Bio-methanol & Methanol Fuel Cells

World Methanol Conference 2015

10 – 12 November - Münich

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Agenda

1) Nordic Green, what do they do?
    1) Today
    2) “Tomorrow”
2) Bio-methanol, in a short glance
3) Between ”Today” & ”Tomorrow”; Methanol as a steppingstone
4) ”The 3 E’s”
   - And why there is plenty of biomass in the future…
5) Fuel Cells
6) Words of Wisdom…

Nordic Green, what do they do?
- Which led to us suplying customers…

1) In IBC's (for FC's and testing)

2) In truckloads

3) And by vessels…

Nordic Green, what do they do?
- “Tomorrow”

We started out being quite naive, thinking *”Two Directives, how difficult can that be?”*
- But since we now understand the complexity of optimizing the value of any given bio-product under RED and FQD, we are able to offer our services for both the biggest and the smallest producers of such – including bio-methanol.

It all comes down to feedstocks and approvals of these, CO_2– reductions and their local value, applications and quality of products and finally national legislations and the tax-incentives put out by each individual government in EU and associated countries…

When you know all this we can avoid producers basing their calculation on bio-premiums of anything between €30 and €1.600 per metric ton.

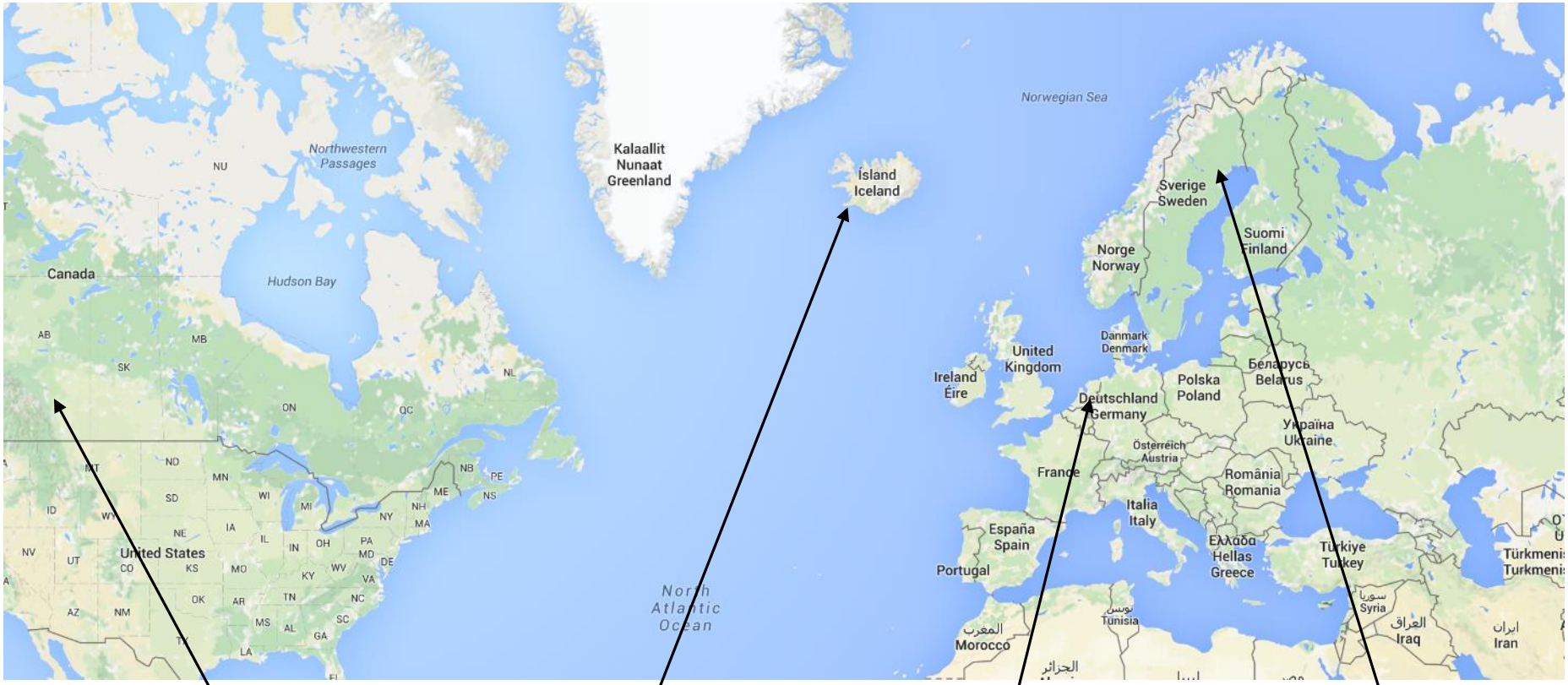
Bio methanol, in a short glance

The question we hear the most is (and which has already been widely covered here earlier in the conference) is:

”Is there actually anyone out there producing BIO-methanol?”

And ”Yes, there is… + More and more are coming”

Bio methanol, in a short glance
- Bio-methanol production



Enerkem

From municipal waste

CARBON RECYCLING INTERNATIONAL

From H2+Co2

BioMCN

From Biogas

CHEMREC
Energy to succeed

From waste wood

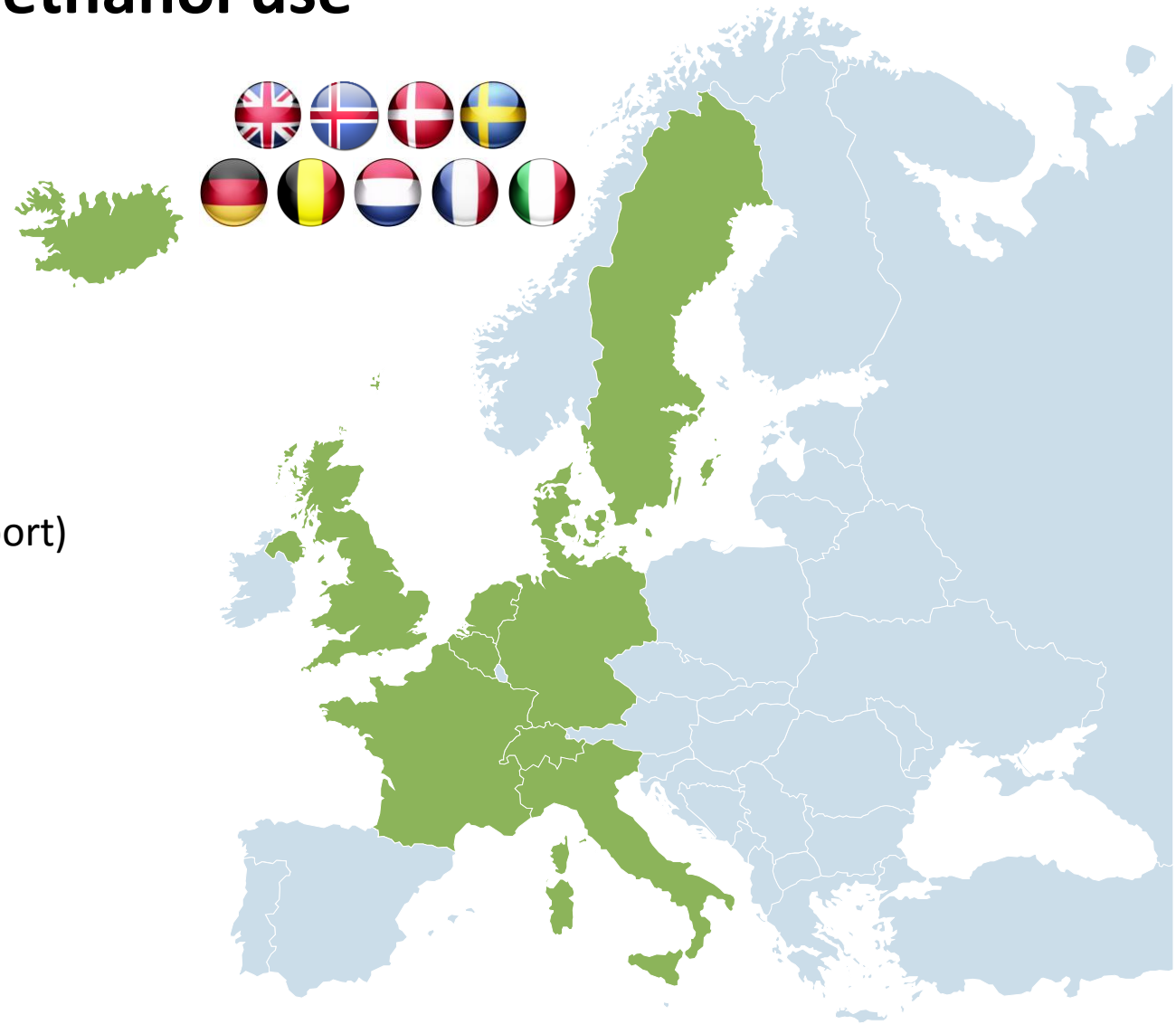
Bio methanol, in a short glance
- Huge investments are being incented

Further to this, billions of €'s are being awarded to bio-projects in the NER300-program and other programs
Thereby the EU are paving the way for private funding, estimated to be at least twice this size, on their own.
Included in this is the massive expansion "Wood Spirit"-project in NL.

We know also of methanol plants being planned/constructed/expanded in

- Iceland
- Sweden
- Germany
- Spain
- France
- Finland
- Denmark
- Netherlands (besides Wood Spirit)
- And several in Eastern Europe

Bio methanol, in a short glance
- Current bio-methanol use



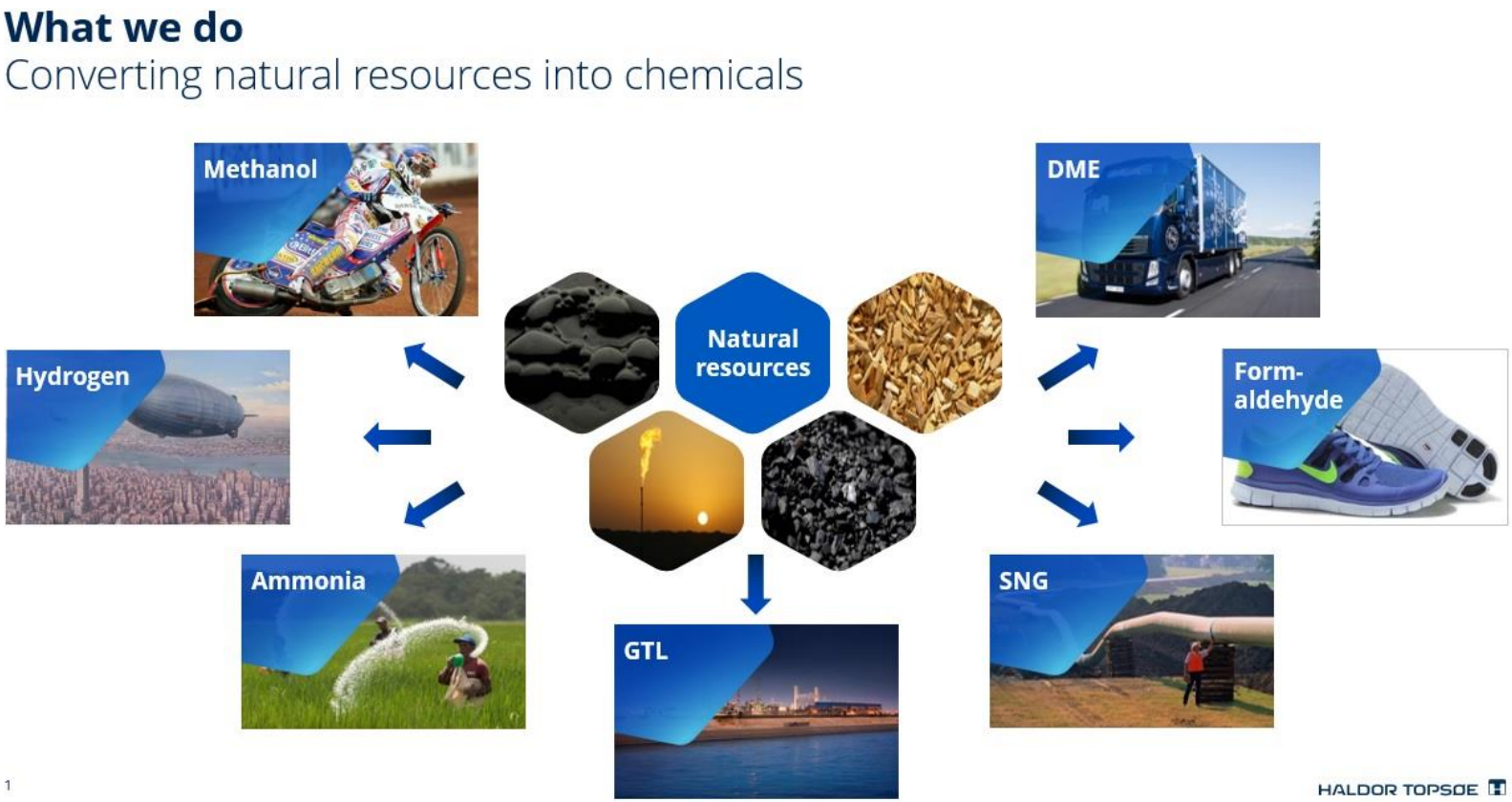
Applications

- Gasoline low blend
- Bio-MTBE
- Bio-diesel
- GEM-fuel (motorsport)
- Fuel cells

Methanol as a steppingstone
- How do you eat an elephant?

And this is exactly what we have to do when making methanol a part of the future solution to road-transport…

Nordic Green was recently appointed Haldor Topsoe Ambassador



Traditional concept
1000 t/d wood → 523 t/d methanol

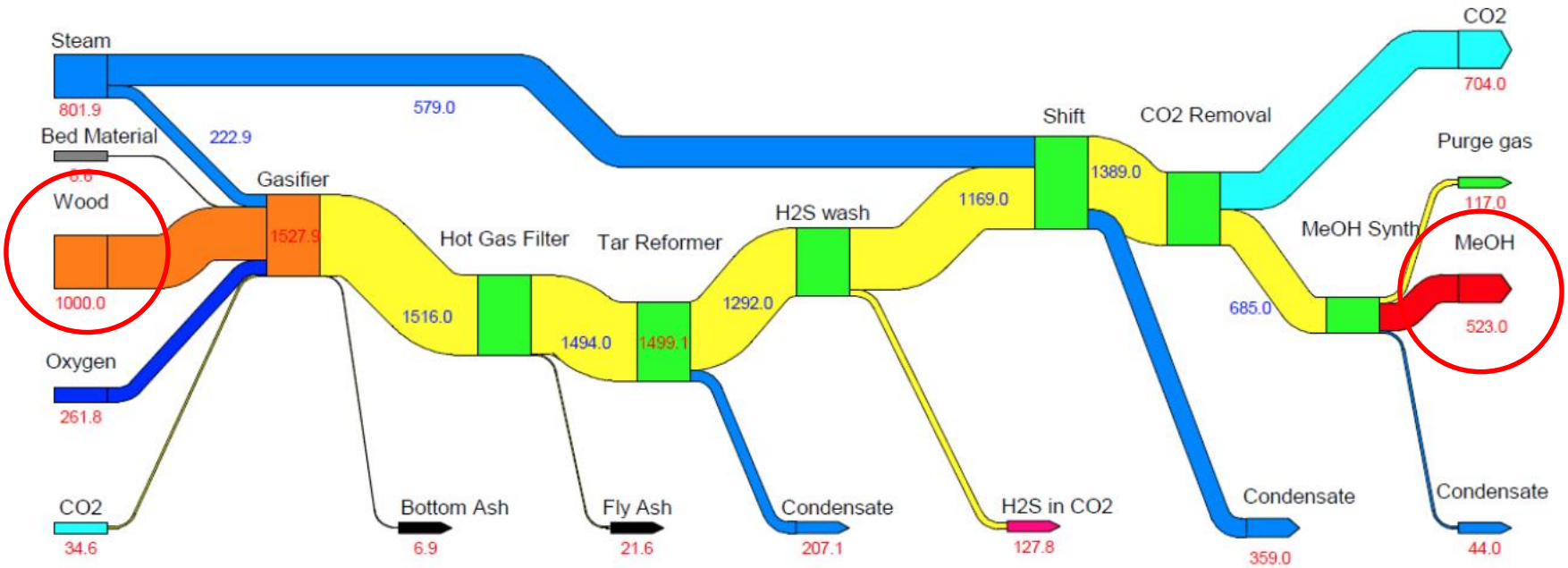


Figure 46: Traditional methanol production plant based on biomass gasification, units are in metric tonss per day [t/day]

1000 t/d wood

Efficiencies (%)	Novel Concept
Methanol	59.2
District heating	22.6
Total	81.8
Carbon utilization	42

523 t methanol/d

Novel concept
1000 t/d wood → 1053 t/d methanol

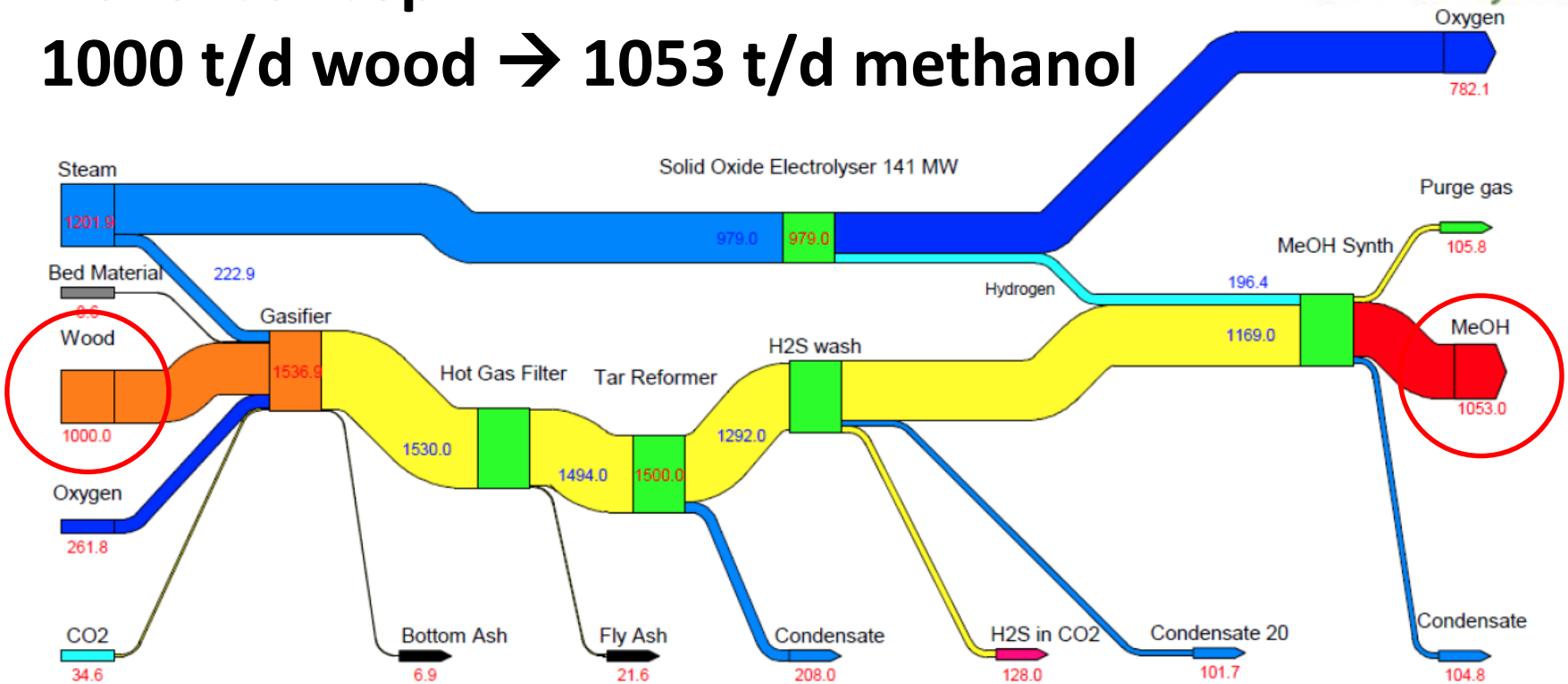


Figure 47: Sankey chart of mass flows in the gasification concept, units are in metric tons per day [t/day]

1000 t/d wood +
141 MW electricity
yields

Efficiencies (%)	Novel Concept
Methanol	70.8
District heating	10.8
Total	81.6
Carbon utilization	84

1053 t methanol/d

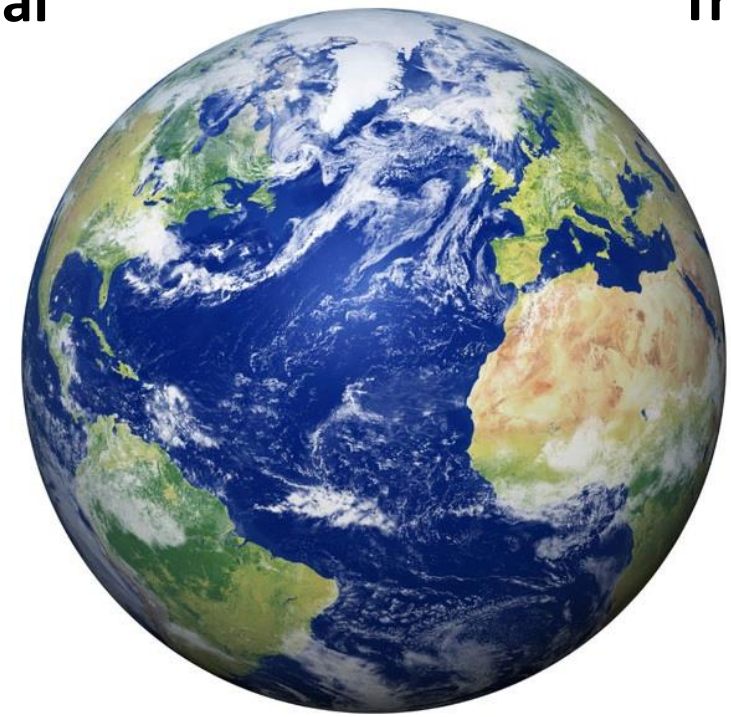
Methanol..
The two times two matrix

Bio-carbon from.. Bio-hydrogen from…	Biomass (concentrated)	Air (not concentrated)
Biomass	Pro: Simply and cheap (if biomass is cheap) Con: Low carbon utilisation (rest is emitted as CO2) ***1st to become commercial***	Not relevant
Electrolysis	Pro: Can effectively double the biomass potential Con: Depending on cheap electricity ***2nd to become commercial***	Pro: Unlimited supply of both products Con: Most CAPEX and energy-intensive ***3rd to become commercial***

Not enough bio-mass…

Biomass potential

200 EJ/yr



Transport fuel demand

108 EJ (2010/7 bio)

168 EJ (2050/9-10 bio)

Conclusion

Since we can not convert ALL biomass to fuel and since there are losses the numbers DO NOT add up!.... Or do they…

Wrong conclusion from IEA

"Biofuels can provide up to 27% of world transportation fuel by 2050"

We believe the IEA conclusion is wrong and if we use the three E's as our guiding principle there will in fact be plenty!

The three E's!

The three E's – Efficiency! Index 100 → 50

EFFICIENCY GAINS AND COSTS			
	Technology	Reduction in CO_2 emissions	Incremental price per vehicle
Engine	Low-friction lubricants	0.5%	$3
	Engine friction reduction	1–3%	$50–100
	Variable valve timing and lift	3–4%	$125–259
	Cylinder deactivation	6%	$150–169
	Turbocharged downsized engine	5–7%	$149–1,099
	Camless valve actuation	3–15%	$501
	Gasoline direct injection (stoichiometric)	[illegible]	$209–346
Transmission	Continuously variable transmission	6%	$192–224
	Six-speed automatic	4.5–6.5%	$99
	Six-speed dual clutch	5.5–13%	$47–92
Vehicle	Aerodynamic drag reduction (20% cars, 10% trucks)	2–3%	$42
	10% reduction in tire-rolling resistance	1–2%	$6
	10% reduction in weight	6.5%	$518–666
	High-efficiency alternator and electrified accessories	1–2%	$76
	Electric power steering	1.5–2%	$94
	Integrated stop-start system	7.5%	$351–437
	Hybrid motor assist	20–30%	$2,854–4,431

Well known incremental innovations where we know the cost and the fuel reduction

We are not here to talk about engines so let's move on!

The three E's – Electrification Index 50 → 40

Battery-costs will drops and cars like VW Golf-e, Tesla Model S, BMW i3 and Nissan LEAF will become common in the future

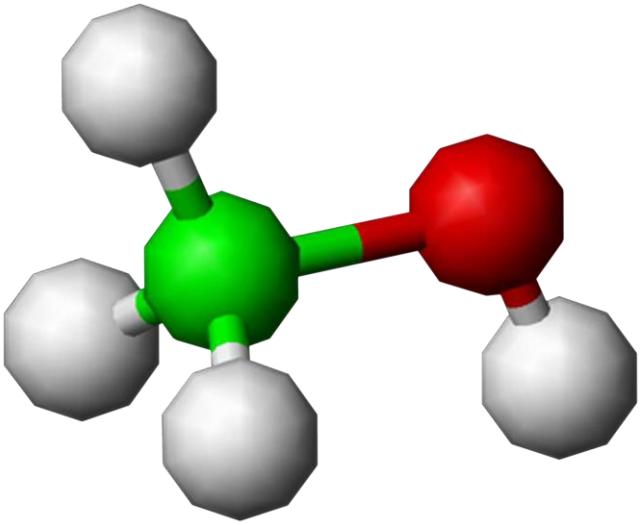
We are not here to talk about batteries so let's move on!

The three E's - Electro-fuels Remaining 40 → 0

Why methanol as electro-fuel?

The simplest of all liquid energy-carriers suitable as transport fuel and having the highest hydrogen to carbon ratio

(4 hydrogen to each carbon atom)



2) Fuel Cells

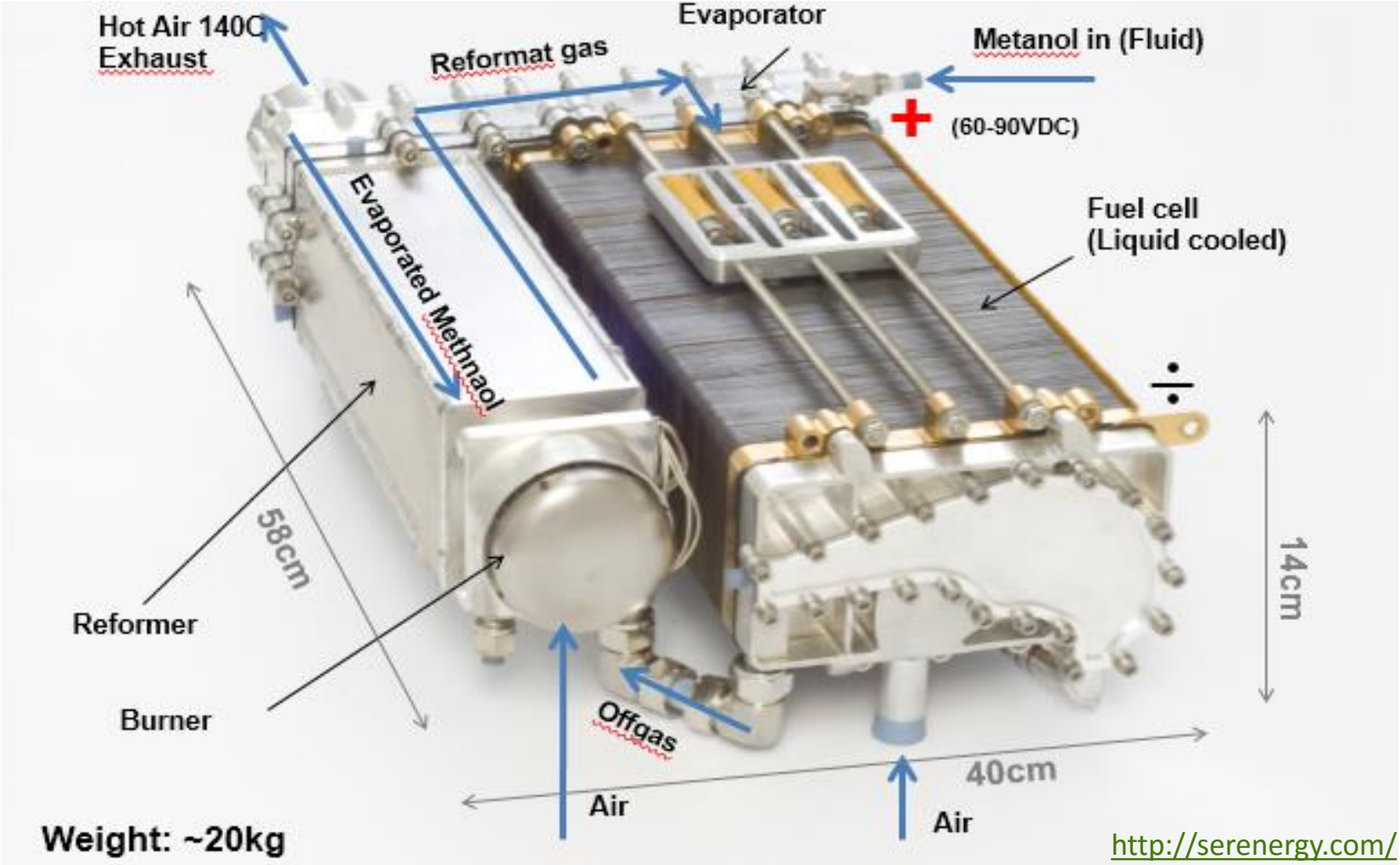
Methanol fuel cell types

Conclusion is based on 6 years of experience (10.000 hours +) with hydrogen infrastructure, LTPEMFC and HTPEMFC

For fuel cells using methanol there are three main types;

Type	Description
DMFC Direct Methanol Fuel Cells	+ Relatively mature and simple technology that use liquid methanol directly - Low power density and relatively low efficiency means big and heavy systems and a high use of platinum means the system cost is high **Conclusion** Not a viable solution for transport due to size, weight, cost and low efficiency
LTPEMFC Low Temperature Proton Exchange Membrane Fuel Cells	+ Relatively mature technology with a high power density - Operates at low temperatures (80 – 95 C) and therefore require extreme pure hydrogen (99.999% +) with very low carbon monoxide (CO) **Conclusion** Reformed methanol is not a possibility due to purity requirements (of which reason almost all LTPEMFC systems operates on pressurized hydrogen)
HTPEMFC High Temperature Proton Exchange Membrane Fuel Cells	+ Operates at 160 C of which reason the carbon monoxide tolerance is at least 1000 times higher than LTPEM and therefore the hydrogen only has to have a purity of 99 % - Relatively un-mature technology, relatively long start-up time **Conclusion** This just might be the s…!

The technology..



http://serenergy.com/

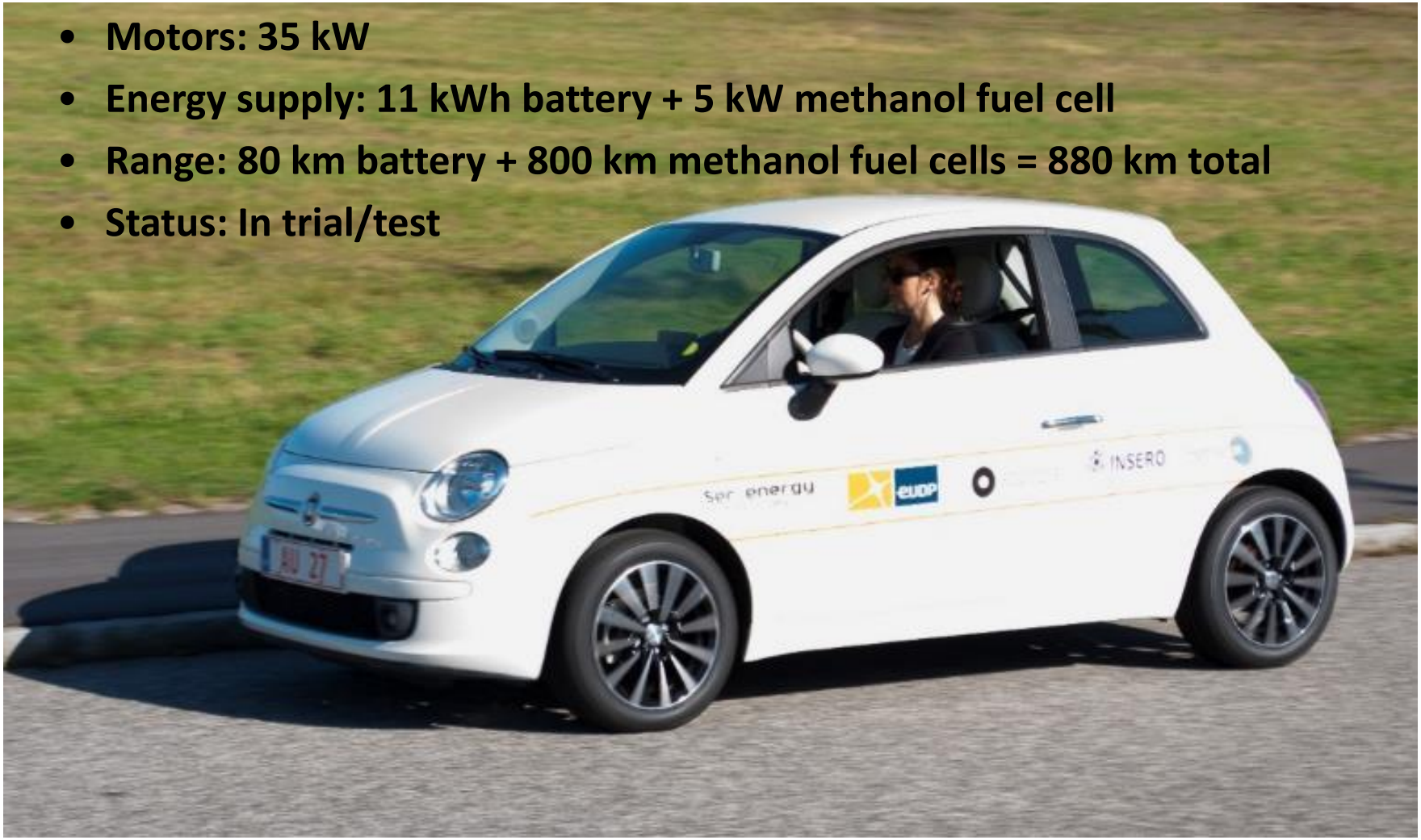
For non-Fuel Cell experts: The relatively high operating temperature of the fuel cells (160 Celcius) means that the fuel cell can tolerate high levels of CO and therefore the evaporator and reformer is small, cheap, simple and efficient

High Temperature PEM Fuel Cell advantages

- Operation temperature: 160 °C
- Start up: 15-30 min (possible down to 5min)
- Operation with methanol fuel with no gas clean-up needed = very simple system
- Waste heat from fuel cell drives the reforming process leading to high efficiency; 40-50% net
- Non pressurised system ensures simple and safe design
- Close to 20.000 hours operational lifetime demonstrated

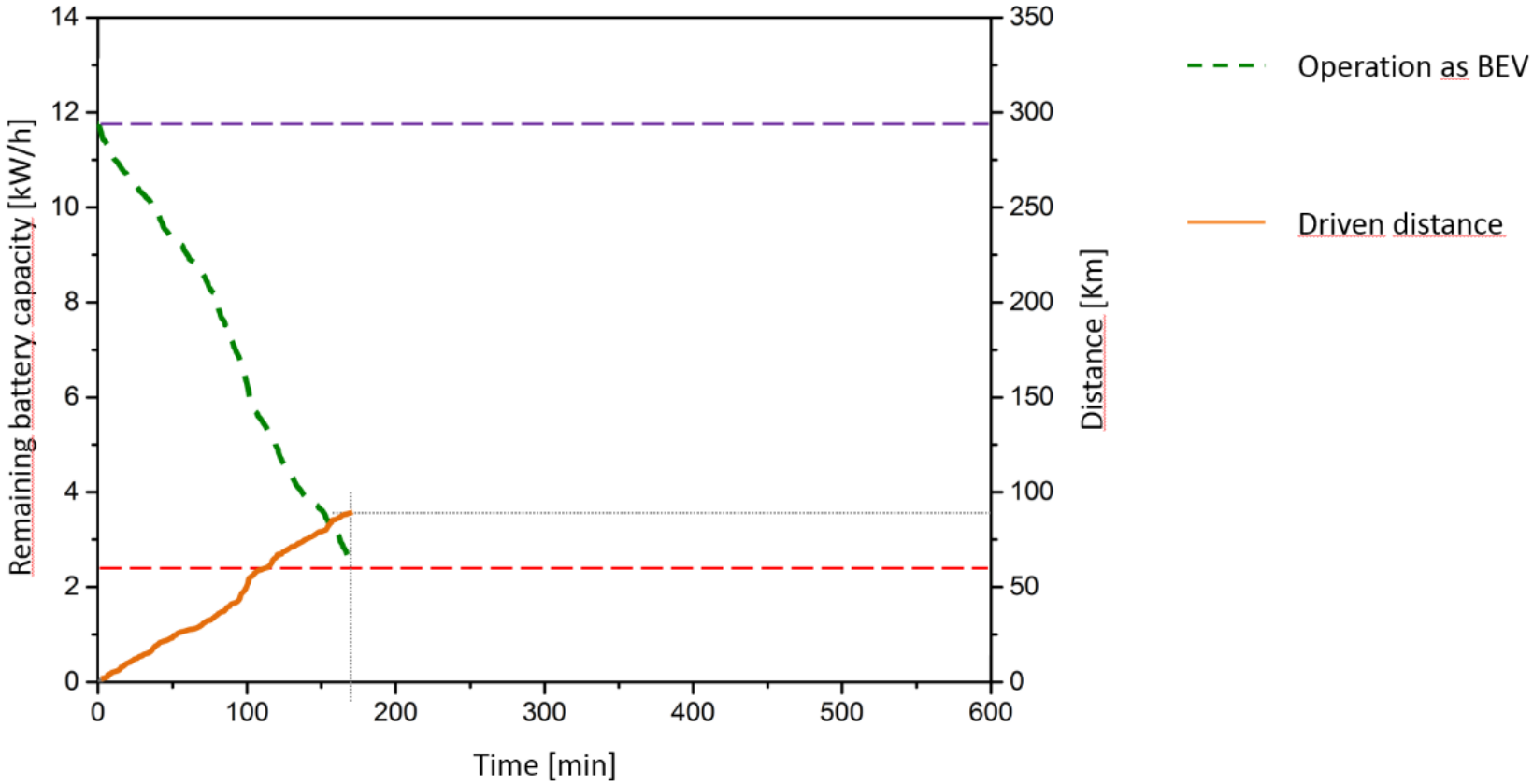
Passenger vehicle – Fiat 500 ME

- Motors: 35 kW
- Energy supply: 11 kWh battery + 5 kW methanol fuel cell
- Range: 80 km battery + 800 km methanol fuel cells = 880 km total
- Status: In trial/test



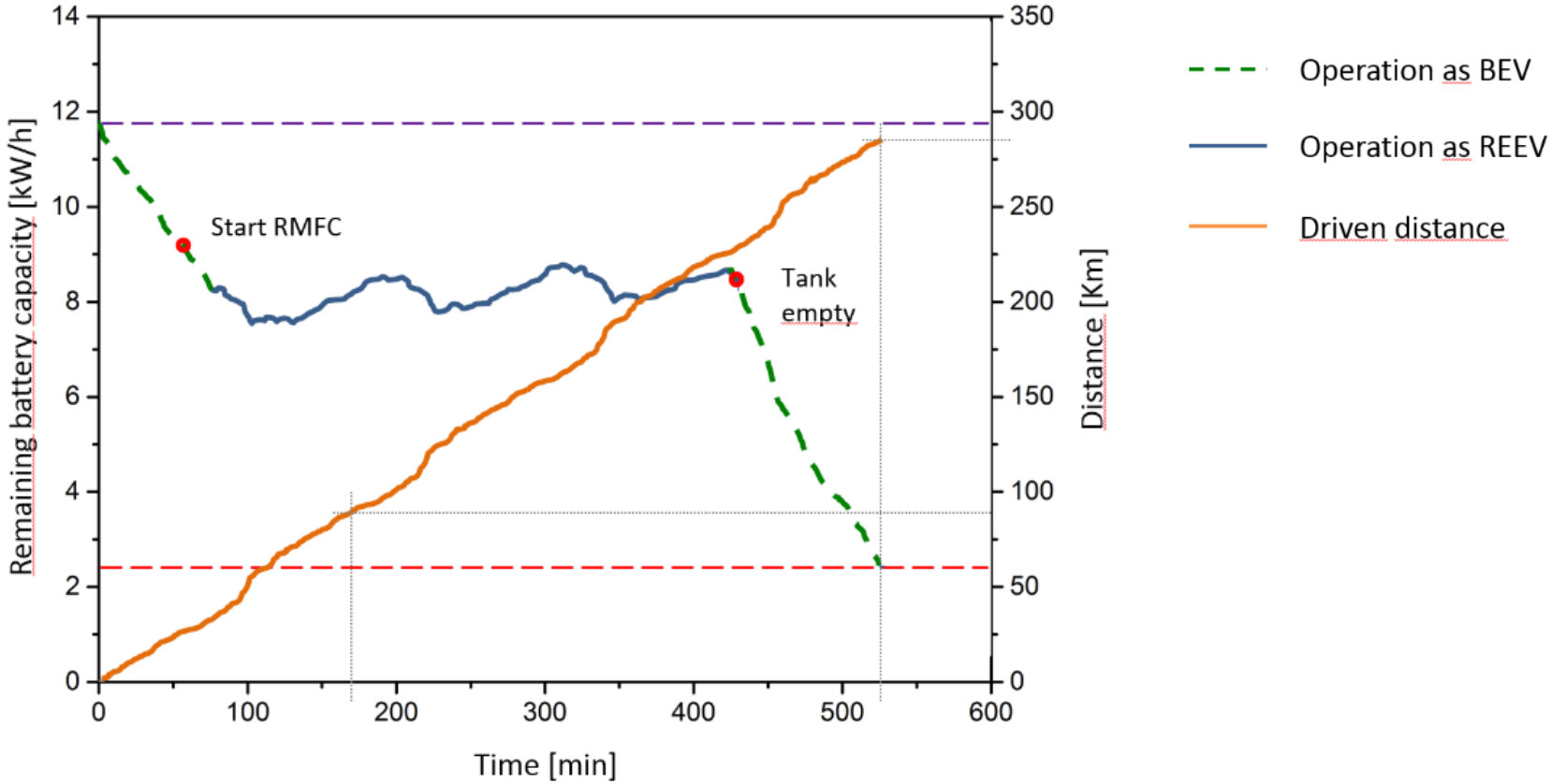
Without Fuel Cells

12 kWh battery capacity, 80 km range

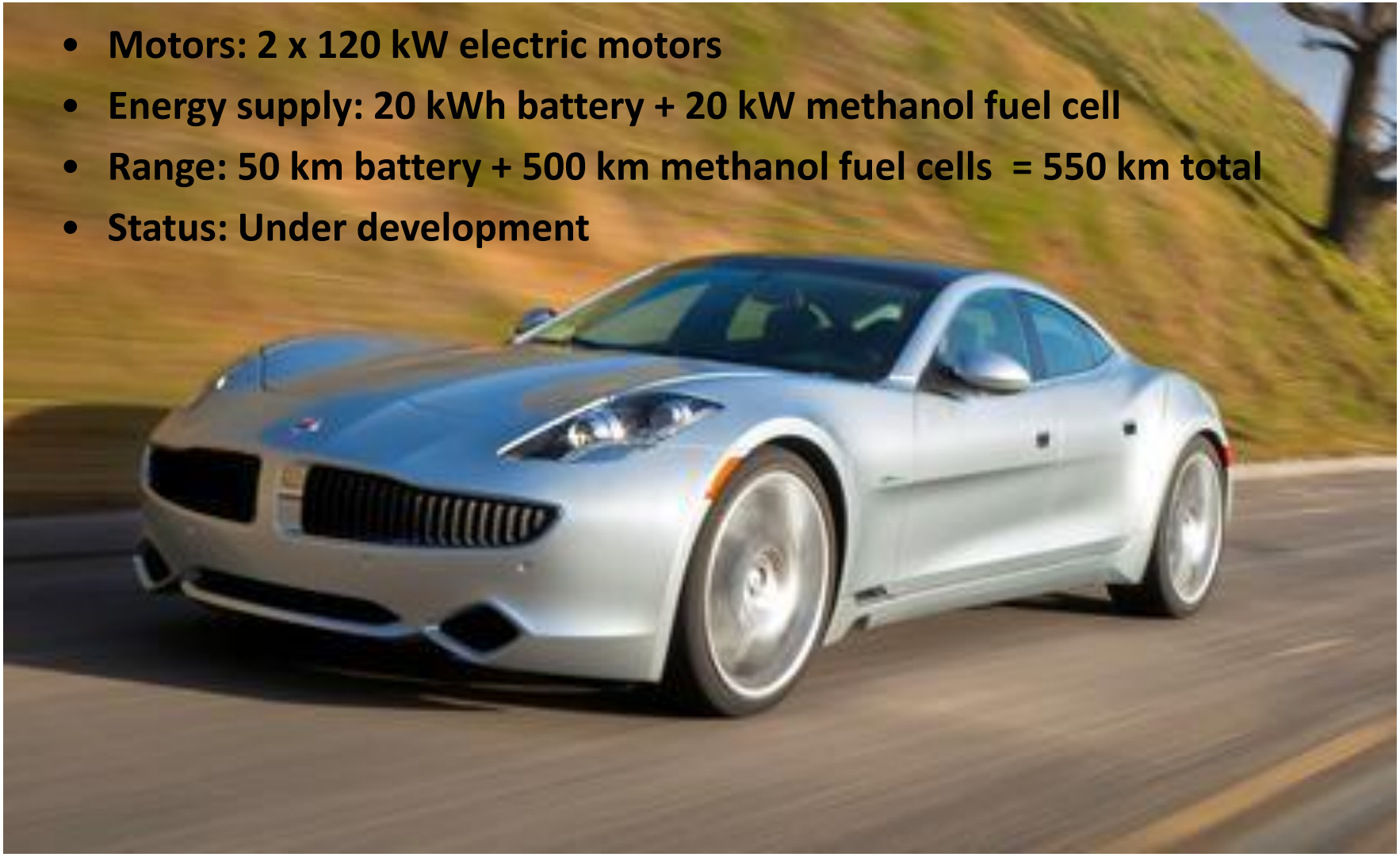


With Fuel Cells

12 kWh battery capacity, 5 kW fuel cell & 25 l tank, 270 km, 50 l tank → 500 km range



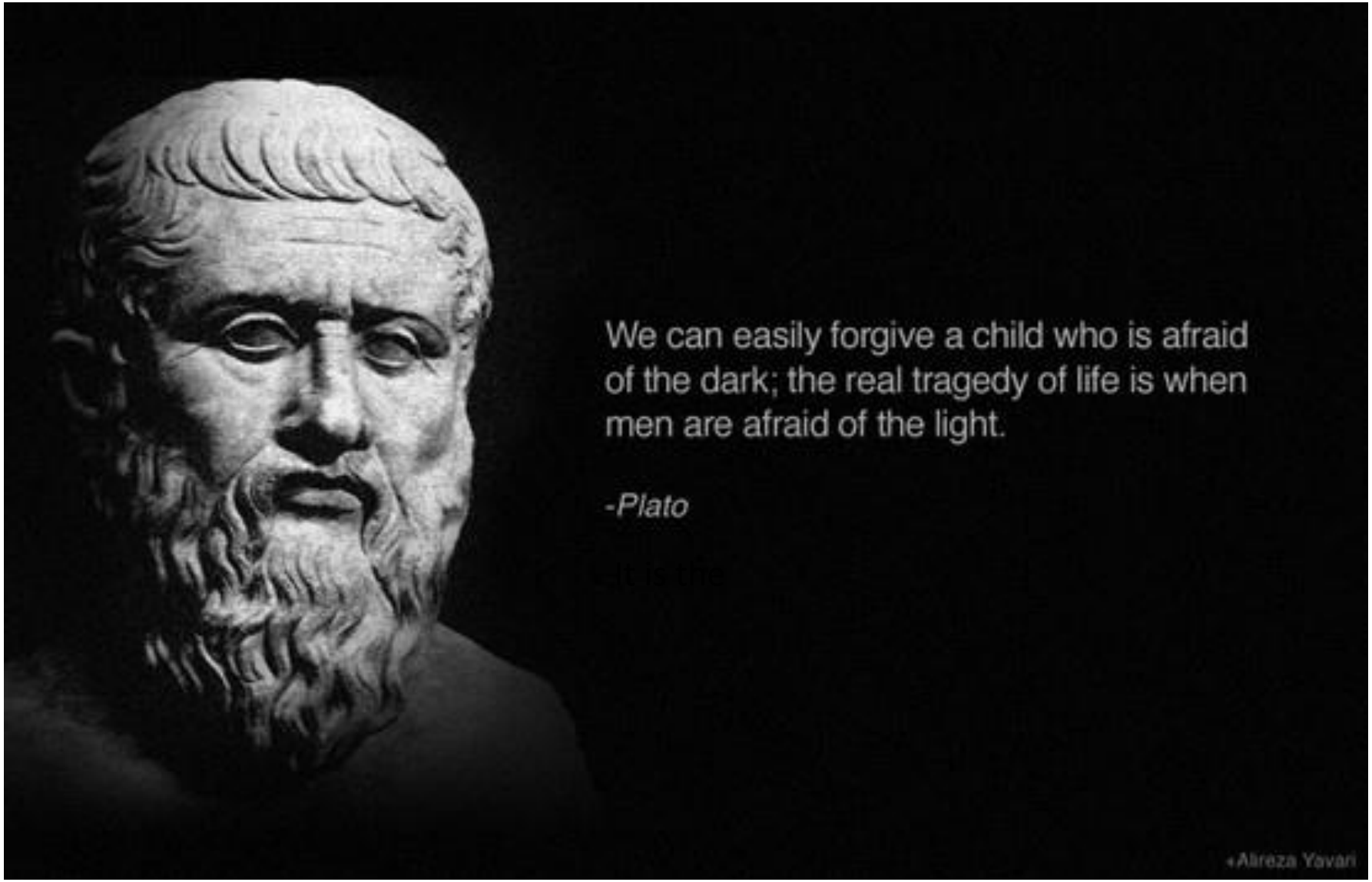
Performance vehicle – Fisker Karma



- Motors: 2 x 120 kW electric motors
- Energy supply: 20 kWh battery + 20 kW methanol fuel cell
- Range: 50 km battery + 500 km methanol fuel cells = 550 km total
- Status: Under development

First methanol fuel station in Europe

A sustainable future is within reach if we dare



Thank you for your attention!

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