TENSION 12 V TO 800 V

EFFICIENT POWERTRAIN SOLUTIONS

FISITA 2015

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AVL List GmbH

Public

CHANGE OF BOUNDARIES
POWERTRAIN ELECTRIFICATION

AVL

Customer Demands

- Driving Experience
- TCO

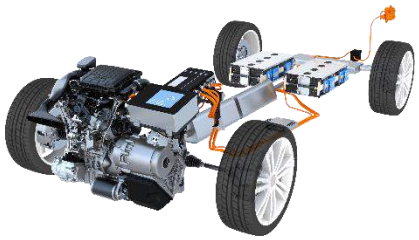
Vehicle Technology

- Electri-fication

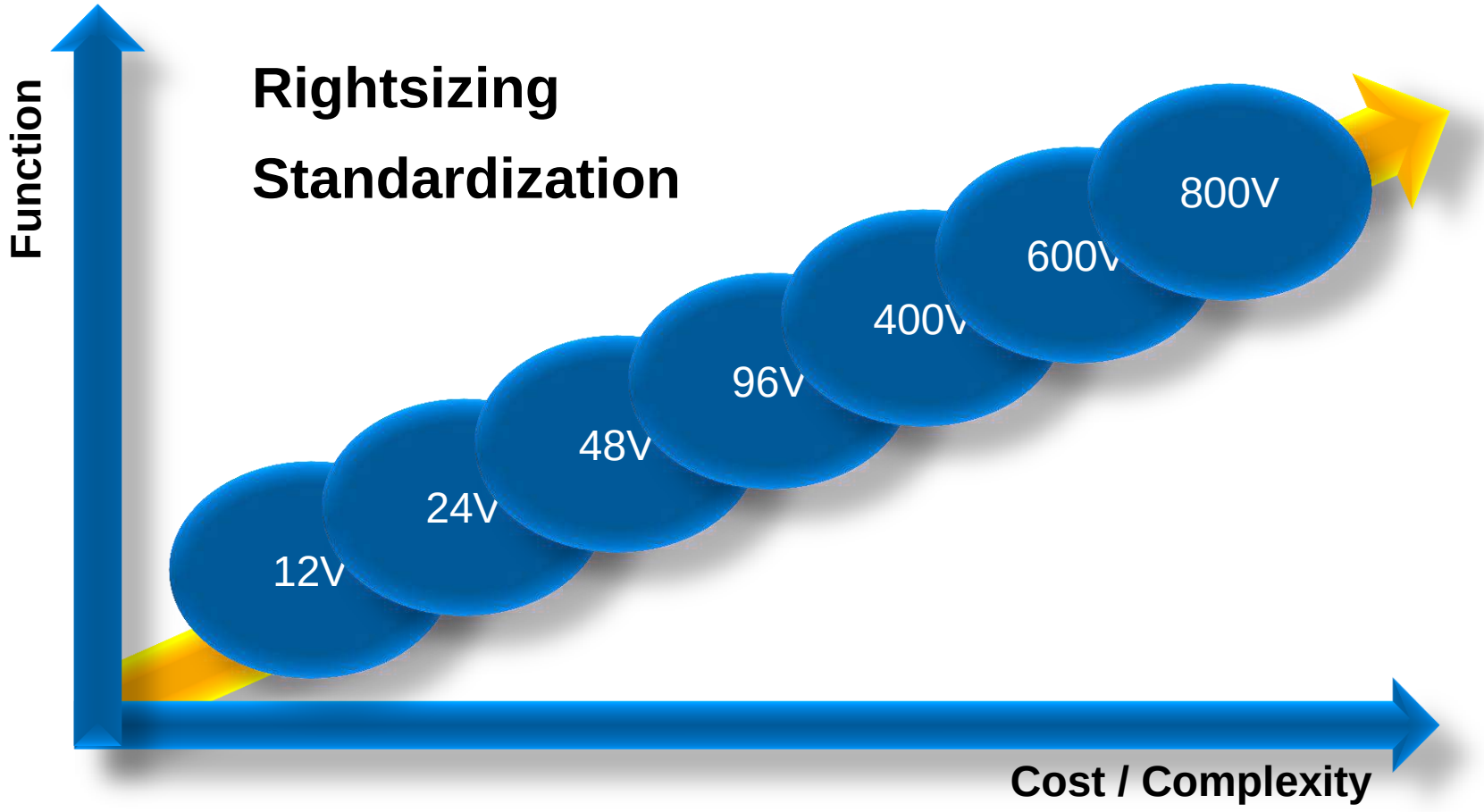
§ Legislation

- CO_2
- WLTP
- RDE

Engine | **Transmission** | **Electrification** | **Vehicle**



TENSION 12 V TO 800 V
WHAT IS THE BEST VOLTAGE LEVEL?



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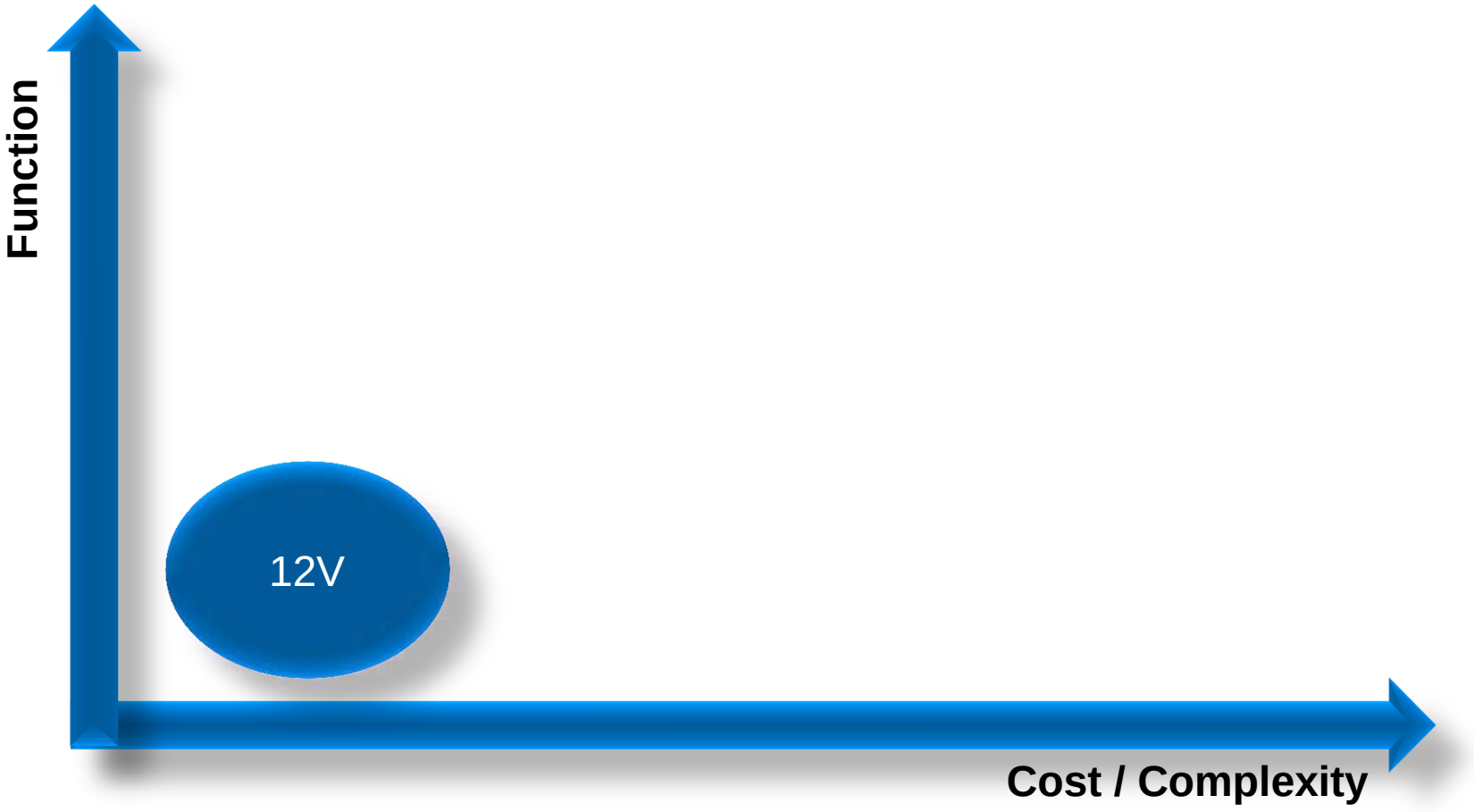
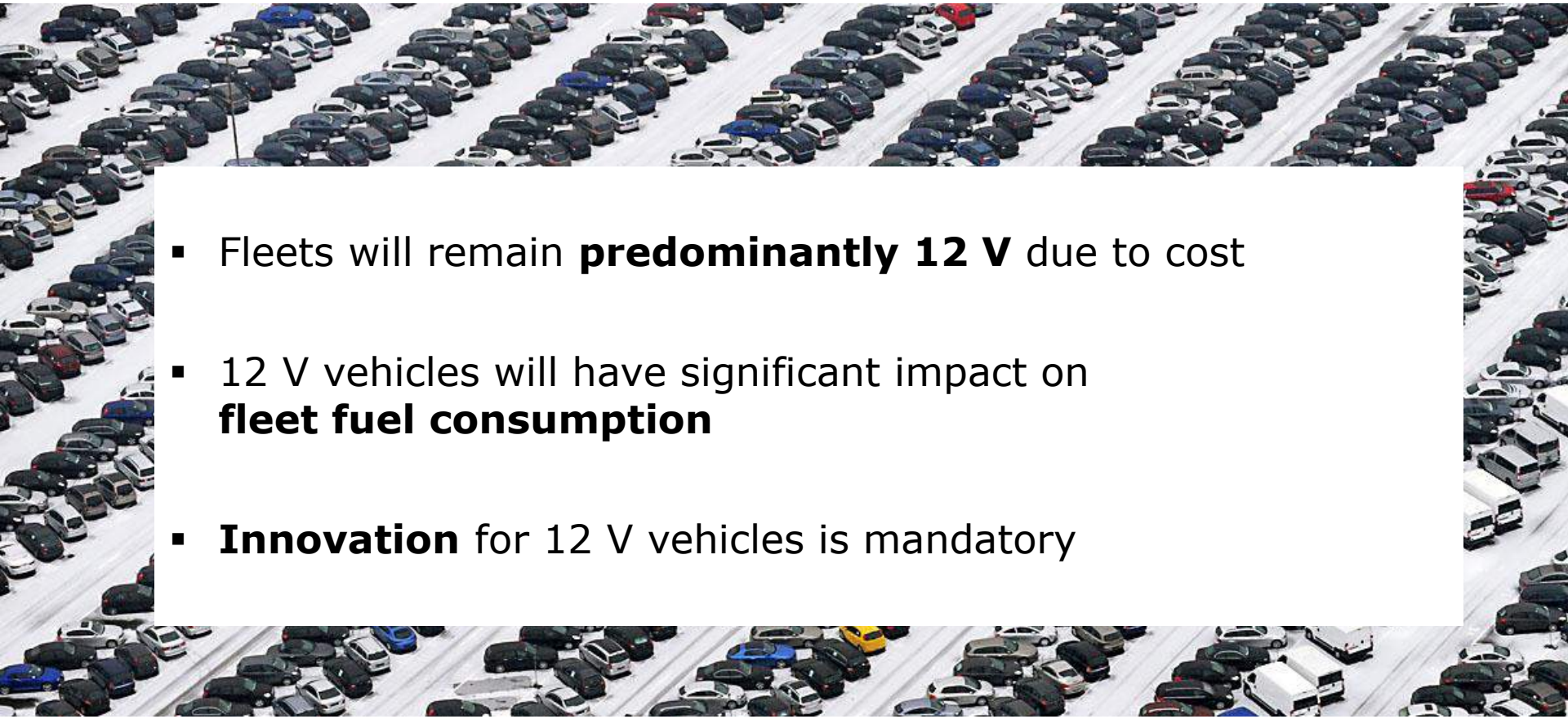


12 V
IS HERE TO STAY

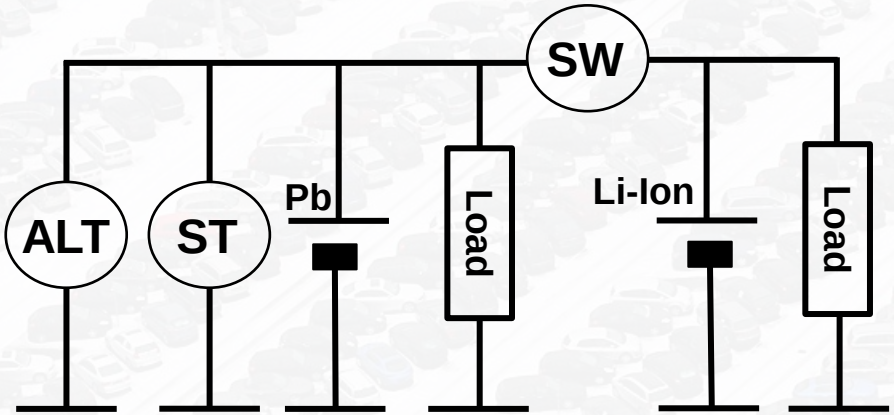


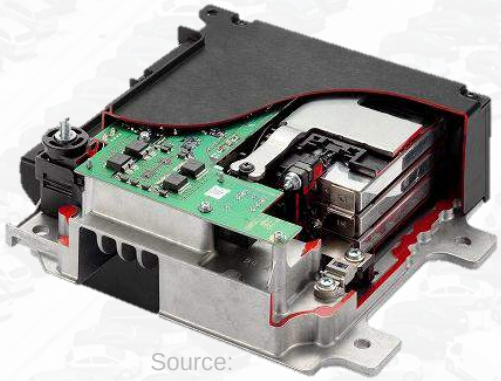
- Fleets will remain **predominantly 12 V** due to cost
- 12 V vehicles will have significant impact on **fleet fuel consumption**
- **Innovation** for 12 V vehicles is mandatory

12 V
POWER SUPPLY SYSTEM

- After stop/start, **Intelligent Power Supply Systems** will become standard

- Dual Batteries or pure Li-Ion batteries gaining
  - Charge acceptance and discharge power
  - Denso already sold > 1 Mio 12V Li-Ion batteries





Source:
www.globaldenso.com

12V
WHAT CAN YOU DO ON POWERTRAIN SIDE?

- 1,6l TGDI, **e-supercharger**
- 104 kW/4000 rpm
- FE Target: **90 g/km CO_2**

- 1,75l TGDI, **e-supercharger**
- 400Nm / 3500rpm
- 350HP / 6500rpm (**148 kW/l**)

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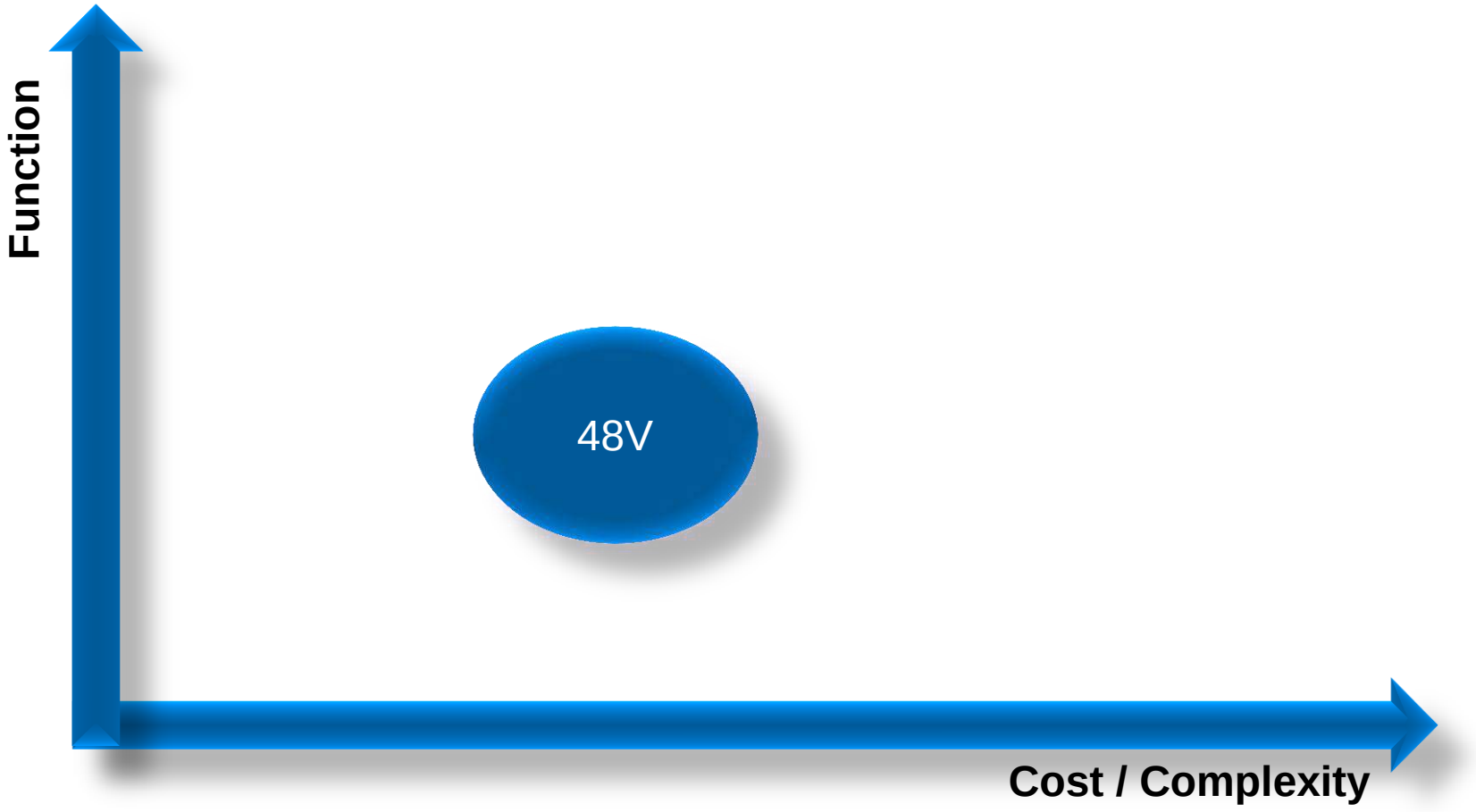


WHY STOP AT 48V?

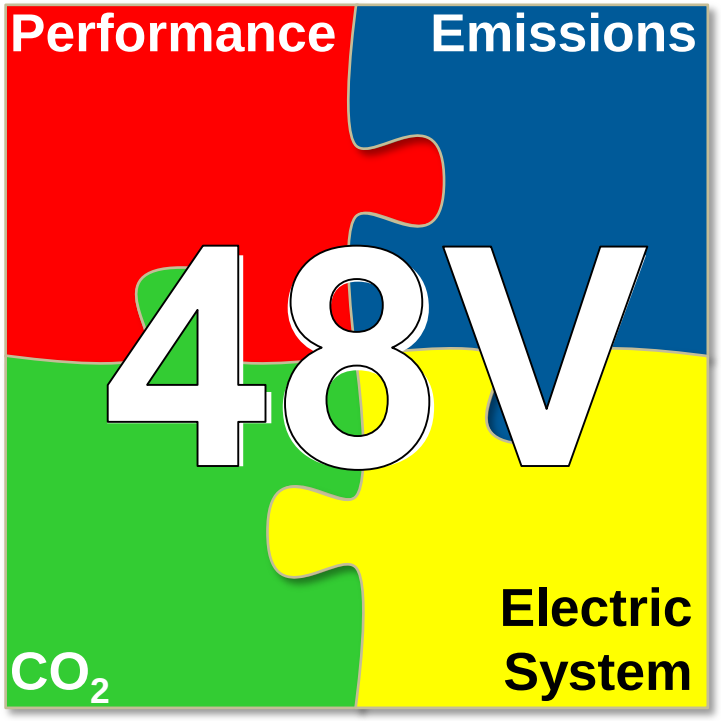
Significant cost saving…

max. voltage < 60 V
➔ NO protection against contact required

… at attractive functionality

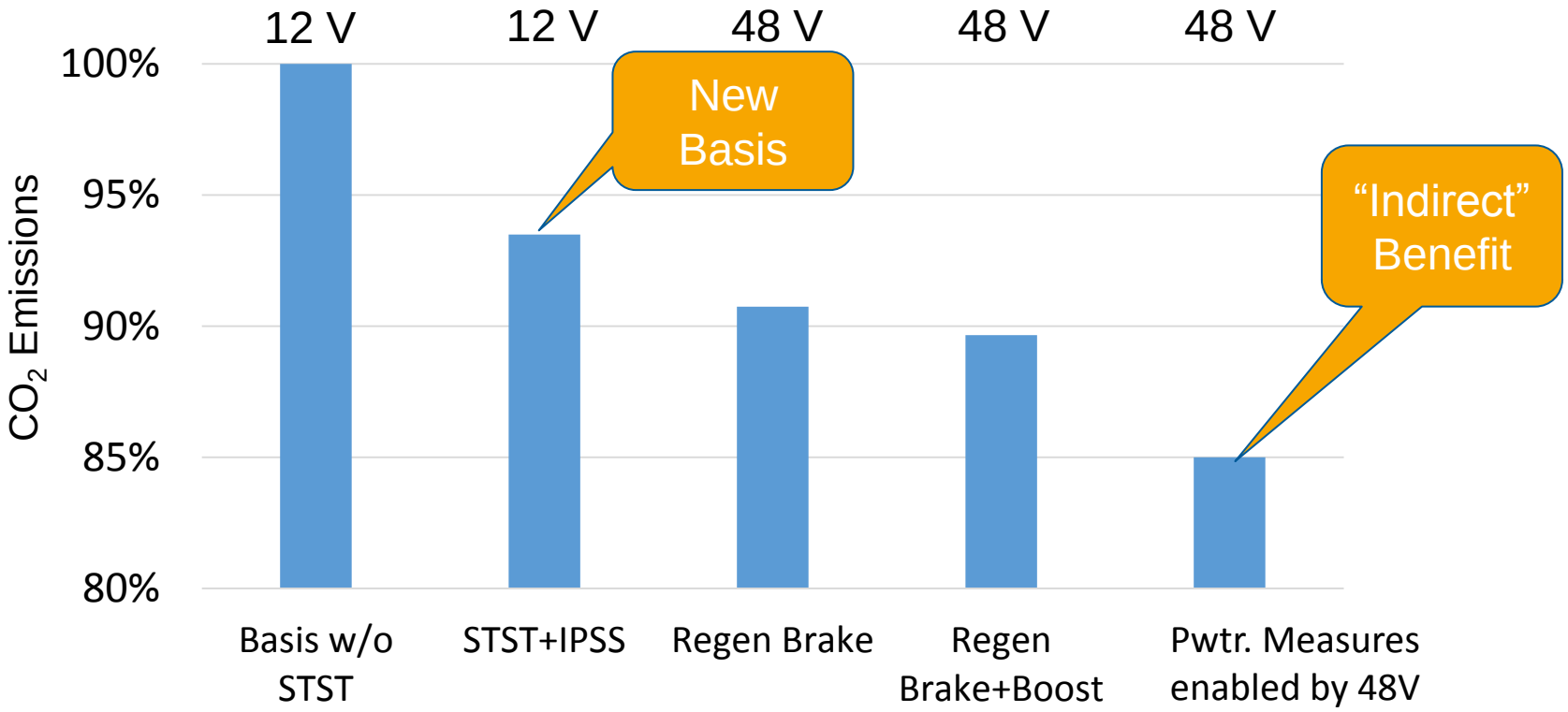
- 14…16+ kW generating
- 8…12+ kW motoring
- Several hybrid options P1, P2, P3, P4
- Unified VDA-standard

4 DRIVERS FOR 48 V



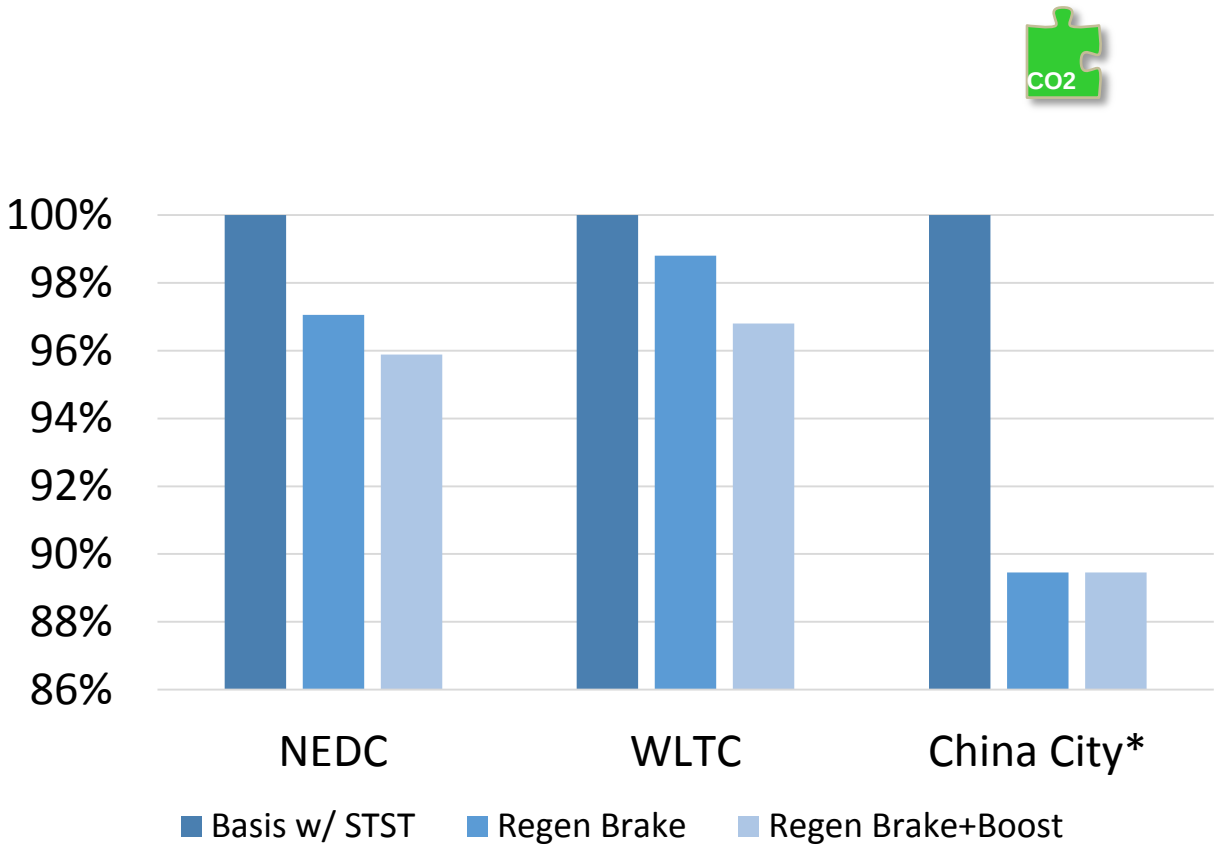
4 DRIVERS FOR 48 V

48 V DRIVER: CO_2 IMPACT OF FUNCTIONALITY



C-Segment, 4 cyl. TGDI, automatic transmission, NEDC

48 V DRIVER: CO_2 IMPACT OF DRIVING CYCLES



*STST inhibited in China City due to energy balance

C-Segment, 4 cyl. TGDI, automatic transmission

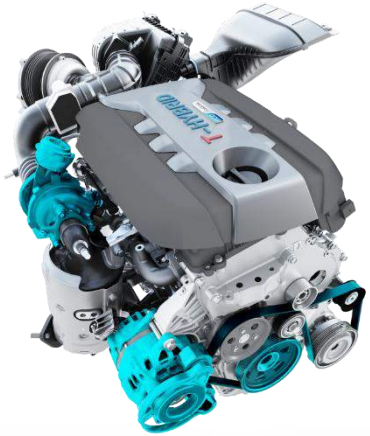
4 DRIVERS FOR 48 V

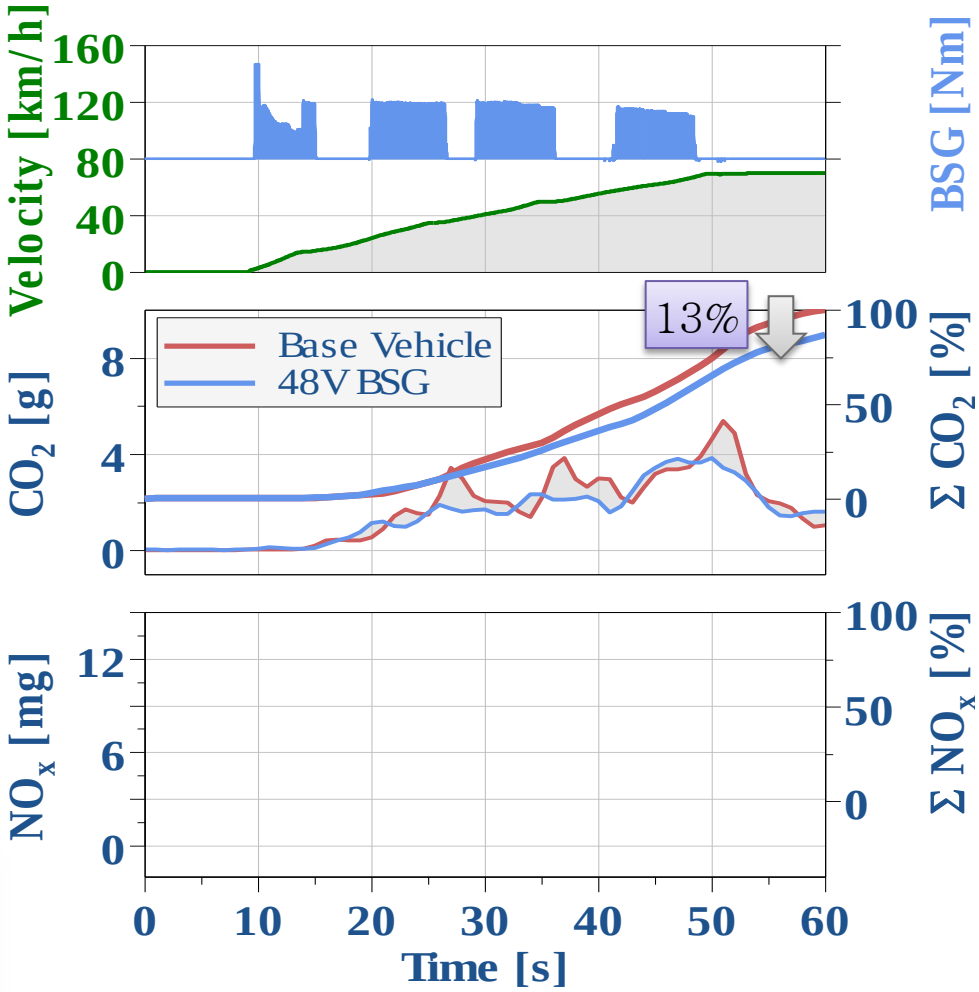
48 V DRIVER: PERFORMANCE

- **Electric supercharger 48V**
- 2.0L 4-cylinder 4V TGDI DVVT engine
- 450 HP
- **168 kW/L**
- 500 Nm (31.9 bar BMEP)
- Bi-Turbo waste gate TC

4 DRIVERS FOR 48 V

EMISSION & CO2 IMPROVEMENT





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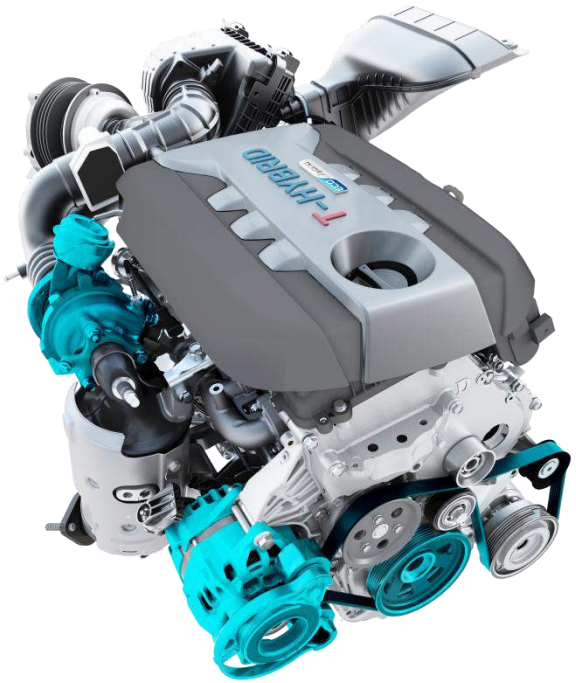

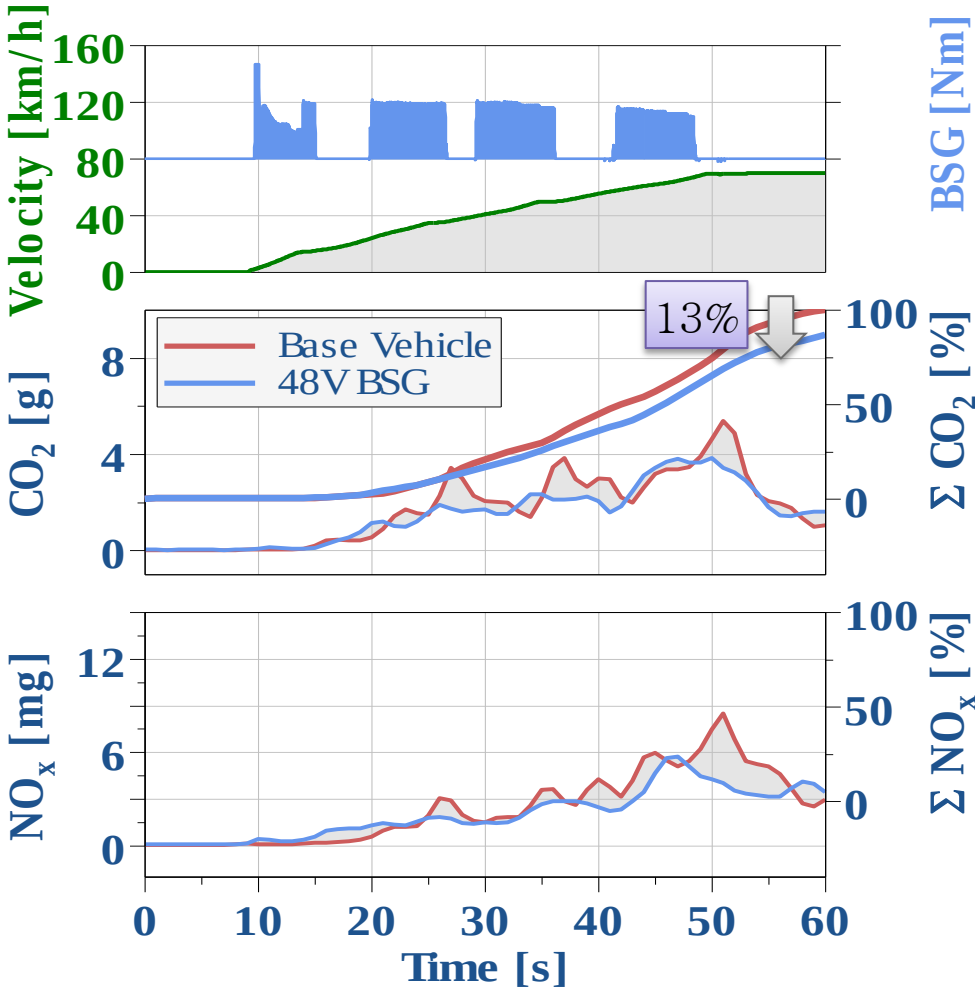

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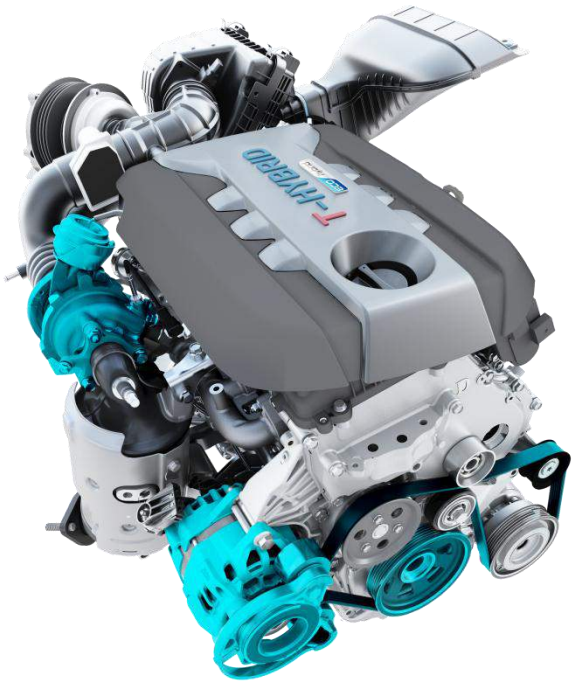

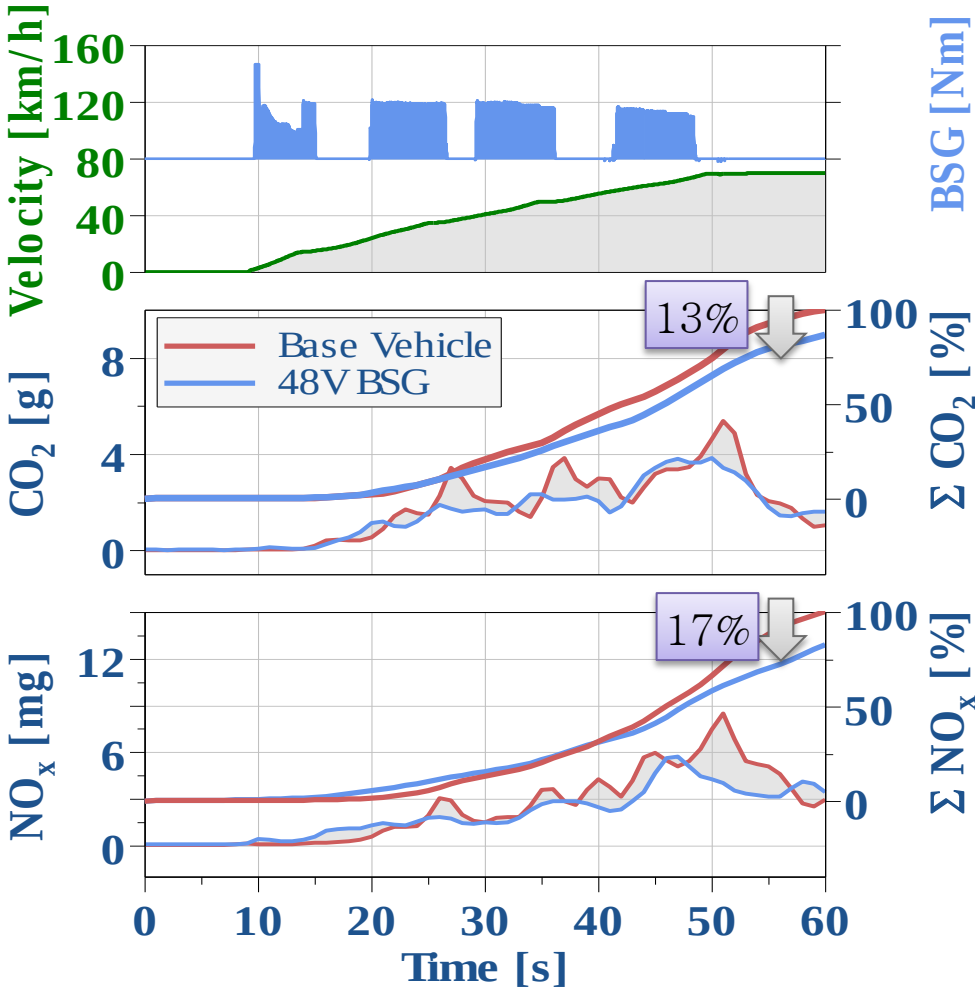

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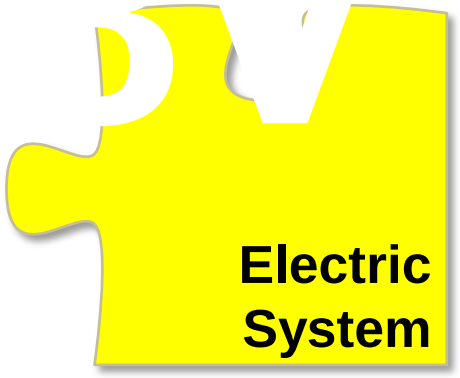
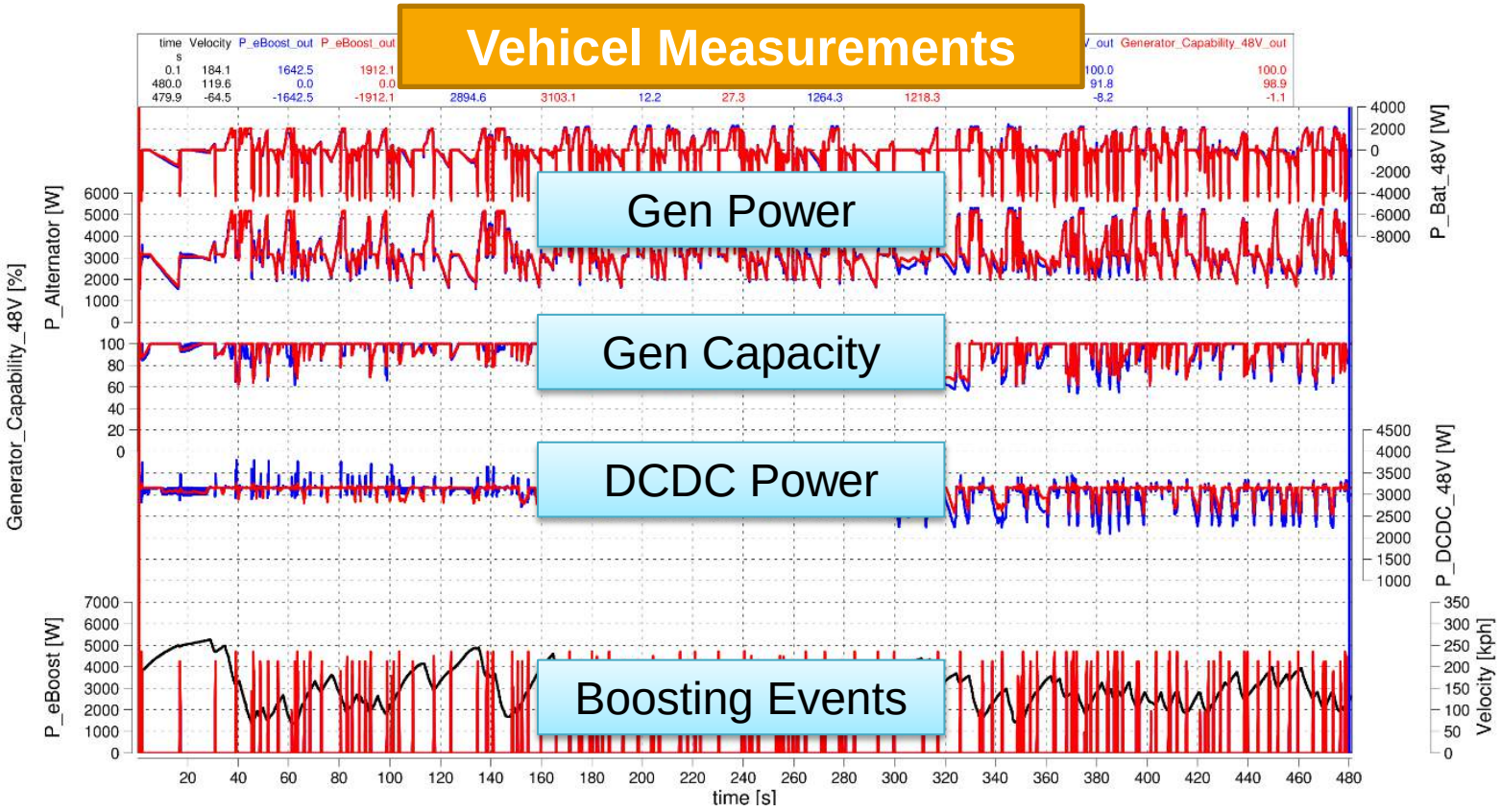


48 V DRIVER:
ELECTRIC POWER SUPPLY SYSTEM

- Three main trends, pushing 48 V Power Supply System (PSS)
- **Fewer opportunities for electrical energy generation**
- **Increasing continuous power consumption**
- **More high power consumer**

48 V DRIVER:
ELECTRIC PSS DESIGN REQUIRED!

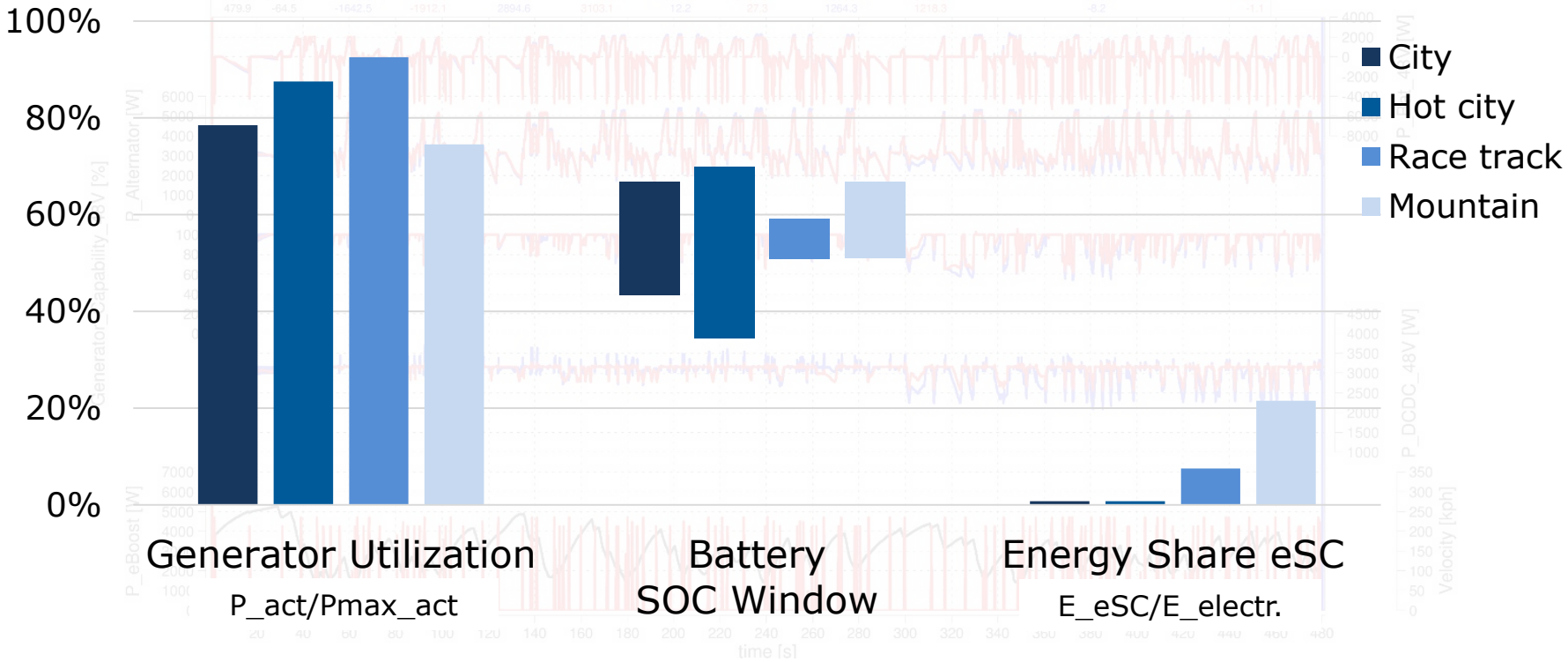
Electric System



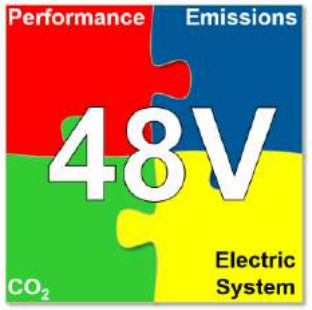
48 V DRIVER:
ELECTRIC PSS DESIGN REQUIRED!

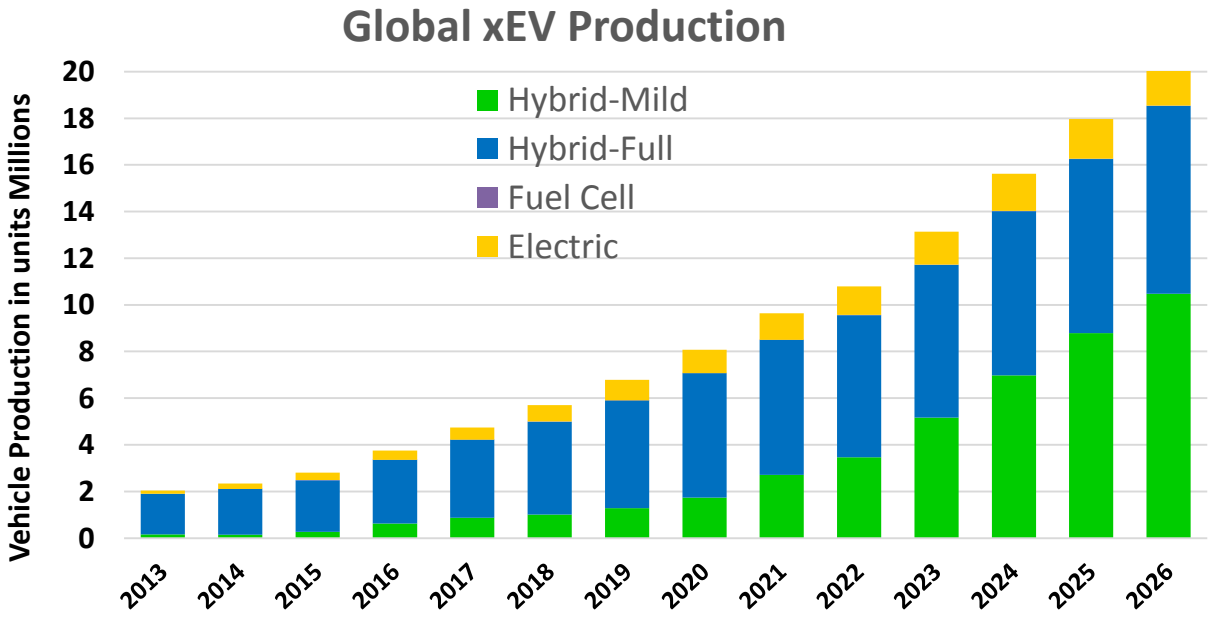
Power and Energy Analysis

Example: Luxury sedan w/ 48V electric supercharger



FORECAST GLOBAL XEV PRODUCTION

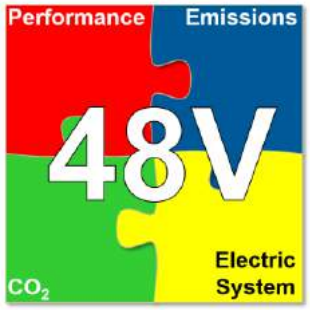


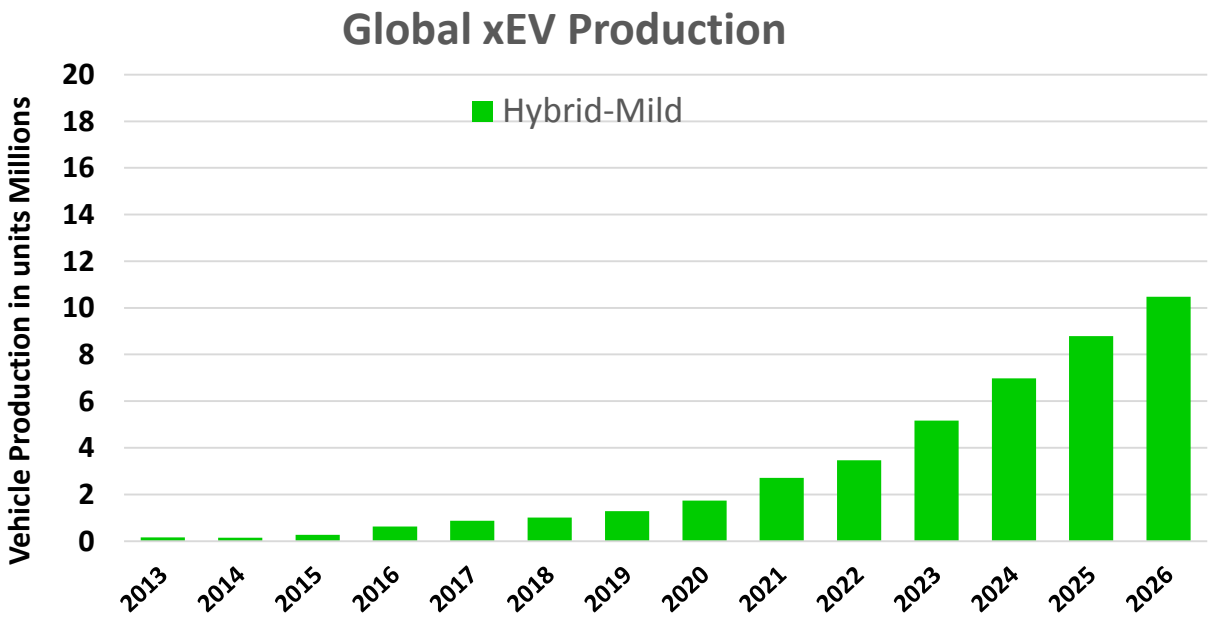


Source: IHS Q4 2014

Market forecasts indicate strong growth of Mild Hybrid, driven by 48 V

FORECAST GLOBAL MILD HYBRID PRODUCTION





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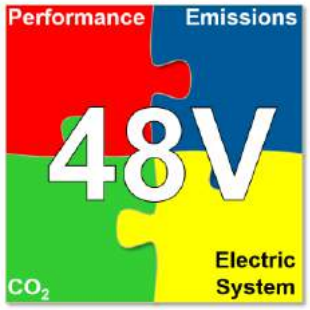

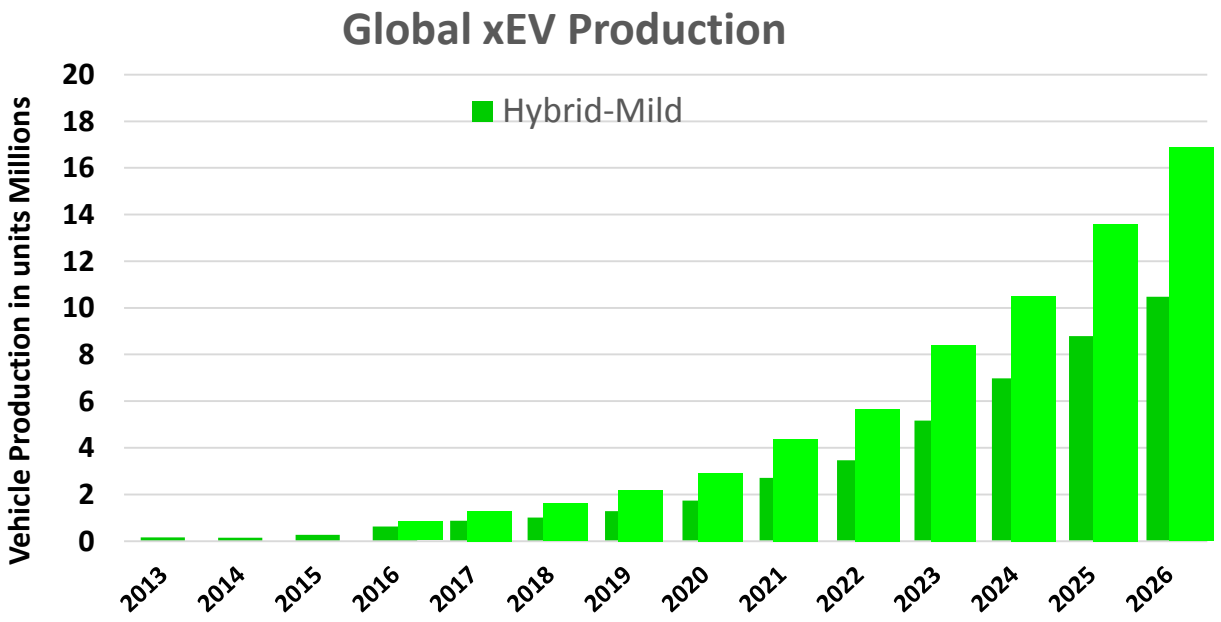

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AVL predicts larger volumes of Mild Hybrids, driven by 48 V

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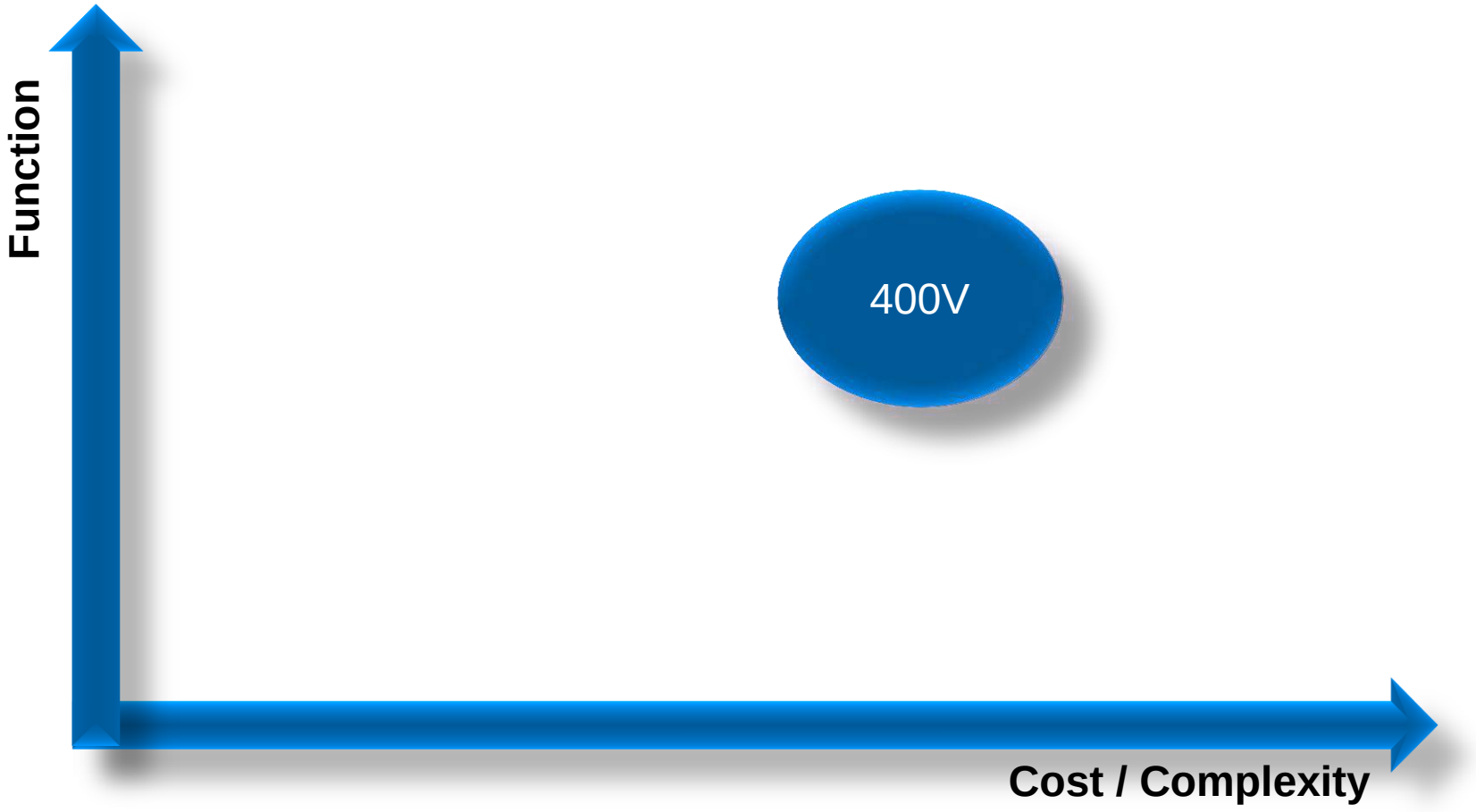
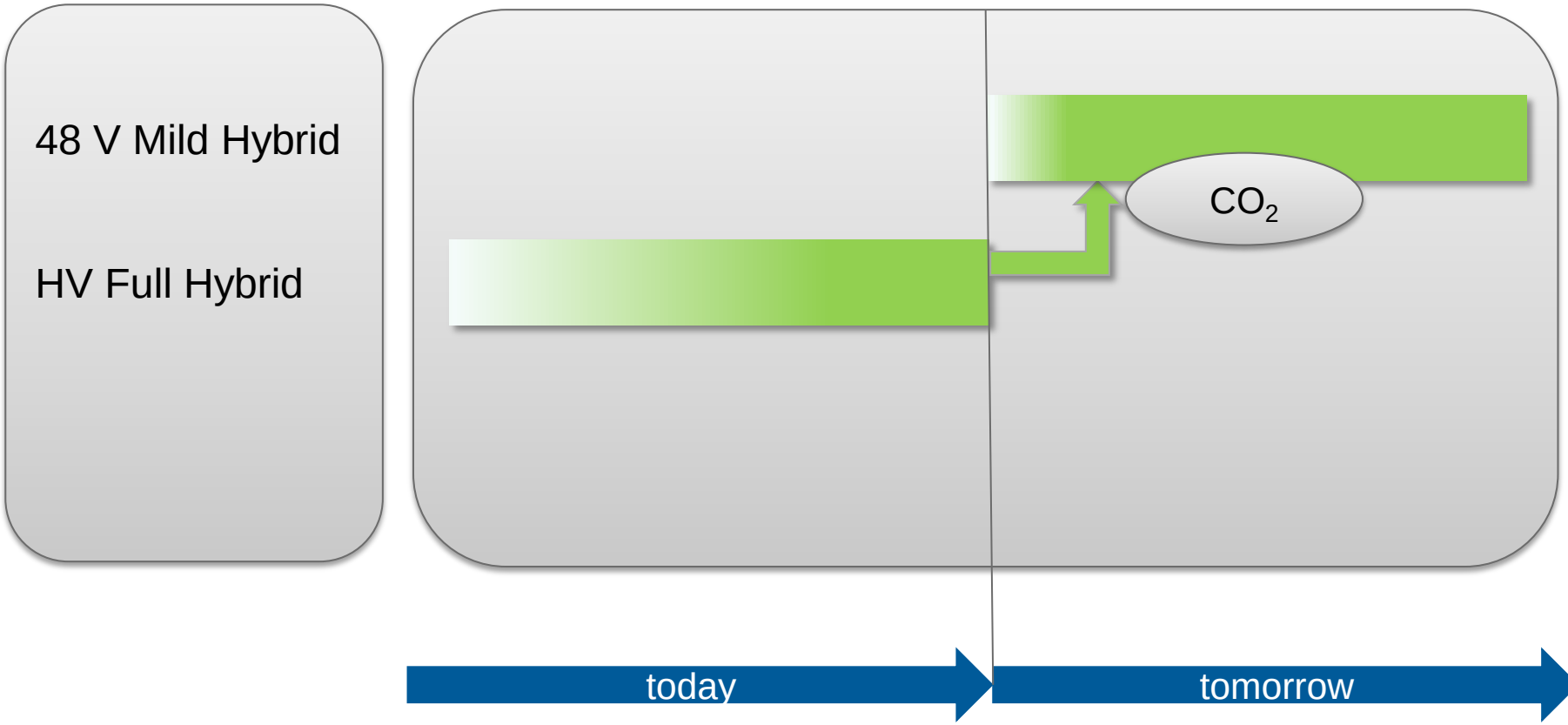


HYBRID ROAD MAP

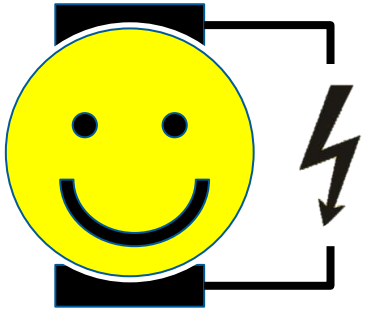


TREND TOWARDS PLUG-IN HYBRIDS

- **Legal CO_2 Requirements**
  - Legally, electric power is created with 0 g CO_2 / Credits

- **Privileges for EV mode**
  - City access, privileges

- **Electric Driving Experience**



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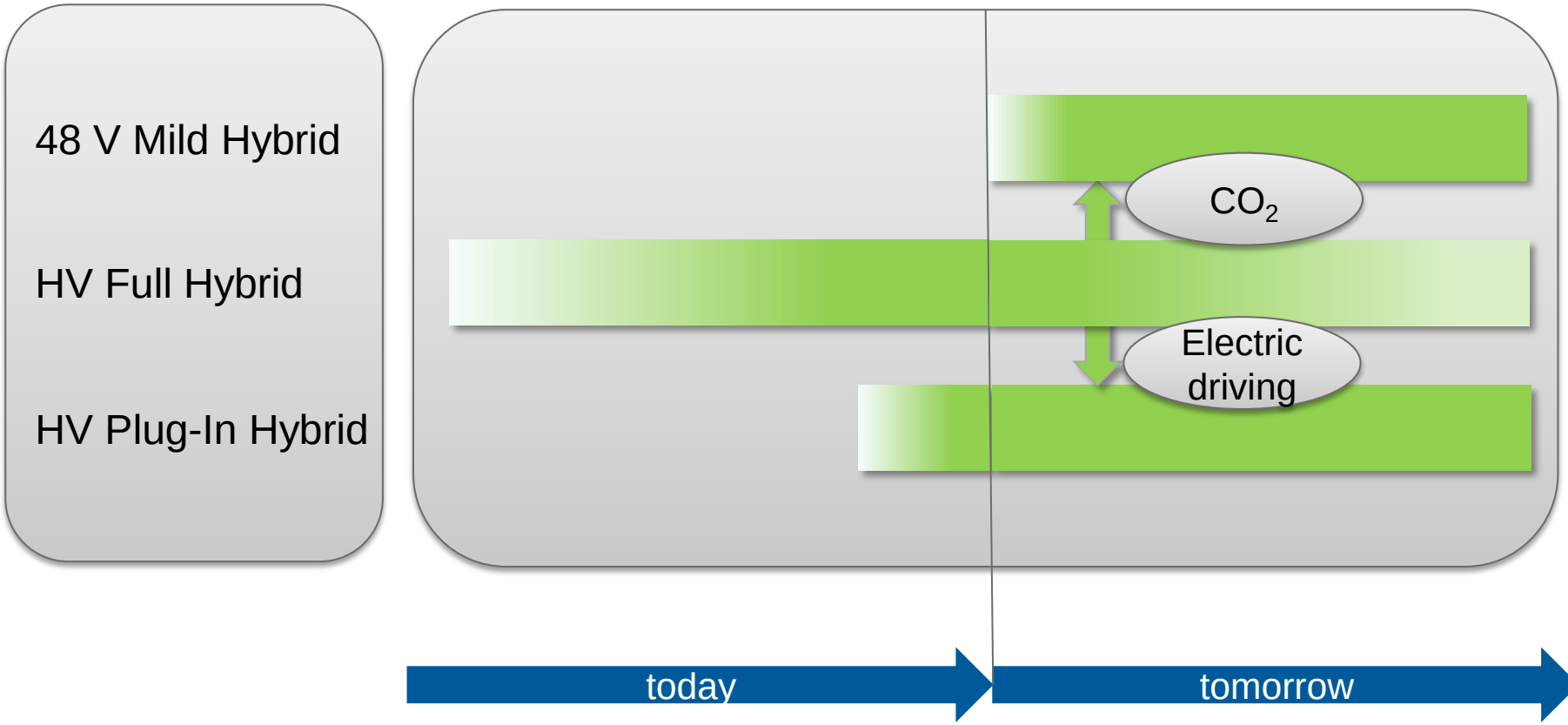
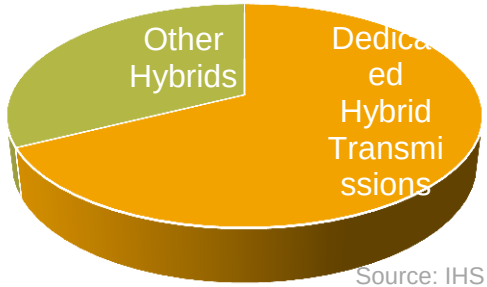


CLEAR TREND TO DEDICATED HYBRID TRANSMISSIONS (DHT)

- Most hybrid vehicle models use standard transmissions or slight modifications thereof (e.g. P2)
- Dedicated Hybrid Transmissions (DHT) will become standard
- Toyota Prius is dominating hybrid volumes already today with DHT

DHT: Transmission not functional w/o e-machine

Market Share 2014



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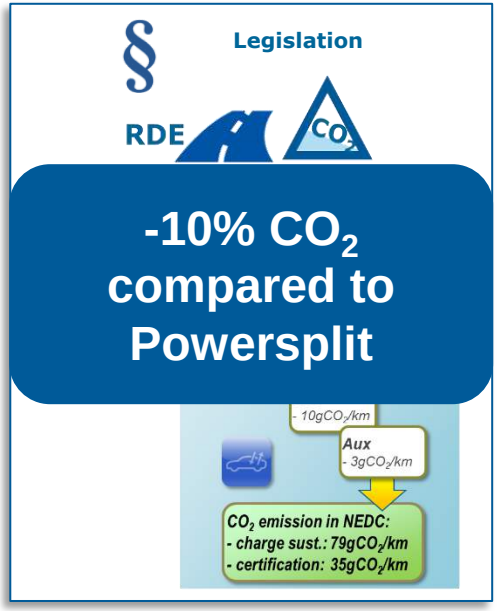
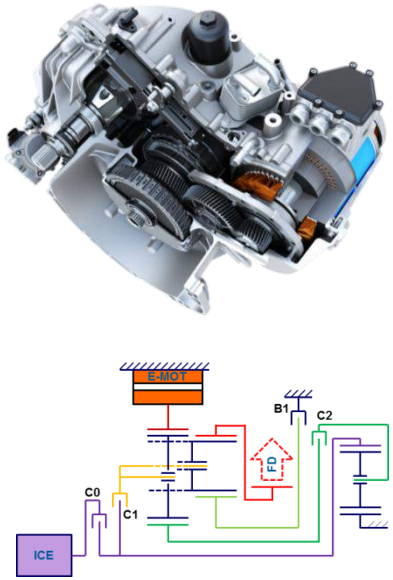
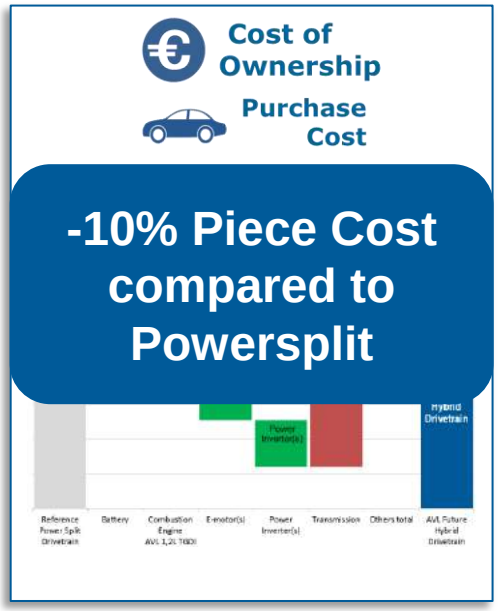
AVL FUTURE HYBRID
NEXT GENERATION DHT







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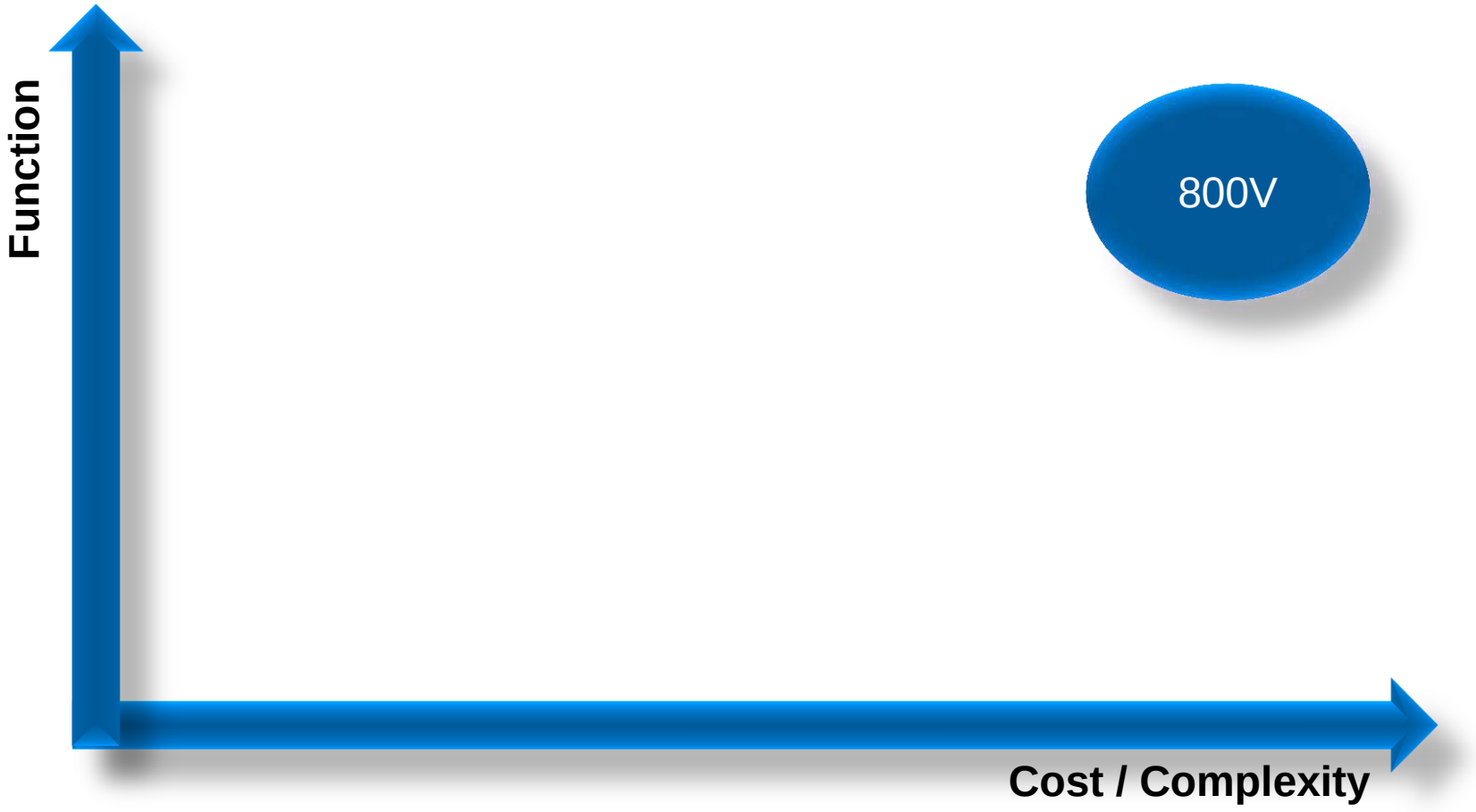


HIGH POWER ELECTRIFICATION MOVING AHEAD

Tesla S P 85D

Audi R8 e-tron

Lexus RX

AMG Electric Drive

BMW i8

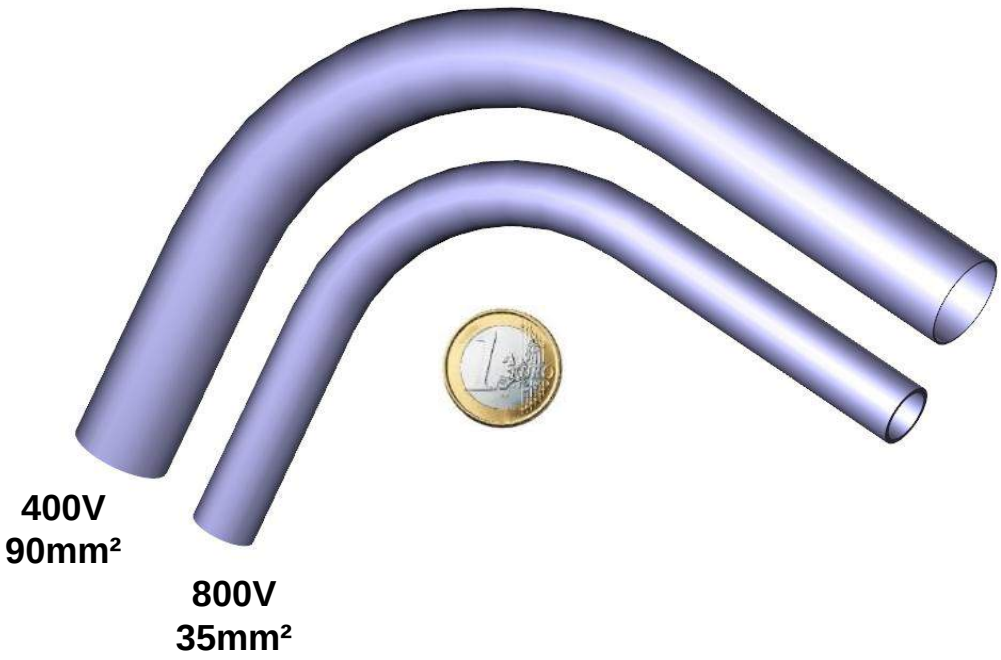
More to come …

800V
ADVANTAGES ON ELECTRIC SIDE

- **Double power output compared to 400V at same current!**
- Package & weight wiring
  - Diameter and bending radius
  - Saving of 10 kg in AVL demonstrator

- Package and weight power electronics
  - Double power density

- Connectors:
  - Cheaper (“paid by Amp”)



CHARGING SPEED AS DECISIVE FACTOR

500km Range
min

@ 40l/min @8l/100km

400V

9 km Range
min

Tesla Supercharger: 270km/30min

800V

>20 km Range
min

800V CHALLENGES

- **Infrastructure**
  - DC charging standard available
    - But no stations > 500 V
  - AC-Charging possible (Onboard-Charger)
    - But limited charging power (22kW)

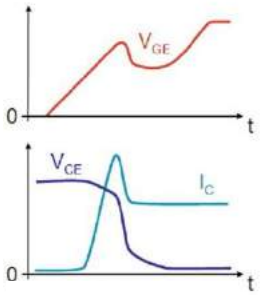
- **Auxiliaries**
  - Different voltage levels in vehicle may be required
    - 800V, 400V, 48V, 12V
    - Heater
    - AC-compressor
    - Power steering
    - …

Source: www.visteon.com

800V CHALLENGES

- **Power Electronics**
- Availability:
  - ✓ **Components** and technologies
    ➔ "proven industry standard"
  - ✓ **Automotive** components
    ➔ test- and release effort, today limited choice
  - ✓ Automotive **systems**
    ➔ development effort (also required for 400V high power)

- Efficiency
  - Higher switching losses in IGBTs
  - Options:
    - Variable PWM frequency
    - New semiconductor technology

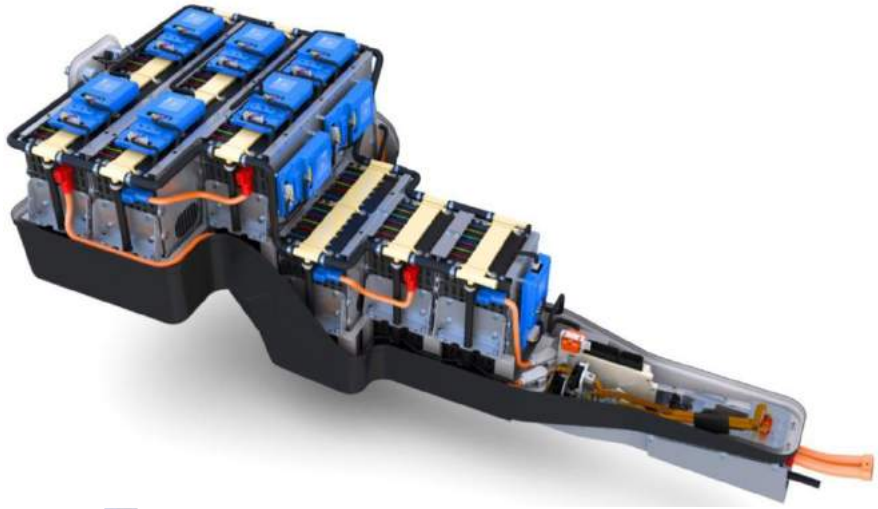


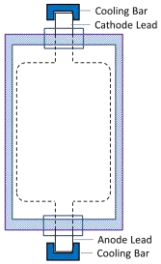
WORLD'S FIRST 800V PASSENGER CAR: AVL COUP-E 800

Peak Power: 200 kW

AVL'S 800V BATTERY

MODULAR POUCH CELL BATTERY WITH AVL BMS





Battery Pack Details

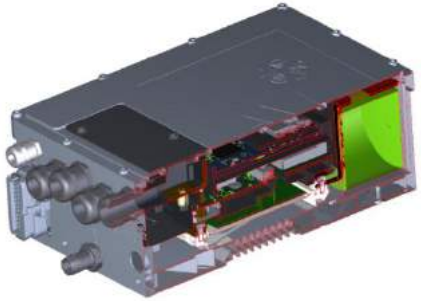
- Configuration 180s1p
- Installed pack energy 27,6 kWh
- Pack weight 255 kg

Highlights

- Self carrying modules
- Bus bar cooling system
- Cell tab clinching instead of Laser welding
- Serviceable E/E box

AVL'S 800V POWER ELECTRONICS

PI450/850 POWER-INVERTER PLATFORM



Technical Data

- U = 850V
- I = 300 A (430 A up to 10s)
- 1200 V IGBT Module
- Water/Glycol- Cooling

Controller Software

- Field Oriented Control Software (FOC)
- Variable PWM Frequency up to 12kHz
- ASM/PSM drives

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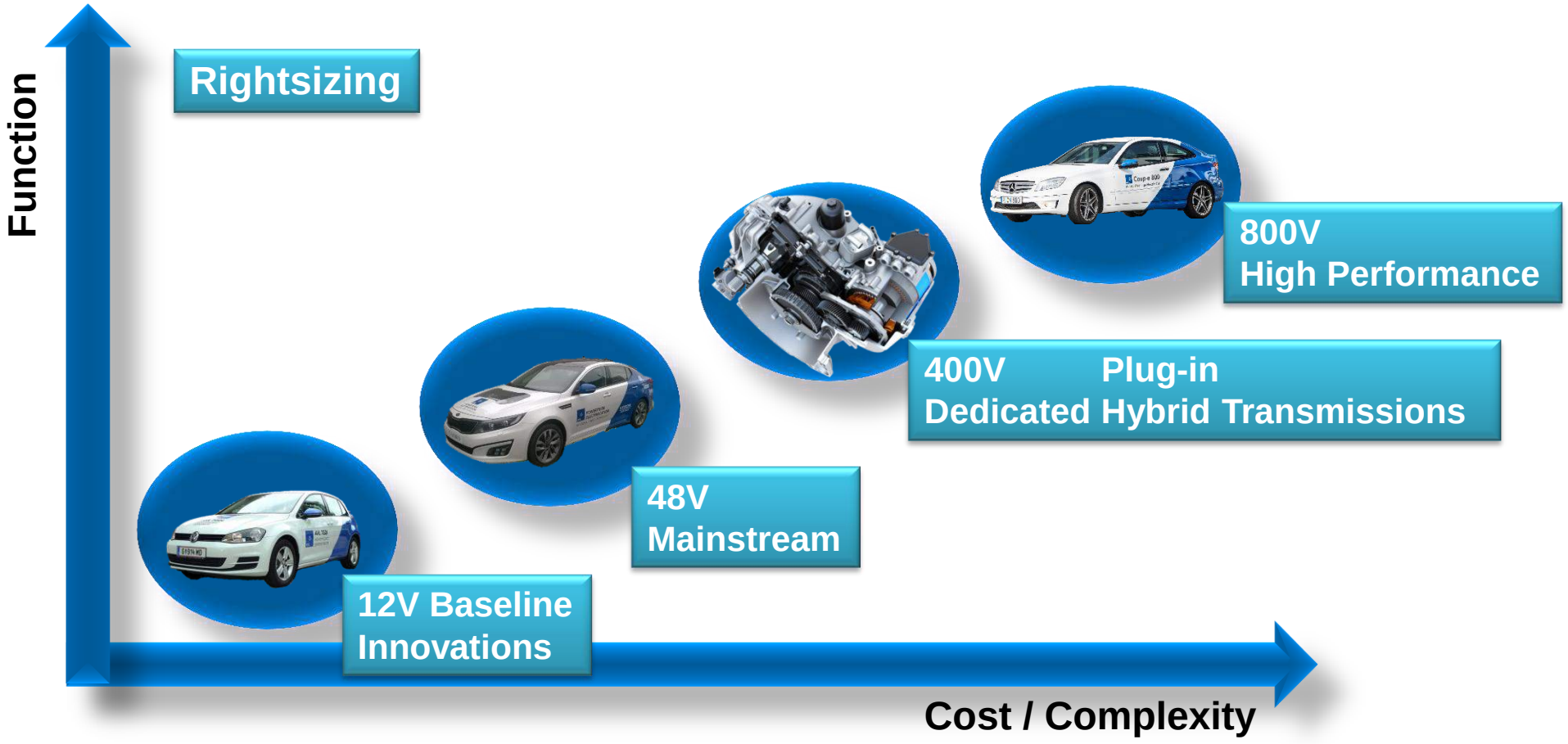

THANK YOU

www.avl.com