punch powertrain
Gear up for the future

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The Resurgence of Punch Powertrain's CVT

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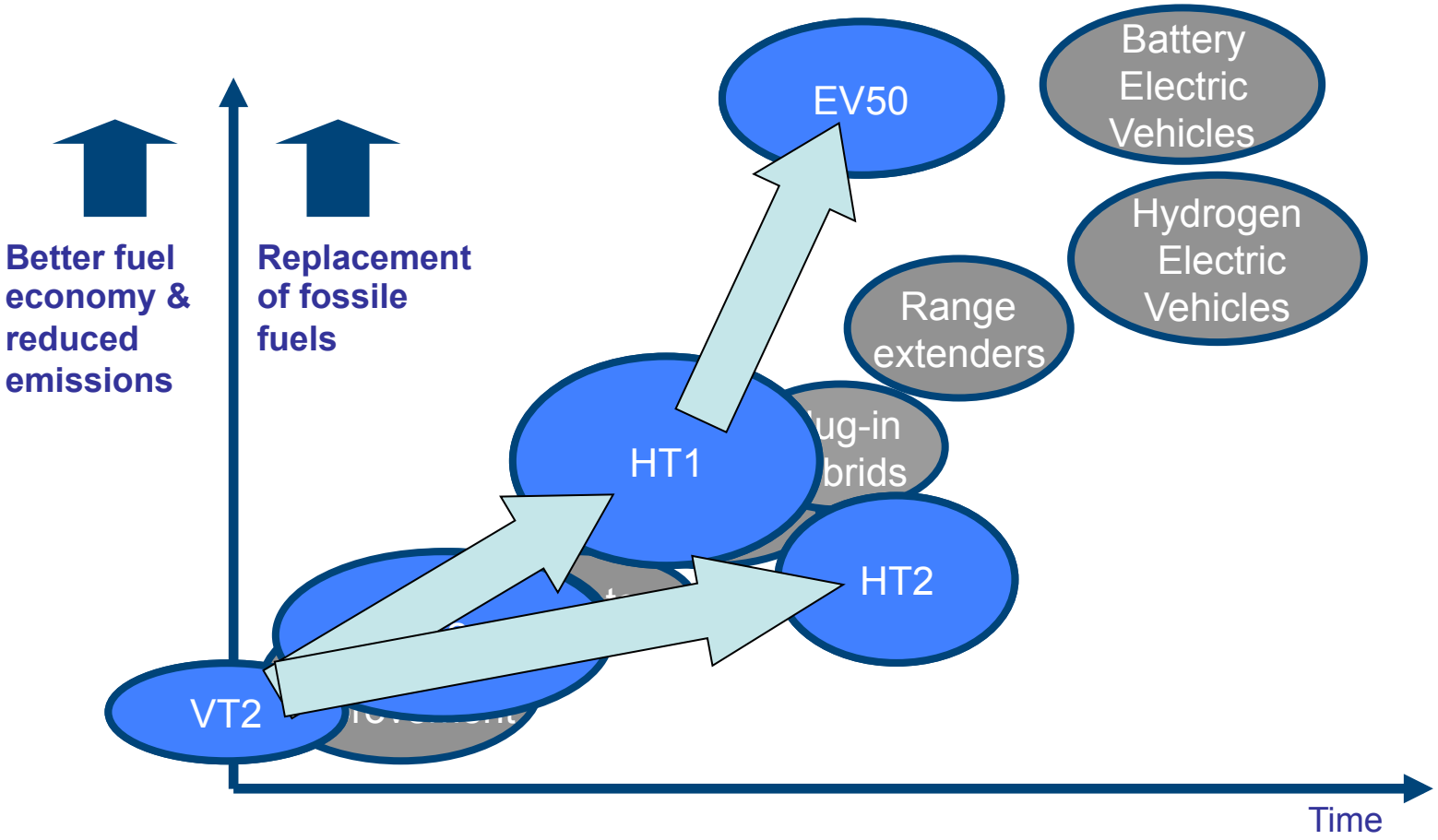
Introduction

- Introduction Punch Powertrain
- Road maps OEMs vs. Punch Powertrain
- FWD transmissions market analysis
- VT2/VT2+ history and outlook of improvements
- Some details of improvements
- Further room for improvement
- VT2 hybrid derivatives
- Summary

Introduction Punch Powertrain

- Independent supplier of
  - CVTs
  - Hybrid powertrains
  - Electric powertrains
- Key technologies
  - CVT
  - Hybrid controls
  - Switched reluctance motors (including power electronics)

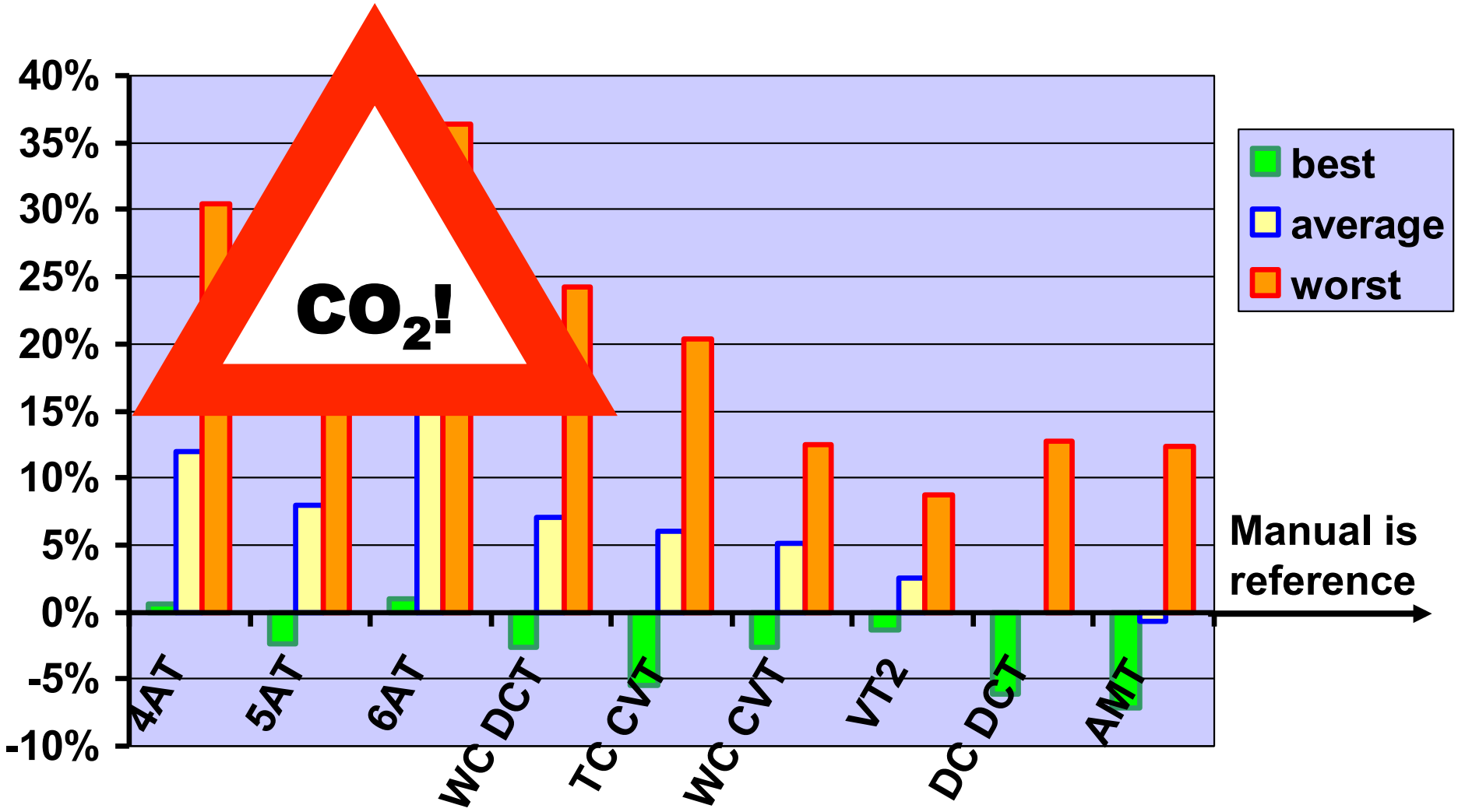
Road map Punch Powetrain for cleaner powertrains



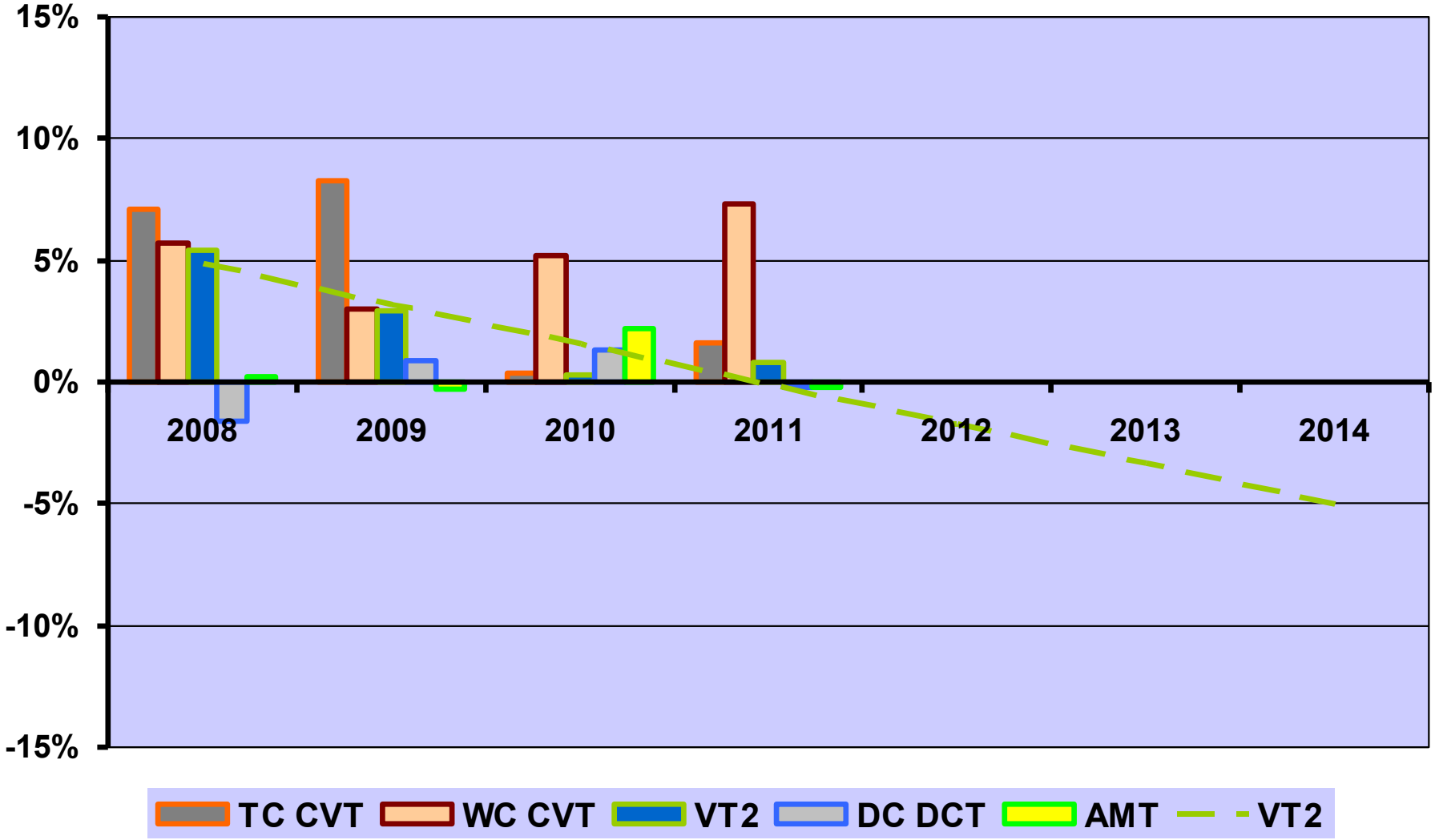
FWD transmissions market analysis

- 8 different transmission concepts
- Reference is Manual Transmission in same vehicle with same engine
- NEDC cycle
- Over 300 FWD powertrains
- Powertrains on sale in Europe between begin 2010 and Q2 2011

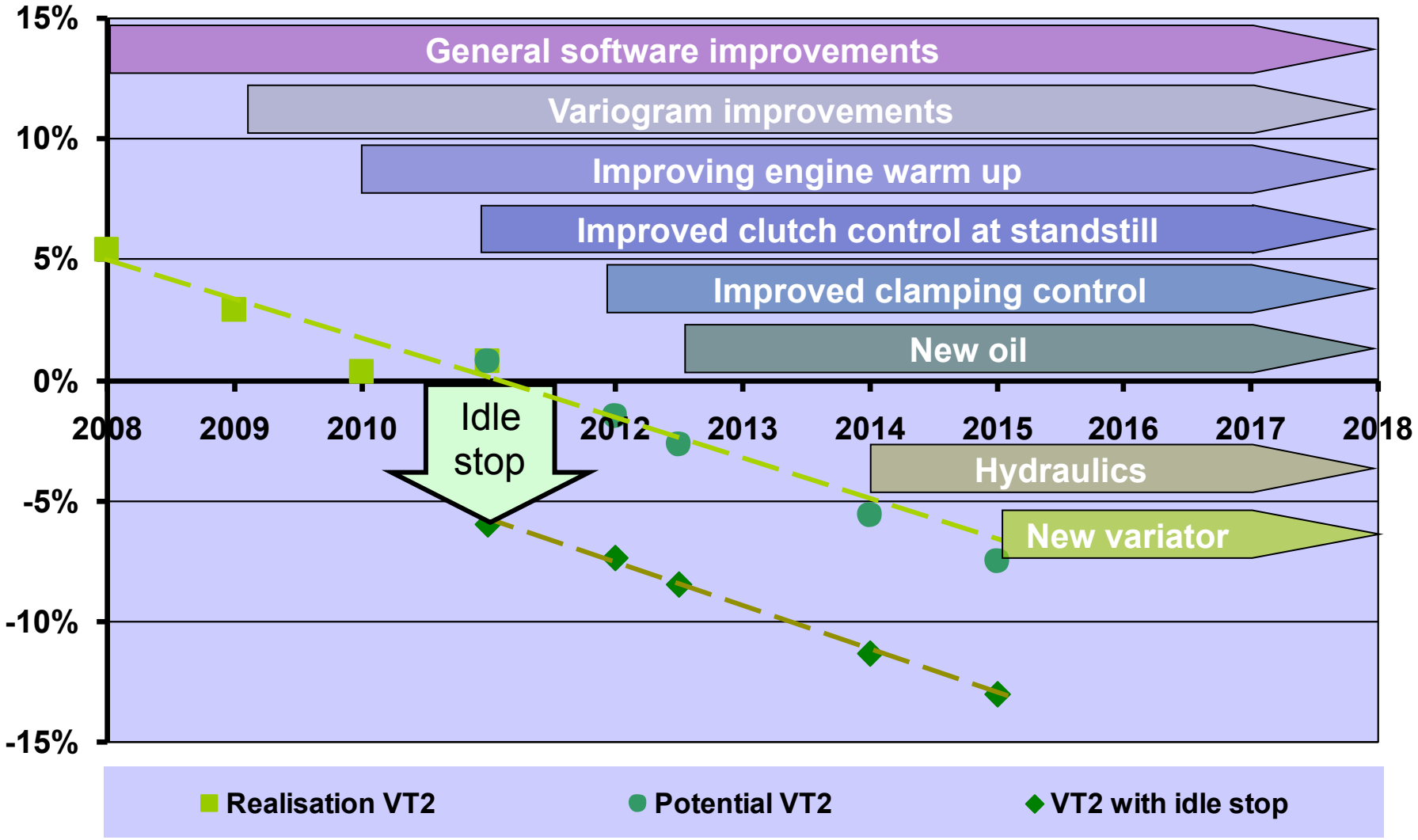
Comparison results



Best concepts



VT2 history & outlook



Improvement details

General software improvements

- Continuous improvement program
- Simplification of functions

Variogram improvements

- Improved interaction with engine calibration
- Looking at overall best solution

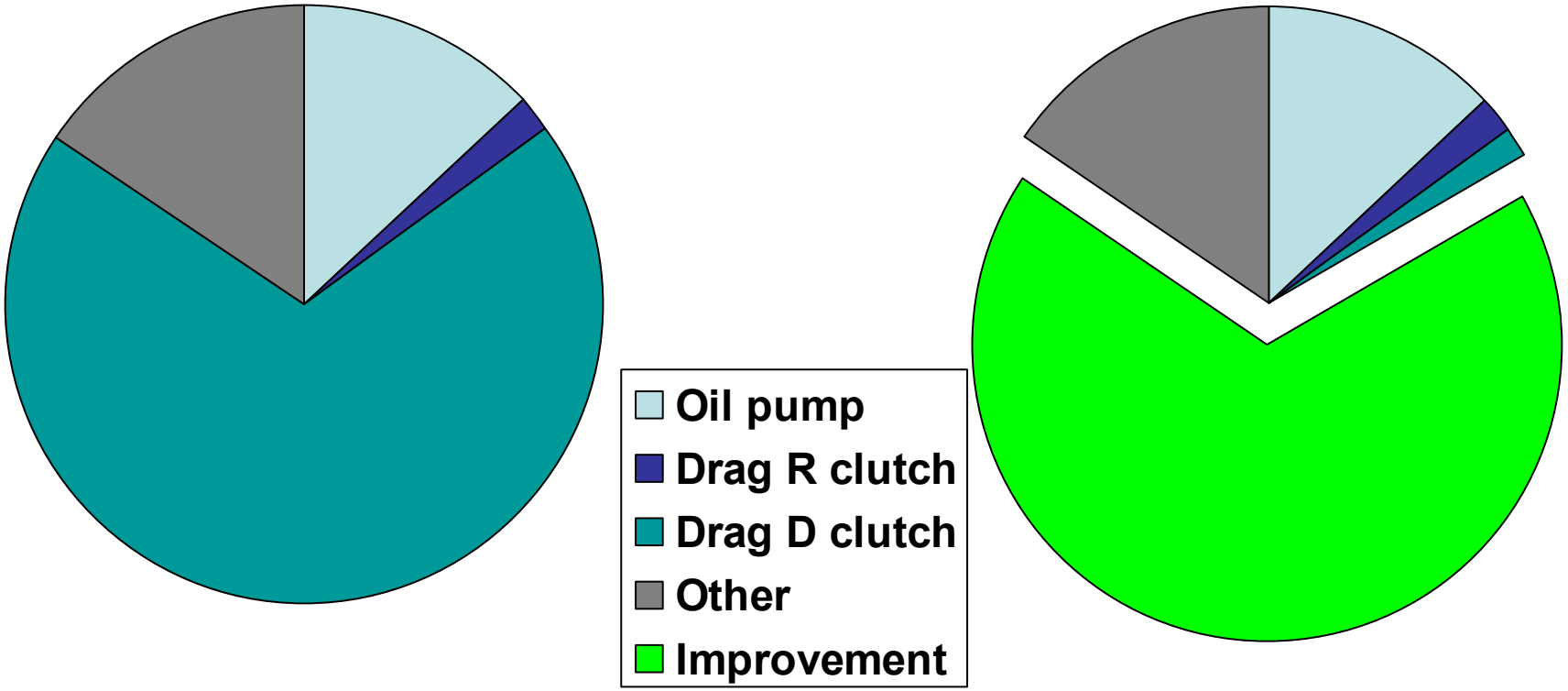
Improving engine warm up

- Engine efficiency is more important than transmission efficiency
- Engine warm up model in transmission software
- Calculates best variogram

Improvement details

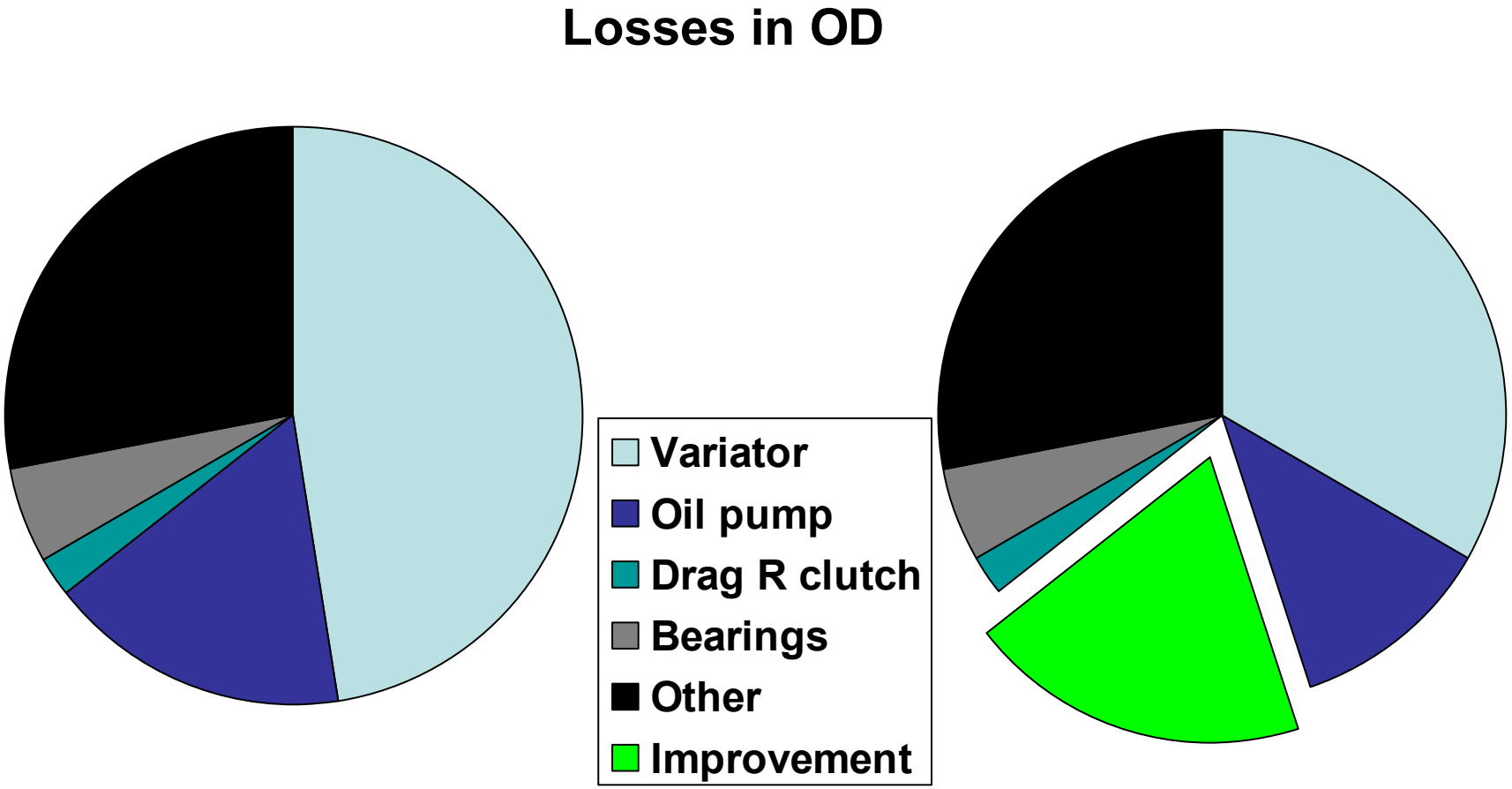
Improved clutch control at standstill

Losses distribution at standstill



Improvement details

Improved clamping control



VT2 history & outlook

New oil

- Lower viscosity
- Increased μ for belt – pulley contact

Hydraulics

- Allowing lower clamping pressure in/near OD
- Lower clamping reduces variator and pump losses

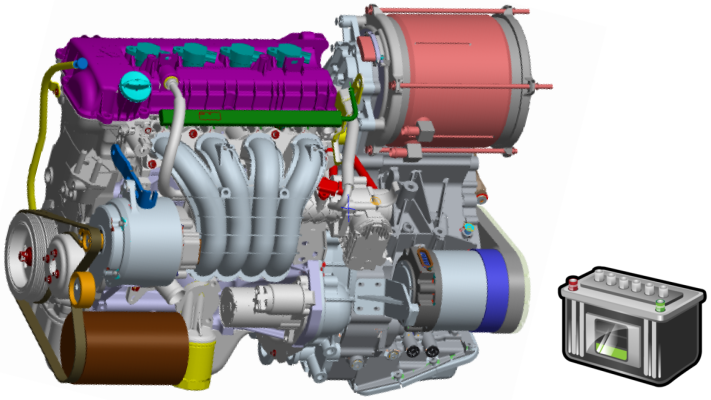
New variator

- Confidential

Challenges for engine engineers

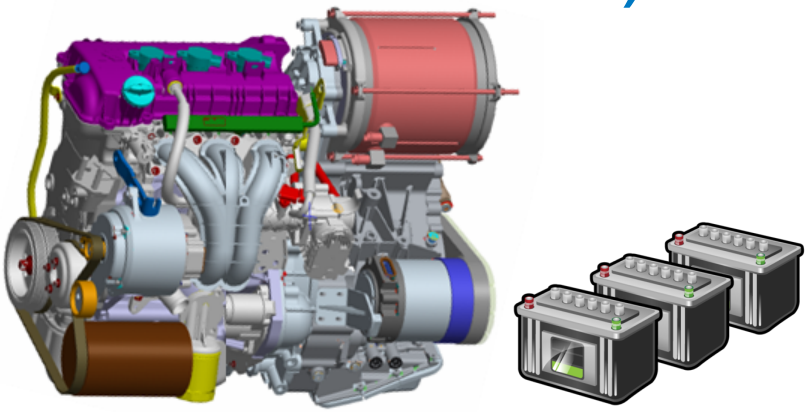
- Increase accuracy of torque signal
  - Allows less safety margin on clamping pressure
  - Results in better fuel economy
- Optimise interaction with transmission
  - Maximize and adapt fuel cut off strategy to variogram
  - Engine calibration to focus on lower engine speeds (below 2200 rpm)
  - Maximize sweet point value rather than increasing the range (a CVT can handle this)

HT1 powertrain configurations (derived from VT2)



Power hybrid 20-25% / 3kWh

ICE remains unchanged

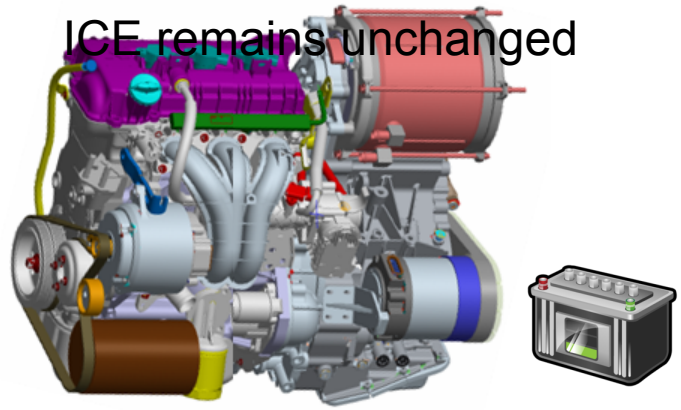


Plug-in hybrid (6-10 kWh)

ICE downsized (e.g. 4 to 3 cylinder)

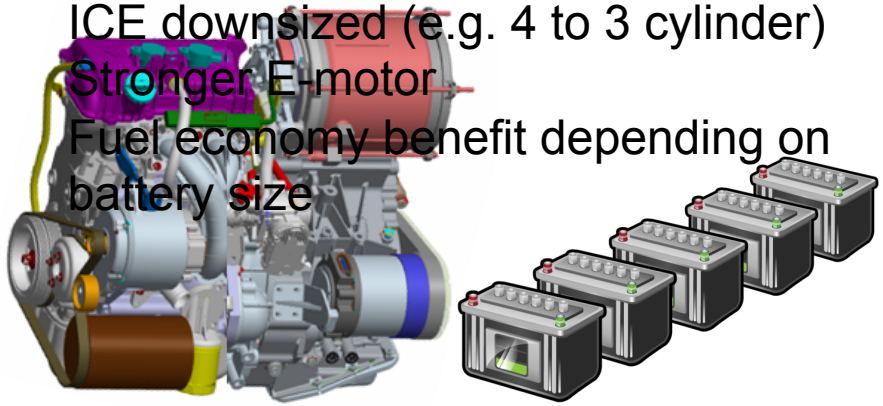
Stronger E-motor

Fuel economy benefit depending on battery size



Economy hybrid 25-30% / 3kWh

ICE downsized (e.g. 4 to 3 cylinder)

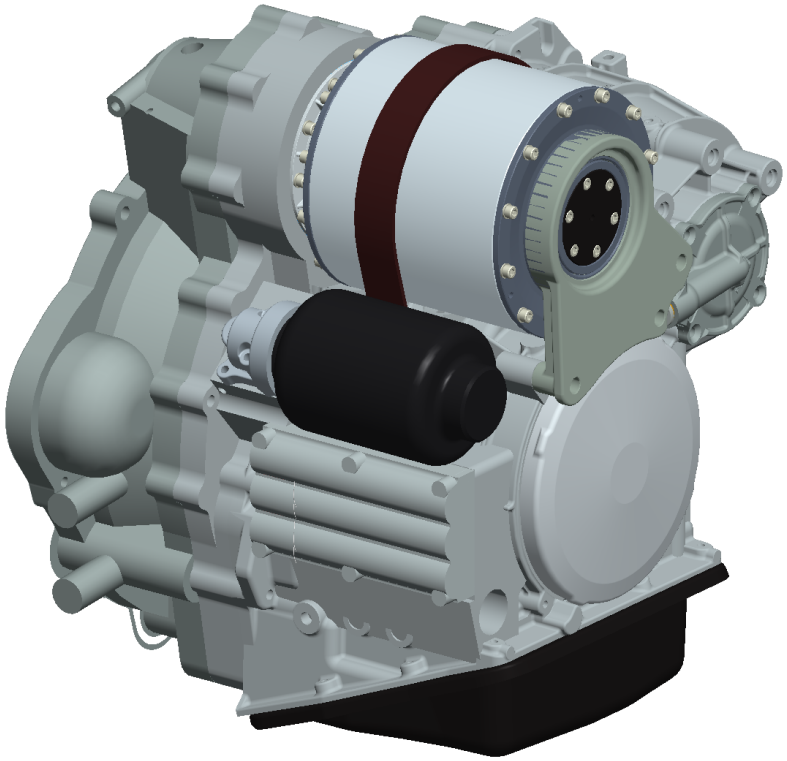


Range extender >12kWh

ICE further downsized (e.g. 3 to 2 cylinder)

HT2: Flywheel hybrid

- Research project
- Fuel economy benefit 20%
- No batteries required
- Low cost alternative
- Same fuel economy benefit as battery hybrids on the market



mecHybrid consortium partners

Summary

- There is a large overlap between different transmission concepts
- 4AT, 5AT, 6AT and Wet clutch DCTs are on average the worst performing transmission concepts
- Torque converter CVTs have moved out of this range
- Punch CVTs provide fuel economy in line with the best performing concepts (Dry DCT and AMT)
- Punch CVTs are improving faster than any transmission concept and will continue to improve
- Hybridisation offers new possibilities for CVT. Punch Powertrain can offer best in class concepts in terms of costs and fuel economy
- The potential for a bright future is clear

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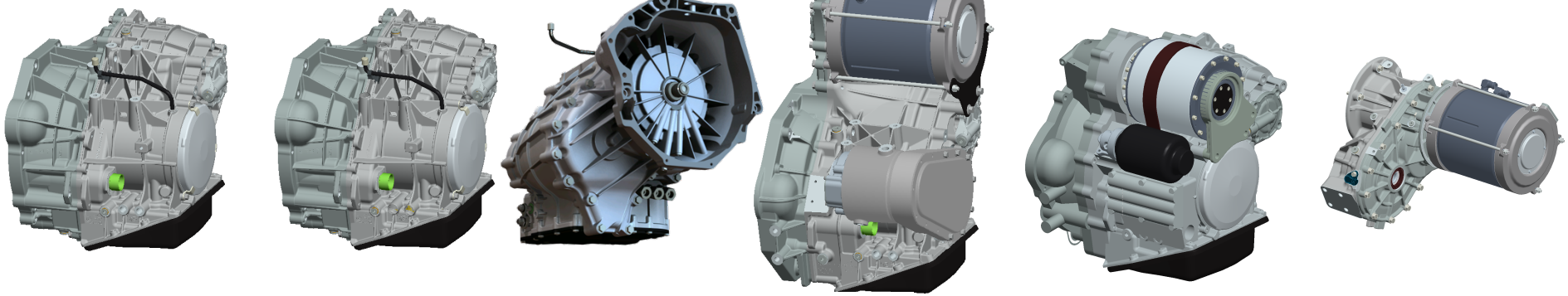
Thank you for your attention



VT2 VT3 VT4 HT1 HT2 EV50