



**CARBON
RECYCLING
INTERNATIONAL**

Low carbon intensity and green methanol: Iceland and beyond

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Problem #1

Ample supply of renewable energy but location and availability doesn't match demand

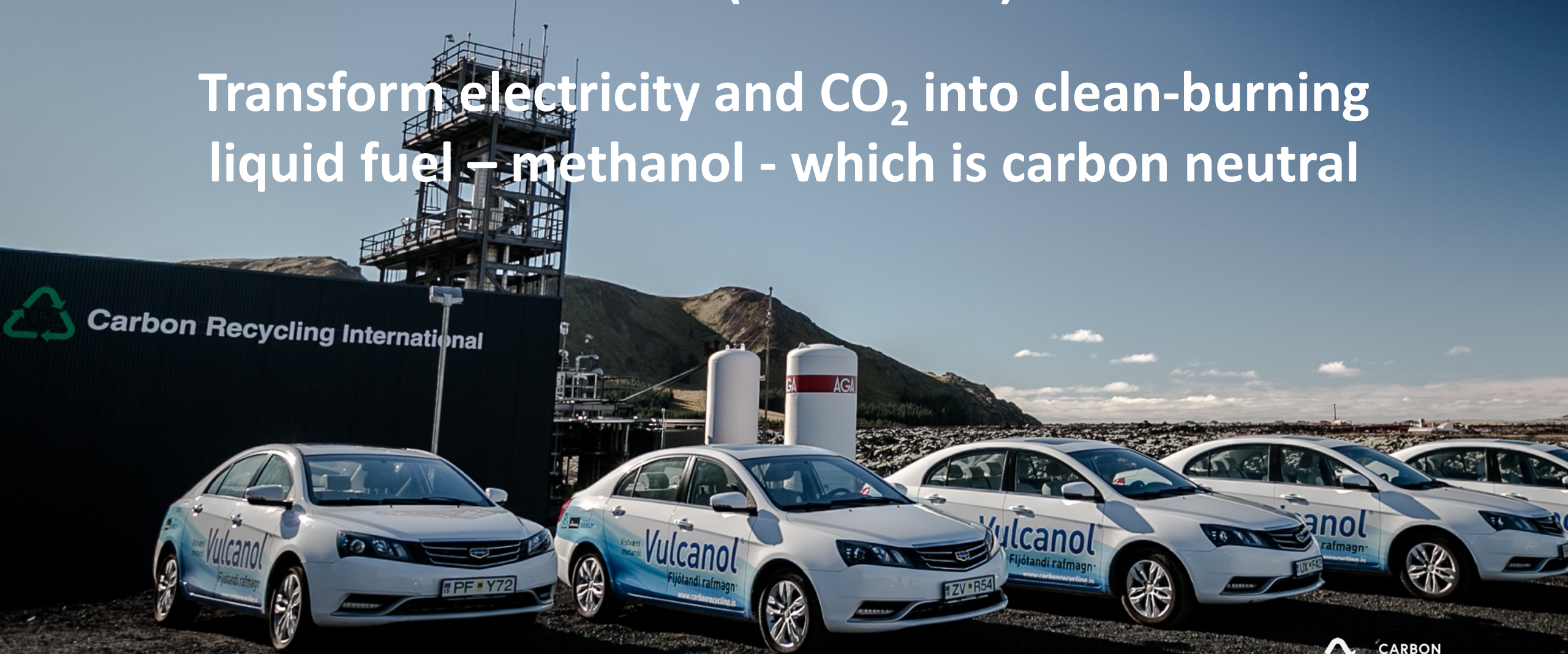
Problem #2

**Growing use of fossil fuels causing climate change,
ocean acidification and urban pollution**

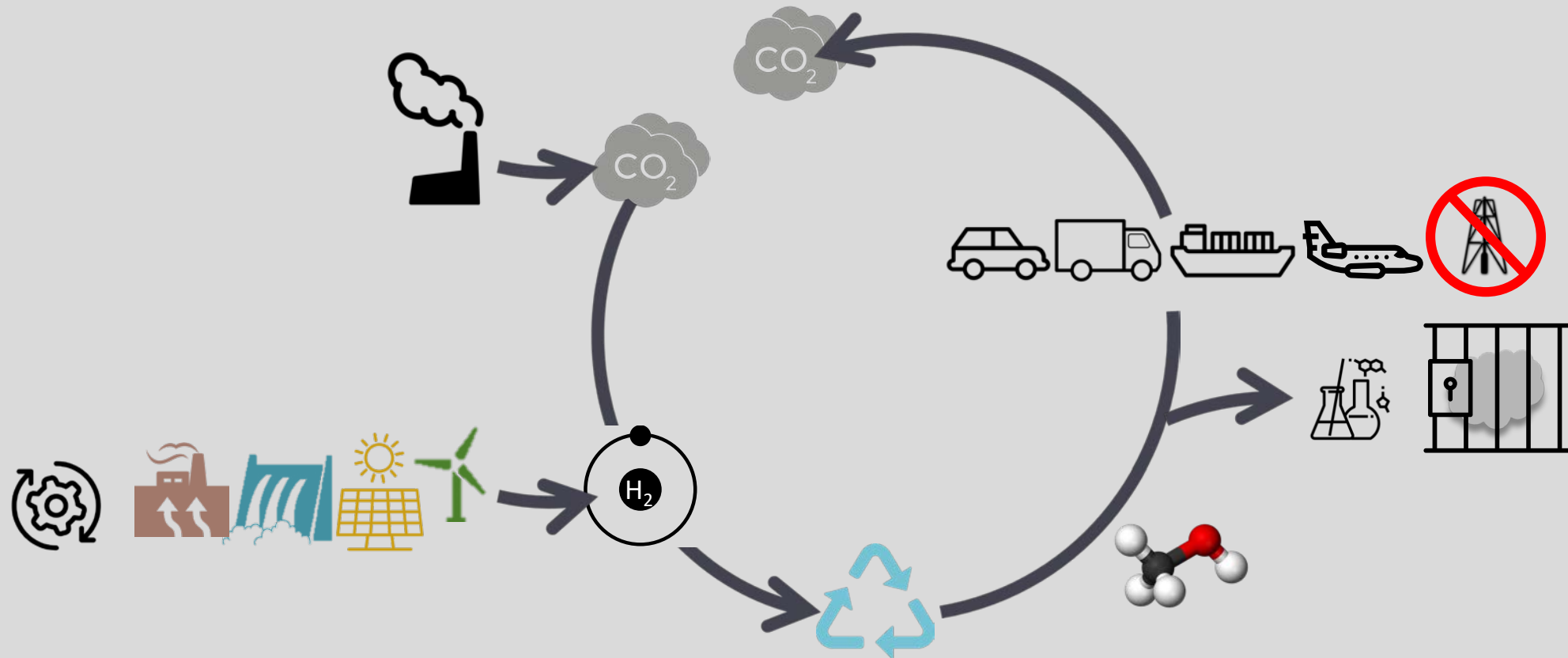


Solution (since 2012)

Transform electricity and CO₂ into clean-burning liquid fuel – methanol - which is carbon neutral

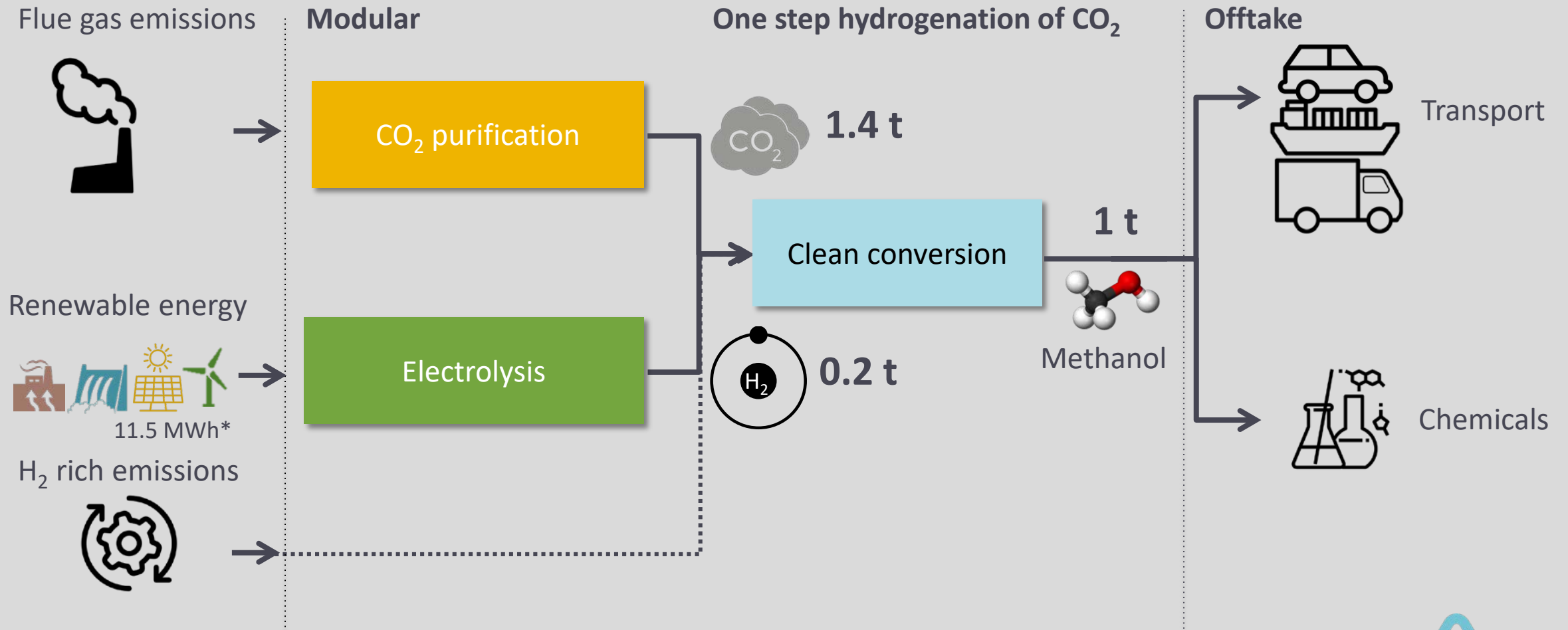


CO2-to-methanol: A liquid energy carrier which scales sustainably



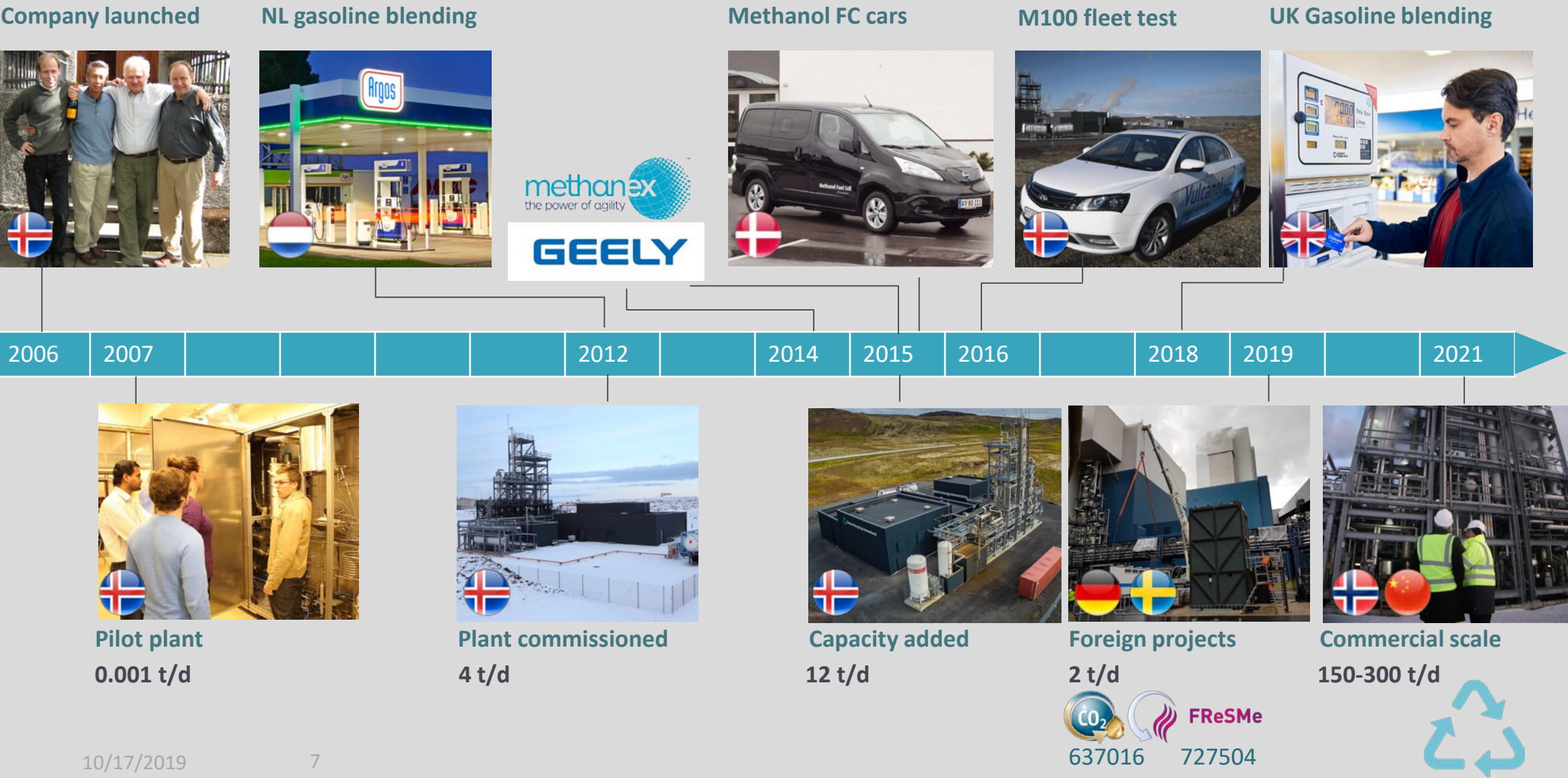
CRI Emissions-to-Liquids (ETL) platform

CRI's Emissions-to-Liquids technology platform



*Total load based on alkaline water electrolysis

Building on more than 12 years of full value-chain experience





First CCU-to-fuel plant

Svartsengi, Iceland 2012 –

Energy source:	Icelandic grid
CO ₂ source:	Geothermal gas
CO ₂ conversion:	5,600 t/yr
Capacity:	4,000 t/yr methanol
Electrolyzers:	6 MW (alkaline)





Site of second CCU-to-fuel plant

RWE power-plant Bergheim-Niederaussem, Germany

Energy source:	Wind power
CO ₂ source:	Coal combustion
CO ₂ conversion:	500 t/yr
Capacity:	350 t/yr methanol
Electrolyzers:	0.6 MW (PEM)



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Plant adapts dynamically providing flexible load and energy storage



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Site of third CCU-to-fuel plant

SSAB steel-works Lulea, Sweden

Energy source:	Blast furnace gas
CO ₂ source:	Blast furnace gas
CO ₂ conversion:	500 t/yr
Capacity:	350 t/yr methanol



Plant uses waste gas streams
from steel-making process



Site of third CCU-to-fuel plant

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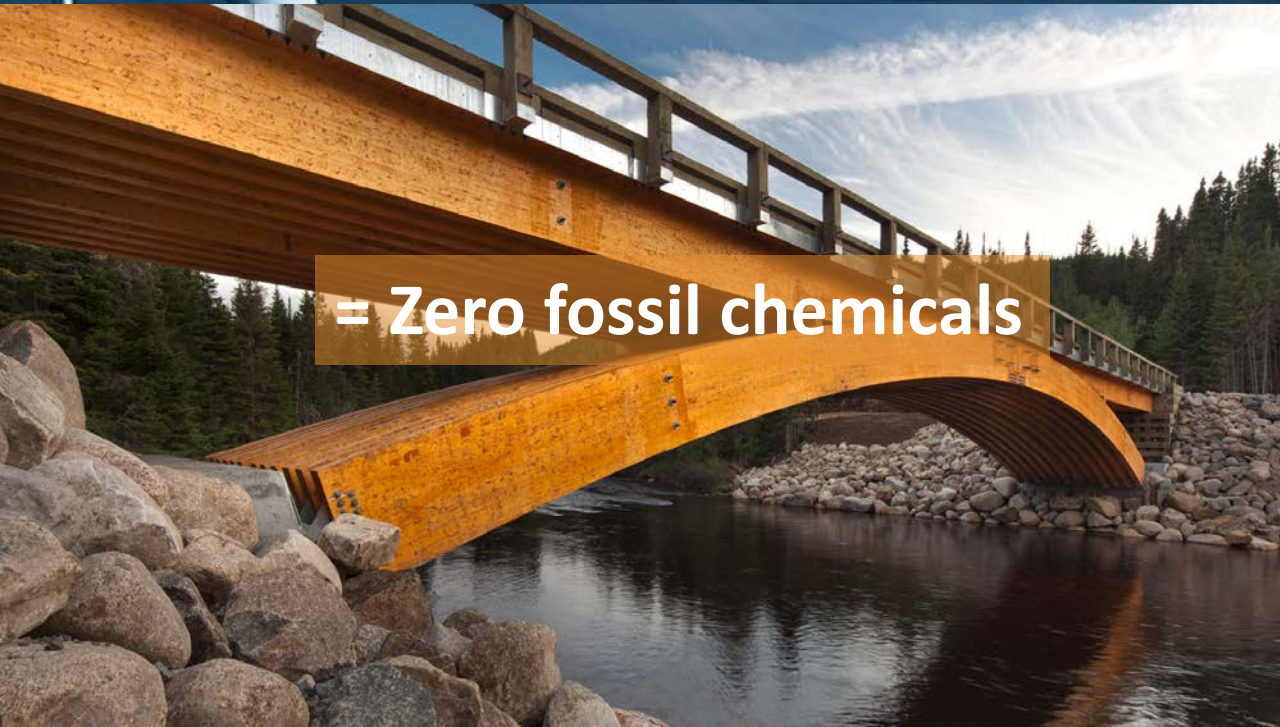


Surplus or stranded energy

+



Industrial waste gas



= Zero fossil chemicals



= Transport fuels

CRI developing pipeline of Carbon Capture and Utilization (CCU) projects

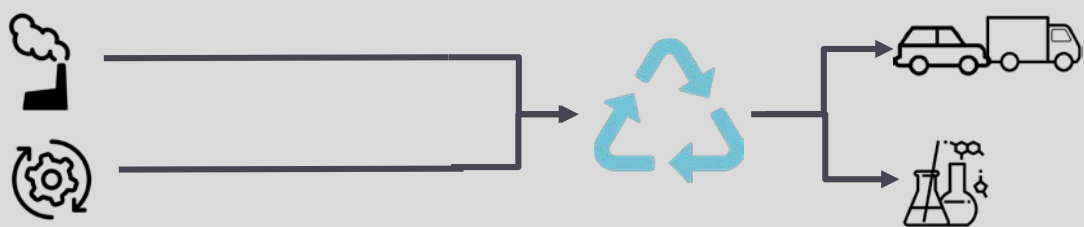
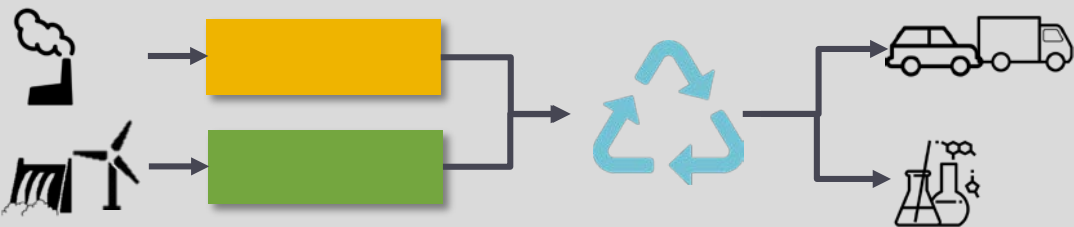
Europe – defossilizing mobility

China: low carbon clean urban air



CRI ETL platform with electrolysis

CRI ETL platform with coke-oven gas







First projects: 50,000 – 100,000 t/yr

First projects: 100,000 – 250,000 t/yr







Geely Emgrand 7 M100 in Iceland

Initial objectives of fleet trial 2016-2017

-  Demonstrate performance of M100 cars
-  Implement a green methanol value chain
-  Document CO2 savings and sustainability
-  Develop and test best practices

Results 2016-2019

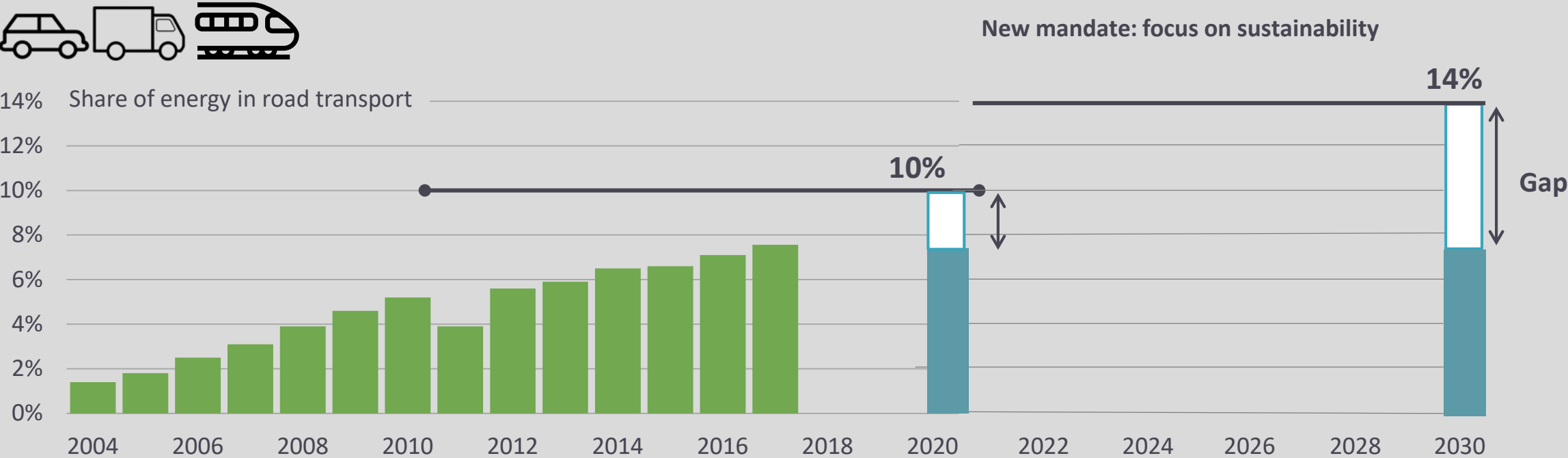
-  > 400,000 km accumulated
-  Over 73% reduction of WTW CO₂ emissions
-  Ownership costs < than BEV
-  Positive driver experience



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Öruggur staður til að vera á

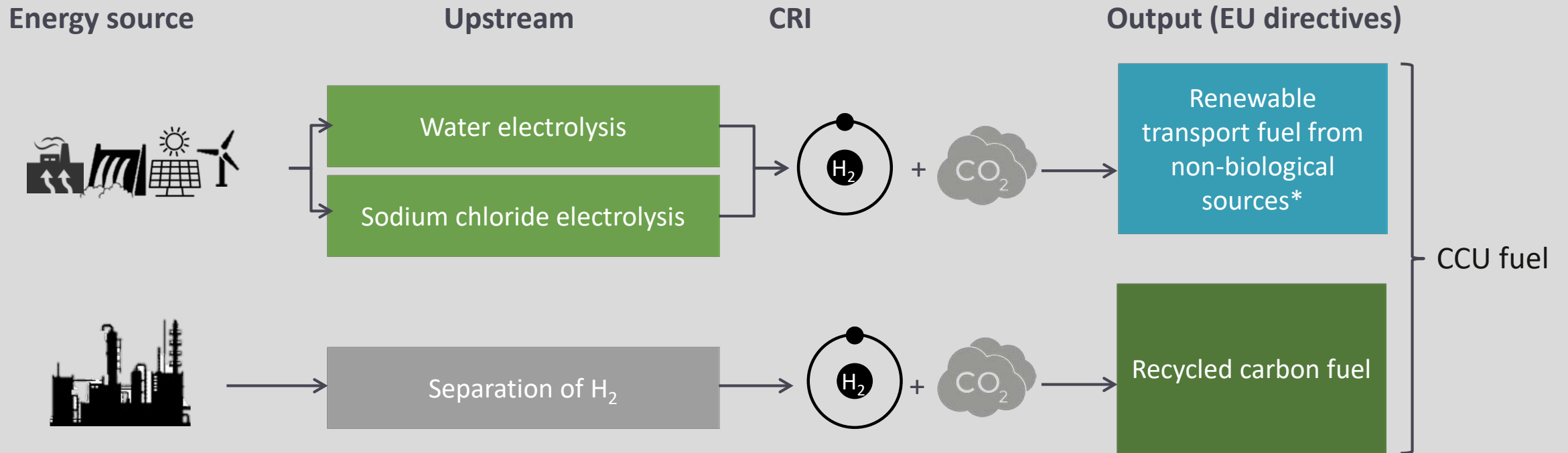
EU 2009- : Increasing obligation for renewable energy in road transport



Source: Eurostat, directive 2009/28, 2018/2001 (RED II)



Low carbon intensity methanol processes and EU framework

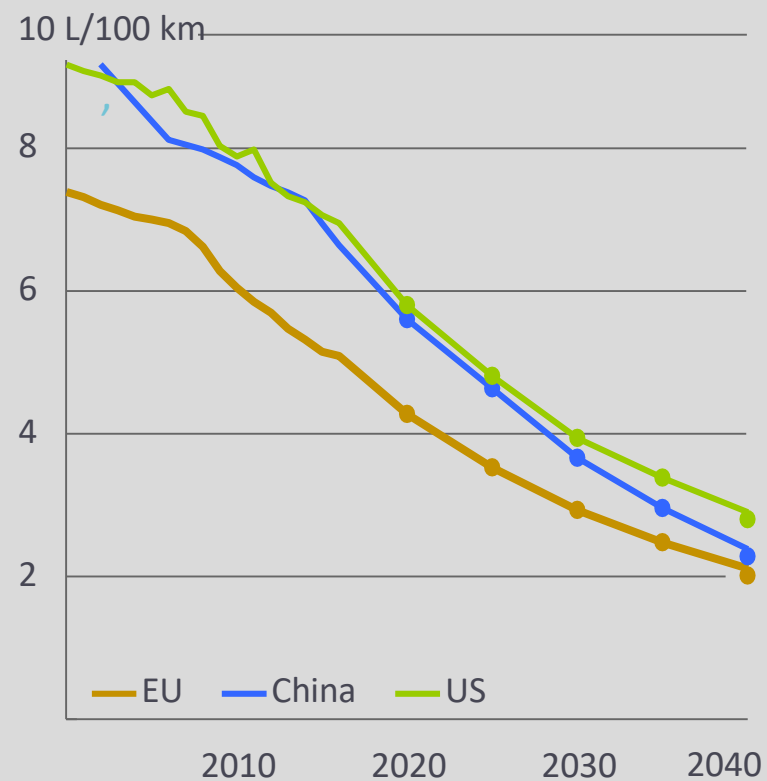


* Also known as e-fuel

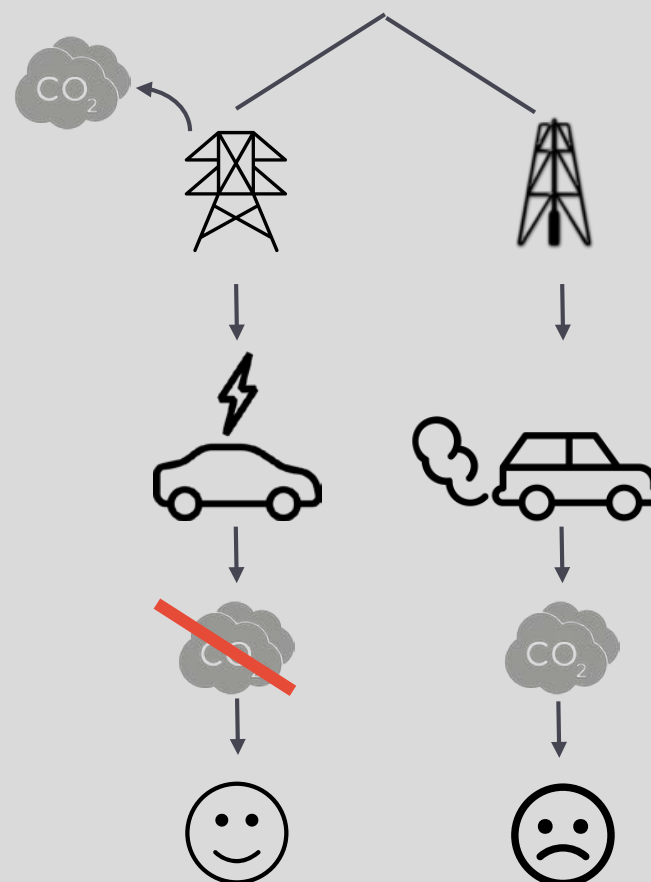


Automaker obligation disconnected from renewable energy mandate

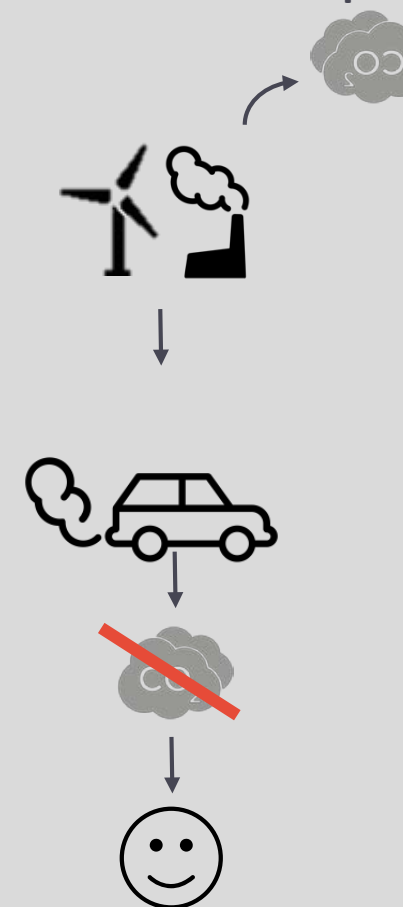
Targets for tailpipe emissions



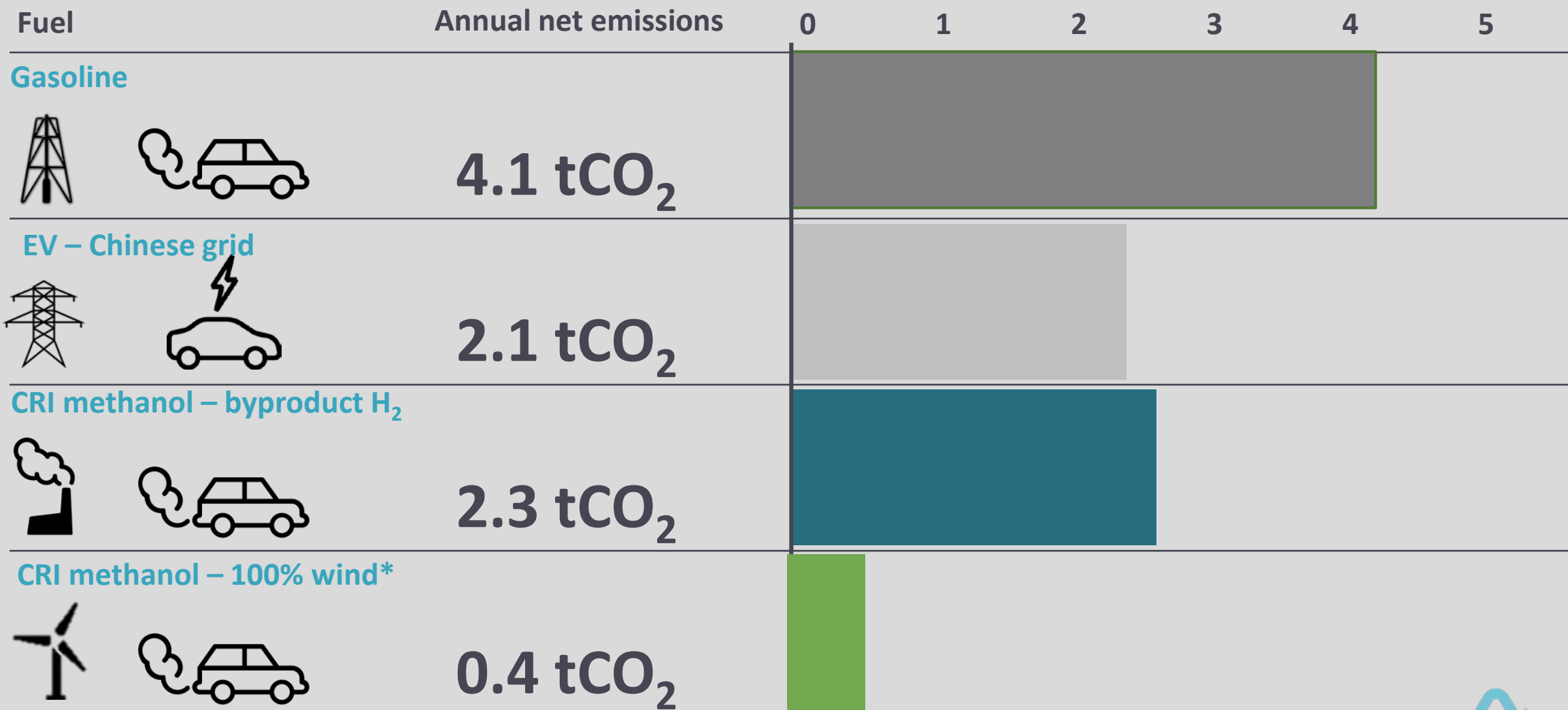
Not battery electric = penalty



Alternative: WTW perspective



CO₂ footprint for light vehicle



Sources: COREPER, OECD, Covenant of Mayors for Climate and Energy, CRI

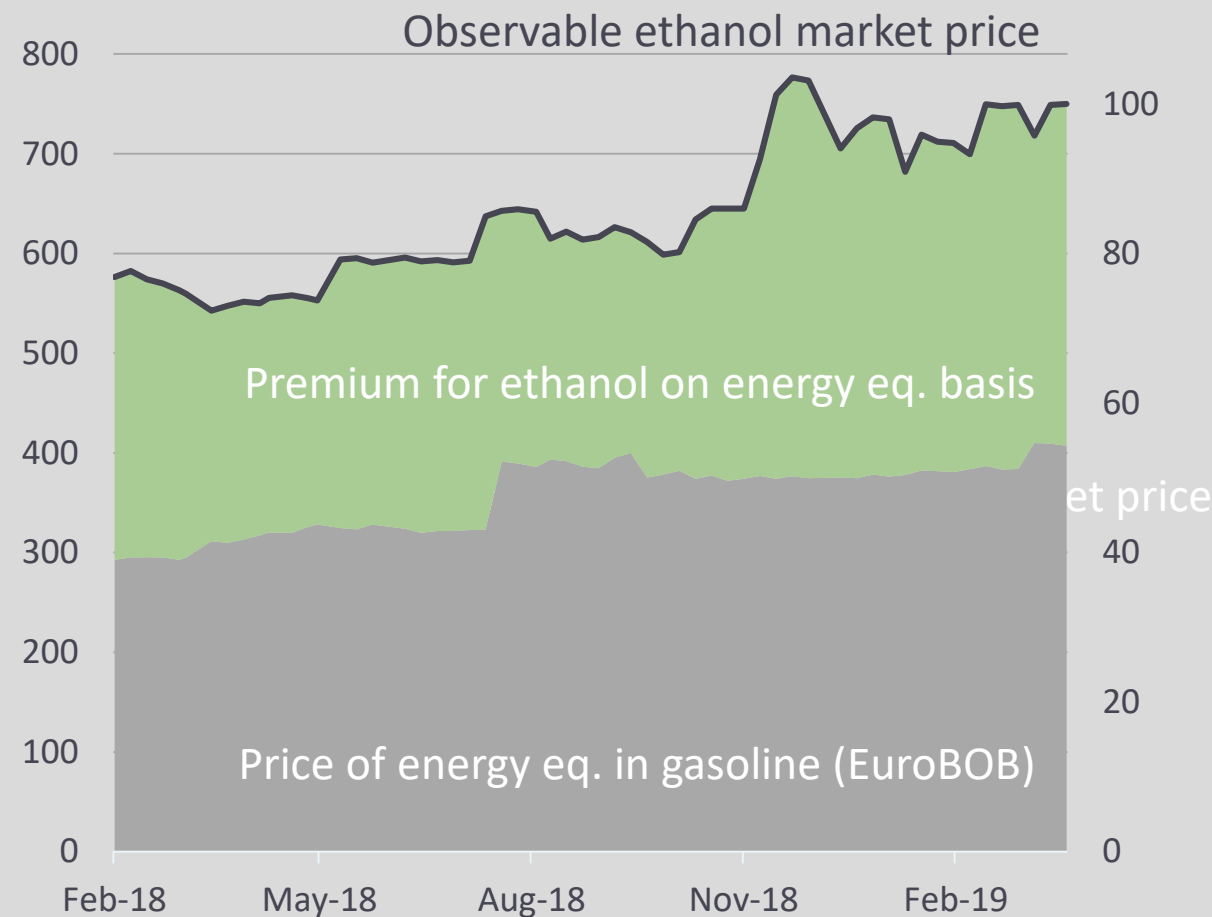


Implied value of CO₂ abatement derived from EU bioethanol market price

Realized market prices 2018-2019*

€900/t ethanol

Per MWh LHV: €120



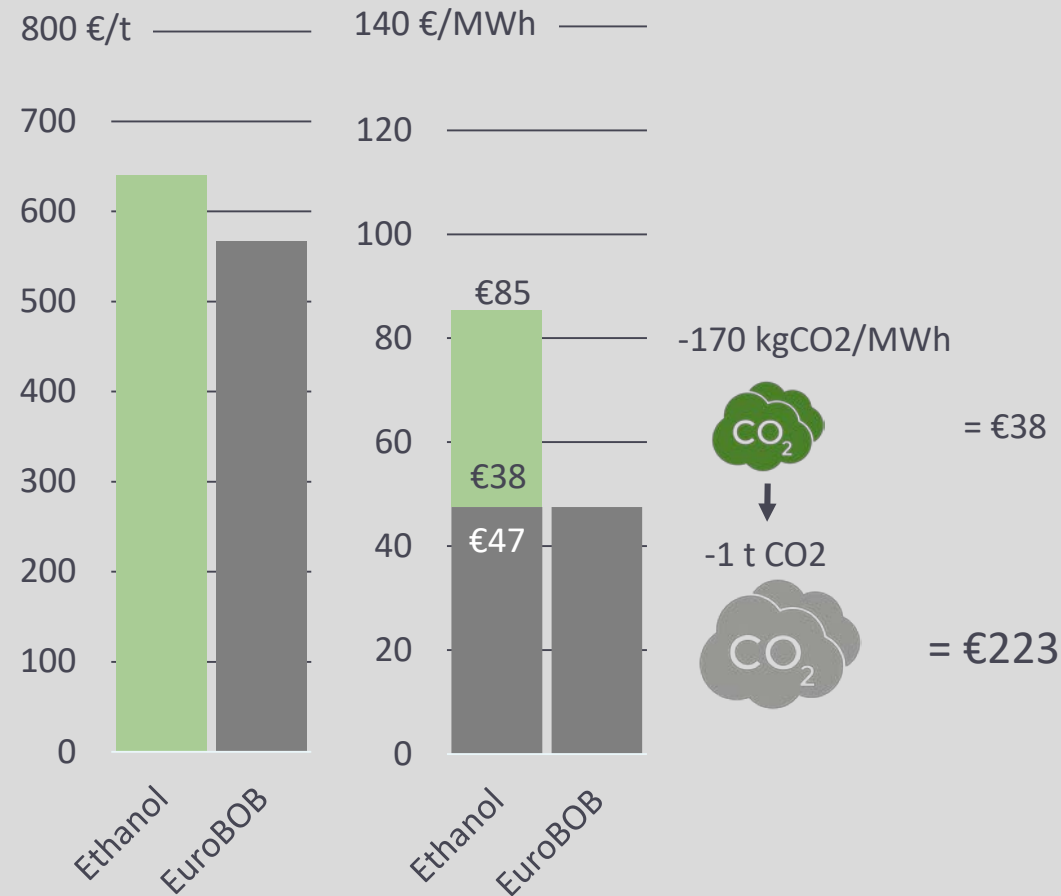
Realized price

Average 2018-2019

Energy eq. price

Value of CO₂ abatement

Imputed from premium for ethanol

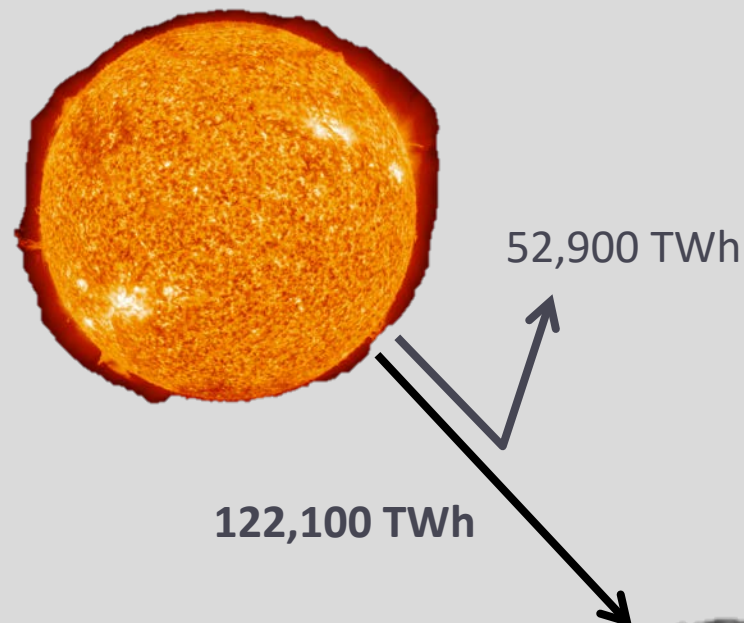


*Source: Energy Census; Ethanol = T2 Ethanol CIF Rotterdam; EuroBOB = European gasoline blendstock CIF Rotterdam



Solar energy striking earth in **one hour** = global energy consumption **per year**

Solar energy striking earth per year



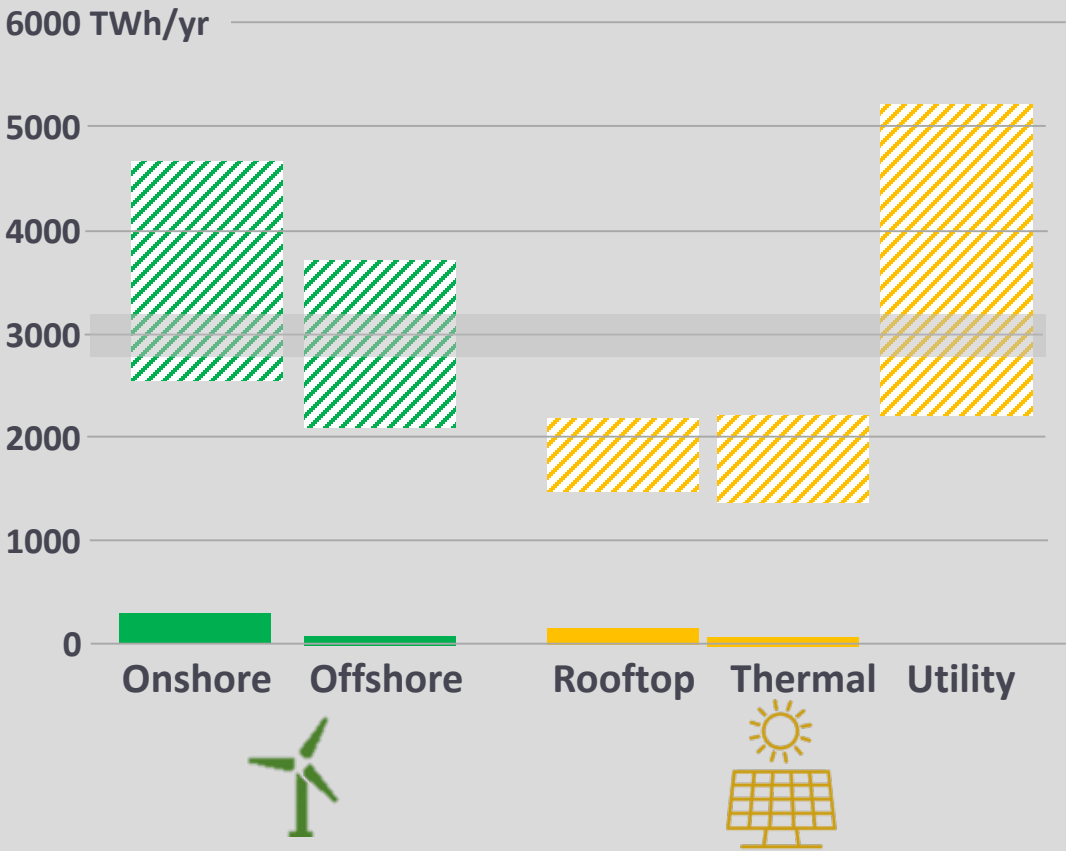
Global primary energy consumption per year

Oil	6.02 TWh
Coal	4.91
Gas	4.15
Hydro	0.42
Nuclear	0.27
Non-hydro renewable	0.12
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Total	15.9 TWh

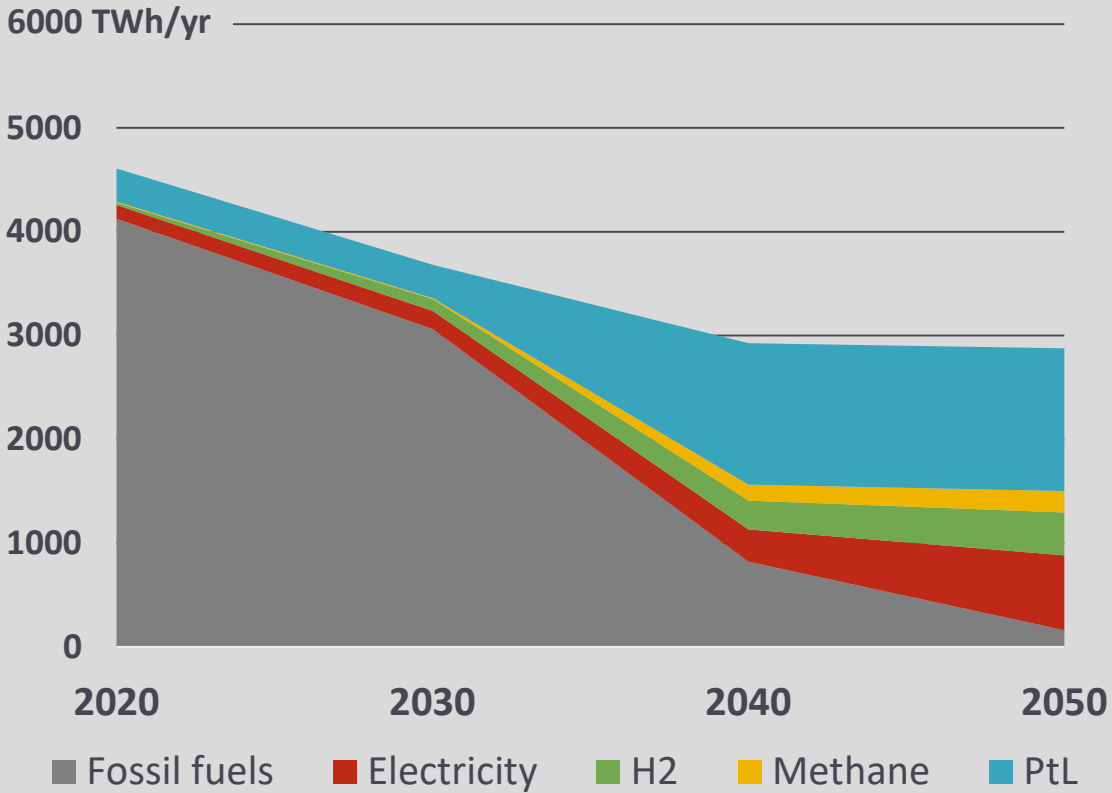


Does Europe have sufficient energy to switch to e-fuels?

Europe: Renewable energy potential



Europe: Road transport energy demand

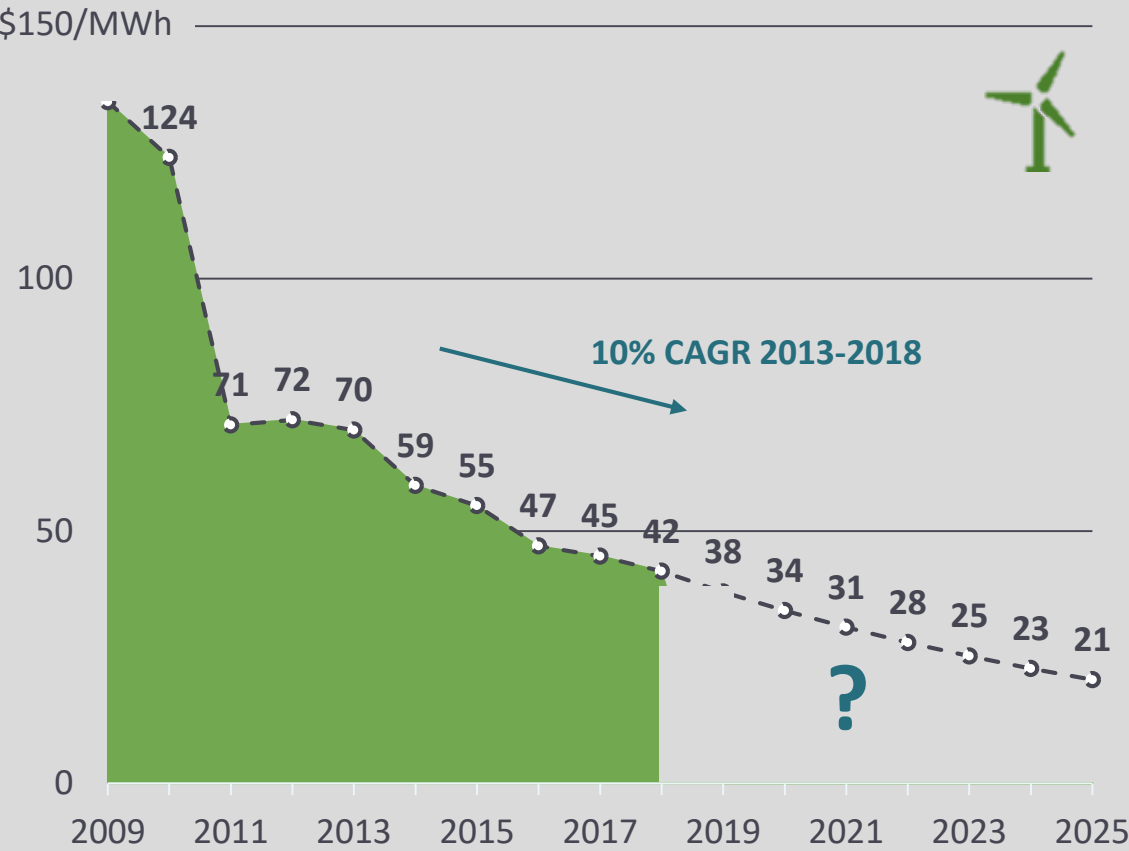


Source: LBST/German Energy Agency 2017 “E-fuels: The potential of electricity-based fuels for low-emission transport in the EU”



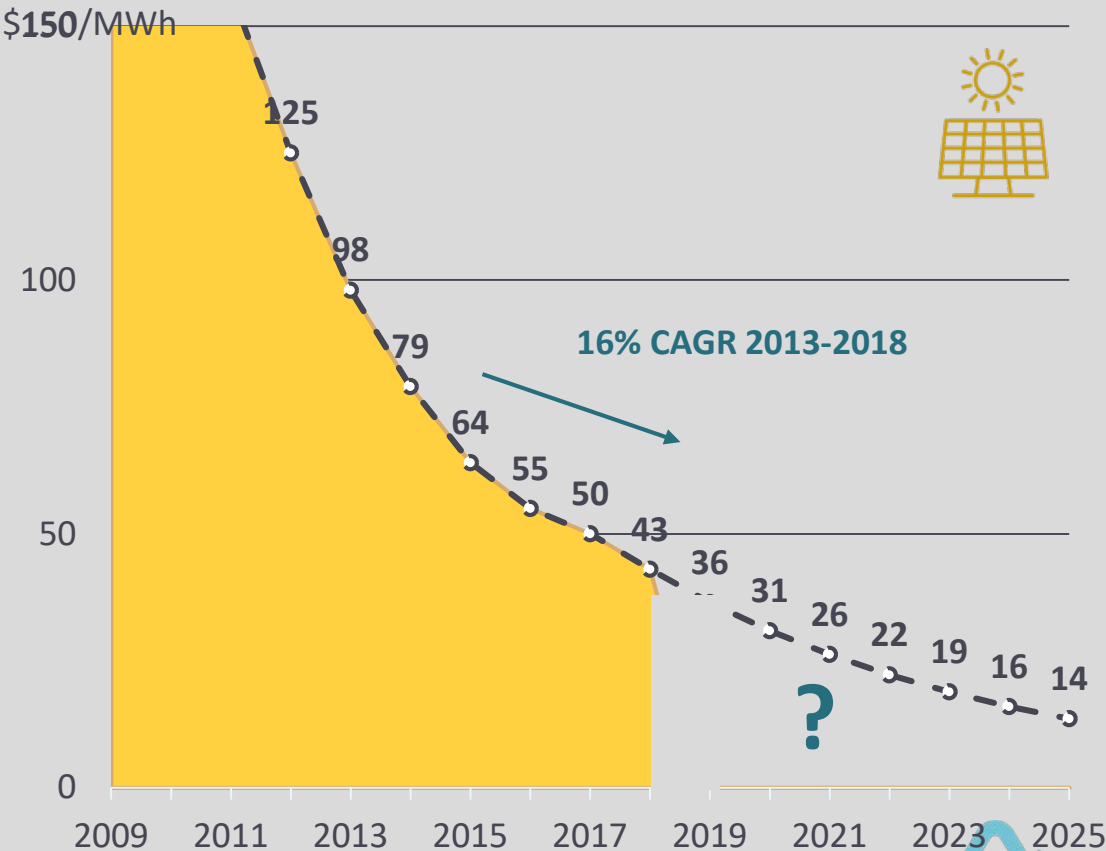
Cost of electricity generation falling sharply

US on-shore wind LCOE - unsubsidized



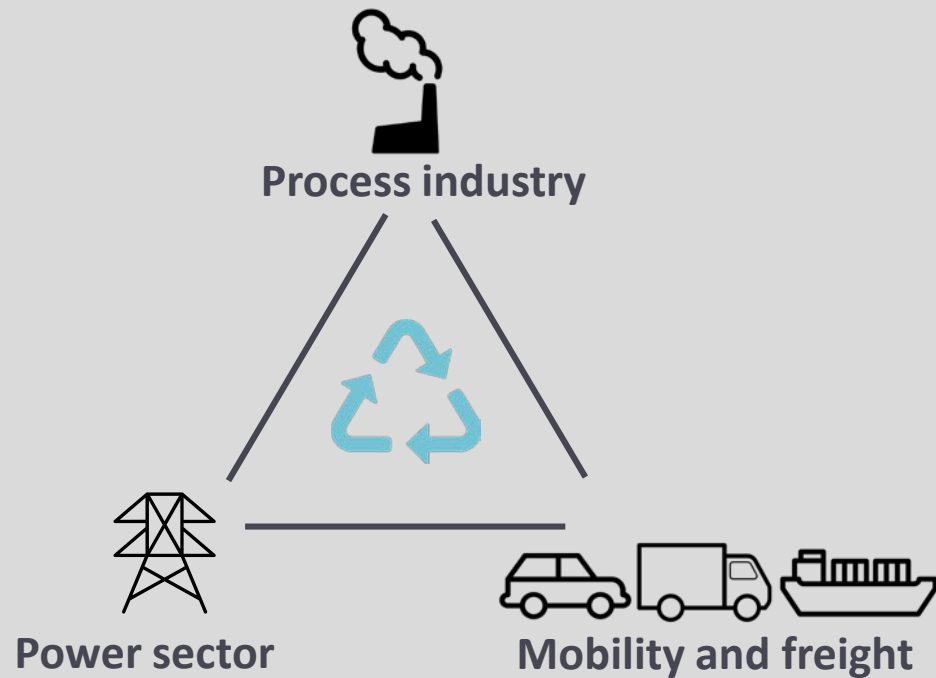
Source: Data 2009 – 2018 from Lazard; Forecast 2019 - 2025: CRI

US utility PV solar LCOE - unsubsidized

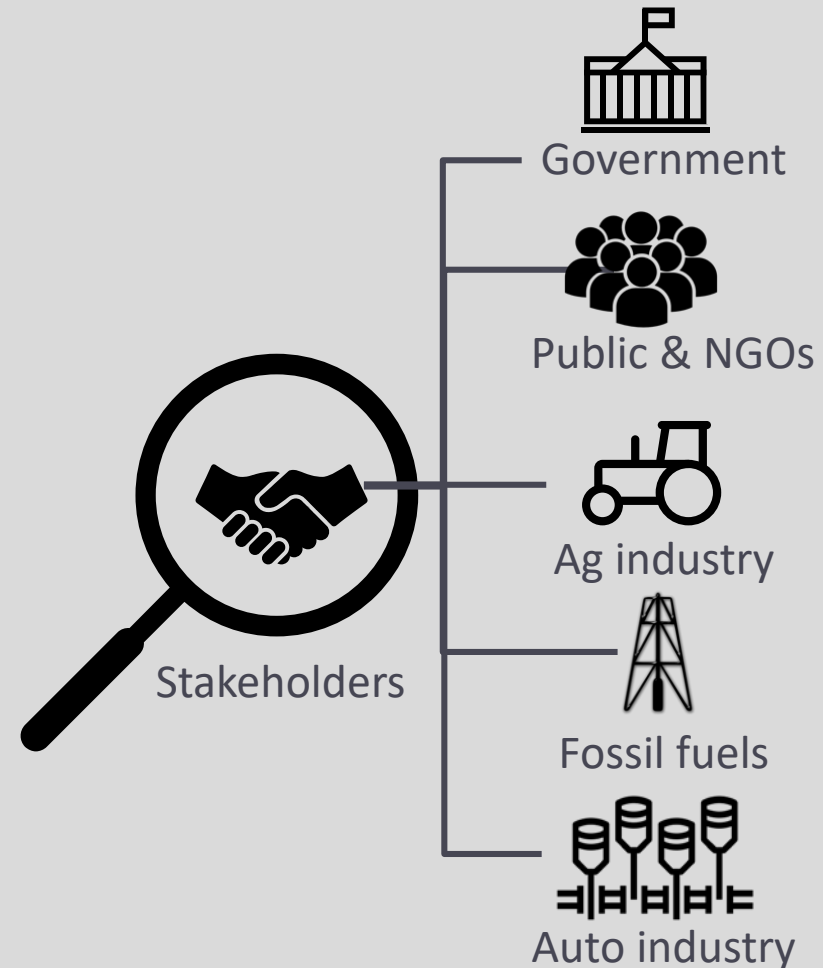


A new ecosystem of circular economy and energy

Direct ecosystem



Indirect ecosystem



Take away points



We have a problem



Technology is ready



Cost falling and supply rising



New markets are opening



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