Blue World Technologies

Methanol Vehicles Exhibition, Chongqing, October 2019

By Mads Friis Jensen, CCO at Blue World Technologies

Who is Blue World Technologies?

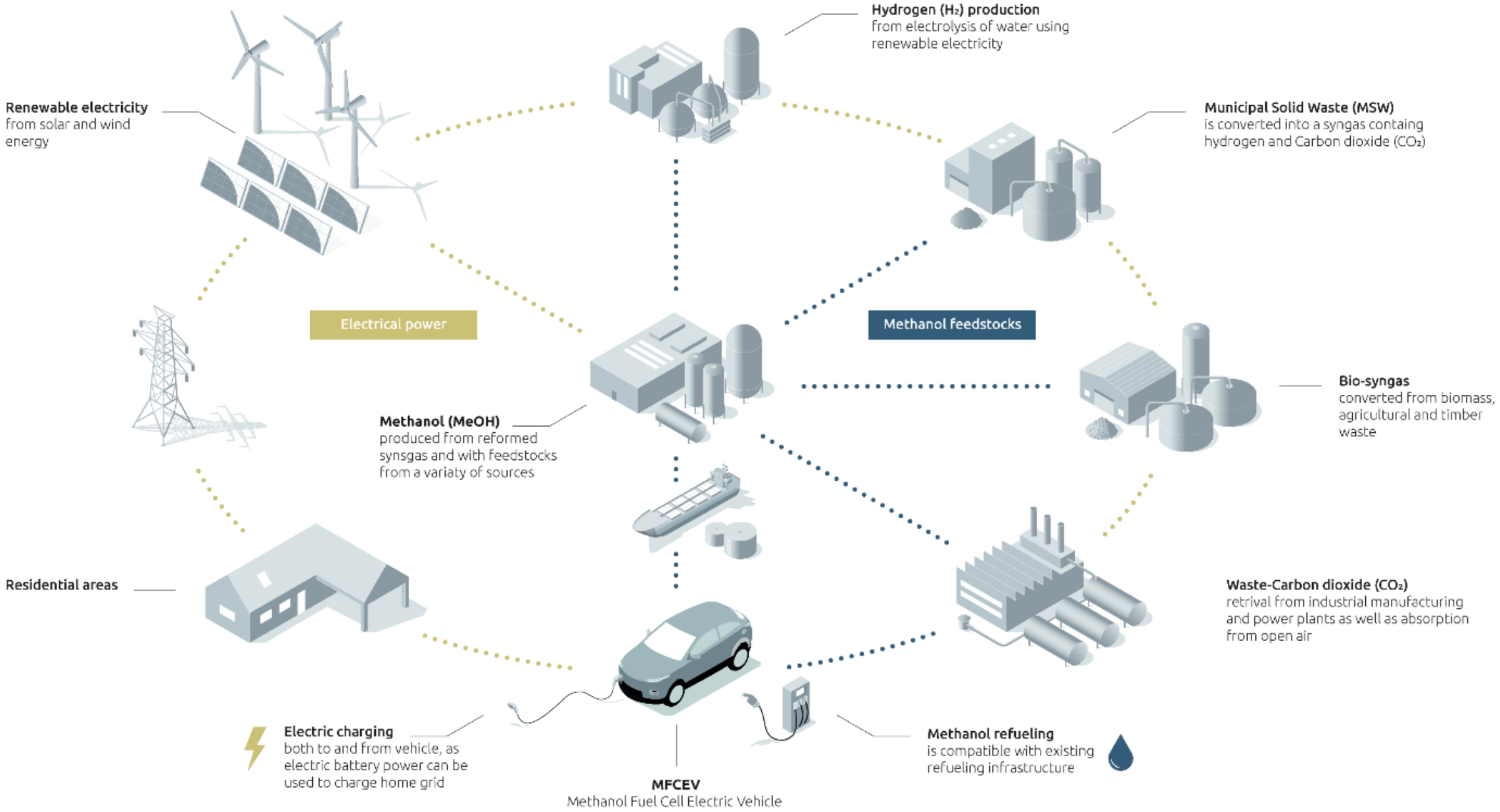
Founded in
October
2018

A team of 41 people
with 10 different
nationalities

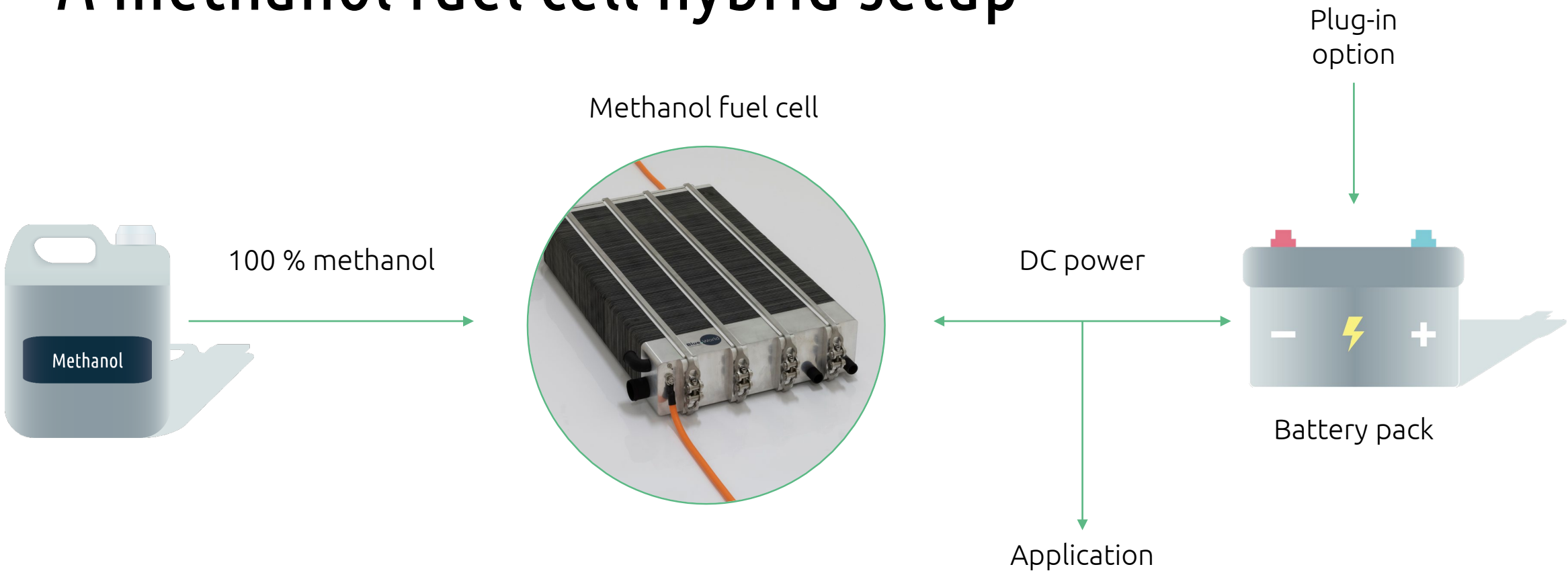
The team holds
214 years
of fuel cell experience

… and counts
10 PhDs

Production goal of
50,000
units / year from
2022 - 23


Hydrogen (H₂) production
from electrolysis of water using renewable electricity
Renewable electricity
from solar and wind energy
Municipal Solid Waste (MSW)
is converted into a syngas containg hydrogen and Carbon dioxide (CO₂)
Electrical power
Methanol feedstocks
Methanol (MeOH)
produced from reformed synsgas and with feedstocks from a variaty of sources
Bio-syngas
converted from biomass, agricultural and timber waste
Residential areas
Waste-Carbon dioxide (CO₂)
retrival from industrial manufacturing and power plants as well as absorption from open air
Electric charging
both to and from vehicle, as electric battery power can be used to charge home grid
MFCEV
Methanol Fuel Cell Electric Vehicle
Methanol refueling
is compatible with existing refueling infrastructure

A methanol fuel cell hybrid setup



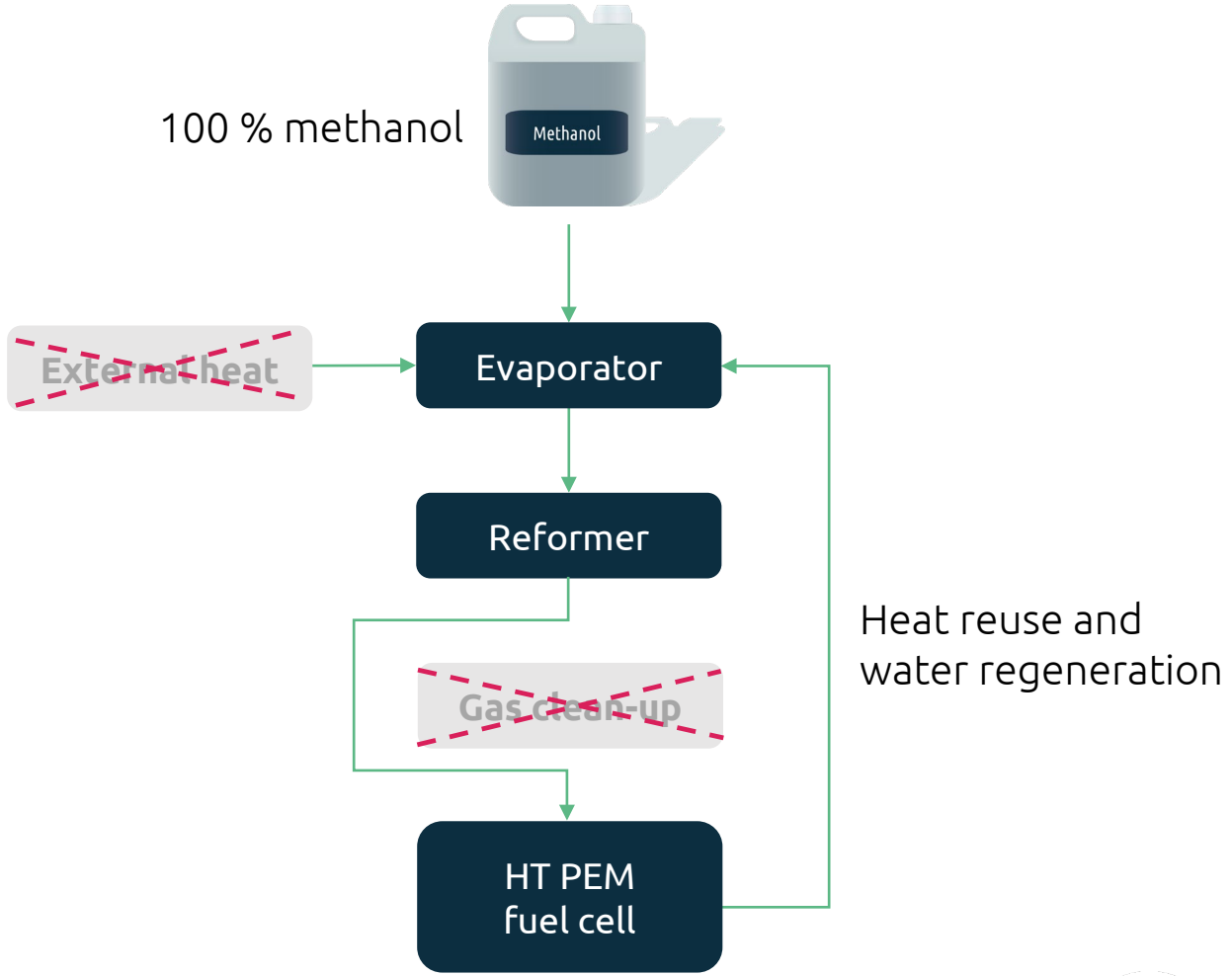
Methanol fuel cell – High Temperature PEM

NEW advanced technology

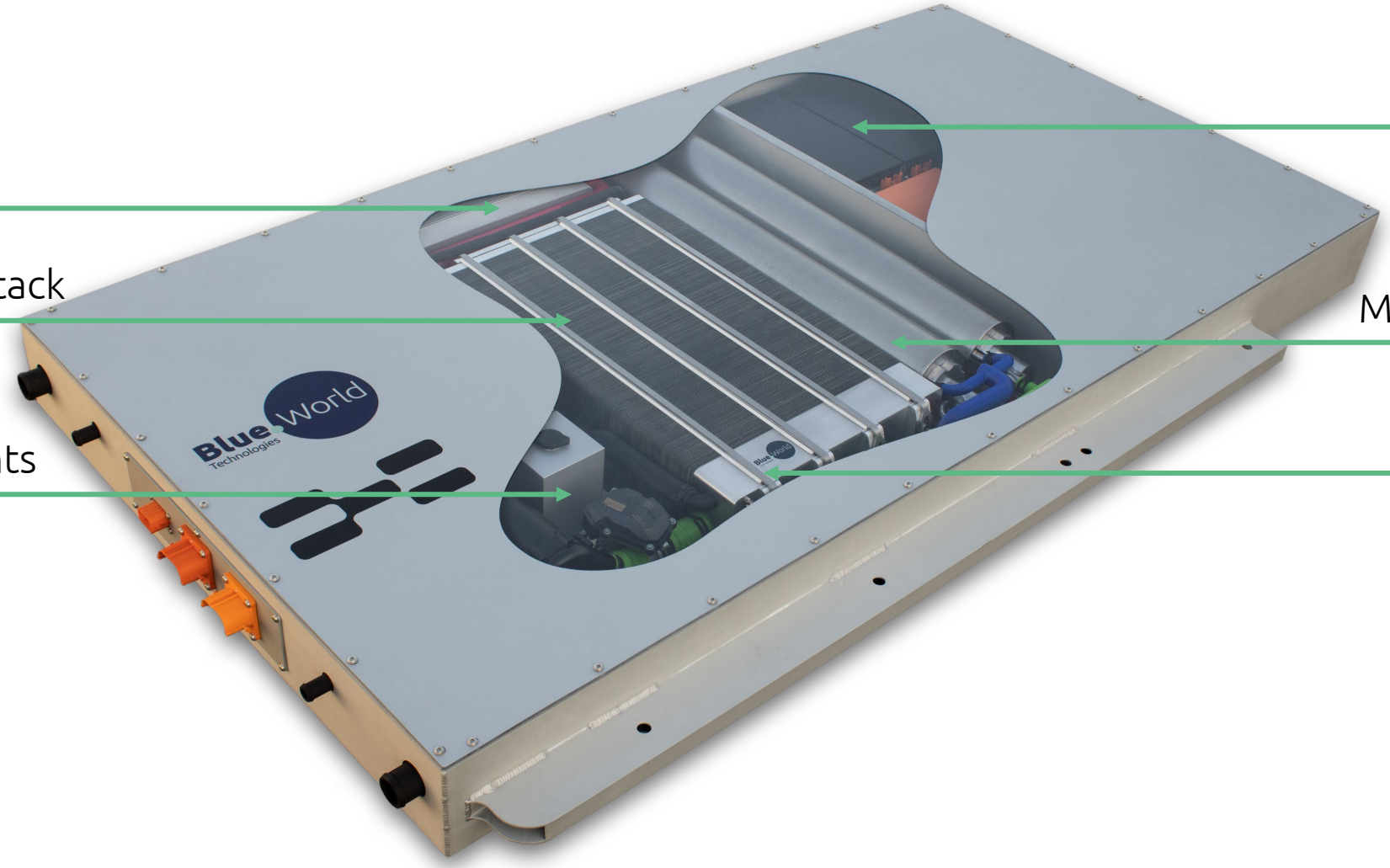
- No external heat needed as waste heat drives fuel evaporation process = **higher** conversion efficiency
- No gas clean-up needed = **simple** and cost effective system
- Water regeneration = **increased** energy storage

Fuel cell operation temperature: 160 °C

- Wide temperature range
  - Low temperature start-up (no free water)
  - High temperature operation (high temperature difference)



The methanol fuel cell hybrid system



Battery pack

Condenser

HT PEM fuel cell stack

Methanol reformer

System components

Evaporator

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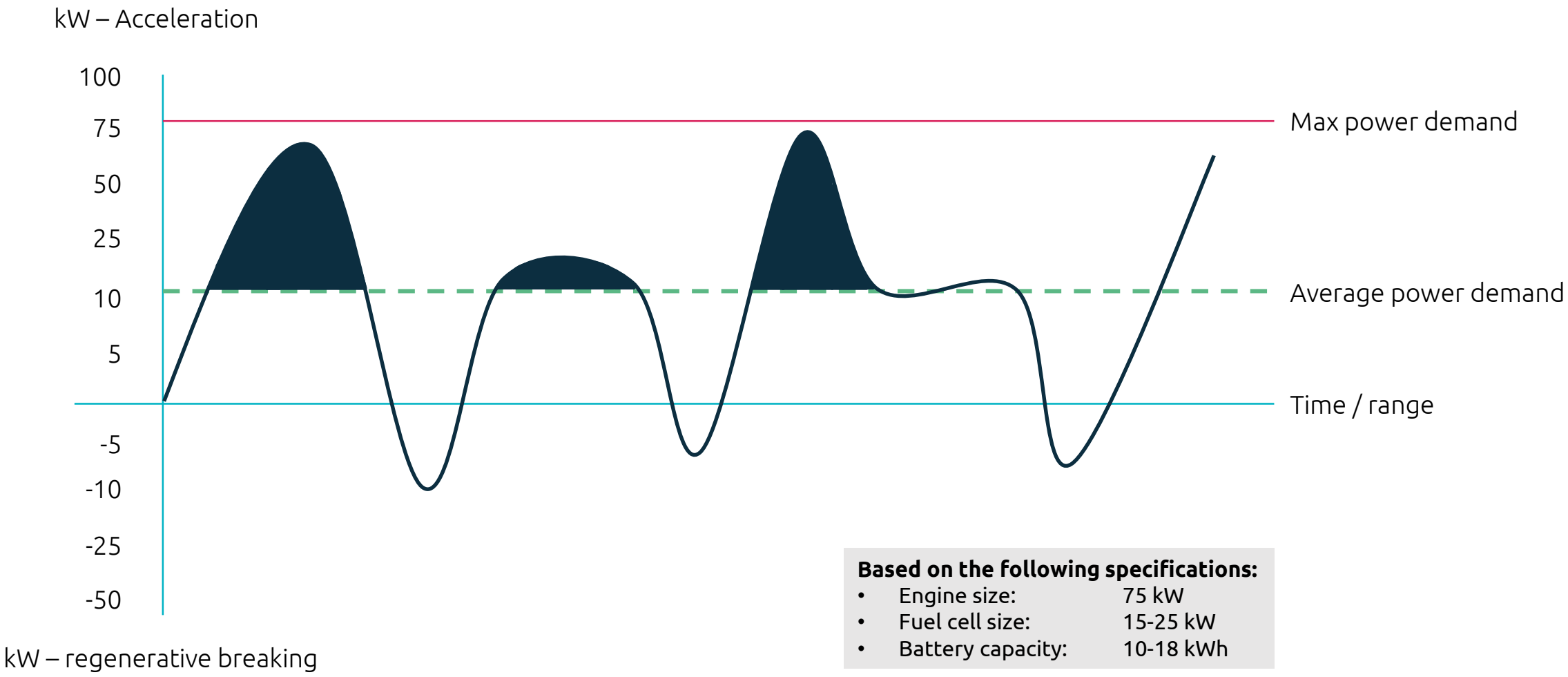
Go hybrid – downsize the components



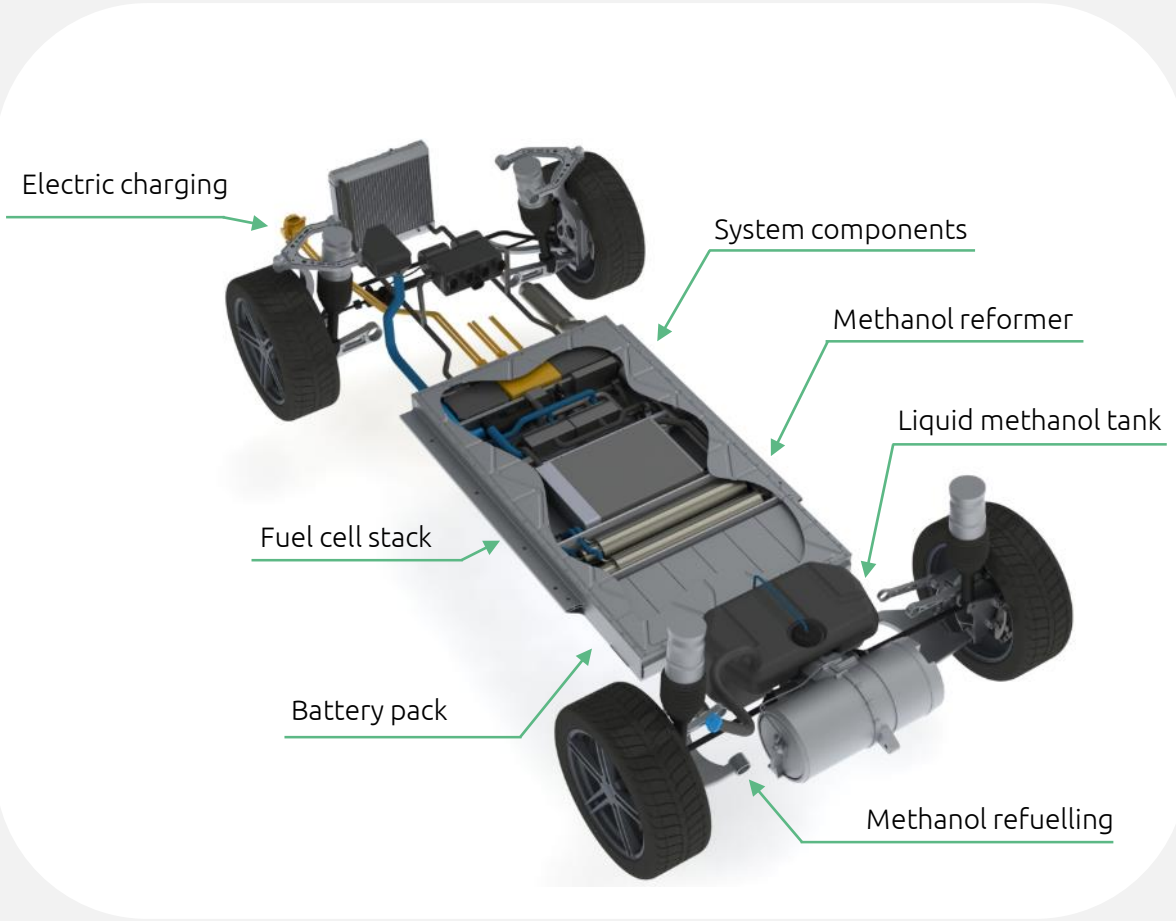
Based on the following specifications:

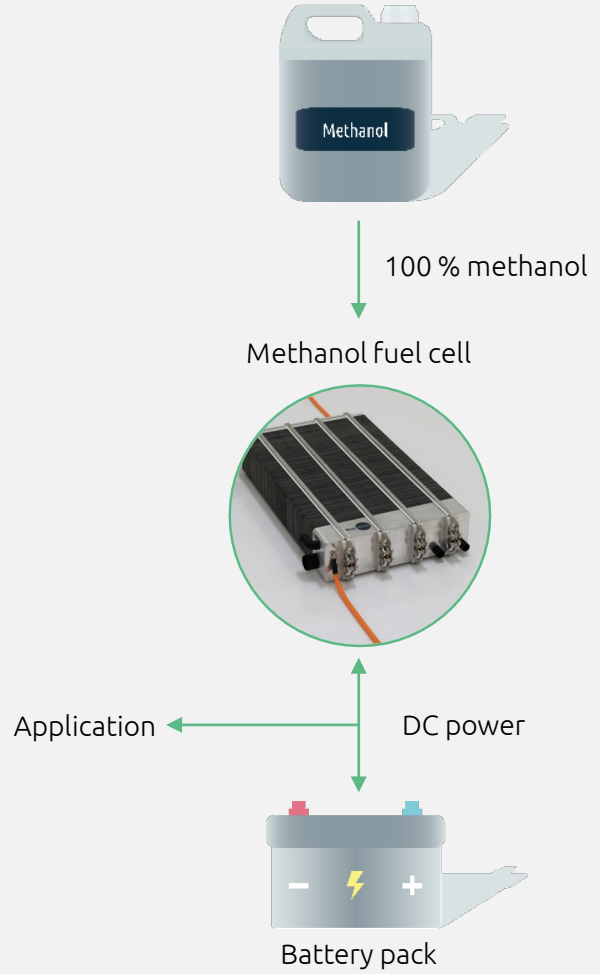
- Engine size: 75 kW
- Fuel cell size: 15-25 kW
- Battery capacity: 10-18 kWh

Methanol fuel cell vehicle

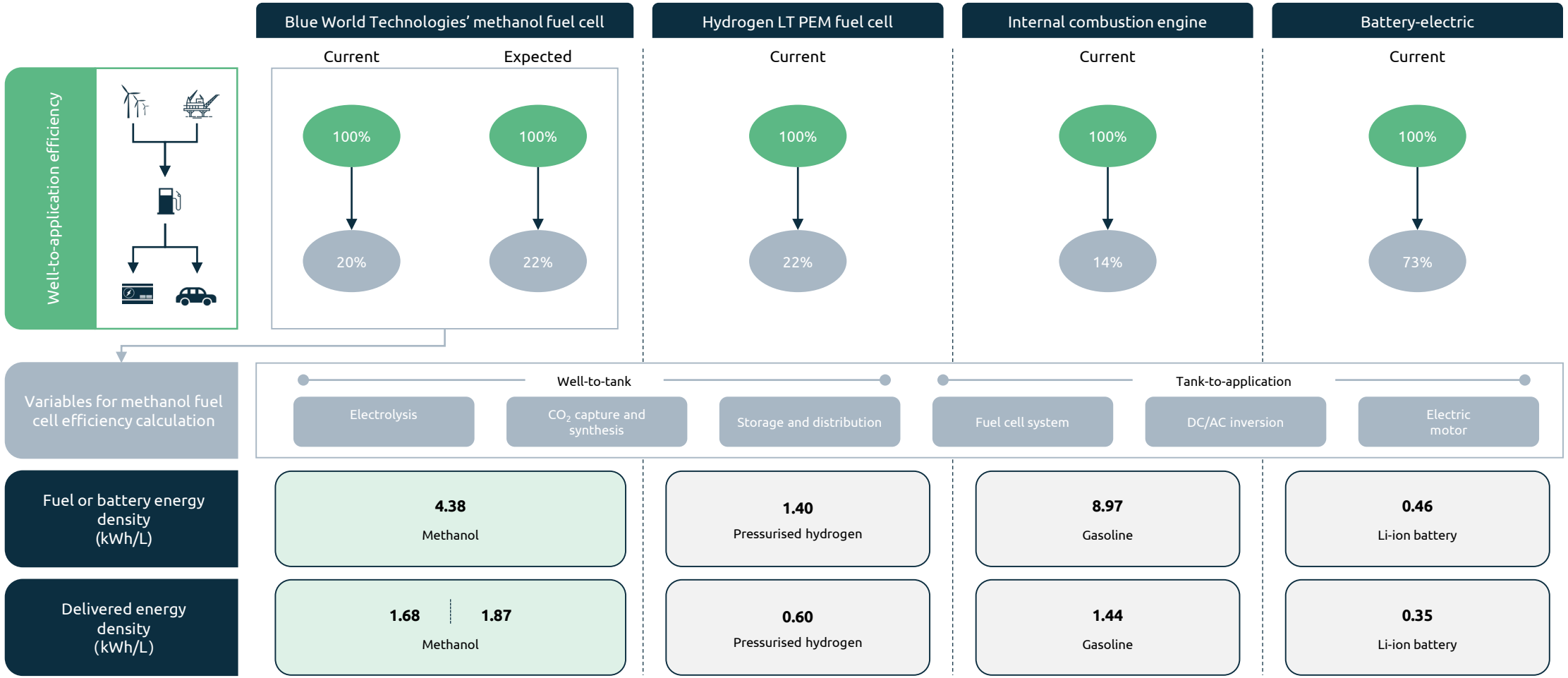
KEY VALUE PROPOSITIONS

- ✓ Same outer box as battery pack
- ✓ Same price as long range battery pack (+65kWh)
- ✓ Same vehicle platform for OEM (FCEV or BEV)
- ✓ 1,000 km range
- ✓ 3 min refuelling time OR plugIN
- ✓ Zero harmful emissions
- ✓ Significant fuel cost savings
- ✓ No noise or vibration





Energy efficiency and energy density



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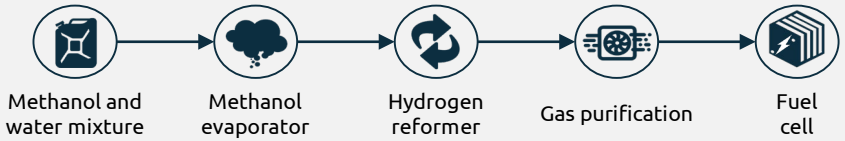
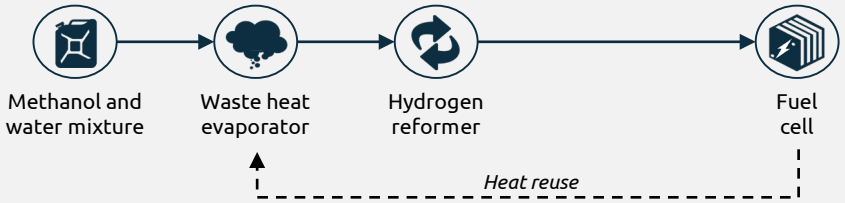
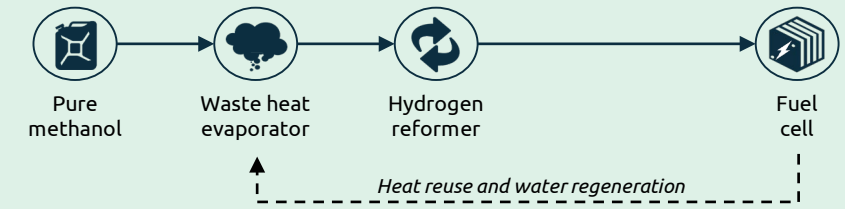
Methanol is a practical and cost-effective fuel

		Hydrogen		Methanol	
Fuel properties and storage	Natural state	• Common element, largely bonded within other molecules • Clear gas at standard temperatures and pressures	✗	• Simplest of the alcohols which can be made renewably • Liquid at standard temperatures and pressures	✓
	Storage	• Typically stored as a gas under very high pressure (700 bar) • More costly to store compared to liquids	✗	• Easy to transport and store in fuel tanks, similar to gasoline • Methanol already widely distributed for industrial use	✓
	Energy density	• Low density per unit volume, even under high pressure • 1,400 kWh/m^3	✗	• High density per unit volume at standard temperature and pressure • 4,400 kWh/m^3	✓
Infrastructure	Current fuelling infrastructure	• Few stations exist • ~150 stations in Europe versus ~80,000 regular filling stations	✗	• Early technology being rolled out • Chinese state support for ~10k new methanol vehicles expected in Guizhou province in 2019	↗
	Filling station cost	• New infrastructure is required to store hydrogen • Costs up to EUR 3.3m per station with eight filling points	✗	• Existing fuelling infrastructure cheap to convert – clean fuel tanks and replace fuel nozzles • ~EUR 2,250 per pump	✓

A simple and effective methanol-based system

	System components	Comments
LT PEM system		✓ Reformed methanol PEM fuel cell systems are efficient and have high power densities ✓ LT PEM technology is currently more mature and well-developed than HT PEM ✓ Short start-up times (although it requires standby heating) × Requires very specific mixture of methanol and water fuel formulation × Fuel cell is sensitive to impurities and requires purification of hydrogen gas
Typical HT PEM system		✓ Higher operating temperature can drive evaporation and increase efficiency ✓ More tolerant of impurities eliminating the need of hydrogen gas purification ✓ Improved efficiency and lower associated costs compared to reformed methanol LT PEM fuel cells × Requires very specific mixture of methanol and water fuel formulation
Blue World Technologies' HT PEM system		✓ Simple design using pure methanol eliminating the need of attenuated methanol and water mixtures ✓ Blue World Technologies' HT PEM fuel cell design is elevated compared to other HT PEM and reformed methanol LT PEM fuel cells, resulting in greater efficiency and lower associated costs ✓ While being a relatively new technology, HT PEM's fundamental electrochemistry is the same as for LT PEM, so intense R&D efforts will lead to an even more effective and competitive product

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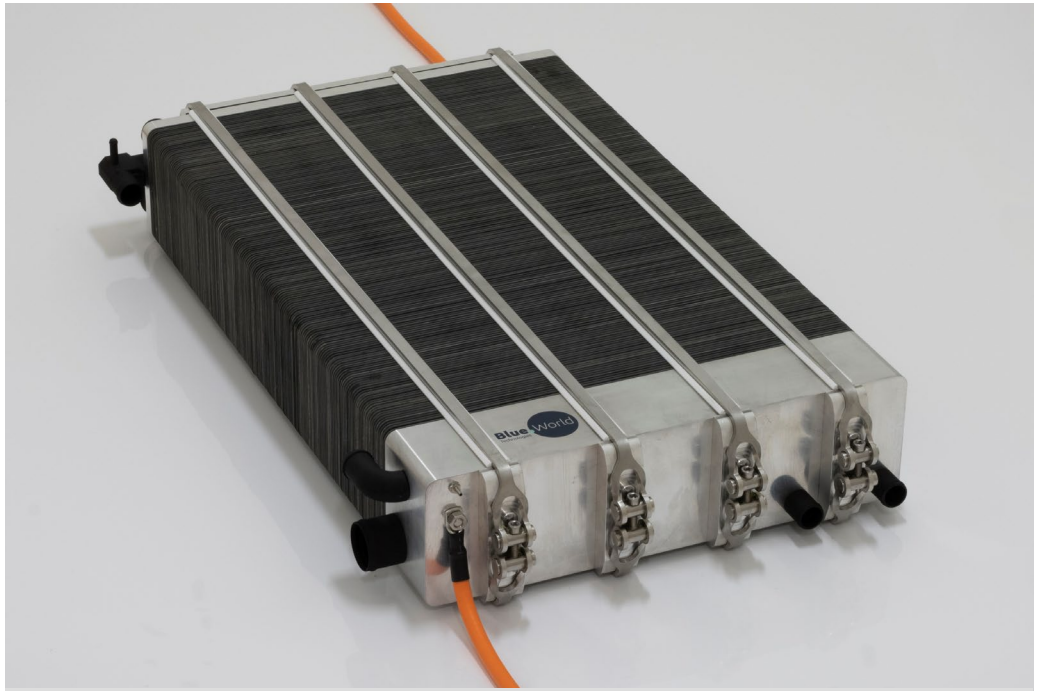
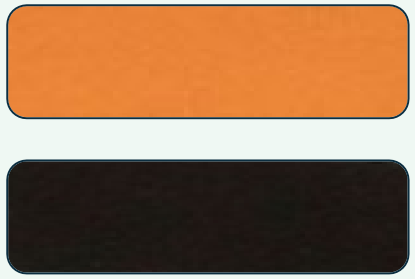
Product platform

- Operation on pure methanol (M100)
- Output power range: 7-25 kW
- System efficiency: 40-50 %
- Fuel consumption: 0,5 L/kWh
- Start-up time: 10 minutes
- Operation temperature: 160 °C



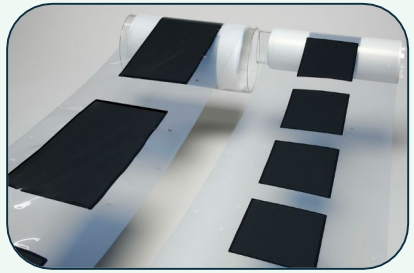
Technology platform

Membrane



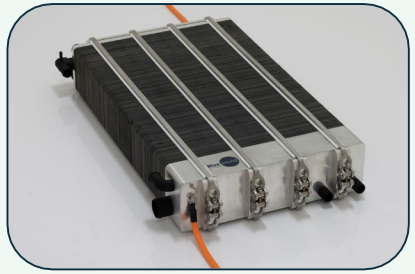
Electrode

MEA (Membrane Electrode Assembly)



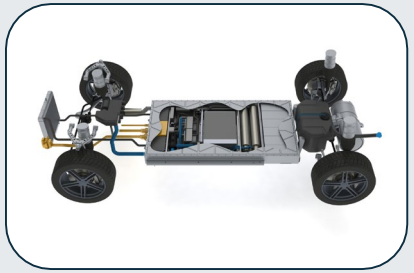
Graphite flow plate

Methanol reformer



Fuel cell stack

Fuel cell system



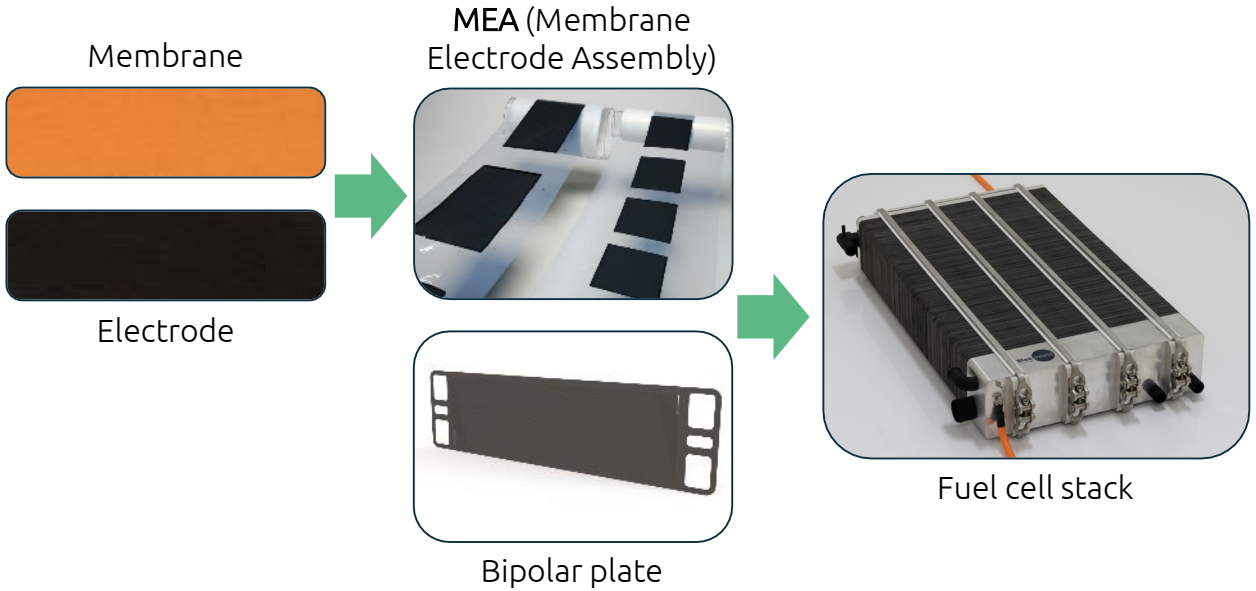
Vehicle integration

BLUE WORLD TECHNOLOGIES' SUPPLY

OEM PARTNER'S SUPPLY

World’s largest methanol fuel cell factory

- Production of core materials, key components, fuel cell stack
- 750 MW capacity (50,000 units per year)
- Production ready 2020

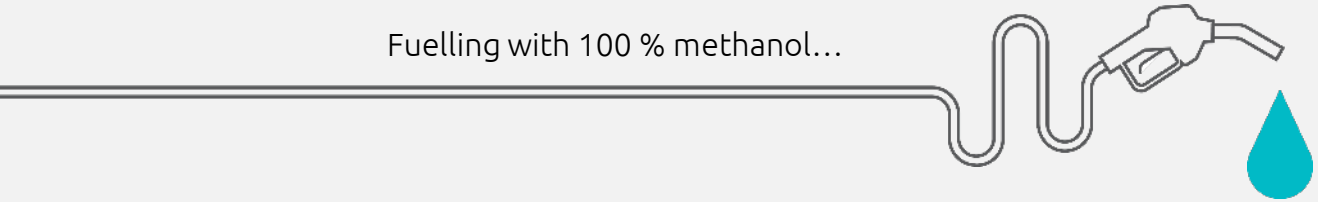


Methanol fuel cell in use

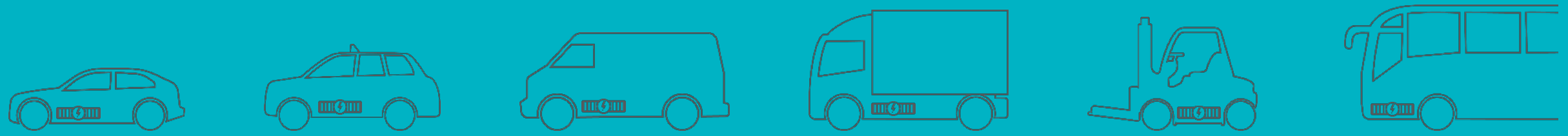
GUMPERT AIWAYS: Nathalie
- a road-legal, electric super sports car with racing performance, powered by methanol fuel cells

AIWAYS: U5
- a smart SUV that is to be delivered in two versions: as battery electric vehicle and as fuel cell electric vehicle running on methanol

Fuelling with 100 % methanol…



… a liquid fuel that can be produced by renewable sources



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Air pollution and CO_2 emission

7 million
People die every year from exposure to fine particles in polluted air

91%
of the world's population lives in places where air quality exceeds WHO guideline limits

Blue World Technologies
makes a difference
with zero harmful emission fuel cell technology

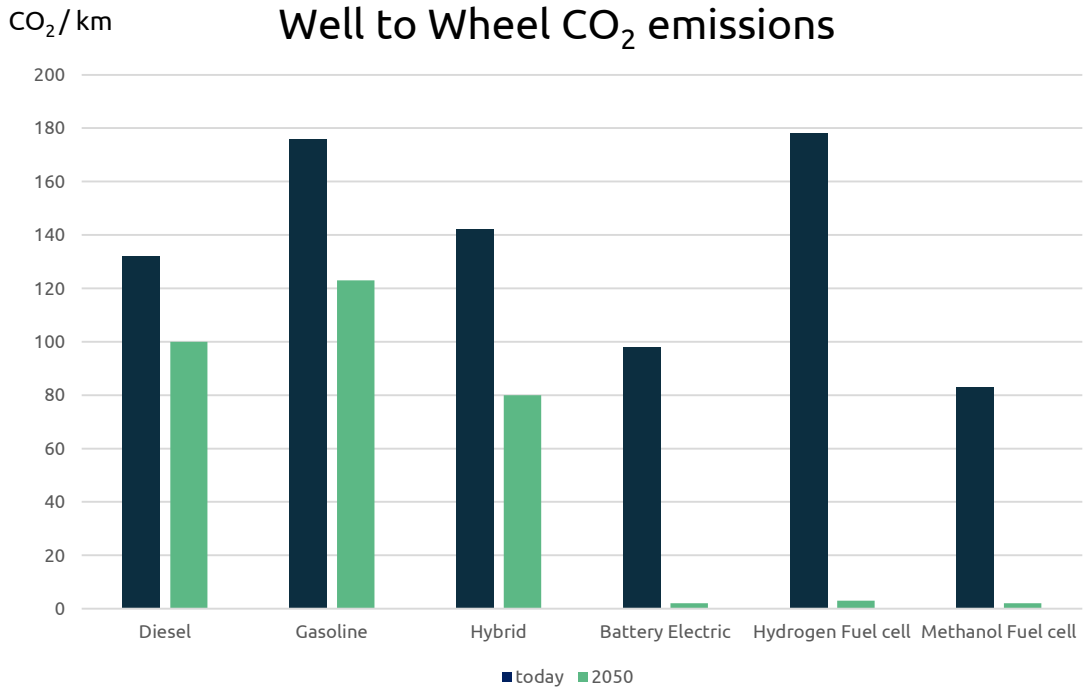
Out of the 7 million premature deaths
4.2 million
die as a result of exposure to ambient air pollution

The transport sector
is responsible for a large proportion of urban air pollution

Tank to Wheel - methanol fuel cell:
- ~500 g CO_2/kWh
- 30-50 g CO_2/km
- **Zero harmful emissions**

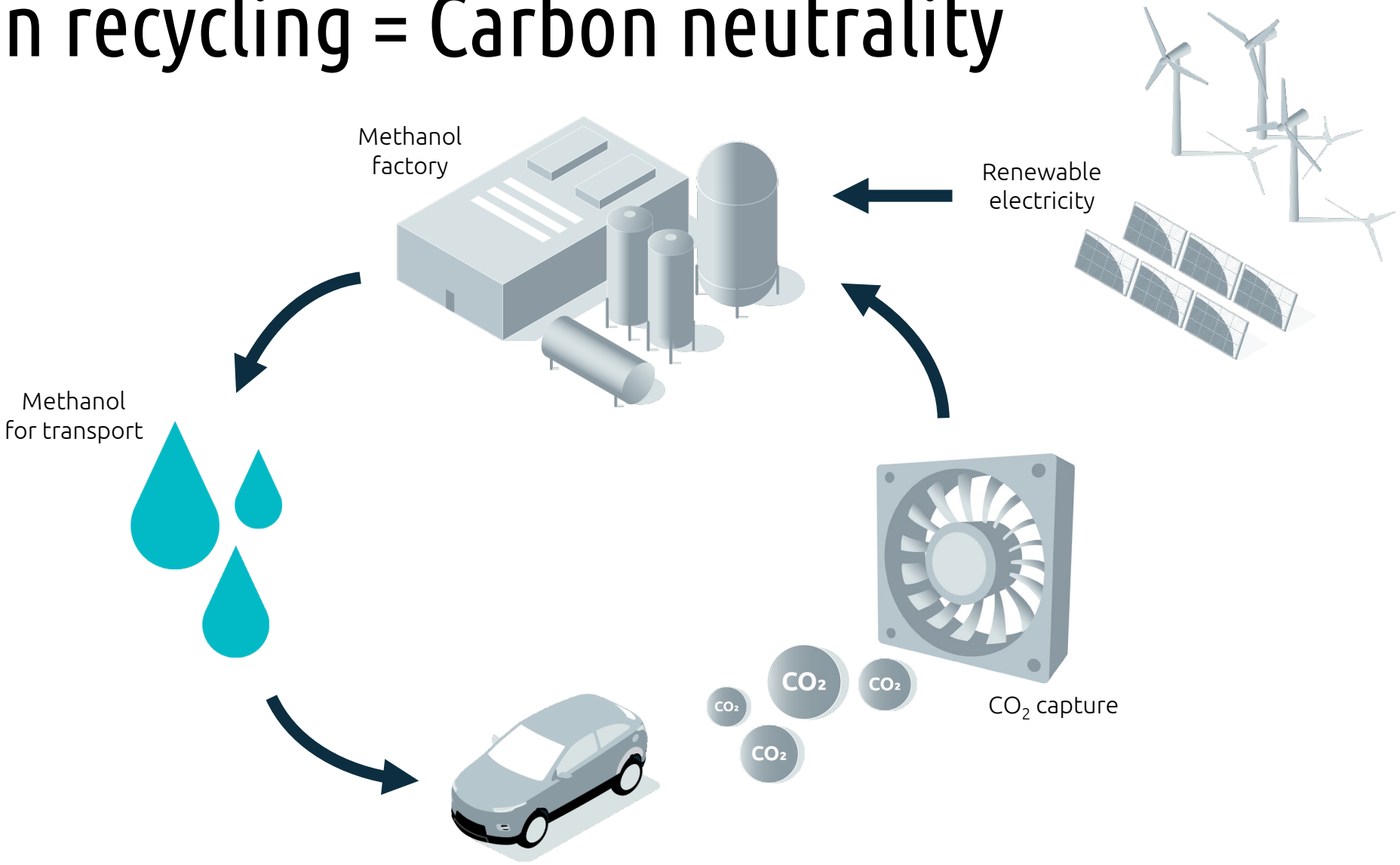
Today:
- Energy mix: oil, coal, natural gas, wind, solar, biomass

2050:
- Renewable energy sources: biomass, solar, wind, biogas



Source: Danish Department of Energy – Alternative drivetrains 2014

Carbon recycling = Carbon neutrality



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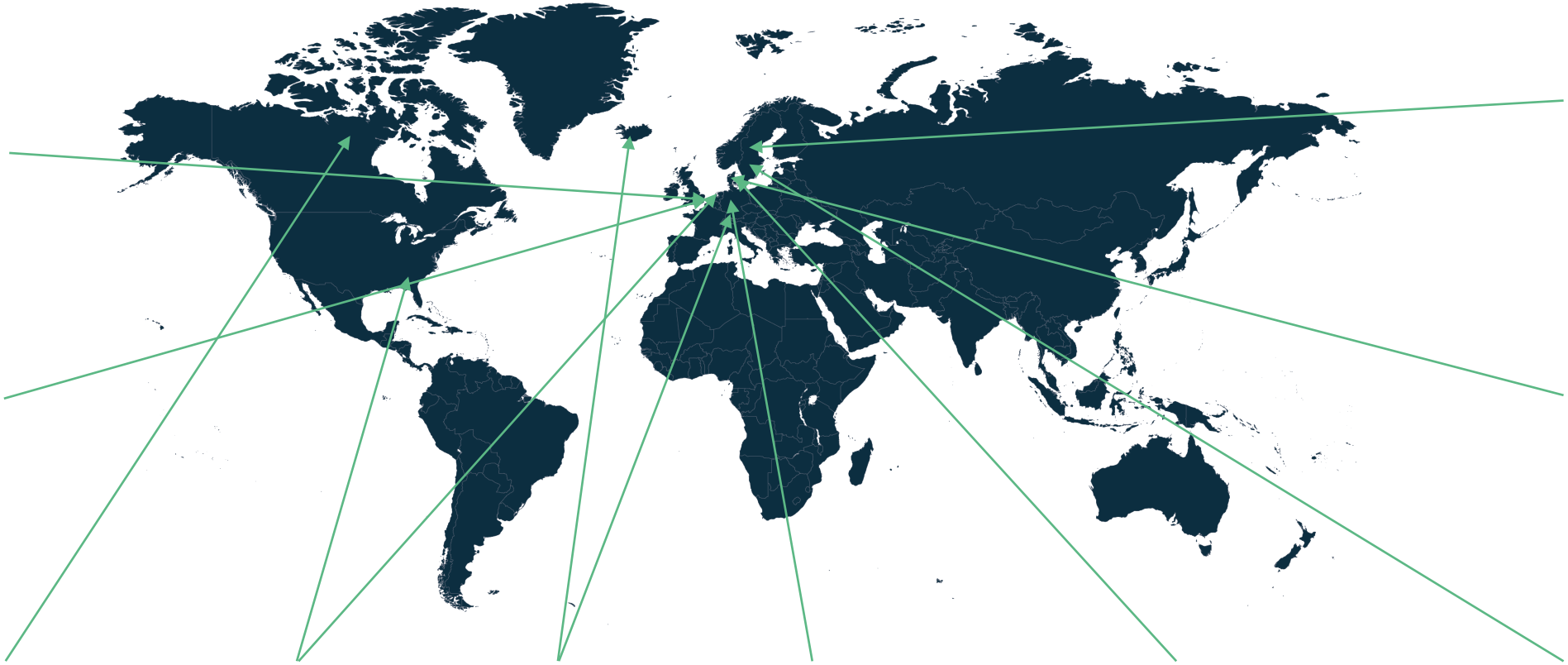
Renewable methanol map



WTC ROTTERDAM
Municipal waste

Port of Antwerp
Hydrogen synthesis

Liquid Wind
Electrofuel synthesis

Power2Met
Synthesis

Enerkem
Municipal waste

BioMCN
Biogas

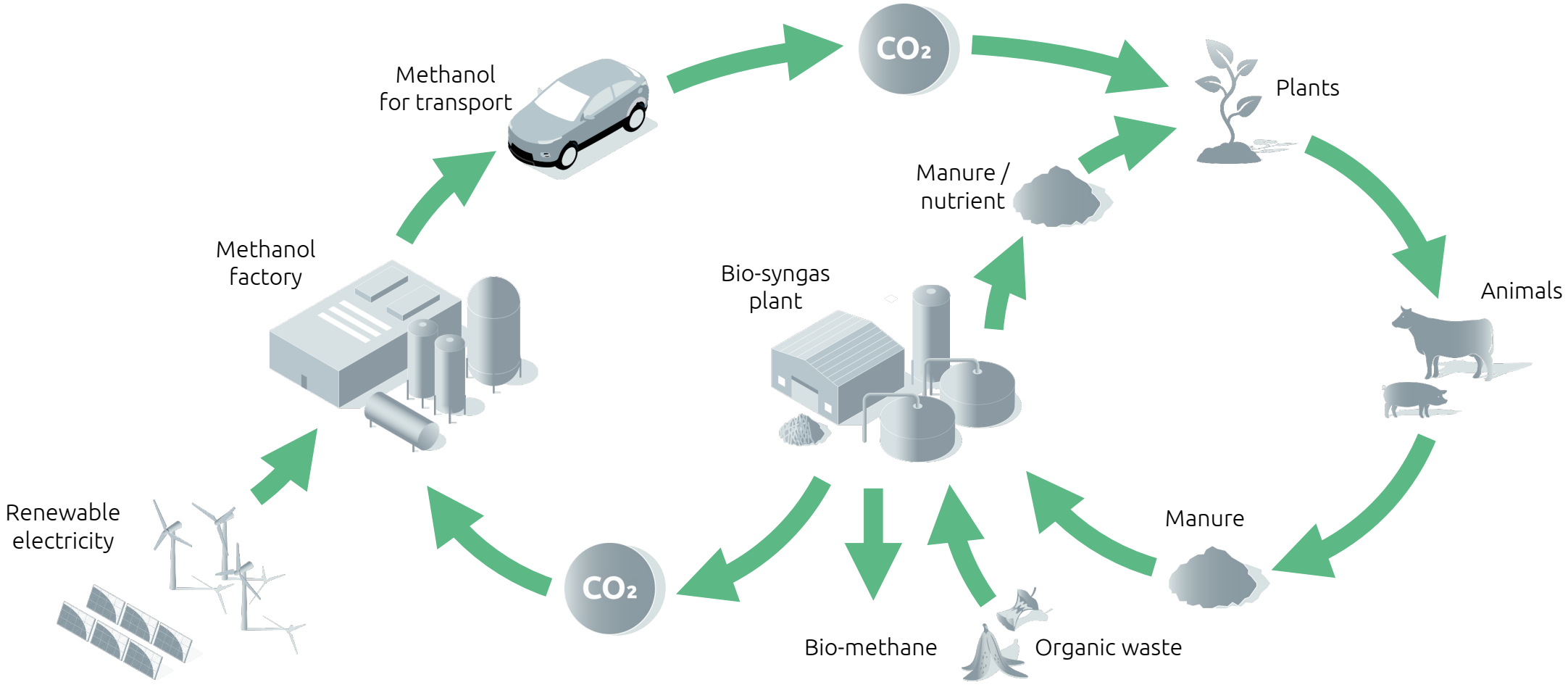
Carbon Recycling International
Hydrogen synthesis

BASF The Chemical Company
Biogas

New Fuel A/S
Biogas

SÖDRA
Wood waste

Carbon recycling = Carbon neutrality



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Power2Met; Biogas - CO_2 upgrading

Biogas production

CH_4 (methane)
1 t/h

CO_2
1.5 t/h

Heat

0,5 MWh

Methanol synthesis

1.1 t/h
CH_3OH

H_2
0.2 t/h

Electrolysis

2.5 MWh

Oxygen
0.1 t/h

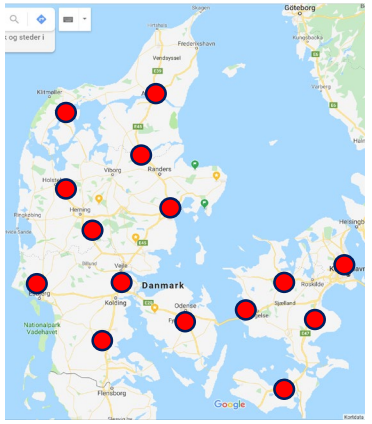
10.5 MWh

Renewable electricity

Source: Søren Knudsen Kjær, AAU, Power2Met

Infrastucture

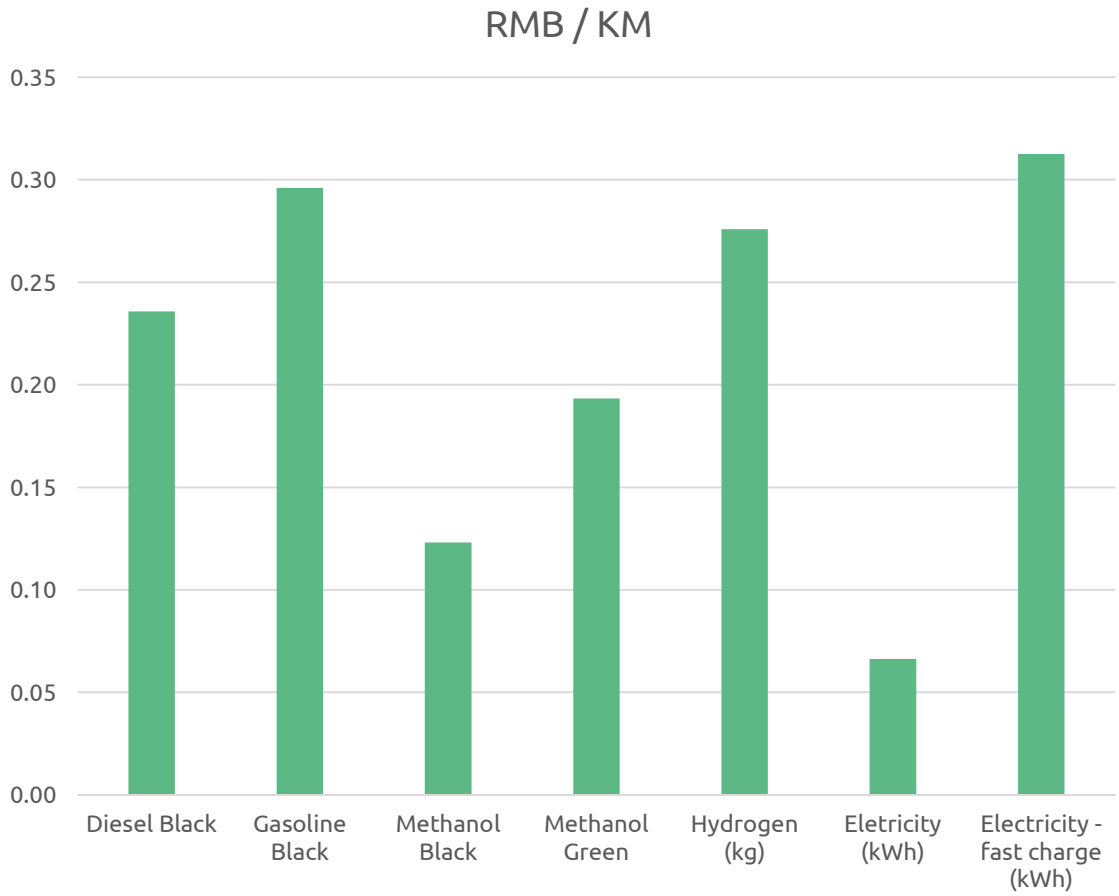
- Methanol can be implemented in existing infrastructure with minimum change
- Aalborg has had the first station since 2015
- Flexible roll-out to support first vehicles and test fleets
- Safe and cost-effective solution



Fuel cost

China example

- Green methanol is cheaper than diesel when using methanol fuel cell
- Electricity is cheap, BUT fast charging is NOT
- Hydrogen price is “future high volume”
- Charge electricity ONLY when renewable and cheap



Methanol fuel cells

- Enable electric vehicles
  - Long range
  - Fast refuelling time
  - Simple infrastructure
- The superior choice
- Fully clean
- Efficient and cost-effective

For further information please contact

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