FACULTY OF ENGINEERING AND ARCHITECTURE

GHENT UNIVERSITY

"Electric cars compared to ultra-light electric vehicles and global warming"

Presenter and author: Prof. Alex Van den Bossche

Ghent University, Electrical Energy Lab

Technologiepark 913, Zwijnaarde, Gent, Belgium

The 3rd Renewable Energy Sources - Research and Business conference (RESRB)

June 18-20, 2018 in Brussels (Belgium)

http://resrb.budzianowski.eu

GHENT UNIVERSITY EELAB

Abstract

"Electric cars compared to ultra-light electric vehicles and global warming"

Although some effort has been done, if the full global warming effect is considered, also the **parasitic methane emissions** should be taken in account and not only CO2 for electric vehicles. Not just -20% (2020), **but big changes are needed to counter the global warming problem.**
Drastic solutions are ultralight electric vehicles instead of the actual heavy ones.
If the technology is well developed, it can reduce CO2 emissions by a **factor 5** compared to usual electric vehicles (2050 target).
It has also effect on the indirect CH4 emissions in electricity, but also at tire dust, which might be even the biggest source of particulate matter PM10-PM2.5.
A vehicle concept **F2E** for two electric is proposed, towards a very good compromise between **energy, comfort, cost, global warming and pollution.**

Leaks of methane?

CH4 LEAKS estimate in 2017….?
https://www.iea.org/Textbase/npsum/weo2017SUM.pdf
*…. estimated 76 million tonnes of methane emitted worldwide each year in **oil and gas** operations…*

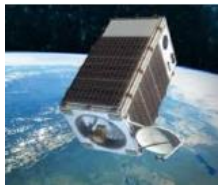
CH4 GLOBAL PRODUCTION 2017
https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy/natural-gas/natural-gas-production.html
3680.4 Billion m^3 ; 0.678 *kg/m^3* = 2495 million ton

So, in 2017 the estimate was 76/2495= **3.05% leak** compared to *natural gas production*
- Does contain the CH4 leaks of oil production as well, does not contain end user leaks.
- Probably methane leaks are seriously underestimated: news 2018

Methane emissions from Pennsylvania's oil and gas sites may be 522,400 tons a year rather than the 112,100 tons oil and gas companies report to the Department of Environmental Protection, according to a new analysis released Thursday by the Environmental Defense Fund.
Methane emissions from Alberta oil/gas production under-reported by as much as 15 times – study Mar 28, 2018
https://energi.news/markham-on-energy/methane-emissions-alberta-oil-gas-production-reported-much-15-times-study/

-- A good *estimate today* could be 5% leak with 1.5% tolerance, so 3.5 … 6.5% --

Good news: big oil companies promise to reduce their part (3.4%) divided by two
Probably remaining 3%+-1% inaccuracy after 10 years
|| **MethaneSAT** will be able to detect and verify sources, launch 2021... ||



--- We take 3% leak in account after 2020, by expected near future improvements ---

GHENT UNIVERSITY EELAB

Global warming effect of methane?

Figure CH4 GWP and AGWP

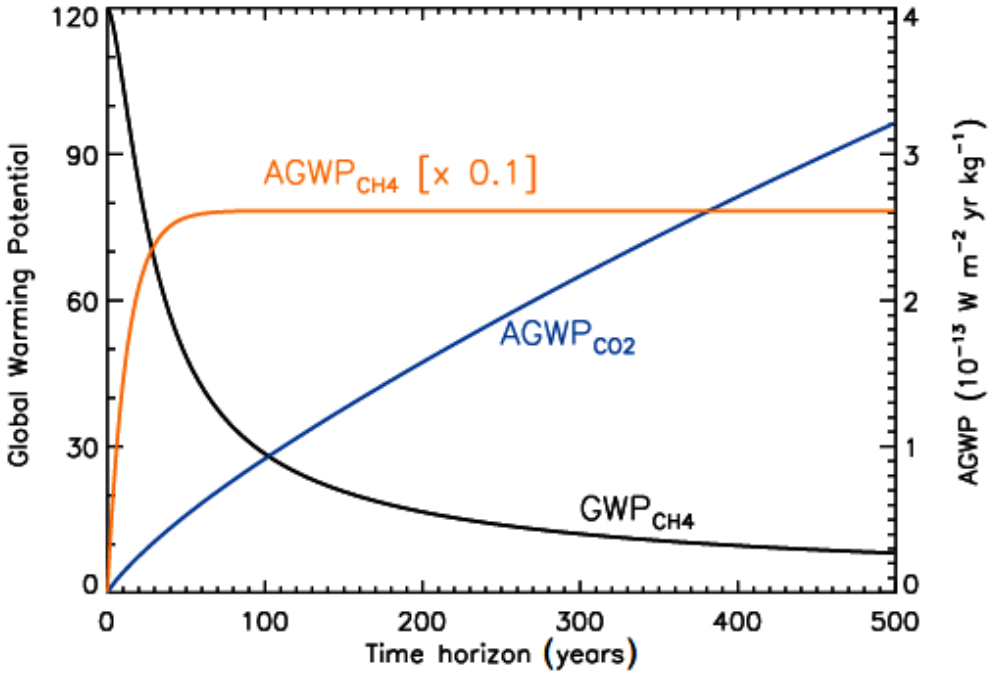
(Fig 8.28 of reference IPCC WG1AR5)

Summarizes what people should know about global warming

GWP_{CH4}= **impulse** effect of methane, a sudden release = **120 times CO2**

$AGWP_{CH4}$ = absolute "**step** response" on a continuous release = **26 times CO2** at 100 year horizon.

Is 84 times at 20 year *horizon = melting of major artic ice surface.*



IPCC Intergovernmental Panel on Climate Change : ---- Fig 8,28 total 1552 pages

Figure: This chapter should be cited as

Myhre, G., D. Shindell, F.-M. Bréon, W. Collins, J. Fuglestvedt, J. Huang, D. Koch, J.-F. Lamarque, D. Lee, B. Mendoza, T. Nakajima, A. Robock, G. Stephens, T. Takemura and H. Zhang, 2013: Anthropogenic and Natural Radiative Forcing. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

http://www.climatechange2013.org/images/report/WG1AR5_ALL_FINAL.pd

Chapter 8 ***Anthropogenic and Natural Radiative Forcing***

GHENT UNIVERSITY EELAB

GWP by cars with electricity from natural gas.

Tesla?
19,9 kWh/100 km ≈ 0.2kWh/km

Additional kWh will be covered mainly by GTCC gas turbine combined cycle (even worse if partly coal…)
Nuclear power plants are likely to close, not all are charging during day or when sun or wind is available.
Average people will also not tolerate more wind turbines when "forced" to drive electric cars…

400 gCO2/kWh for GTCC
Without methane
0.2*0.4= *80 g CO2/km*
With methane leaks in account
0.2*0.4*(1+0.03*26)=142 gCO2e/km

Tires? Rubber = PAH poly-aromatic-hydrocarbons
7 kg rubber wear for 20 000 miles =32000 km; = 0.219 g dust/km: air, land, water, worse than diesel 0.005g even with "gate"?
+ Battery?
Moves energy and pollution from end user to chemistry and mineral exploitation, **adds about 33% on energy needs** in 160 000 km.
-> **189 gCO2eb/km in total?**

GHENT UNIVERSITY EELAB

GWP by cars with electricity from natural gas.

Today, “good” electric Car?
About 15 kWh/100 km at wall plug.

Additional kWh will be covered mainly by GTCC gas turbine combined cycle (not better if partly coal…)
Nuclear power plants are likely to close, not all charging during day or when wind is available.
Average people will also not tolerate more wind turbines as they are forced to drive electric cars…

400 gCO2/kWh for GTCC
Without methane
0.15*0,4= *60 g CO2/km*
With methane leaks
0.15*0.4*(1+0.03*26)=106.8 gCO2e/km
<20% better than diesel or gasoline?

Tires? Rubber = PAH
PAH poly-aromatic-hydrocarbons = toxic
https://en.wikipedia.org/wiki/Polycyclic_aromatic_hydrocarbon
5 kg rubber for 50 000 km
= 0.1 g dust/km ** (similar to actual cars)
-> air, water, land
843 Billion car km in Belgium
= 84300 tons of rubber particulates
https://mobilit.belgium.be/sites/default/files/kilometers_2016_nl.pdf
**** Euro 6 tailpipe “limit” is 0,005 g/km**
+Battery?
33% energy for manufacturing of battery in 160 000 km
-> 142 gCO2eb/km in total

GHENT UNIVERSITY EELAB

F2E For Two Electric Concept at UGENT EELAB

type	F2E
persons	two
curb weight (+/-20%)	150 kg
Total weight for the performance	350 kg
Driven front wheels	2
Rear wheels (under discussion)	2
Drag coefficient	0.35
Frontal area	0.9m^2
Rolling resistance	0.008
Auxiliaries (light, dashboard, fan)	35W
Battery <30 and <40 kg based on LiFePO4, 96V	4.5kWh
Acceleration 0-50km/h	8 s
Maximum speed	90km/h
Gradeability	20%
Average efficiency from battery to wheel (The peak efficiency is much higher)	>80%
Maximum efficiency from battery to wheel	>90%

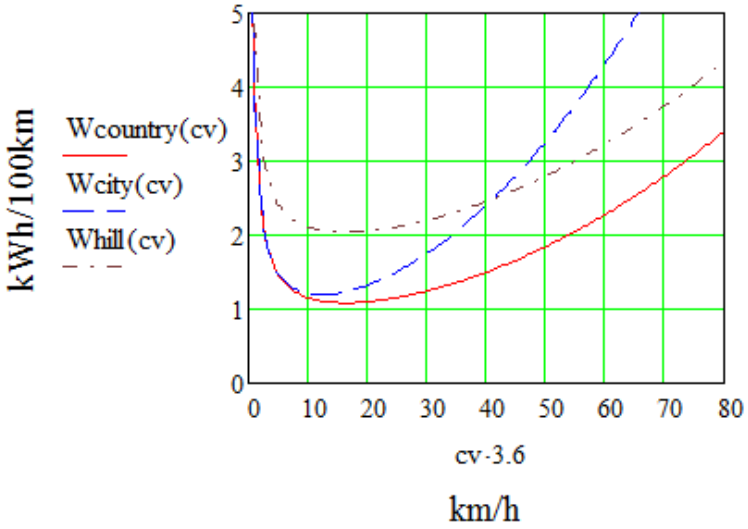


Fig: Losses at the wheel level for F2E, two persons, at 350kg total weight (two persons in it)

Country= constant speed,
City = stopping 300 times/100km, 50% recovery
Hill= 1000m in 100km

In the example next slide we take **3 kWh/100 km**

GHENT UNIVERSITY EELAB

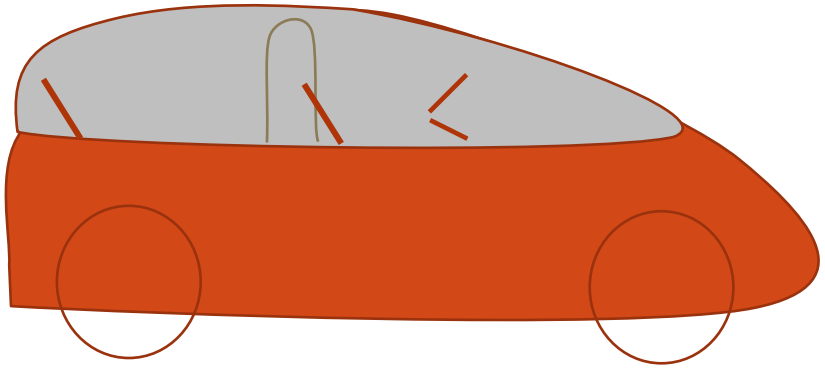
Ultralight electric vehicle, same calculation

Ultralight electric vehicle F2E

kWh covered by GTCC gas turbine combined cycle (not better if partly coal…)

400 gCO2/kWh for GTCC
Without methane
0.03*0.4= *12 g CO2/km*
With methane leaks
0.03*0.4*(1+0.03*26)=21.4 gCO2e/km

It is only beaten by pedelecs and velomobiles, that do not give the same speed nor the same safety.
Two person: so a wider use for people and luggage or shopping.



Tires? Rubber
Emission proportional to weight
0.100*250/1500 = 0.016 g/km
An incredible reduction of tire particulates

+ Battery?
With battery manufacturing: **28 gCO2eb/km**

Electricity partly produced by the PV panel of the roof.

GHENT UNIVERSITY EELAB

Ultralight electric vehicles

F2E “For Two Electric”
Prototype under construction EELAB June 2017
Ugent Technologiepark 913 B9000 Gent

See it riding:
https://www.youtube.com/watch?v=VXKnS0q

It is an improvement on this keynote in Skikda 2012
https://www.researchgate.net/project/Ultralight-and-efficient-electric-vehicles
and
https://www.researchgate.net/publication/281584740_How_to_reduce_the_energy_needs_of_electrical_and_conventional_vehicles

Who wants to invest in further development and production?

It is not only mechanics but a lot of auxiliary power electronic circuits are needed to function well, management of battery, PV panels, chargers, drives, lights, wiper, dashboard, suspension; quite different from what is common available but gives added value.

GHENT UNIVERSITY EELAB

Conclusion and suggestions

- **Global warming should change drastically.**
- **For commuting purpose, a factor 5 is possible compared to the actual electric cars.**
- **F2E "for two electric"**
- **Ultra-light electric vehicles could solve at least the short-medium distance commuting;**
- **Who invests?**

Business plan, international connections, engineering to make it more cost effective, design to make it attractive, marketing…

A warm Thank You