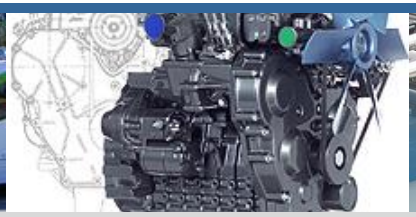
Successful Market Introduction of
Hydrogen Mobility for Heavy Duty Vehicles

20th October 2014

Markus Schneider

9th A3PS International Conference
Eco-Mobility 2014


ALSET GmbH

About Us

CORE COMPETENCE

- Hydrogen Internal Combustion Engines
- Hydrogen Technologies

BUSINESS MODEL

- Engineering Services
- Technology Licensing

PARTNERS

MAGNA STEYR

ASTON MARTIN

TÜV SÜD

TU Graz

MONTAN UNIVERSITÄT

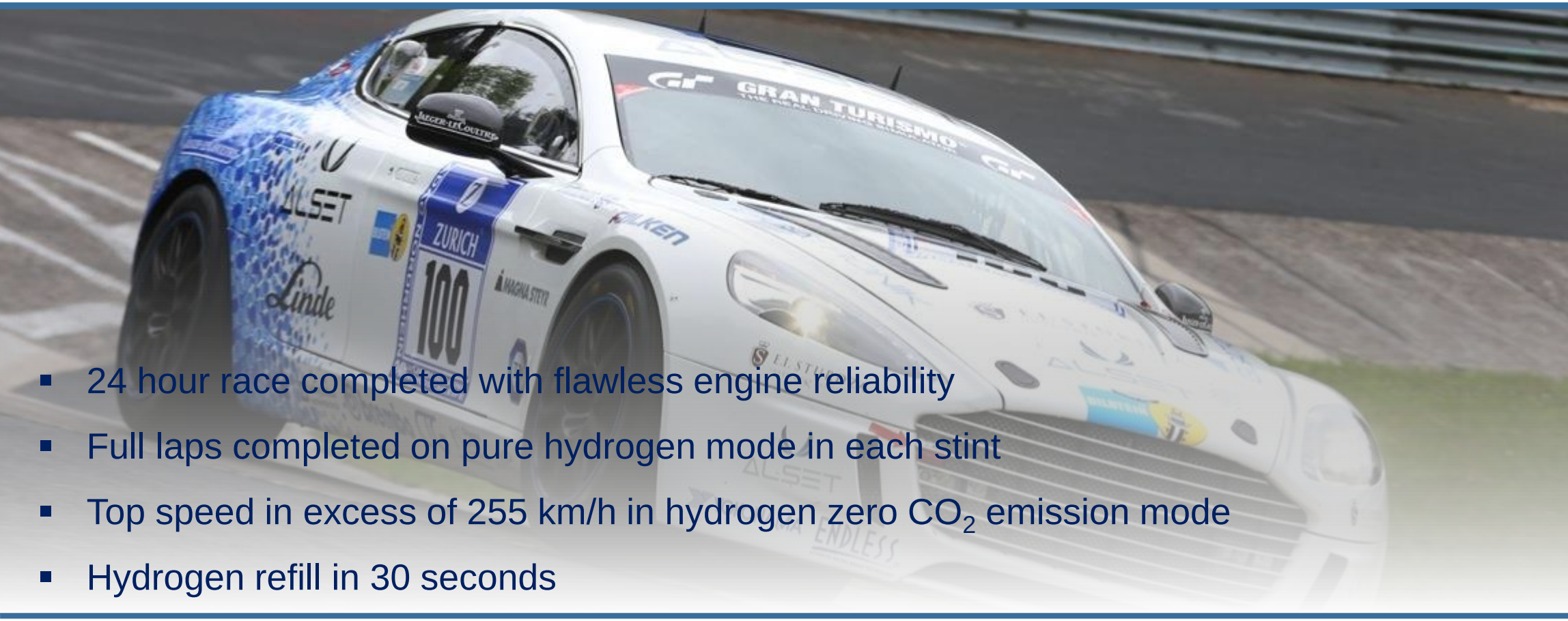
HOCHSCHULE LANDSHUT UNIVERSITY OF APPLIED SCIENCES

TEAM EXPERIENCE

ALSET

Professional MotorSport WORLD EXPO 2013 AWARDS

Powertrain of the Year



- 24 hour race completed with flawless engine reliability
- Full laps completed on pure hydrogen mode in each stint
- Top speed in excess of 255 km/h in hydrogen zero CO_2 emission mode
- Hydrogen refill in 30 seconds

ALSET

Sustainable Energy and Fuel Cycle

Energy Carrier Hydrogen

Distribution and Refueling

Utilization and technology of Hydrogen

Production of Hydrogen from unlimited available sources

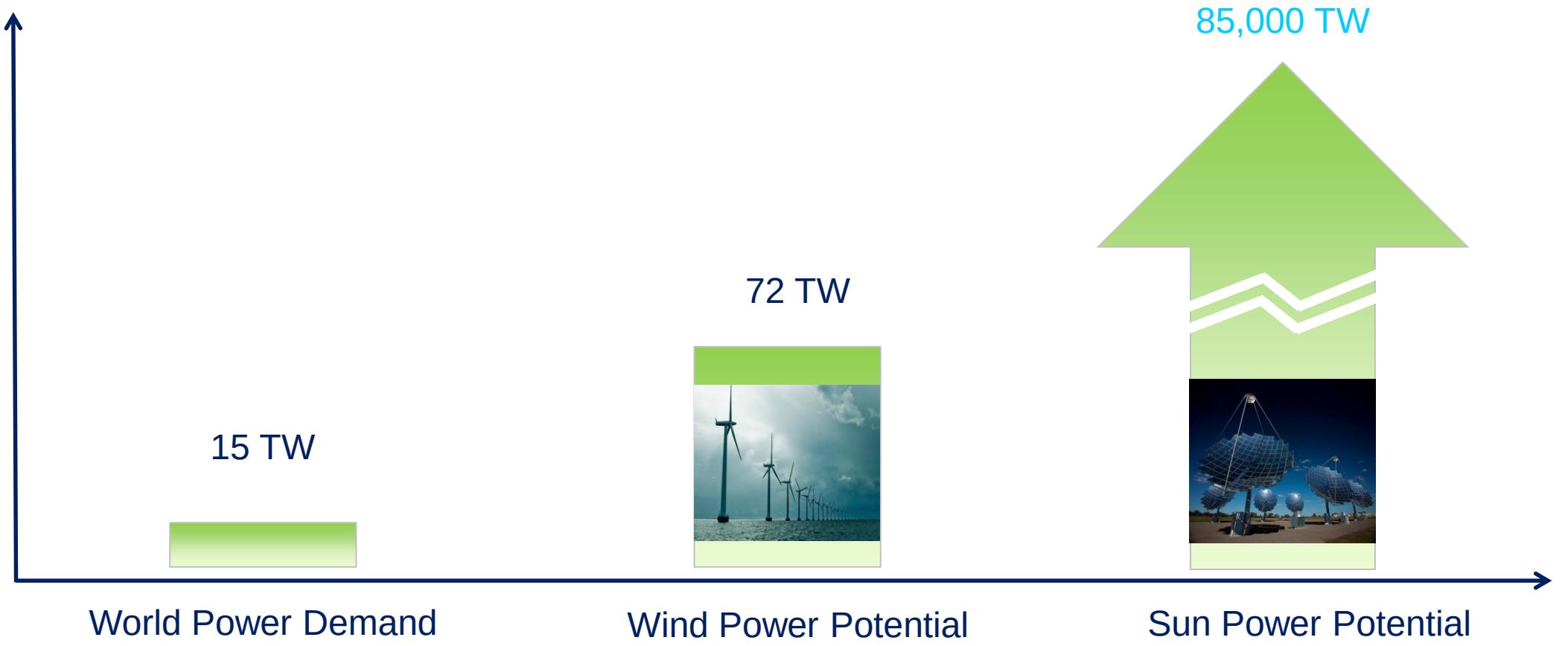
ALSET

The Source

Of Renewable Power

Energy Abundance

Solar and Wind Power



ALSET

Breaking the Chicken and Egg

Hydrogen Mobility Breakthrough

ALSET

Mobility

Current Situation

- Even though gasoline and diesel vehicles emit CO_2 and pollutants, they are well accepted in society: 99.9% of the market.

Clean Mobility

Conclusion

- Alternative propulsion systems have to be competitive from day 1.
- Successful market introduction only possible if solution profits from existing know-how and infrastructures.

ALSET

Clean Mobility

Evolution

Internal Combustion Engine

Gasoline
Diesel
Natural Gas

VEHICLES

- Most developed machine ever, with 100 years of innovation
- Production of 100 million units per year, and growing
- Core of the automotive industry

ALSET

Clean Mobility

Evolution

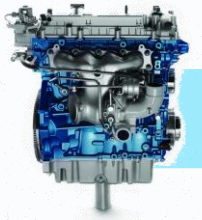
Internal Combustion Engine

Gasoline
Diesel
Natural Gas

VEHICLES

Hybrid

Propulsion



Fuel

Electric Motor

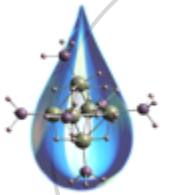
BEV

FCEV

ALSET

Hydrogen Hybrid

Alset Solution



Hydrogen
Carbon-free

Gasoline/Diesel
Practical

1 Engine

Minimal Adaptations

- **Low Cost**
- **Fast Development**

2 Fuels

Dual- / Bi-Fuel Capability

- **Simplicity**
- **Freedom of Mobility**

Software

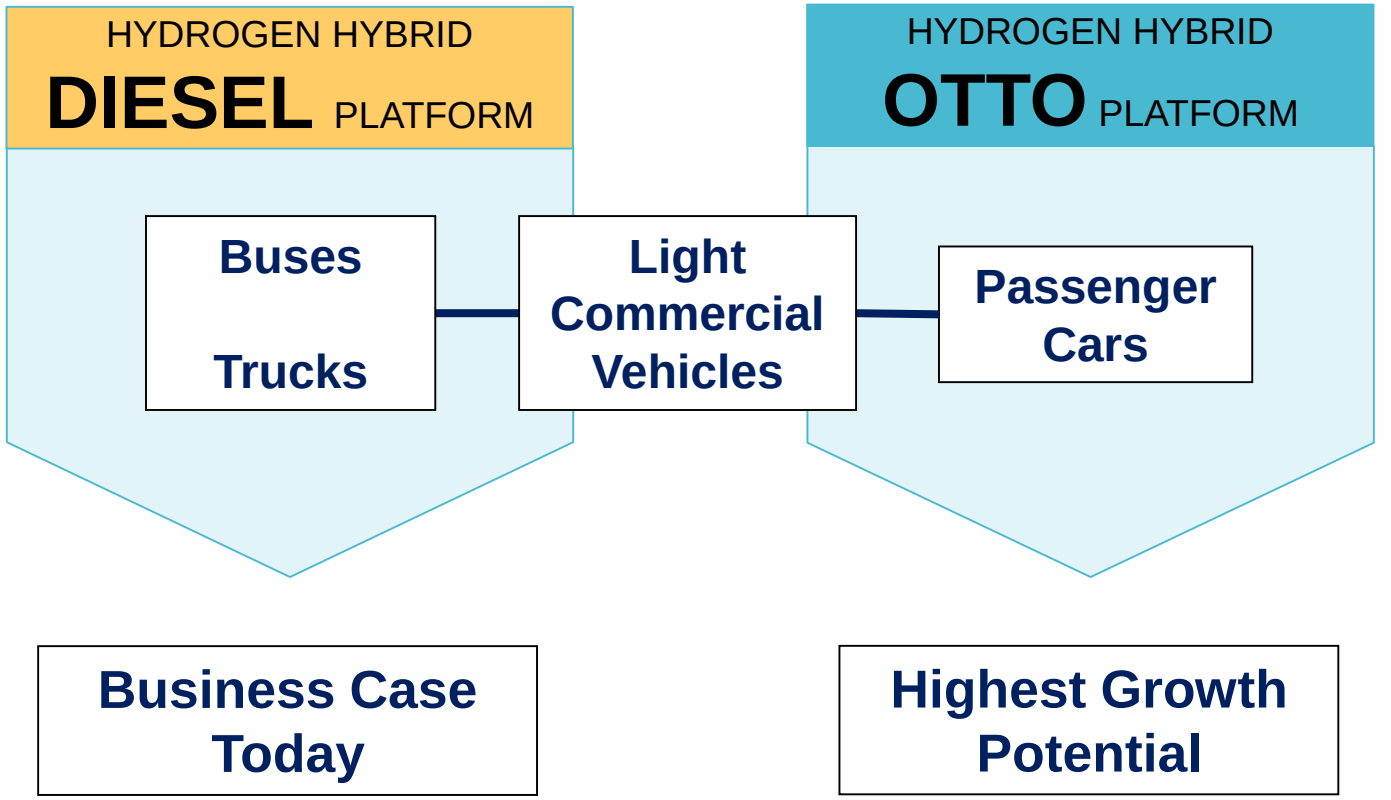
Precise Control

- **Clean**
- **High Performance**

ALSET

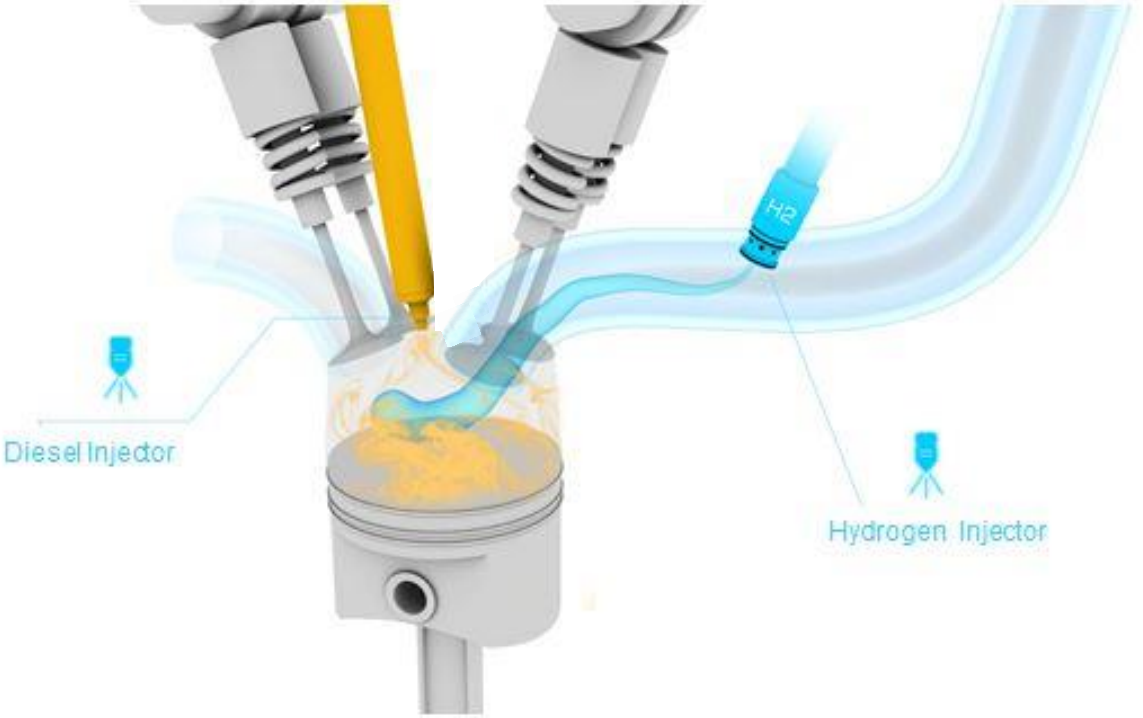
Application Portfolio

Alset Solution



Hydrogen Diesel Technology

Product Attributes



Comparison to latest Diesel Engine Technology:

- **80% CO_2 emissions reduction**
- Euro 6 compliance

- Same efficiency
- Same performance

- Same reliability and durability
- **Lower cost**

ALSET

Sustainable Energy and Fuel Cycle

Energy Carrier Hydrogen

Distribution and Refueling

Utilization and technology of Hydrogen

Production of Hydrogen from unlimited available sources

ALSET

Hydrogen Production

Combination of different sources

- **Full SMR INSTALLED CAPACITY utilization**
- **Industrial BY-PRODUCT**
  - Waste utilization
  - Valorization
- **RENEWABLE Electrolysis**
  - Utilization of excess
  - Grid stability

CLEAN & COST-COMPETITIVE FUEL BLEND

ALSET

Business Case Today

Initial Market Implementation

FLEETS SEGMENT

- Highest mileage, fuel consumption & emissions
- High demand for clean and cost-competitive solution
- Centralized refueling

REGIONAL ADVANTAGE

- Existing Hydrogen Infrastructure
- High Wind Power Potential
- High Market Potential

ALSET

Hydrogen Euro 6 Buses

Value Proposition

Technical Data	MB Citaro*	Solaris Urbino 12*	Hydrogen Hybrid** (Alset Kit)
Displacement	**7.700 cm³**	**6.700 cm³ / Cummins**	**8.700 cm³**
Effective Power	**220 kW / 2.200 U/min**	**208 kW / 2.200 U/min**	**220 kW / 2.200 U/min**
Max. Torque	**1200Nm / 1.200-1.600**	**1100 Nm / 1.200-2.000**	**1200Nm /1.200-1.600**
Consumption (city)	**33**	**34**	**6,8L / 8,1 Kg**
CO_2/year (tons)	**54**	**52**	**11**
Bus Purchase Cost [€]	**285.000**	**190.000**	**+25.000**
Life Time Fuel Cost [€]	**273.000**	**281.000**	**236.000**
Total Cost [€]	**558.000**	**471.000**	**451.000**

Assumptions:

Life Time Operation: 12 years – 60.000 km/year
Diesel Fuel Cost: 1,15 €/L
Hydrogen Fuel Cost: 3,10*** €/Kg

Source: * IBC 2014 Vergleichstest Euro-6-Niederflurbusse
** Alset , own estimation
*** Optionen für den kostenoptimierten Aufbau einer H2-Infrastruktur in NRW – Wuppertal Institut

ALSET

Fuel and Buses Combined

Value Proposition

- Alset's HYDI Bus: **25,000 EUR** premium on-cost over Diesel Euro 6
- H_2 Fuel: **21% cheaper** than Diesel fuel equivalent
  - Pay Back: **6 years**
  - Saving: **20,000 EUR** in 12 years operation

- Secured:
  - Fuel Consumption
  - Vehicle Availability
  - Fuel Price & CO_2 Certification
- Hydrogen Refilling Station at depot

ALSET

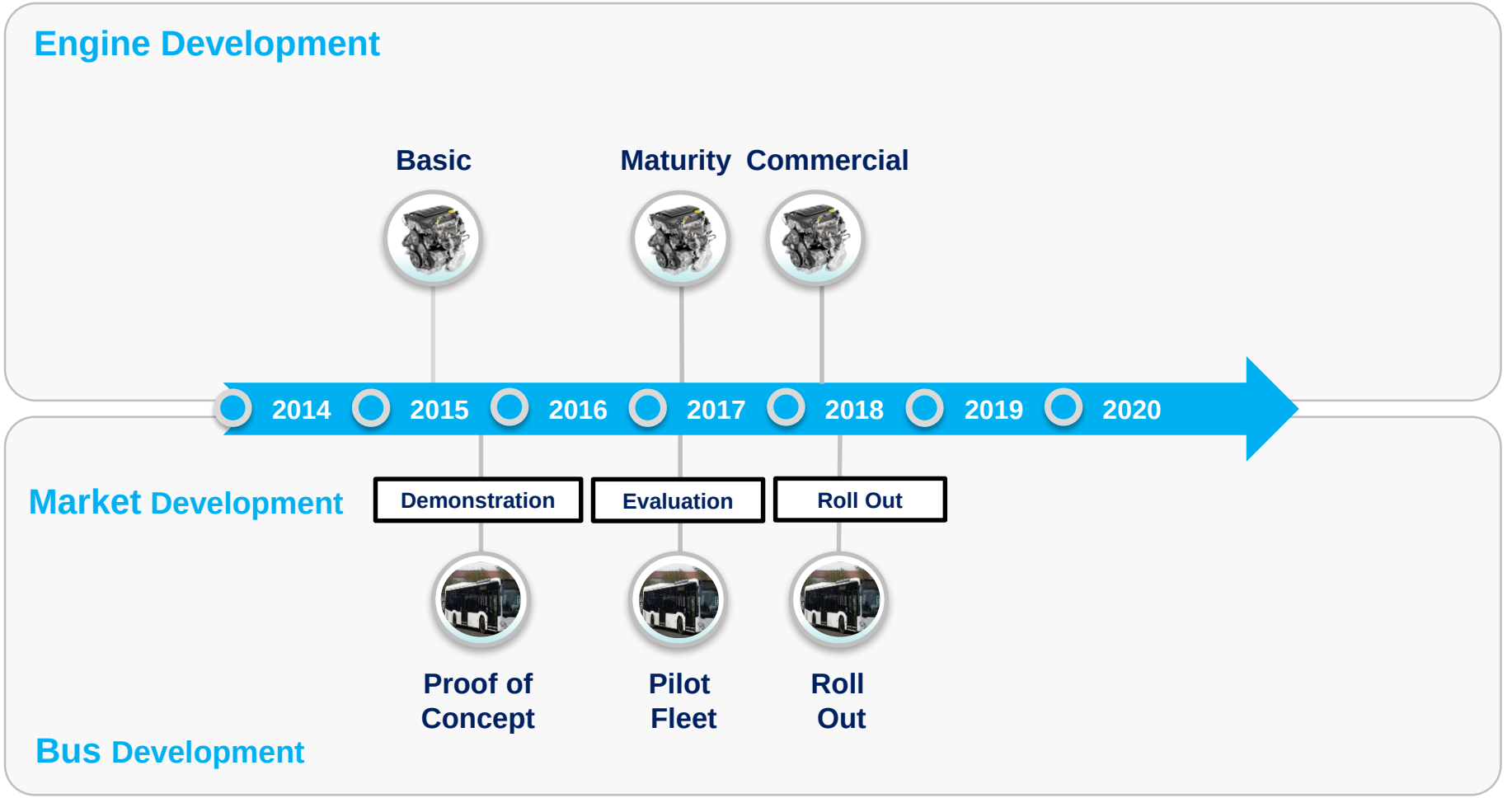
Status

Europe

- LOI with 2 Bus operators
- LOI with Bus OEM
- Cooperation with engine OEM:
- On-going development Project funded Ministry of Transportation, Innovation and Technology in Austria
- Preparation of 2 demonstration projects in Northwest Germany
- Political support: City of Bottrop, Ministry of Environment in Germany
- Support from German Association of Public Transport Companies (VDV)

Execution Plan

Timeline & Milestones



Thank you.

ALSET GmbH
Liebenauer Tangente 6
8041 Graz, Austria
info@alsetglobal.com, www.alsetglobal.com