



# Der Wasserstoffmotor als Baustein für die Defossilisierung im On- und Offroad Bereich

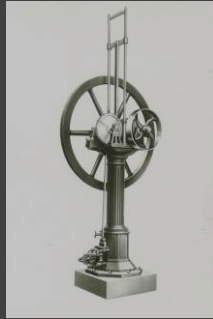
2. Heavy Duty Kongress - ZBT  
Duisburg | 24. Sept. 2024

Dipl.-Ing. Michael Halfen  
Head of innovation Center  
DEUTZ AG

## Founded in 1864: oldest engine factory in the world



Nicolaus A. Otto  
(1832-1891)



Engine no. 1  
(1867)



Factory in Cologne  
(~1900)

## Today: provider of drive systems for different applications



Construction Machinery



Material Handling



Agricultural Machinery

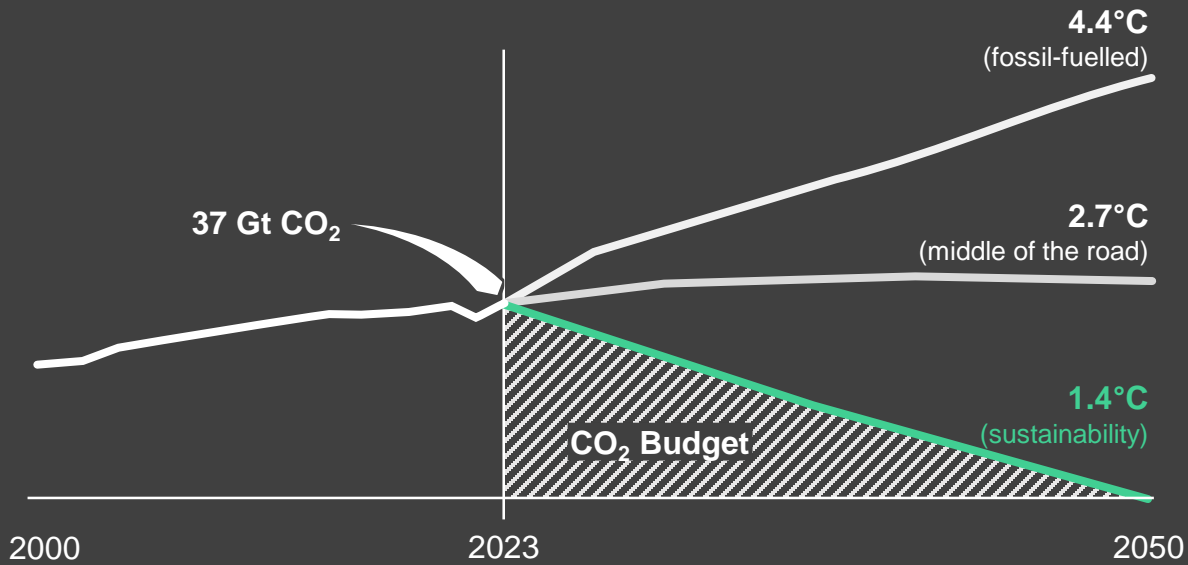


Stationary Systems

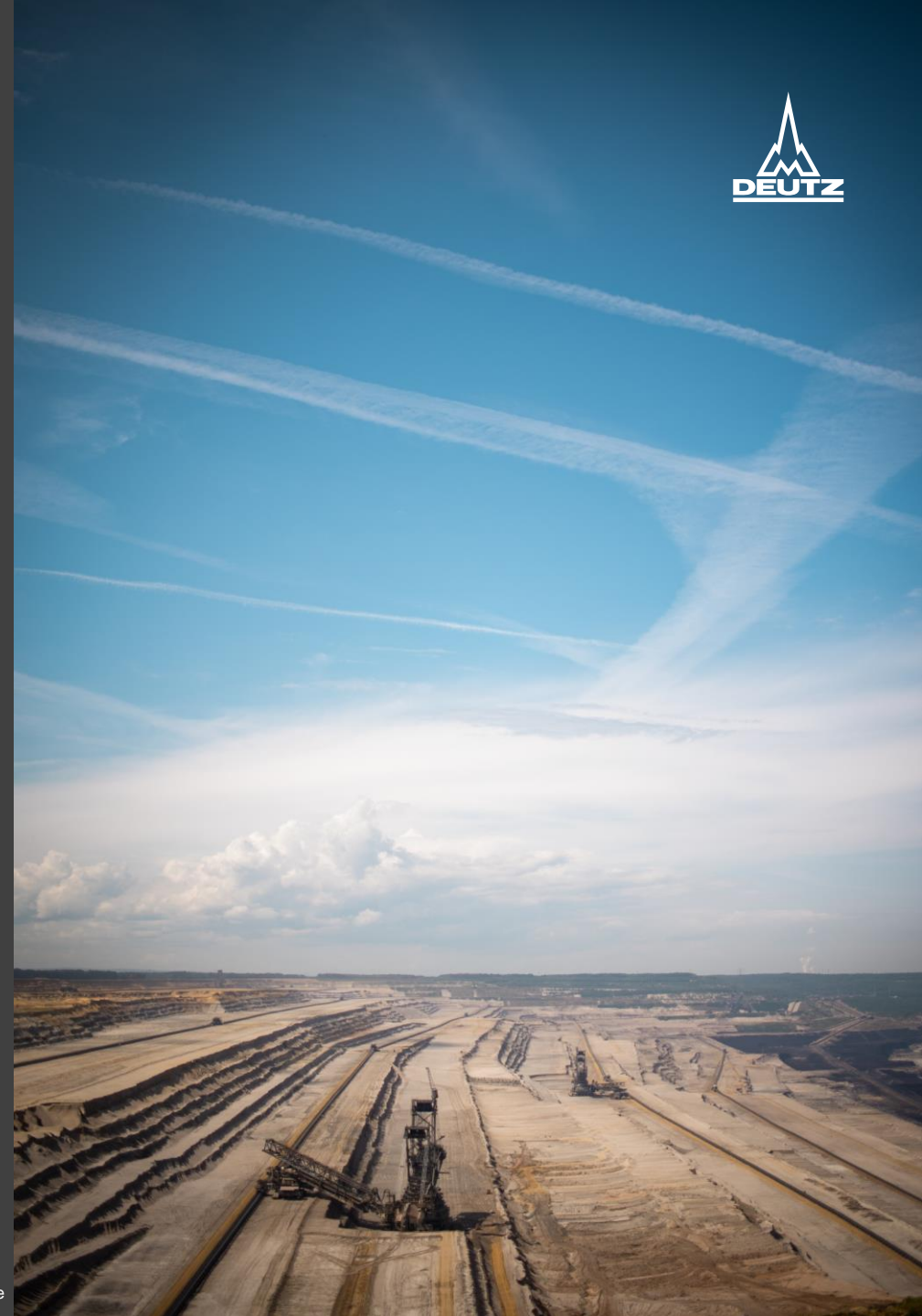
# Climate change is omnipresent



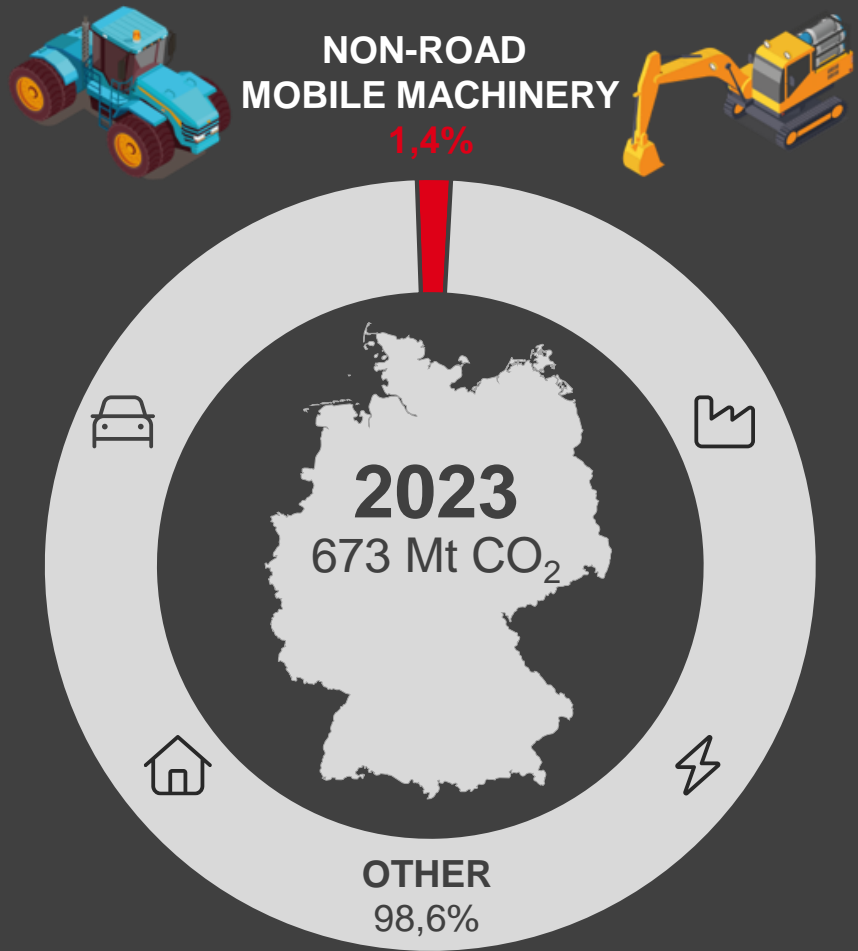
## GLOBAL annual CO<sub>2</sub> emissions



# THE PARIS AGREEMENT DEMANDS IMMEDIATE ACTION



Our industry might not have the biggest impact at first glance...



... but:



**>2.0 Million**

DEUTZ engines are in the global market



**~200.000**

DEUTZ engines are sold per year



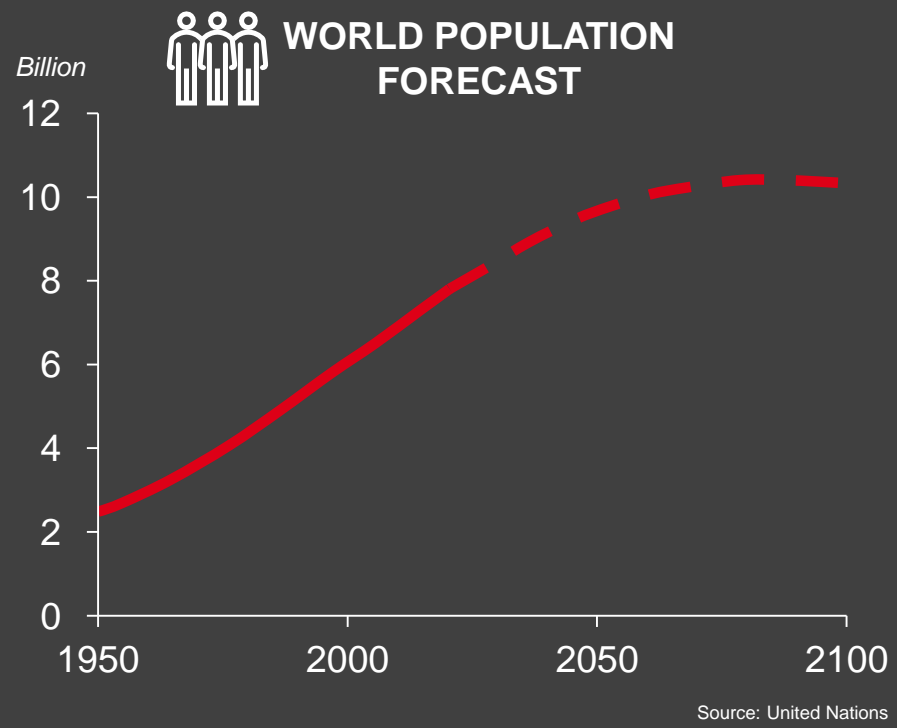
**Investment cycles**

are significantly longer than for cars & trucks

**WE ARE COMMITTED**

TO MAKING OUR PRODUCT ECOSYSTEM  
CLIMATE-NEUTRAL BY 2050

# The off-highway sector serves the key needs of mankind



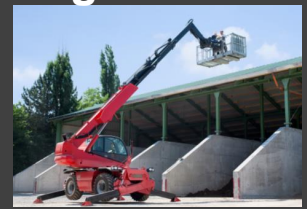
1

Infrastructure



2

Logistics



3

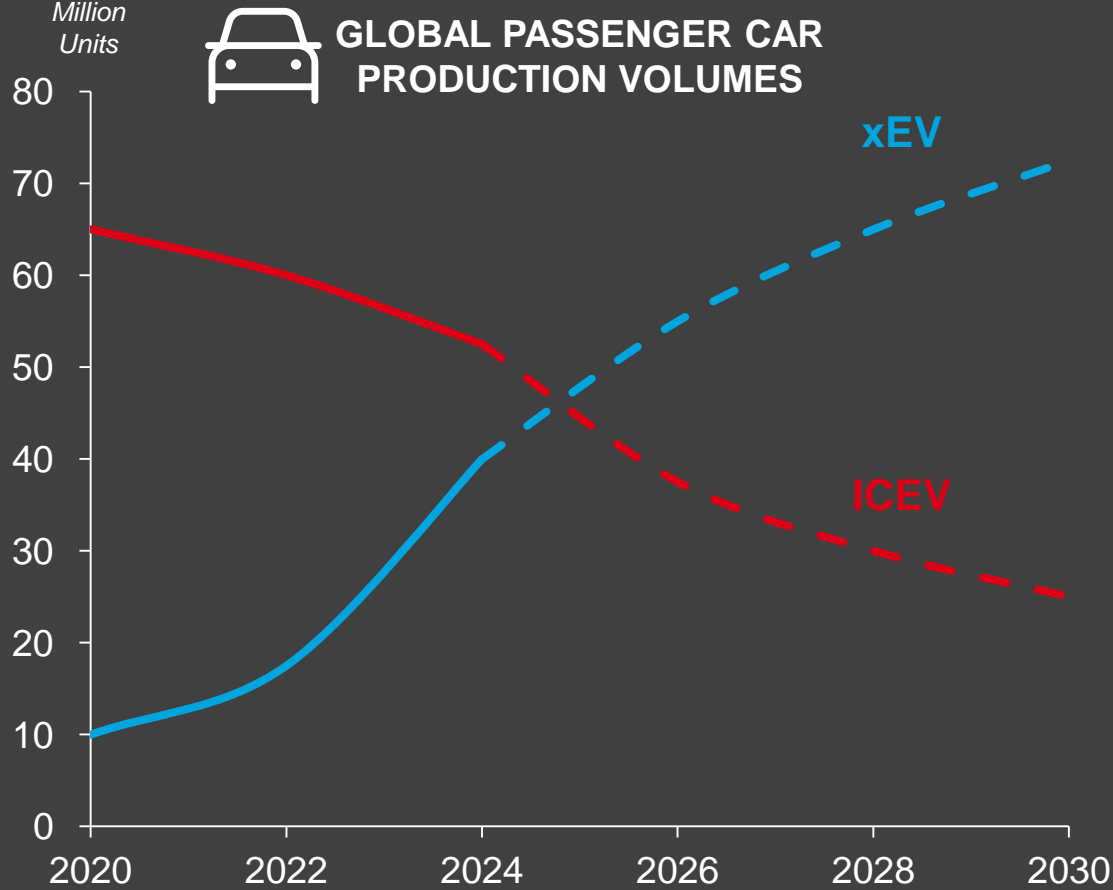
Food



## RENUNCIATION

IS NOT AN OPTION:  
WE NEED TECHNICAL SOLUTIONS

For some sectors, the decision has already been taken...



Source: G. Fraidl (AVL)



The off-highway industry is a little different



## HEAVY-DUTY

powertrains face high utilization in rough conditions



## REMOTE

lack of charging infrastructure



# All-electric also for the off-highway industry?



TESLA MODEL 3



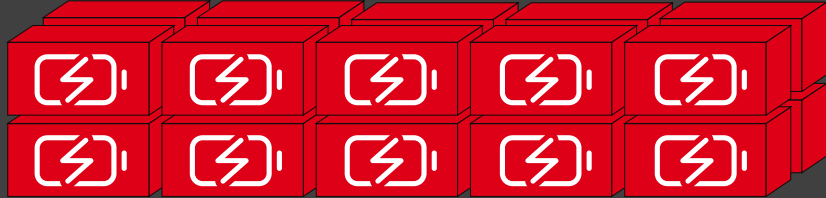
75 kWh – 500 kg



FENDT 800 VARIO



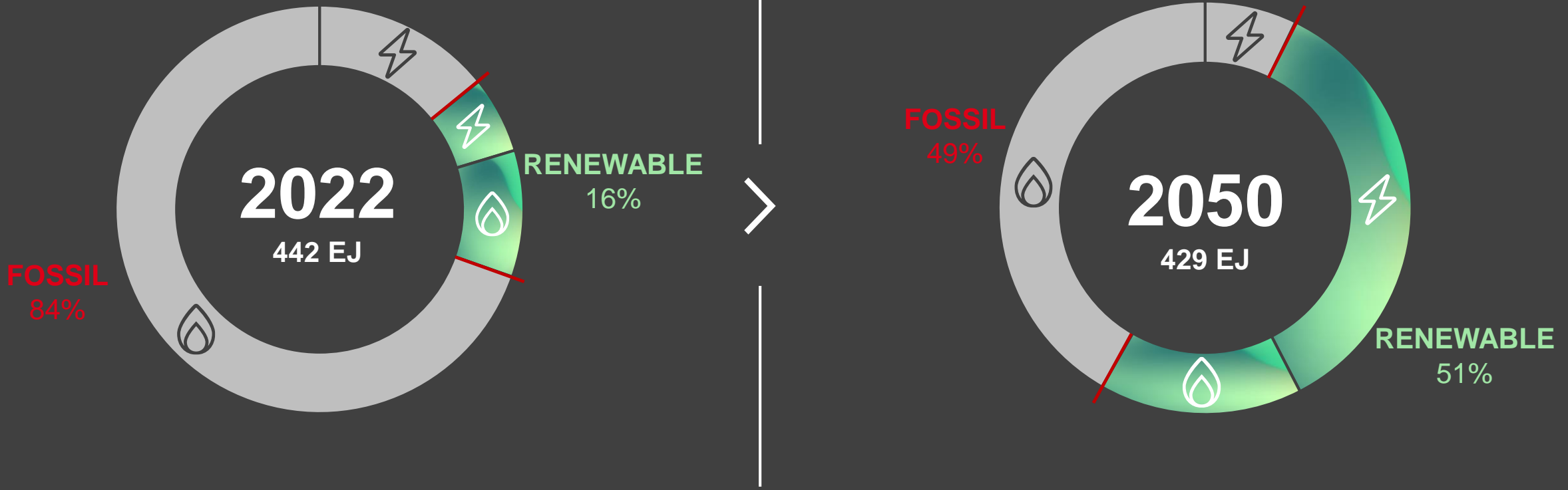
Source: Fendt



1500 kWh – 10.000 kg



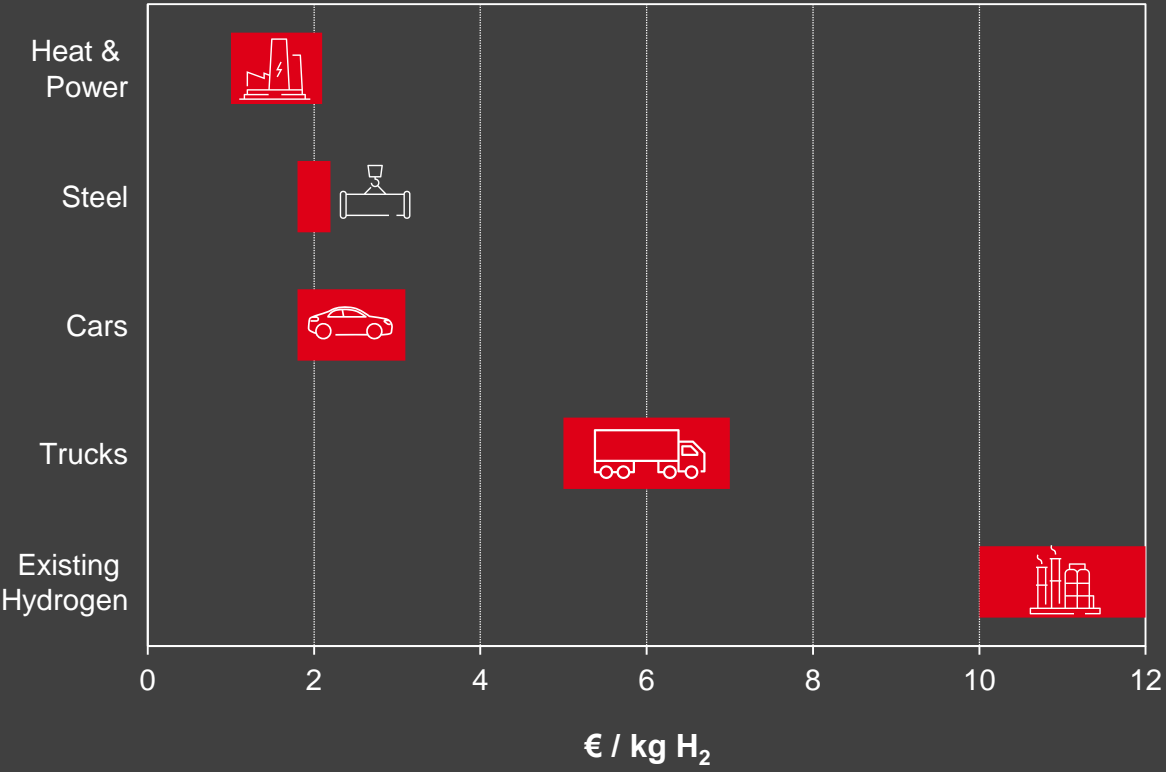
# Let's have a look at the physics: global final energy consumption



Source: IEA World Energy Outlook 2023 – APS Scenario

**Getting rid of fossil energy requires the ramp-up of sustainable fuels**

# Hydrogen breakeven cost in different industries



**WILLINGNESS TO PAY**  
for hydrogen in transport is higher than in other industries



# Our approach: A Pluralist Drive Mix Will Lead to a CO2-free Future



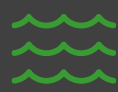
## SUSTAINABLE FUELS



Biodiesel



Alternative Fuels



Hydrogen



Synthetic Fuels

**DEUTZ**

**FUTAVIS**  
THE BATTERY EXPERTS

Blue World  
Technologies



## GREEN ELECTRICITY

48V Systems



36V Systems



Modular Battery Kit



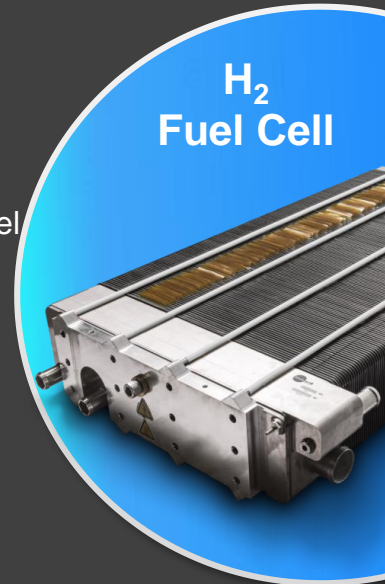
Fuel Cell



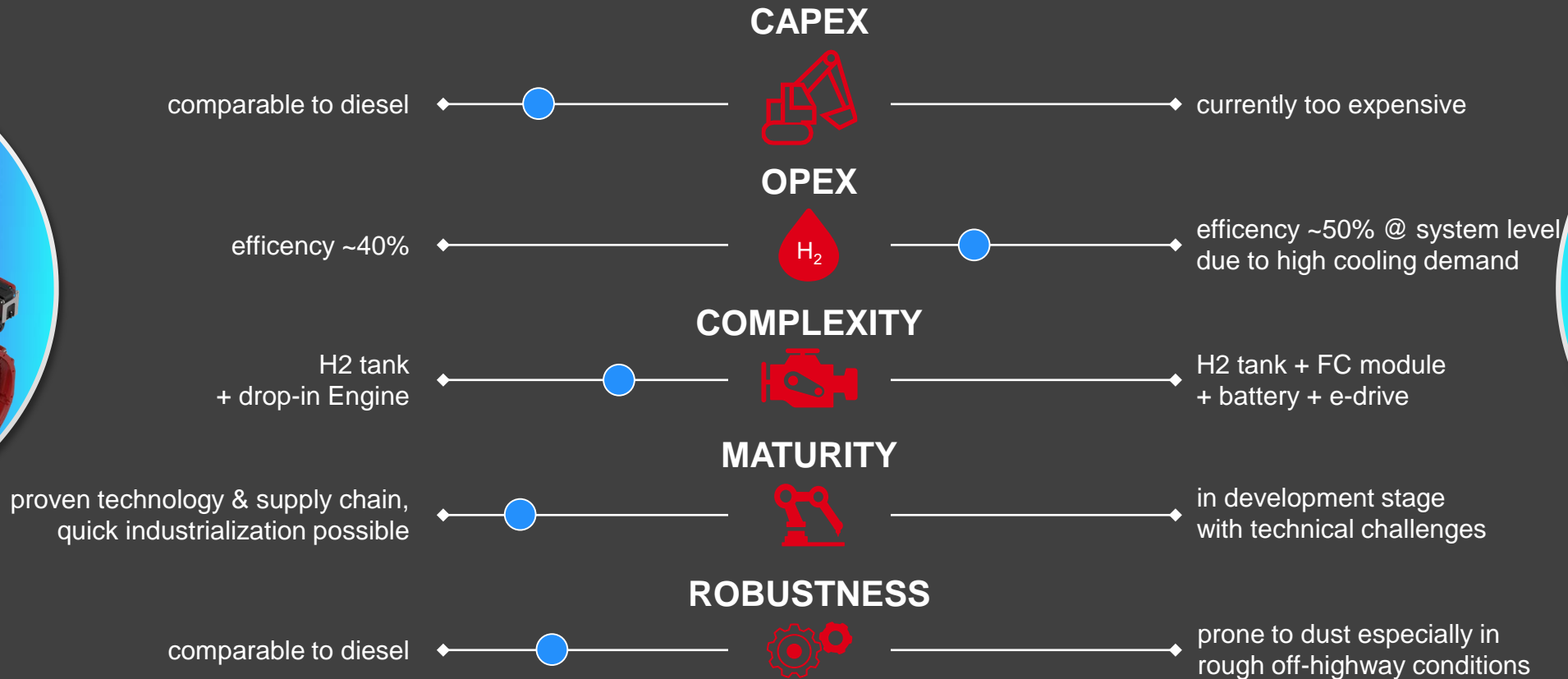
# H<sub>2</sub> combustion engines and H<sub>2</sub> fuel cells – two complementary technologies



H<sub>2</sub> ICE



H<sub>2</sub> Fuel Cell



Source: Blue World Technologies

H<sub>2</sub> ICEs offer a robust CO<sub>2</sub>-free technology, short time to market and diesel-like performance



H<sub>2</sub> fuel cells face some challenges, yet remain a viable technology for the future

# DEUTZ as a pioneer in the development of hydrogen combustion engines



## CO<sub>2</sub>-FREE TECHNOLOGY

Meets current emission limits for zero-emission heavy-duty vehicles (<1g CO<sub>2</sub>/kWh)



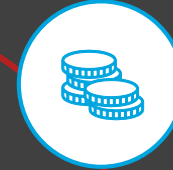
## HIGH PERFORMANCE

Power density and efficiency comparable to diesel engine



## ECONOMICAL ALTERNATIVE

Attractive overall cost perspective



## HIGH RELIABILITY

Based on well-known engine technology  
Quick Industrialization possible



DEUTZ TCG 7.8 Hydrogen Engine

**H<sub>2</sub>DEUTZ**  
HYDROGEN TECHNOLOGY



1<sup>st</sup> Engine on test bench



2021



1<sup>st</sup> Demonstrator



2022



Order for small series  
of H<sub>2</sub> GenSets for China



2023



Field testing  
and prototypes



2023 – 2024

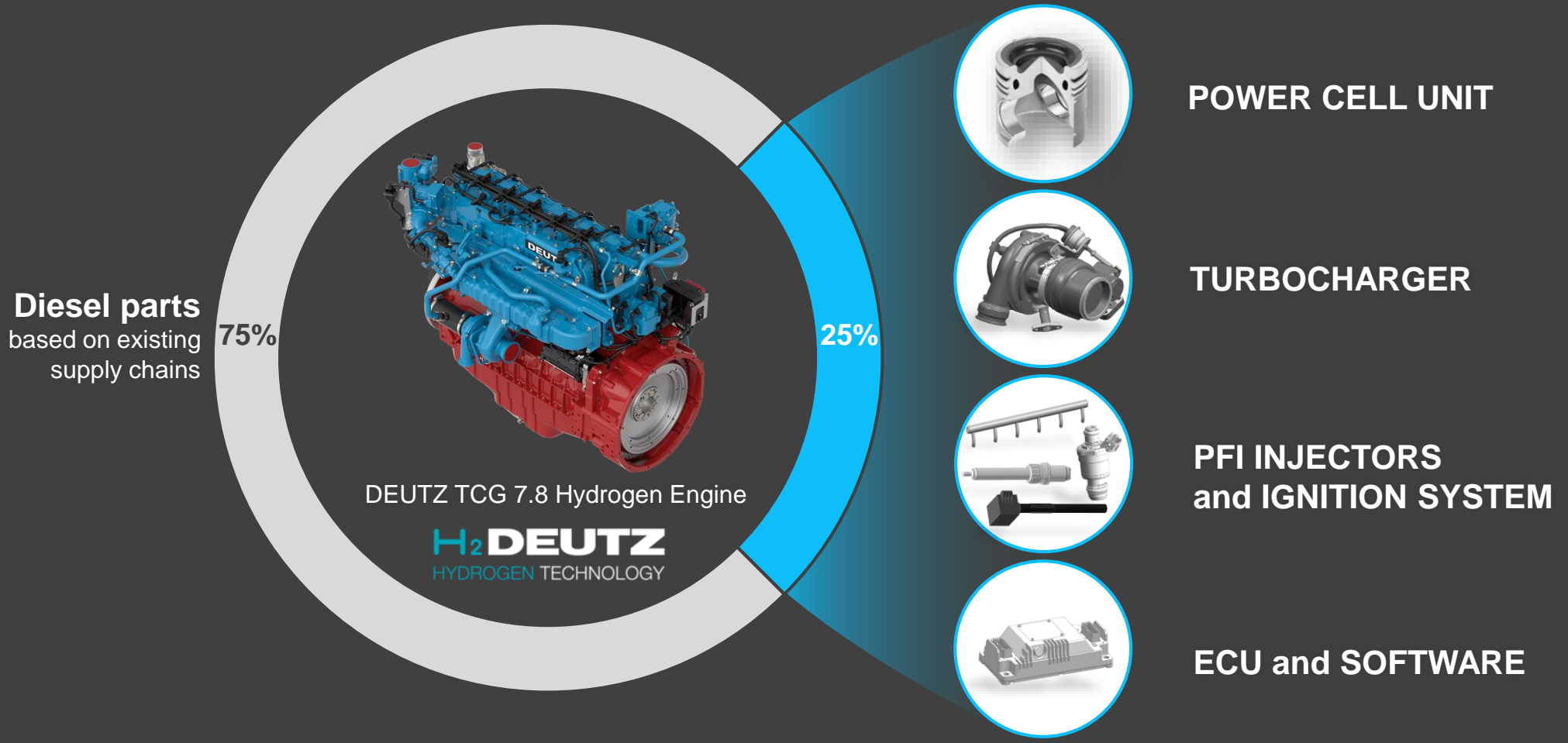


Series production



2024

Based on 160 years of knowledge, the hydrogen engine is a consistent progression

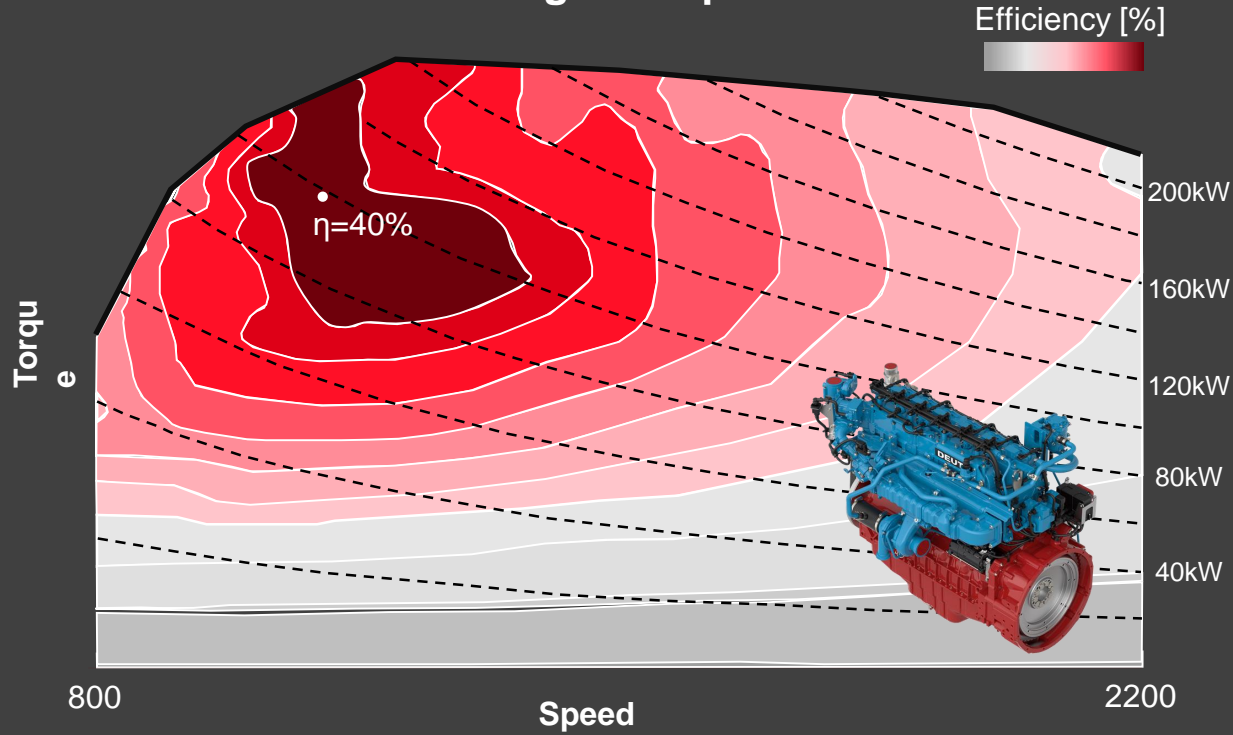


With ~75% equal parts, the H2 engine is close to our established diesel platform

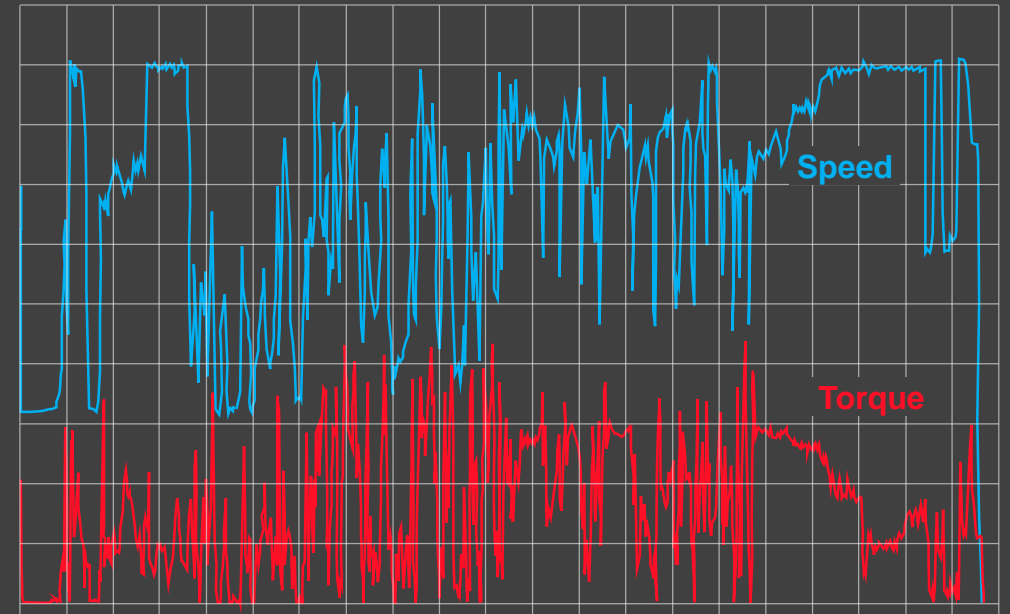
# TCG 7.8 H2 – performance data



### Engine Map



### Nonroad Transient Cycle (NRTC)



**Diesel-like performance**

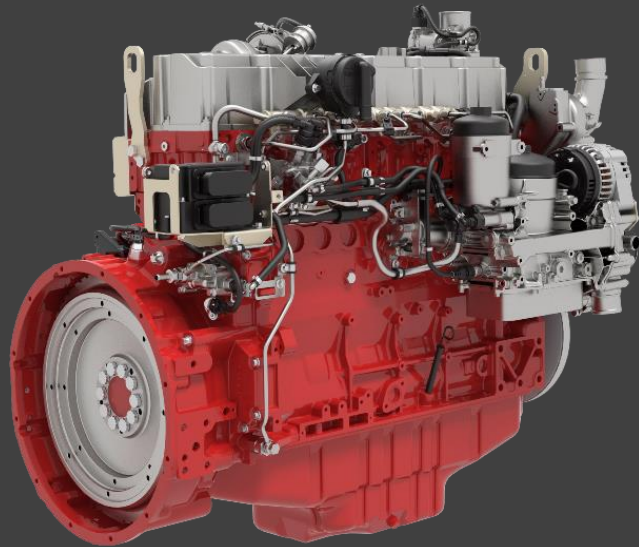
**Transient operation is a challenge**

# H<sub>2</sub> ICE: NVH behavior compared to diesel engine



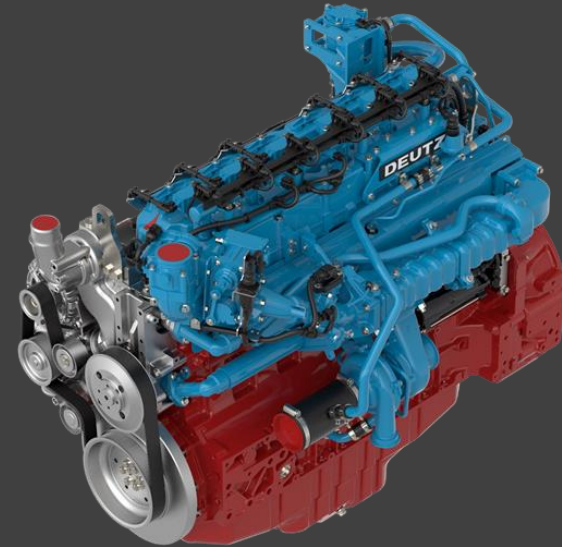
## Diesel Engine

TCD 7.8 | Full Load



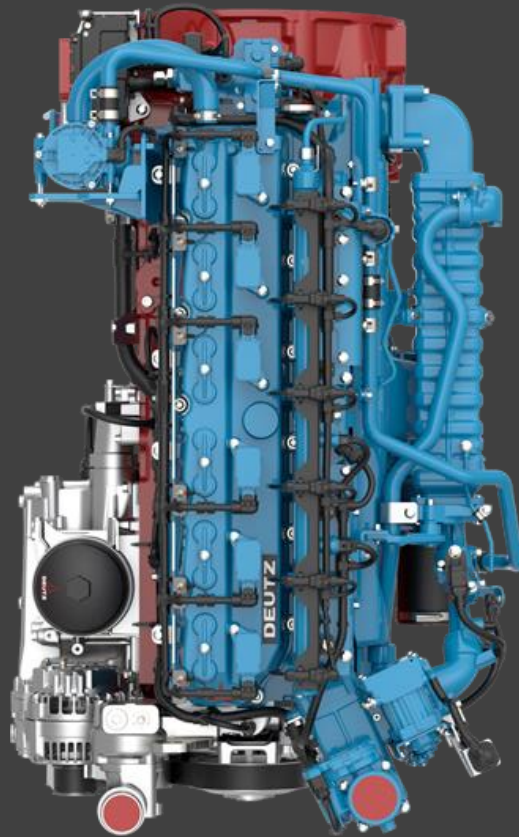
## Hydrogen Engine

TCG 7.8 H<sub>2</sub> | Full Load





Despite this track record, there is still a lot ahead of us



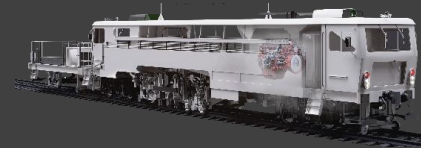
**1** STATIONARY  
POWER  
GENERATION



**H2 GenSet**

📅 First serial order from China

**2** RAIL  
APPLICATIONS



**Train**

📅 Innotrans 2024

**3** DELIVERY  
TRUCK



**HyCET – Distribution Truck**

📅 Prototype 2024

**4** OFF-  
HIGHWAY  
APPLICATIONS



**H2-MAM – Hydraulic Excavator**

📅 Prototype 2025

**Pilot series for stationary application scheduled for fall 2024 – transient operation is a challenge**


# DEUTZ will demonstrate the use of green H<sub>2</sub> from generation to consumption



Industrial use of  
**hydrogen**




Pilot plant start  
January

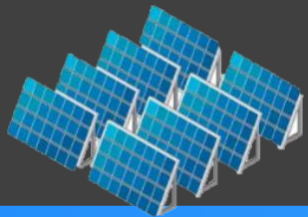


**2025**

Covering  
the entire



**value chain**



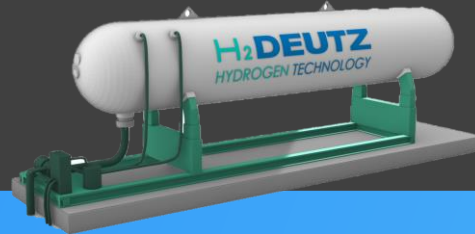
**1**

**PHOTOVOLTAICS**



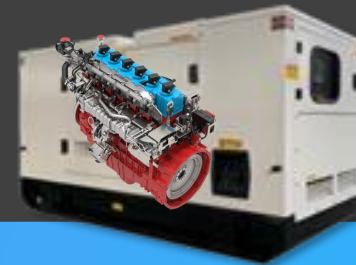
**2**

**ELECTROLYZER**



**3**

**HYDROGEN STORAGE**



**4**

**GENSET  
POWERED BY DEUTZ**



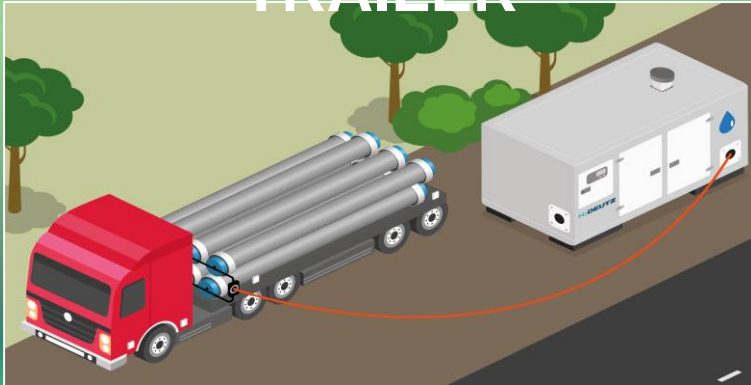
**5**

**CORPORATE  
BUILDINGS**

# Hydrogen refueling scenarios in off-highway conditions



## TUBE TRAILER



## MOBILE SUPPLY



## H<sub>2</sub> FUELLING STATION



# But sometimes tech moves quicker than one thinks



From one car among horses...

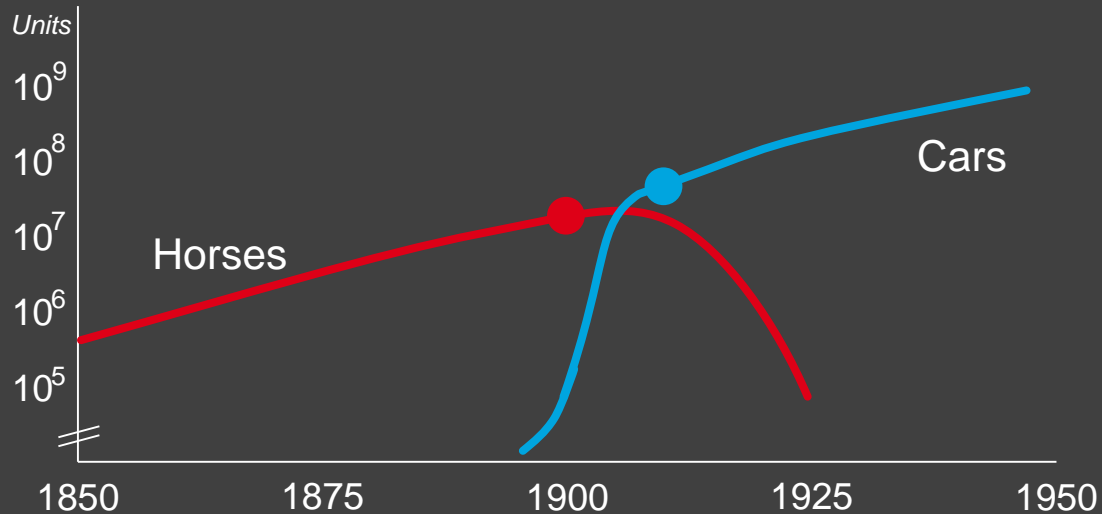


1<sup>st</sup> of April 1900, 5<sup>th</sup> avenue

... to cars only in 13 years



1<sup>st</sup> of April 1913, 5<sup>th</sup> avenue



Source: US National Archive



“

*We always **overestimate** the change that will occur in the next two years and **underestimate** the change that will occur in the next ten*

~ Bill Gates

# WE ENSURE THE WORLD KEEPS MOVING



1867



2024

Products are  
available –  
what we need is a  
**comprehensive  
green energy  
system**