Predictive Energy Management on Powertrain

Thomas Knorr, Energy Saxony Summit, September 18, 2017

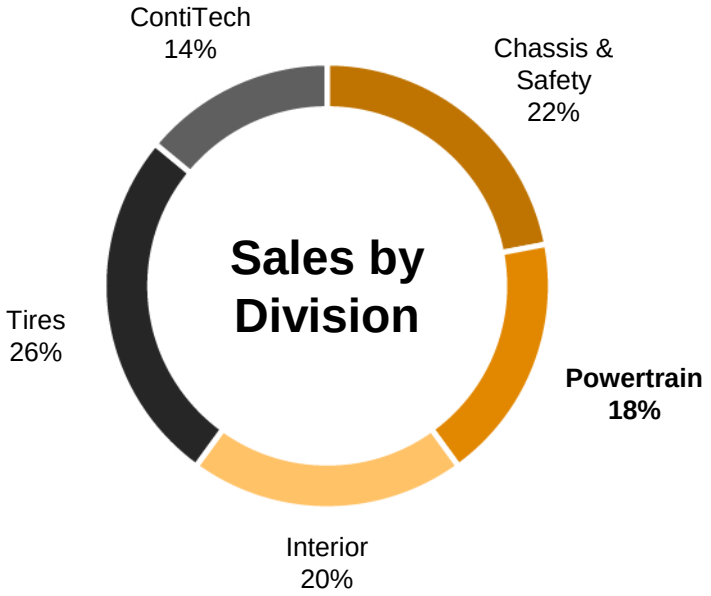
Continental Corporation
Facts & Figures 2016

Since 1871 with headquarters in Hanover, Germany

Sales of €40.5 billion

220,137 employees worldwide

427 locations in 56 countries



Status: December 31, 2016

Powertrain Division

94 Locations in 22 Countries

Germany*

Regensburg, Bebra, Berlin, Dortmund, Eisenach, Gifhorn, Grünstadt, Karben, **Limbach-Oberfrohna**, Lohmar, Nuremberg, Roding, Schwalbach

Europe

France (Boussens, Cergy-Pontoise, Faulquemont, Foix, Toulouse)
Czech Republic (Brandys, Frenstat, Ostrava, Trutnov)
Romania (Brasov, Iasi, Sibiu, Timisoara)
Russia (Kaluga, Moscow)
Hungary (Budapest)
Italy (Pisa)

North America

USA (Auburn Hills, Dearborn, Deer Park, Delavan, Fountain Inn, Newport News, Seguin)
Mexico (Cuautla, Guadalajara, Juarez)
Canada (Chatham)

Asia

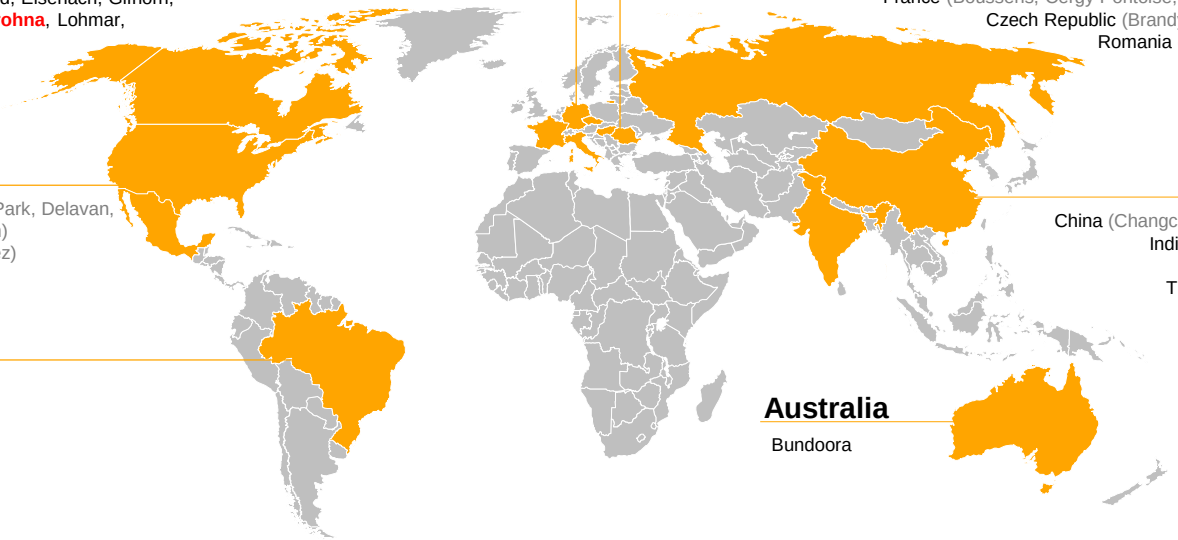
China (Changchun, Shanghai, Tianjin, Wuhu)
India (Bangalore, Manesar, Pune)
Korea (Icheon, Sejong)
Thailand (Amata City, Bangkok)
Japan (Yokohama)
Malaysia (Penang)

South America

Brazil (Guarulhos, Salto)

Australia

Bundoora



*Headquarters in Regensburg (Germany)

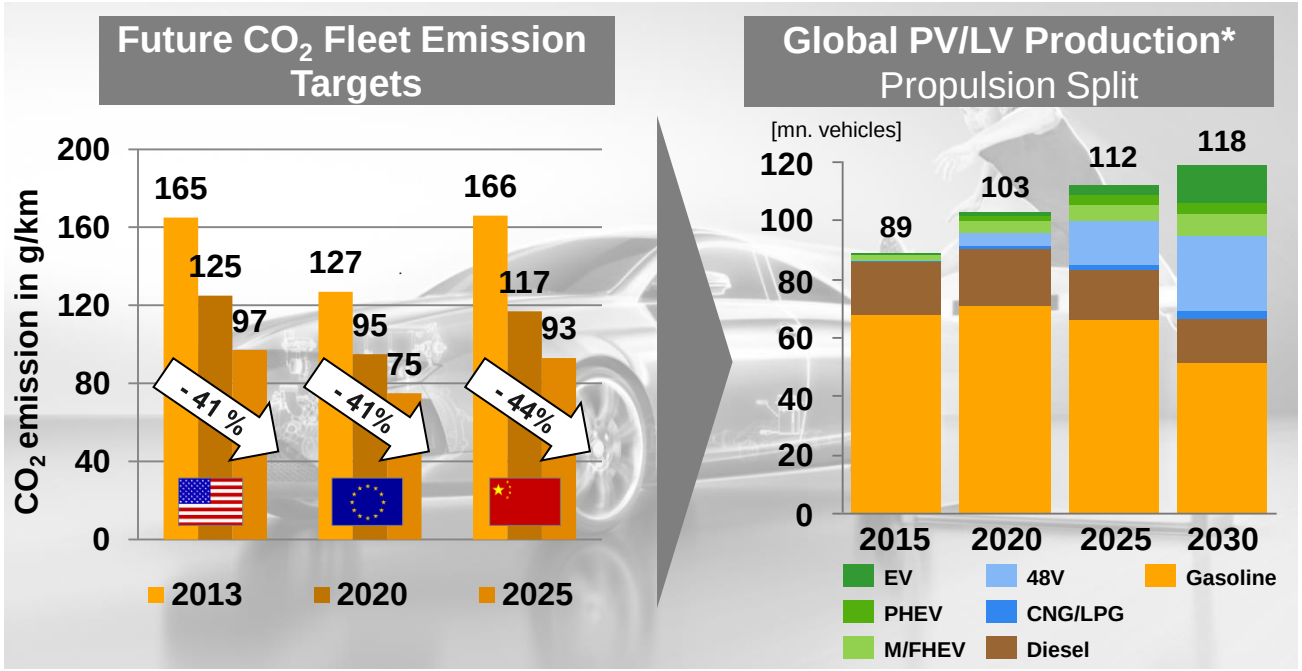
Status: December 2016

Powertrain Technology & Innovation

Areas of Work

Powertrain Development

Peak Combustion Expected by Middle of Next Decade



- **Internal combustion engines** remain dominant till 2030 with approx. 90% share
- **48V** (high volume mass market) and **Plug-In hybrids** are transition technologies till then
- Significant **EV share** towards the end of next decade

Source: Powertrain Outlook 2030 (May 2016)

Electric Vehicle (EV)

Motivation – High Availability for Driving of A Fuel Cell

Inductive

Conductive

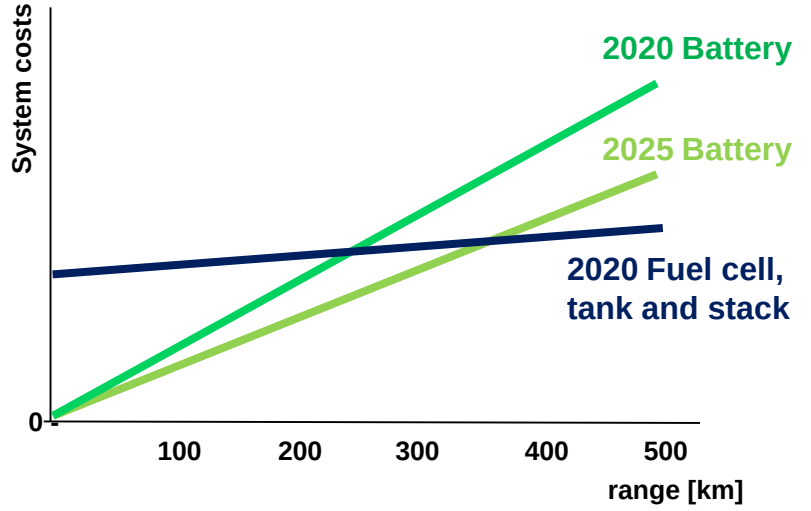
< 1 km/min	**BEV Charge @ Home** (AC)	1-ph	3.7kW	1.9kW	3.7kW
		3-ph	**11kW**	-	-
< 2 km/min	**BEV Charge @ Work** (AC)	1-ph	6.6kW	7.4kW	6.6kW
		3-ph	**22kW**	-	**22kW**
< 4 km/min	**BEV Charge @ Shop** (AC / DC)	AC **43kW**	DC 40kW	AC 22kW	
30 km/min	**BEV Charge @ Rest** (DC)	Mode 4 **350kW**	Level 3 240kW	GB/T 250kW	

H_2 for Fuel Cell
> 300 km/min

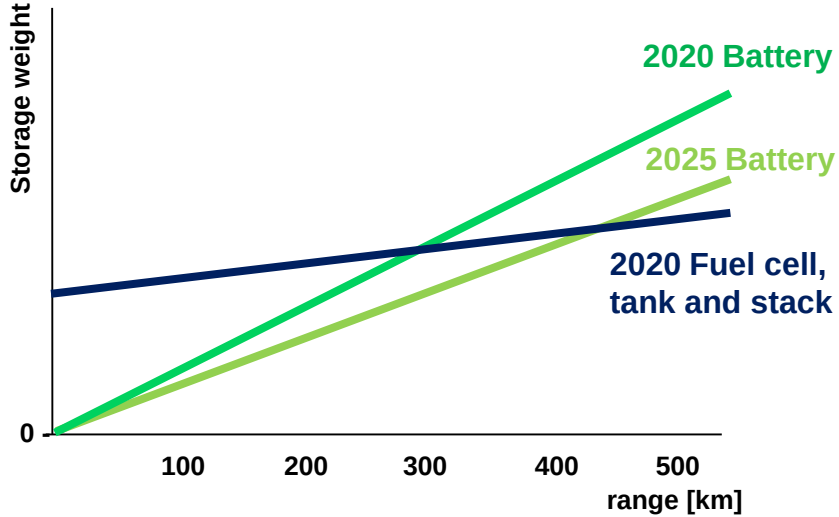
Electric Vehicle – Battery (BEV) or Fuel Cell (FCEV)?

System Costs & Weight over Range Comparison

Estimated system costs at vehicle driving range



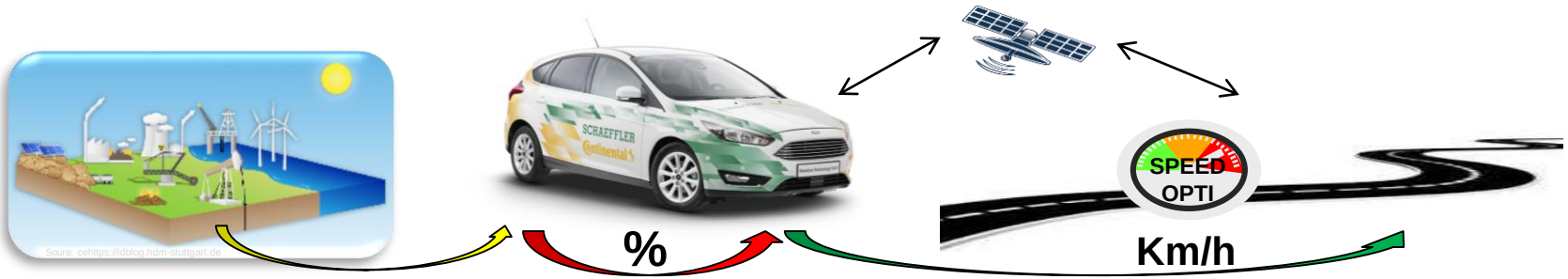
Estimated storage weight at vehicle driving range



Considering 18 kWh/100km electrical energy consumption, 100 kW FC-stack power (@ 100 k units/year)

Connected Energy Management

A Holistic & Connected Optimization



from Well to Tank | **from Tank to Wheels** | **from Wheels to Miles**

Energetic Paths

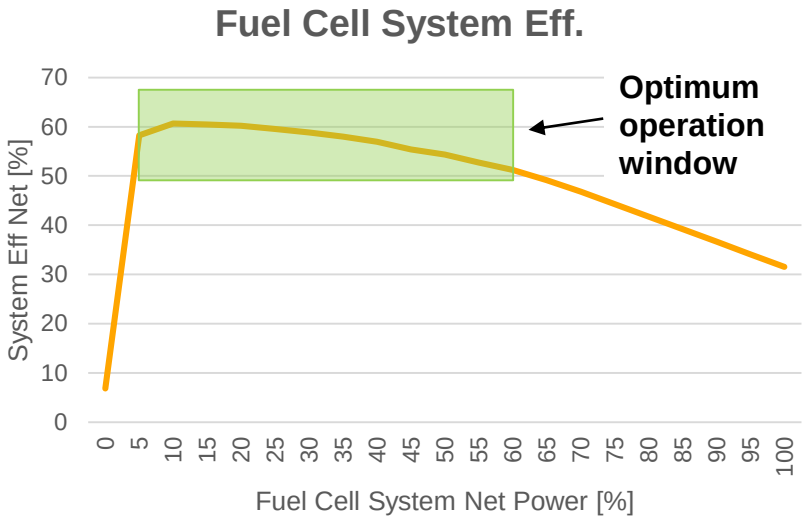
- Selection of – and application to – **HYBRID** cars
- Optimization of **EFFICIENCY** of energy onboard
  - Gear shift + hybrid strategy
  - Torque repartition (ICE/EM)
  - Load and electrical consumers control
- Optimization of **USAGE** of mobility
  - Speed & acceleration profiles
  - Boost/ coasting/ recuperation
  - Eco-driving, trip preparation…

In-Vehicle Energy Mgmt.

Kinetic Energy Mgmt.

Fuel Cell Electric Vehicle (FCEV)

FC System Optimization in Cooperation with TU Chemnitz



Battery is used for Recuperation:

- Brake recuperation
- Operation point shift possible

Battery supports high dynamic:

- Air path design is optimized for efficiency

Use battery for low power propulsion:

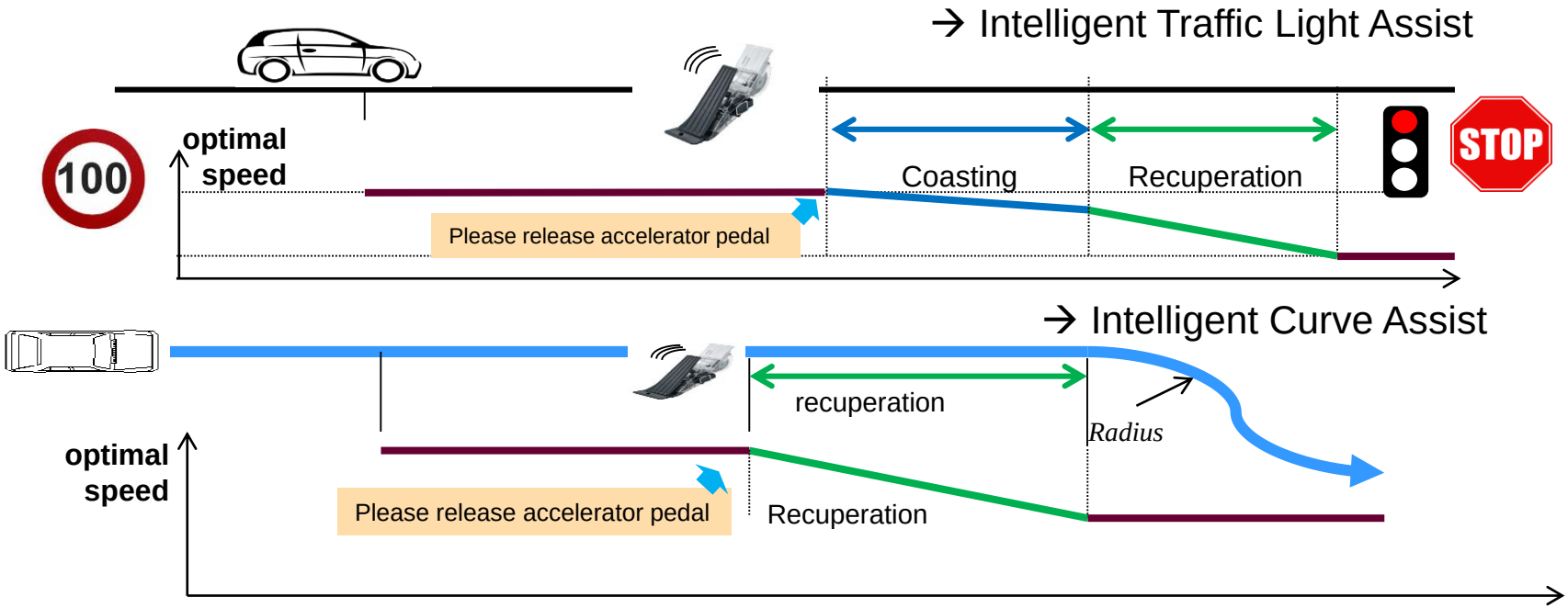
- Fuel cell auxiliaries can be switched off
- Vehicle comfort functions can

Battery capacity should be as small as possible!

* Data from „Tank-to-wheels report version 4.0 JEC well-to-wheels analysis“, July 2013

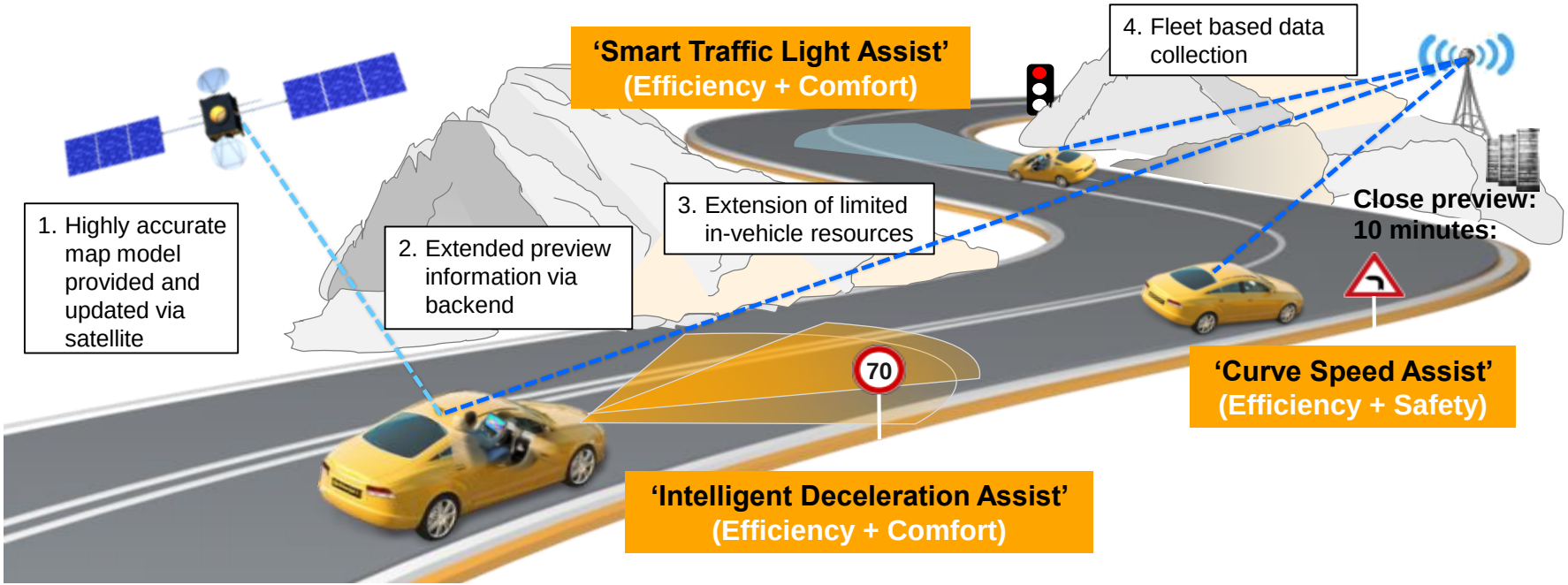
Connected Energy Management

Examplary Use Cases – Energy Optimized Deceleration



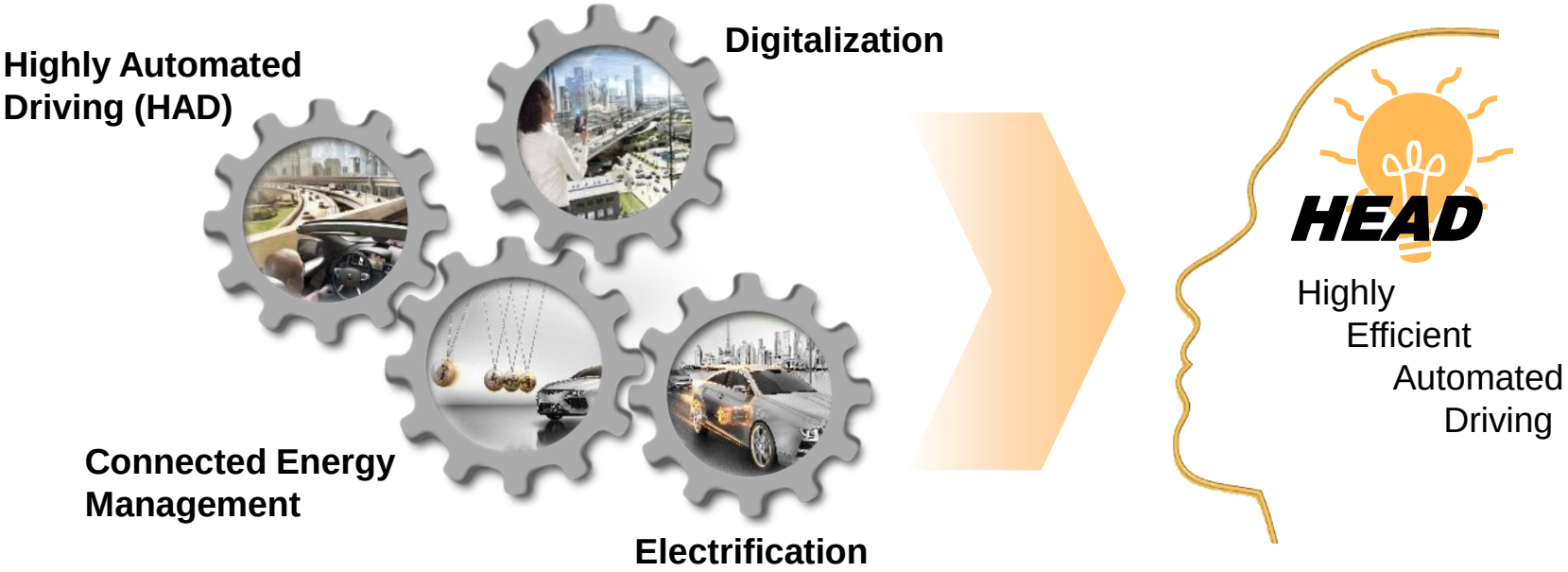
Connected Energy Management

Efficiency Feature w/Comfort and Safety Value for the Driver



Mobility of the Future

Highest Efficiency by the Combination of Four Dimensions



THANK YOU
for your interest and attention!

Continental
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