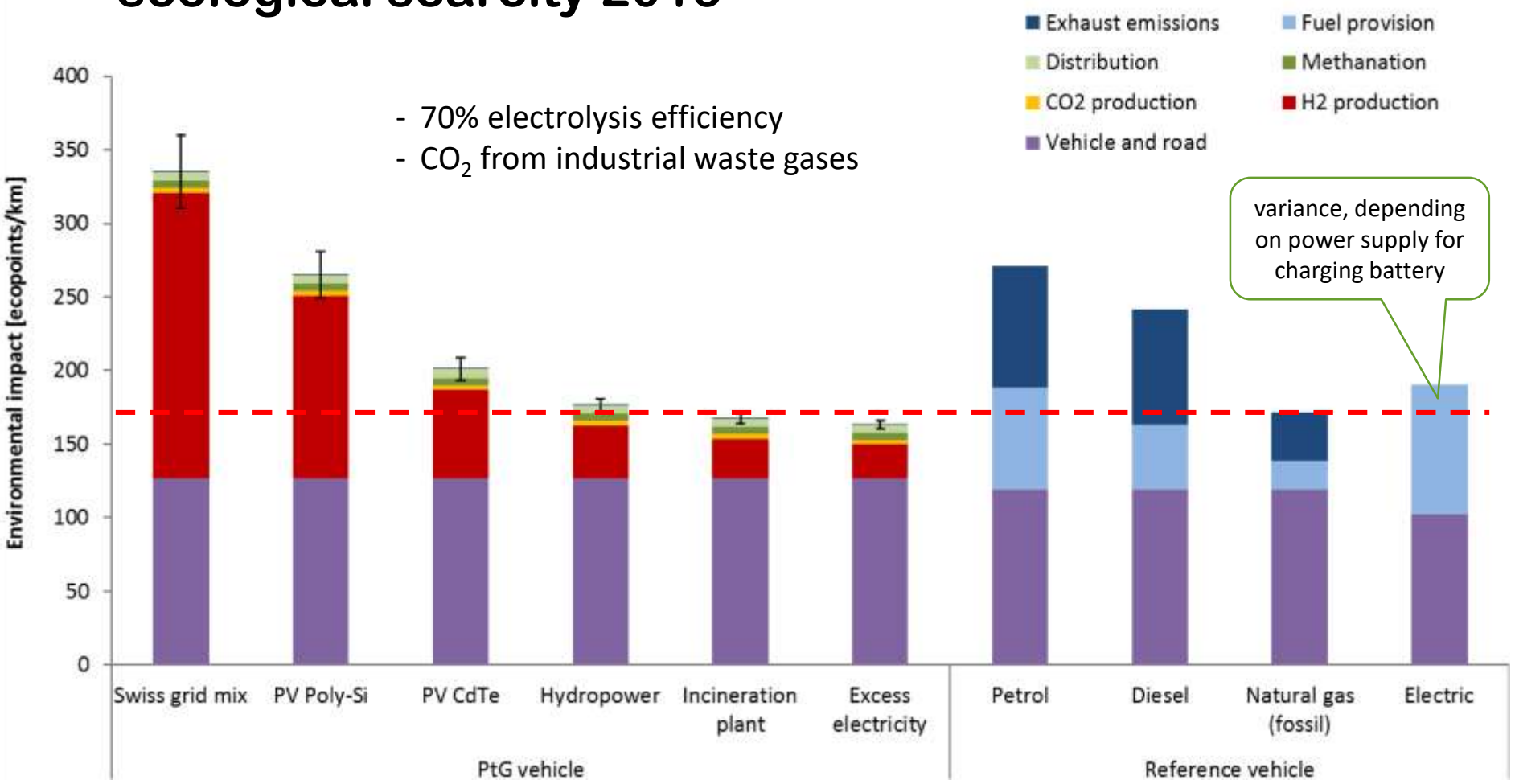
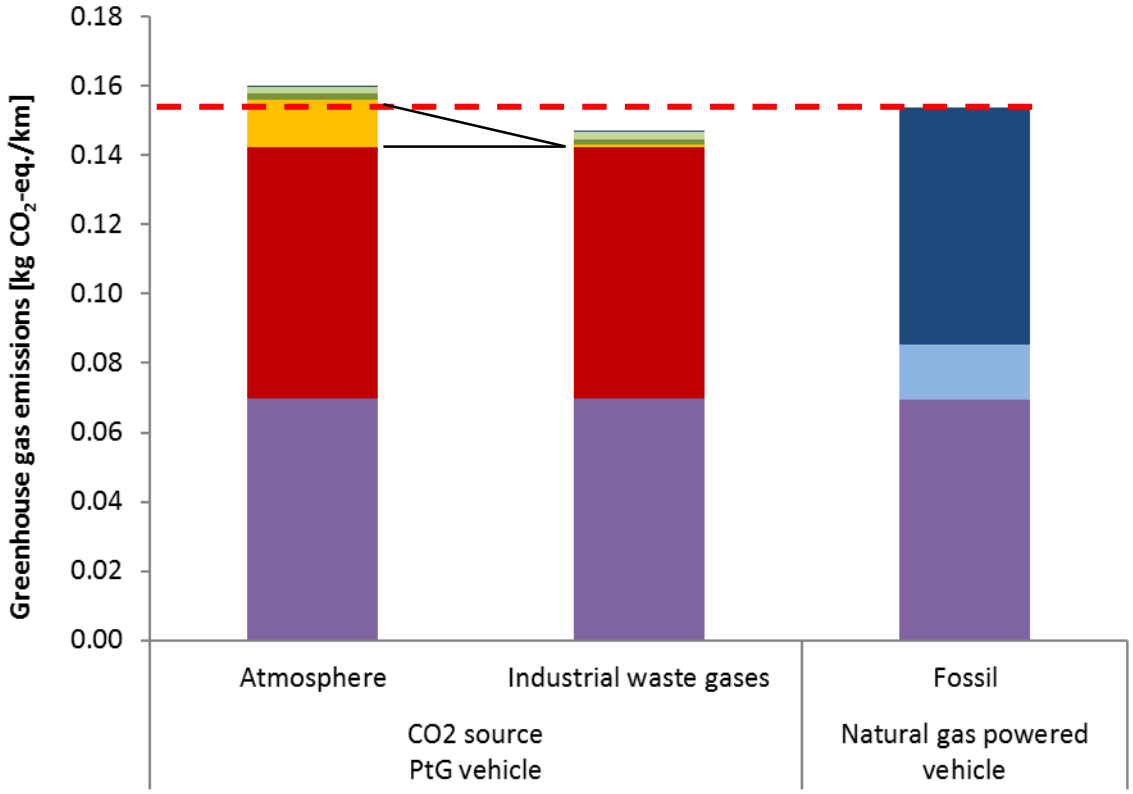


Error bars indicate the variance due to change in electrolysis efficiency from 70% to 62% and 80%.

Scenario CO_2 source: Greenhouse gas emissions per vehicle kilometre

- Swiss electricity mix at grid for H_2 production
- 70% electrolysis efficiency



CO_2 collection from atmosphere causes higher greenhouse gas emissions but enables decentralised methanation!

The separation of the CO_2 from atmosphere causes only minor greenhouse gas emissions compared to the hydrogen production.

Conclusions

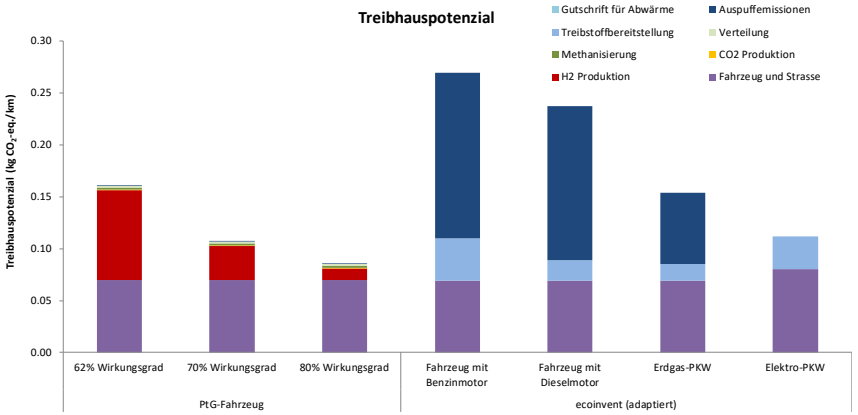
- Mobility fuelled by **PtG methane causes lower GHG emissions** per vehicle kilometre than diesel and petrol fuelled vehicles.
- Regarding GHG emissions, **electrolysis efficiency** has to exceed **70%** in order to be competitive with conventional natural gas.
- Depending on the electricity source used, a **reduction up to 42% and 51%** can be achieved according to life cycle GHG emissions and the total environmental impacts per vehicle kilometre, respectively.
- Total environmental impacts per vehicle kilometre for PtG methane are higher compared to conventional natural gas unless **excess electricity** is used for methanation.

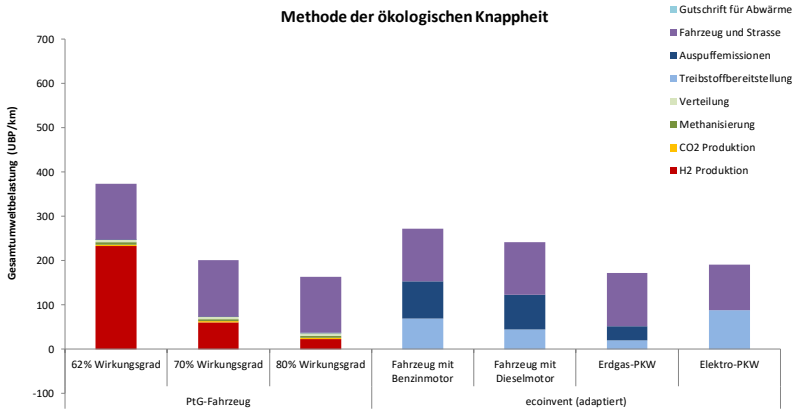
Outlook: Calculation tool

Parameter	62% Wirkungsgrad	70% Wirkungsgrad	80% Wirkungsgrad	Fahrzeug mit Benzinmotor	Fahrzeug mit Dieselmotor	Erdgas-Auto	Elektro-Auto
Stromquelle H_2-Elektrolyse	CH Strommix	Photovoltaik CdTe	Überschussstrom				
Wirkungsgrad H_2-Elektrolyse	62%	70%	80%				
CO_2-Quelle	Abgase	Abgase	Abgase				
Stromquelle CO_2-Bereitstellung	CH Strommix	CH Strommix	CH Strommix				
Stromquelle Methanisierung	CH Strommix	CH Strommix	CH Strommix				
Gutschrift für Abwärmenutzung	nein	nein	nein				
Stromquelle Batterieladung Elektroauto							CH Strommix

Kommentar:
- für alle gelb markierten Zellen per Dropdown-Me

Ergebnisse für die einzelnen Prozesse (pro Kilometer)		PtG-Fahrzeug			ecoinvent (adaptiert)				PtG-Fahrzeug			ecoinvent (adaptiert)			
		62% Wirkungsgrad	70% Wirkungsgrad	80% Wirkungsgrad	Fahrzeug mit Benzinmotor	Fahrzeug mit Dieselmotor	Erdgas-PKW	Elektro-PKW	62% Wirkungsgrad	70% Wirkungsgrad	80% Wirkungsgrad	Fahrzeug mit Benzinmotor	Fahrzeug mit Dieselmotor	Erdgas-PKW	Elektro-PKW
		kg CO_2-eq	kg CO_2-eq	kg CO_2-eq	kg CO_2-eq	kg CO_2-eq	kg CO_2-eq	kg CO_2-eq	UBP	UBP	UBP	UBP	UBP	UBP	UBP
H_2 Produktion	0.0126 kg	0.09	0.03	0.01	0	0	0	0	233	60	23	0	0	0	0
CO_2 Produktion	0.06948 kg	0.001	0.001	0.001	0	0	0	0	3	3	3	0	0	0	0
Methanisierung	0.0336 m3	0.002	0.002	0.002	0	0	0	0	5	5	5	0	0	0	0
Verteilung	0.0336 m3	0.002	0.002	0.002	0	0	0	0	6	6	6	0	0	0	0
Treibstoffbereitstellung	1 km	0	0	0	0.04	0.02	0.02	0.03	0	0	0	70	44	20	88
Auspuffemissionen	1 km	0.000	0.000	0.000	0.16	0.15	0.068	0.000	0	0	0	83	79	33	0
Fahrzeug und Strasse	1 km	0.07	0.07	0.07	0.07	0.07	0.07	0.08	127	127	127	119	119	119	102
Gutschrift für Abwärme	1 km	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0	0	0
Total	1 km	0.161	0.11	0.09	0.269	0.237	0.154	0.112	374	201	163	271	242	171	190
		161	107	85	60%										





- Variable electricity source
- H_2 production efficiency
- CO_2 source
- Methanation process
- Credit for waste heat

- Work in progress
- Available on request, maybe online

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Questions?

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References and data sources

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- Vehicle data with real consumption, compiled by Christian Bach, EMPA
- CO2 collecting data from atmosphere, Climeworks AG, Zurich

Ecological Scarcity Method 2013 (ecopoints)