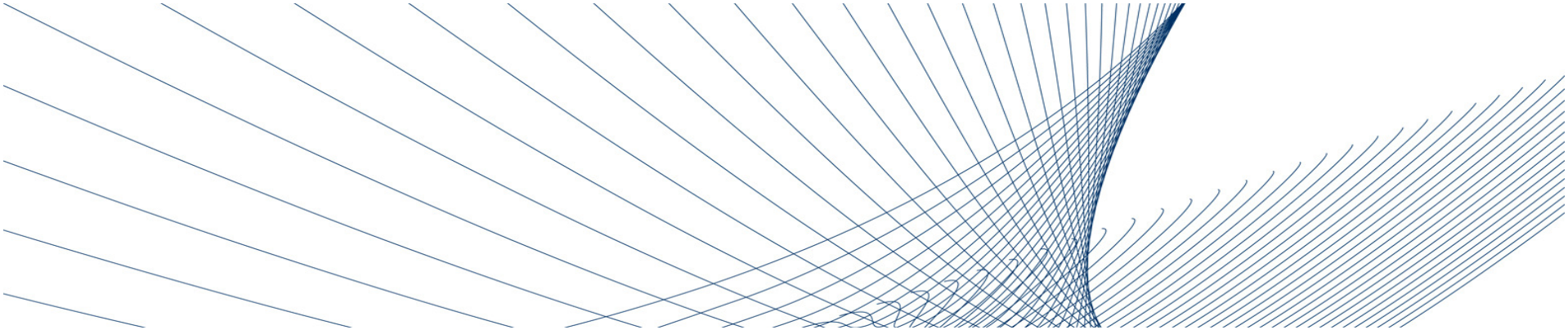
VOLKSWAGEN

AKTIENGESELLSCHAFT



Energy-efficient Mobility: Challenging Technologies for Tomorrow's Transportation Systems

Prof. Dr.-Ing. Wolfgang Steiger

Volkswagen AG, Group External Affairs
Chairman ETP ERTRAC

16.02.2009 EIT Sustainable Energy Seminar, Vienna, Austria

7 Mega Trends with Effects

Volkswagen's Fuel- and Powertrain Strategy





Renewable

Electricity

Battery E-Drive

Hydrogen

Fuel Cell E-Drive

SunFuel®

CCS®

Hybrid

TDI®/TSI®

DSG®

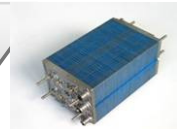
Natural Gas

SynFuel

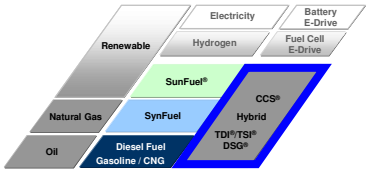
Oil

Diesel Fuel

Gasoline / CNG

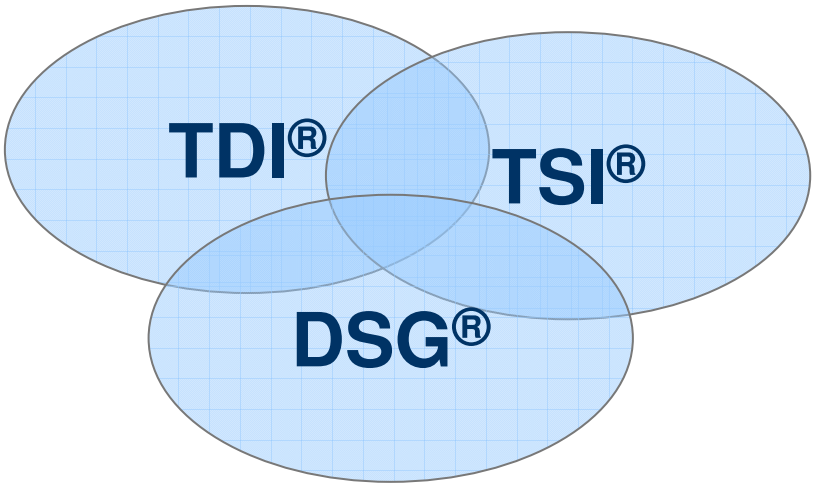




Innovative Powertrain Strategy by Volkswagen



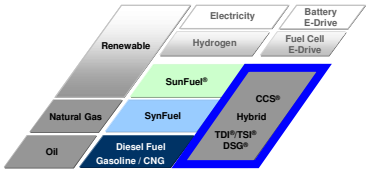
High Charged Direct Injection Engines and outstanding Dual Clutch Transmissions by VW are Pacemakers in the Field of low Consumption and high Drivability

- **TDI** since **1992**
- **DSG** since **2003**
- **TSI** since **2004**

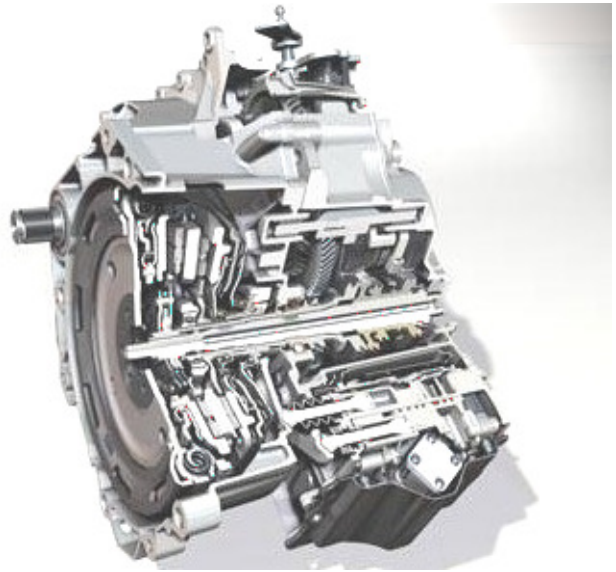


The Combination of TDI® - or TSI® - Engines with DSG® - Transmissions setting Targets in Consumption Comfort and Drivability

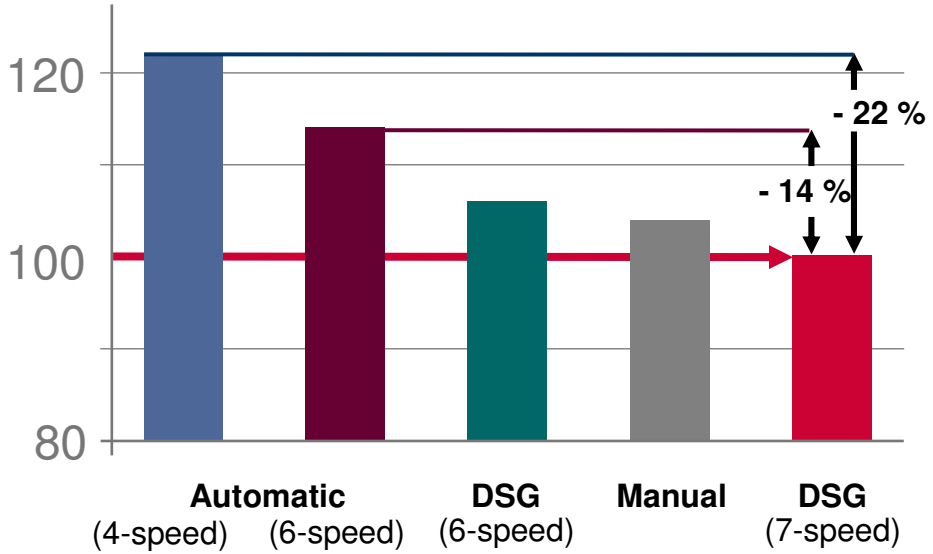
DSG Dual-Clutch Gearbox



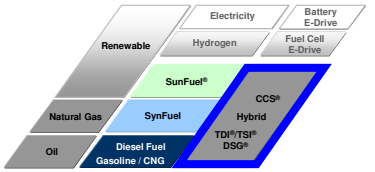
- 6 / 7-speed direct shift gearbox
- Consumption lower than manual gearbox
- Shorter shift times without interruption in power flow
- Maximum shifting comfort



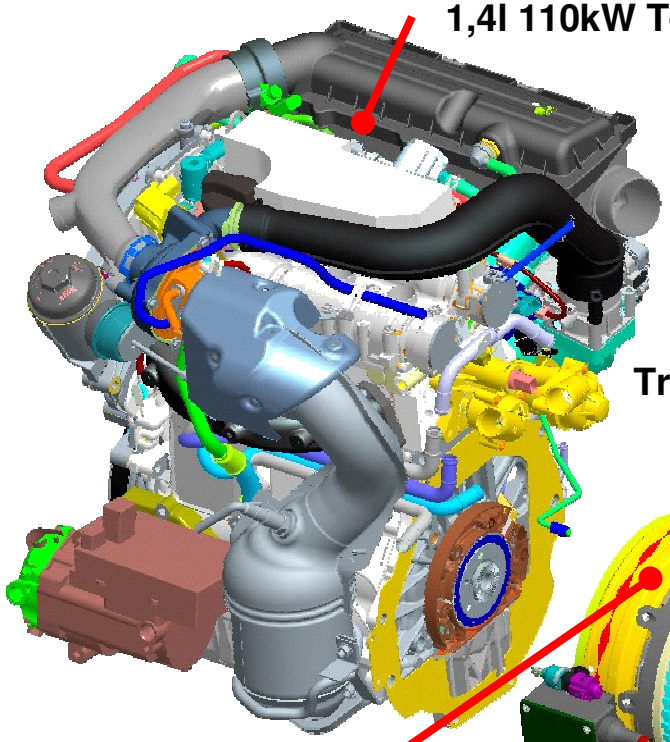
Rel. Fuel Consumption [%]



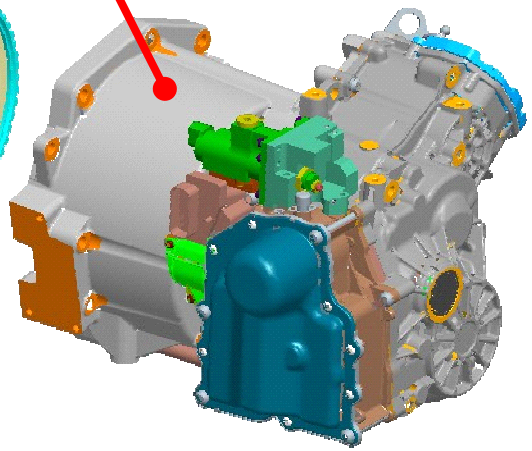
Hybrid Powertrain 1,4l T-FSI with DQ200



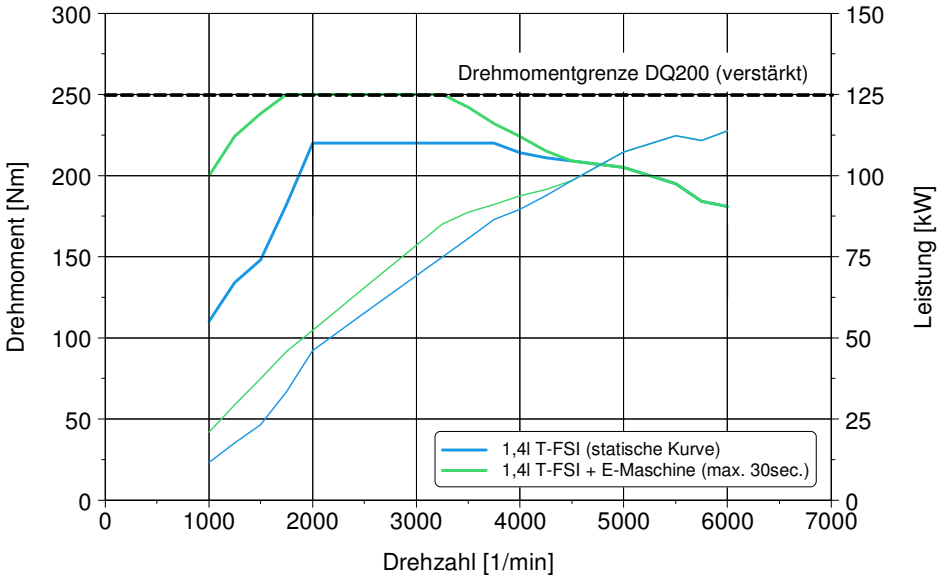
Combustion Engine
1,4l 110kW T-FSI



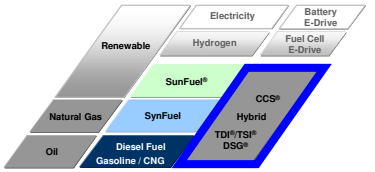
Transmission DQ200-7



E-Motor (20kW) + Clutch
(Impulse Start Module)



Passat TSI EcoFuel



Engine 1.4l TSI CNG
6-speed-manual/ 7-speed-DSG transmission
Euro-5-Emission level

Power	110 kW / 150 hp
Torque	220 Nm (1.500 – 4.000 rpm)
Max. speed	210 km/h

Consumption 4,9 kg / 100 km

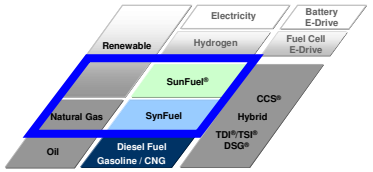
CO_2-Emissions 129 g / 100 km

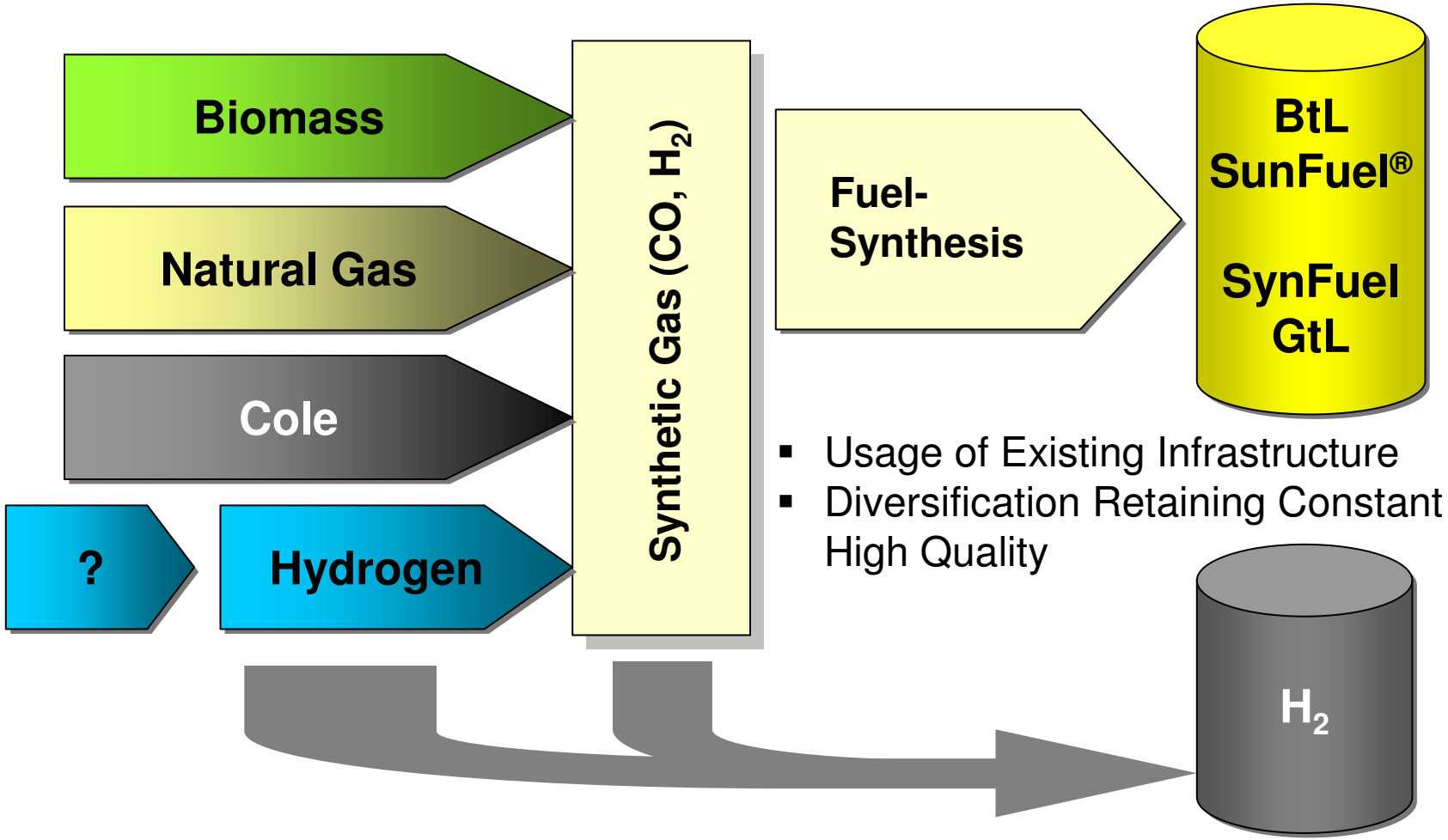
Mileage total mileage 820 km

Natural gas mileage 420 km
storage capacity 135 Litre (22 kg)

gasoline mileage 400 km
fuel tank capacity 31 Litre

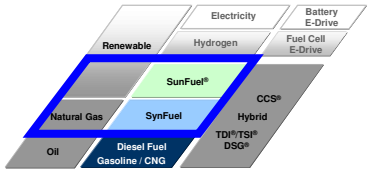
Synthetic Fuels
Diversification in Energy Sources





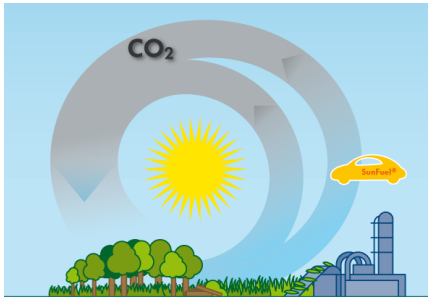
- Usage of Existing Infrastructure
- Diversification Retaining Constant High Quality

Improvements by Synthetic Fuels

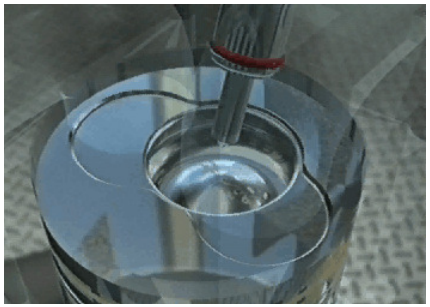


- Direct Improvement of Local Air Quality by Usage of Synthetic Fuels in Existing Vehicles Based on the Outstanding Purity of the Fuels

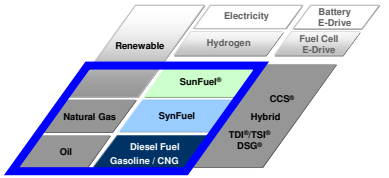
- Reduction of Global CO2-Emissions if Biomass is Used as Primary Energy for Synthetic Fuels



- Possibility to Develop New Combustion Systems with Widely Improved Characteristics Based on the Designability of Synthetic Fuels

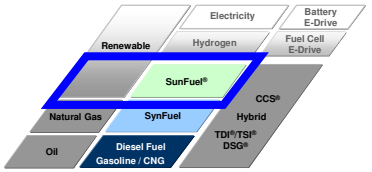


Sustainability Issues for Biofuels



GHG performance	Certification for production sites and raw material
Land use & biodiversity	Land efficiency - risk of mono cultures - use of pesticides and fertilizers
Raw material	Social impacts – usage of food materials – influence on food prizes
Substitution Potential	Is a Substitution of Existing Fuels Possible by More than 10 %?
…	

Characterization of Various Bio Fuels



1st Generation

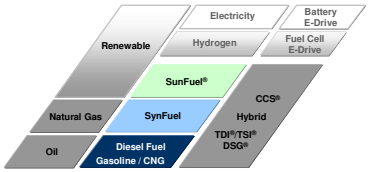
- Biodiesel (Rapeseed)
- Ethanol (Wheat, Sugar Beet)

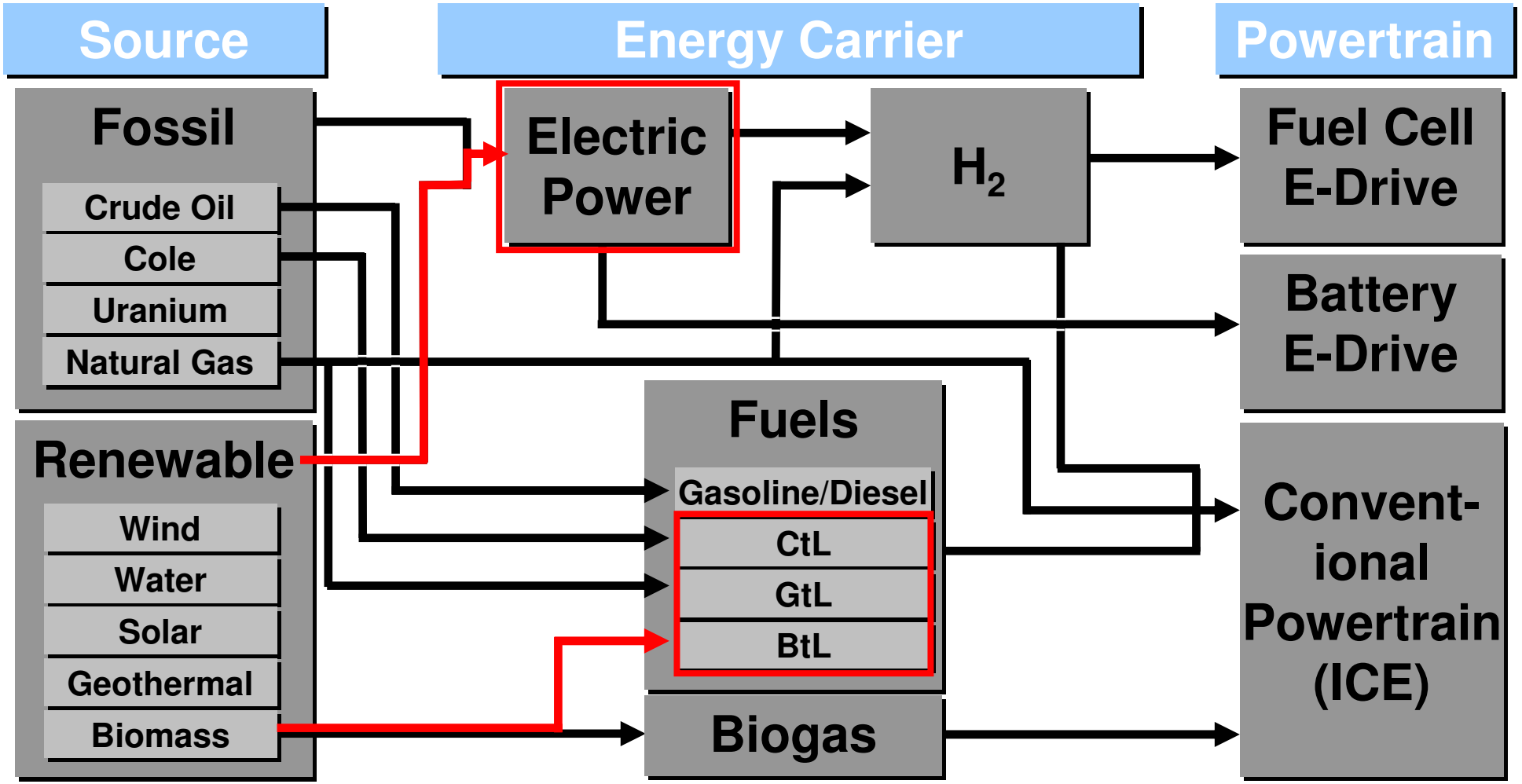
2nd Generation (SunFuel®)

- Biomass to Liquid (Choren)
- Cellulose Ethanol (Iogen)

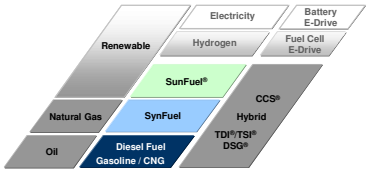
- **High CO_2 Avoidance Potential**
- **No Interference in the Food Chain**
- **High Hectare Yields**

Energy Pathways
Overview





2 Way Roadmap to "Sustainable Powertrains"



Focus: Combustion Power

Zero Impact Powertrain

Integrated Hybrid

Topics

- *Single Cylinder Displacement > 400 cc*
- *Optimized Combustion (CCS®/GCI)*
- *Optimized Fuels XTL*
- *Total Emission Reduction*
- *High Charging, Friction Reduction*
- *Fully Variability (Air/Fuel)*
- *E-Technology-Integration in Powertrain*
- *High Power Battery*

Topics

- *Single Cylinder Displacement < 250 cc*
- *Combustion Optimization for high Load (no HCCI)*
- *Emission Reduction at Full load*
- *High Charging, Friction Reduction*
- *High Power Electric Motor*
- *High Energy Battery*
- *40-50 kW –FC-Stack*

Full-Hybrid

Plug-In-Hybrid

Mild-Hybrid

TwinDrive Plug-In

Combustion Engine

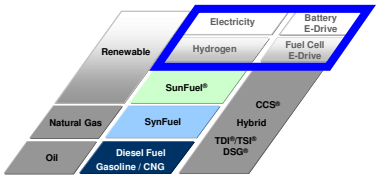
Development & Production

E-Drive with Range Extender

Long Distance-E-Drive

Focus: Electric Power

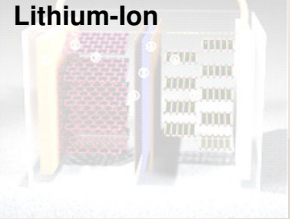
Challenges for Electrical Energy Storage Systems in Vehicles



Energy

All Electric mileage,
availability, Comfort consumers
Charging time, -infrastructure

Future Technology: Lithium-Ion



Cost

Economy,
Market acceptance,
Recycling

Power

Drivability,
Performance,
Dynamic,

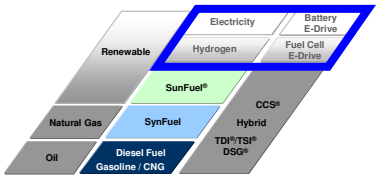
Durability

Cycles, Lifetime

Safety

failure, Accident,
Misuse, Service,
Comfort, Reliability

Evolution in High Energy Storage Technology



Pure electric mileage NEDC [km]

500

150 75

130 65

110 55

EV 200 l

Plug-In 100 l

Golf Platform
1500 kg, 18 kWh/100km

Revolutionary Change in Technology

1500 Wh/kg* 1000 W/kg

Limit for Lithium-Ion Technology

| New Materials

200 Wh/kg* 1000 W/kg

|Evolutionary Development|

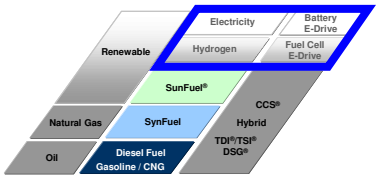
170 Wh/kg* 800 W/kg

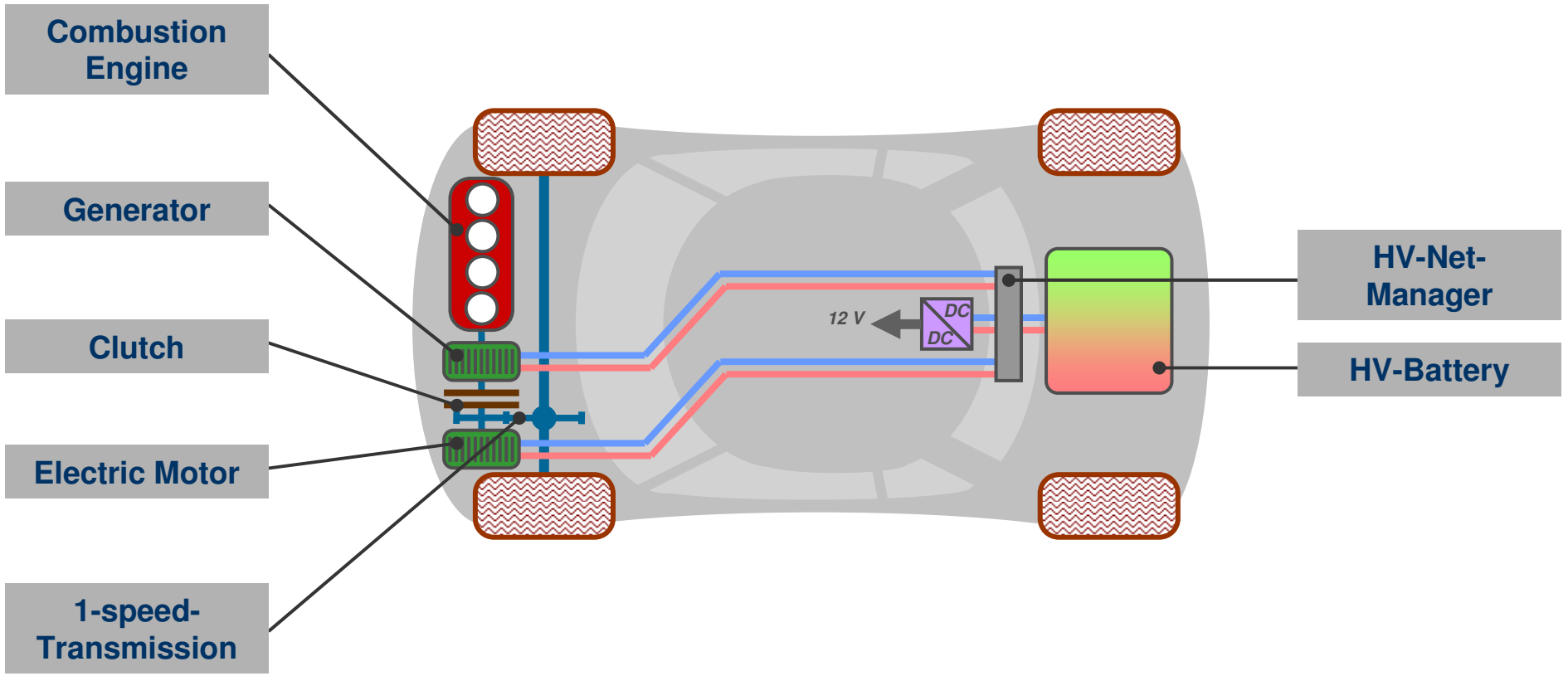
140 Wh/kg* 600 W/kg

*) Energy Density based on Cell Weight

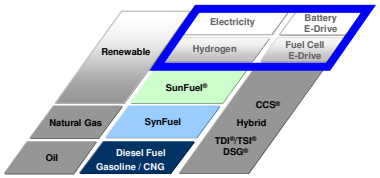
2008

twinDRIVE: Powertrain Cencept





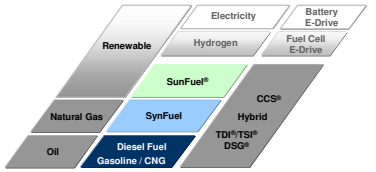
Space up! Blue - Zero Emission Van

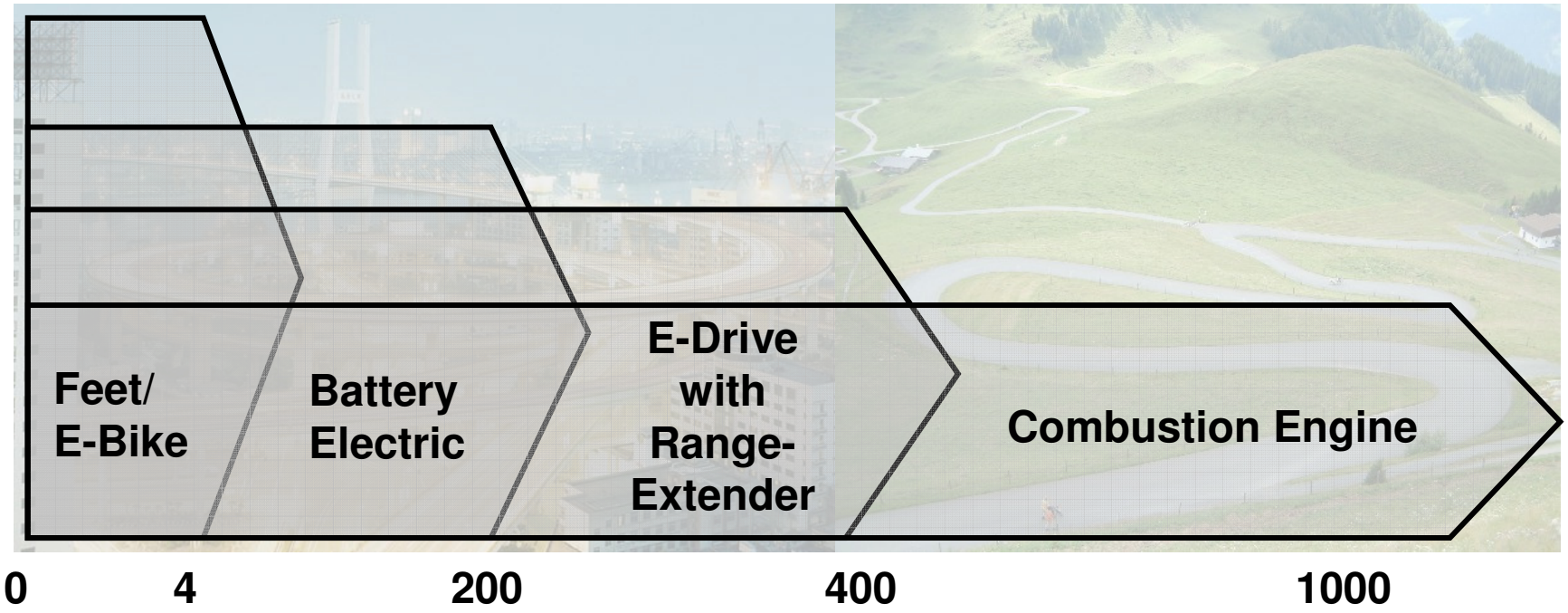


Electric Drive
with
Lithium-Ion Battery
and
HT-PEM Fuel Cell
as
Range-Extender

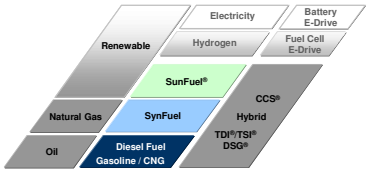
Size	**3680x1630x1570 mm**	**Electric Drive**	**45 kW 120 Nm**
Seats	**4**	**Battery**	**Li-Ion 12 kWh**
speed$_{max.}$	**120 km/h**	**Fuel Cell**	**High Temperature**
0-100 km/h	**13,7 sec.**	**Hydrogen**	**700 bar 3,3 kg**
Zero Emission		**Mileage Battery**	**100 km**
mileage	**350 km**	**Mileage H2**	**250 km**

Adapted Powertrain Concepts for individual Mobility

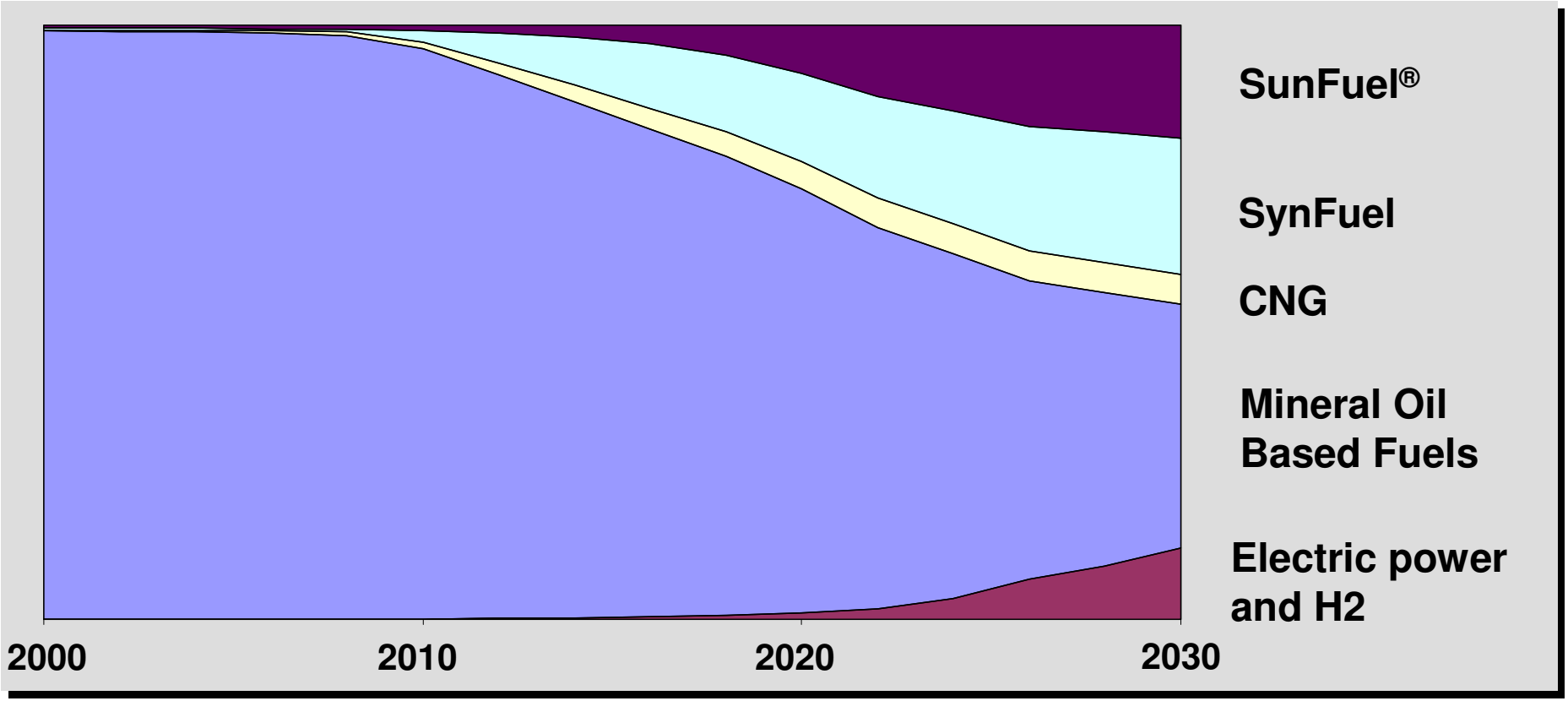


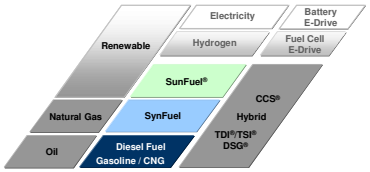


Energy Carrier in Mobility



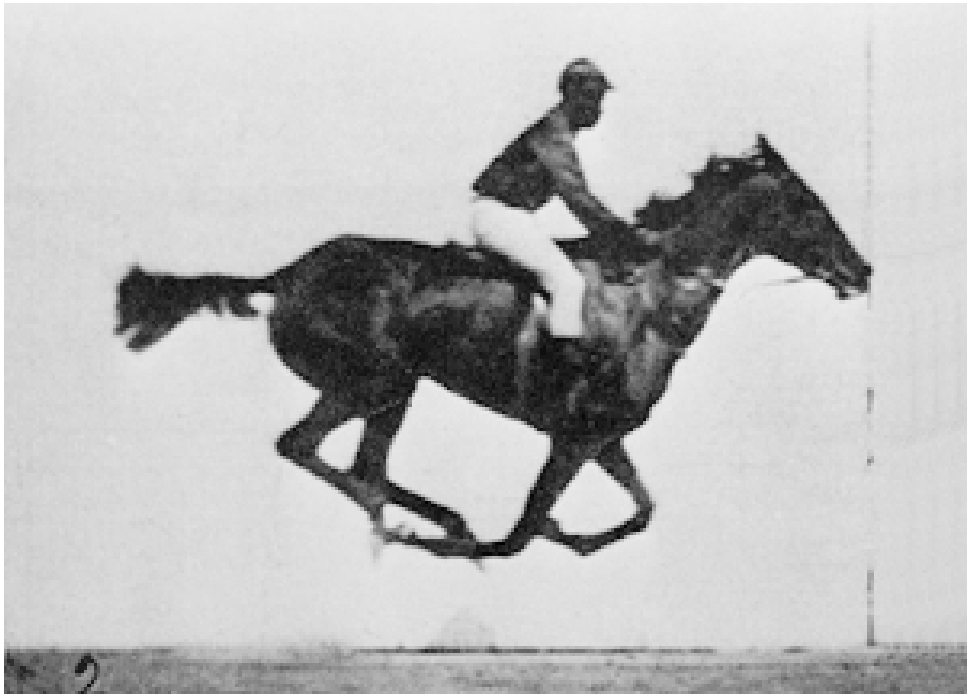
A European Scenario

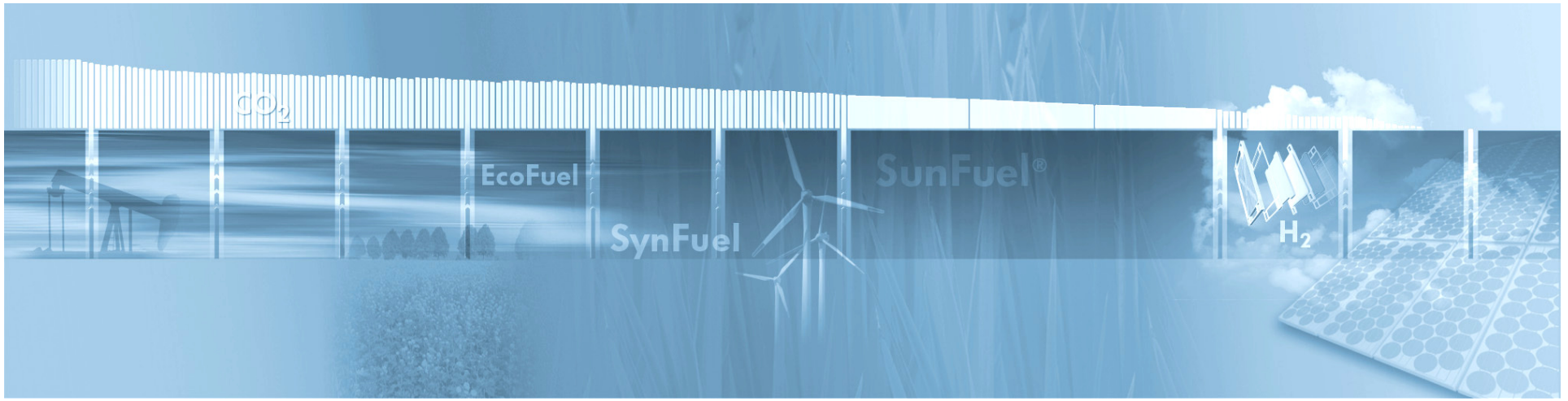




THINK BEYOND

„If I´d asked them what they wanted, they would have said – a faster horse.“ Henry Ford





Thank You for Your Attention!