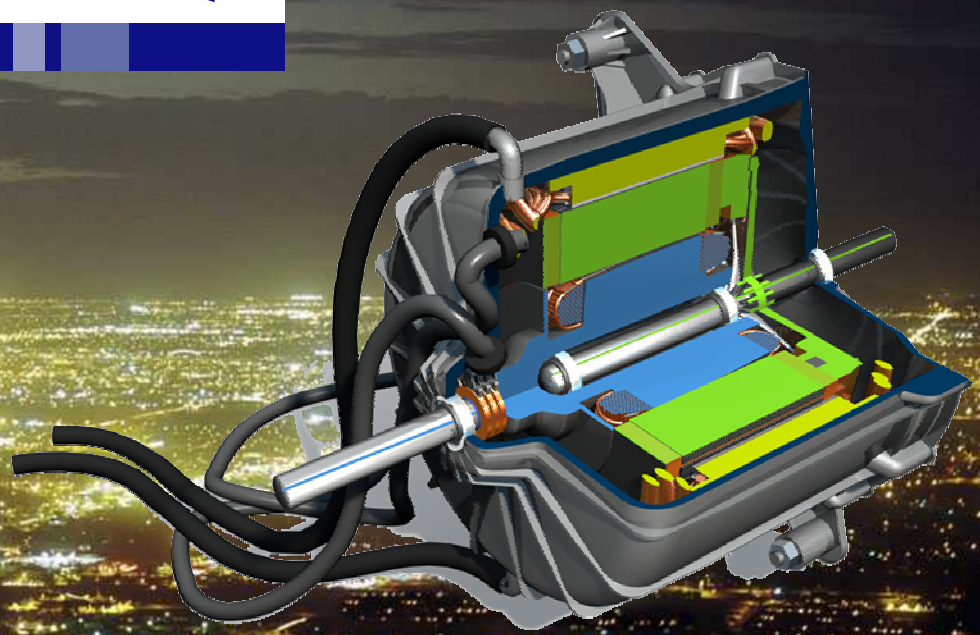
Electrical Variable Transmission

June 2010, David van de Wall

TNO | Knowledge for business



Business Unit Automotive

TNO in a Nutshell

- TNO is the Netherlands' Organization for Applied Research
- Independent R&D organization
- Over 75 years of experience
- 5,000 employees world-wide
- HQ in Delft, the Netherlands
- Annual turnover approx. 550 M€

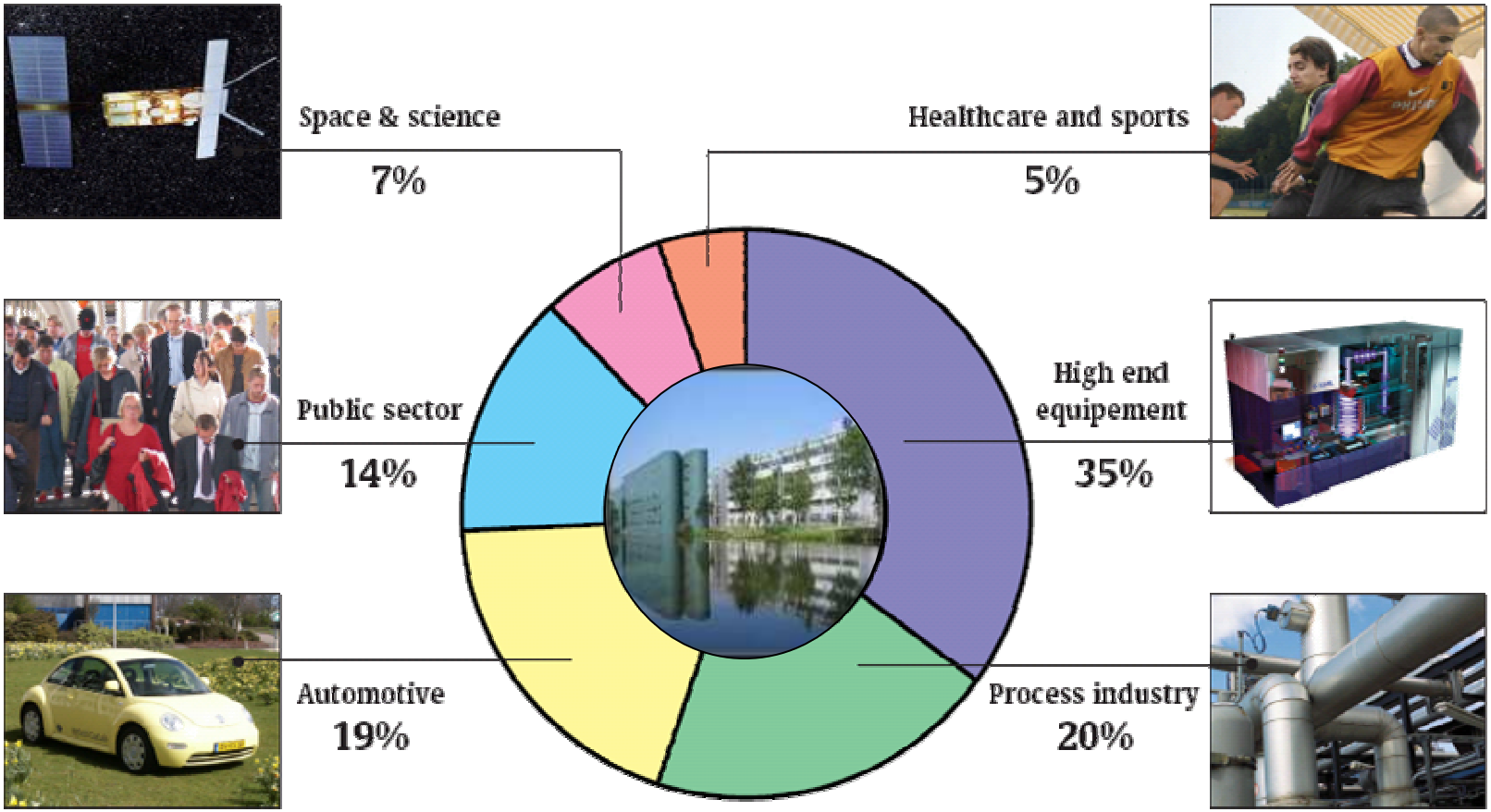
Five core areas

- Quality of Life
- Defence, Security & Safety
- Science & Industry
  - a.o. automotive
- Built Environment & Geosciences
- Information & Communication Technology





Market Portals of TNO Science & Industry



TNO Automotive Research Programs

Sustainable Powertrains

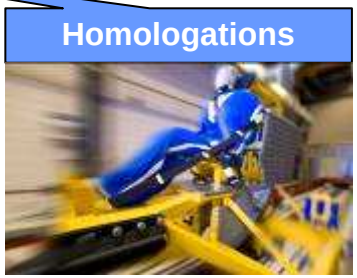
Future Automotive Fuels
Diesel Emission Control
Advanced Powertrains

Focus: Automotive Control Systems

Integrated Safety

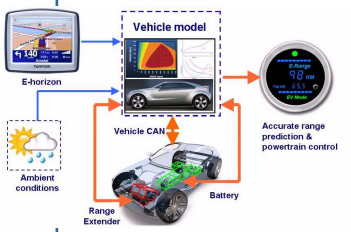
Injury Prevention
Advanced Driver Assistance
Vehicle Dynamics Control

TNO Test Facilities in Helmond

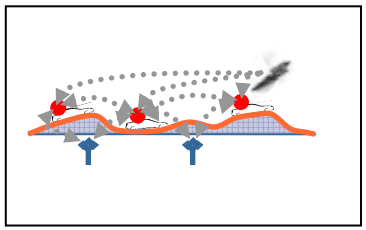


Product overview TNO Automotive Advanced Powertrains

High Level Energy and Power Train management



E-Horizon: Optimize e-consumption by navigation forecast



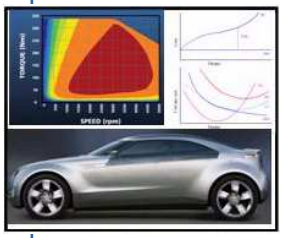
E-Horizon H/W: Packaging and user interface

E-Range predictor

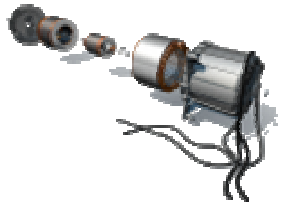
Accurate prediction based on battery & vehicle parameters

Prototype Vehicle building: Garbage truck

Hybrid & EV modeling



Electronic PowerTake-off (EPTO)



Electronic variable transmission (EVT)

Real life drive cycle generation

Prototype Vehicle building: Series hybrid, ultracaps

(H) EV active and passive safety

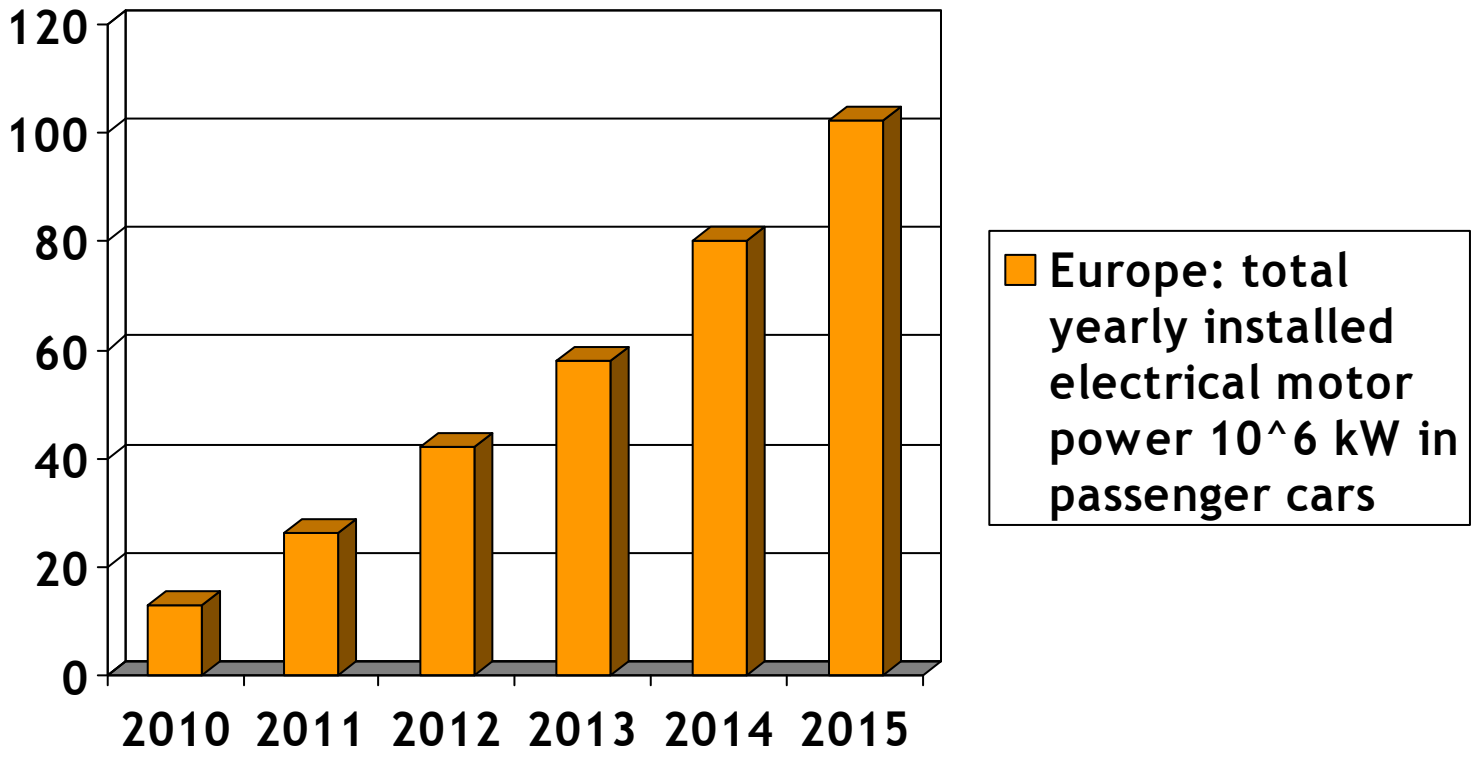
Calibration on vehicle level

Engine and chassis dyno emission measurements

Certifying CO2 reduction

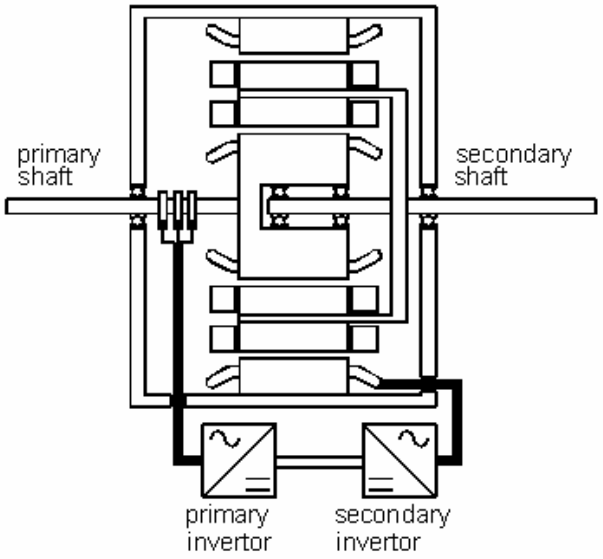
Prototype Vehicle building: ChangAn

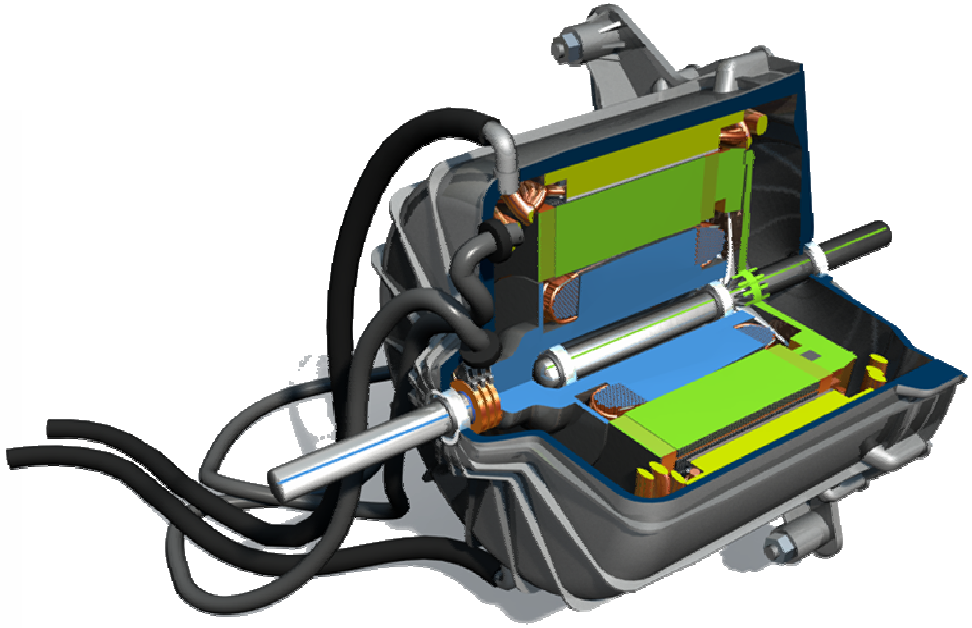
Market Potential Electric Motor in vehicles



Concept - What is the EVT?

- Two mechanical ports and two electrical ports
- Electromechanical transmission
- EVT = Electrical variable transmission
- Electrical ports require two power inverters



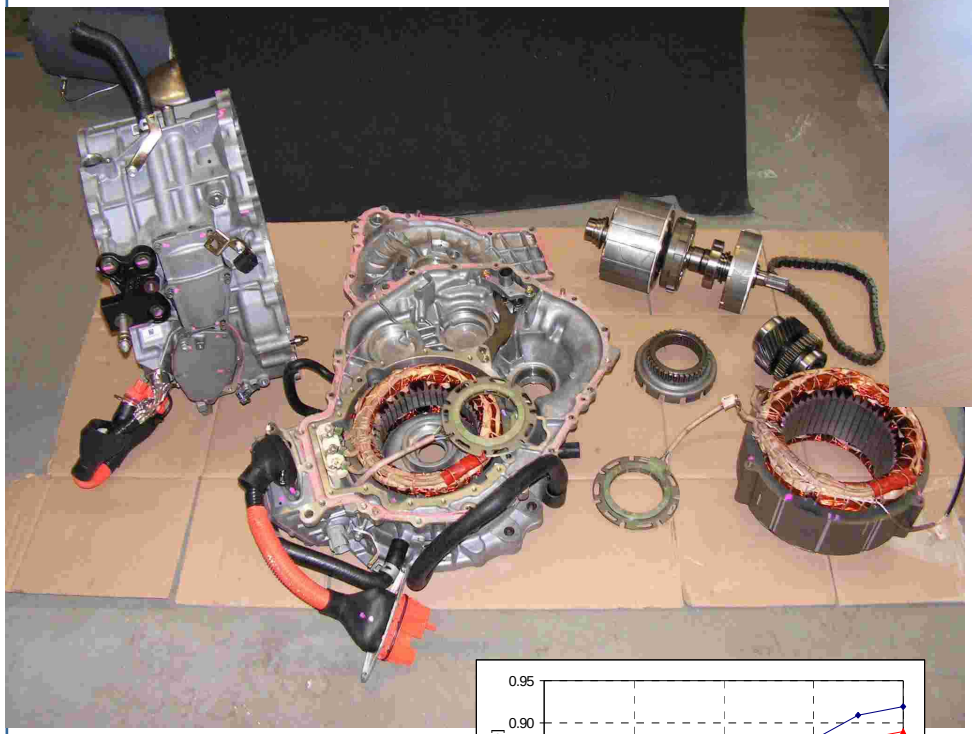


Applications: Light Duty

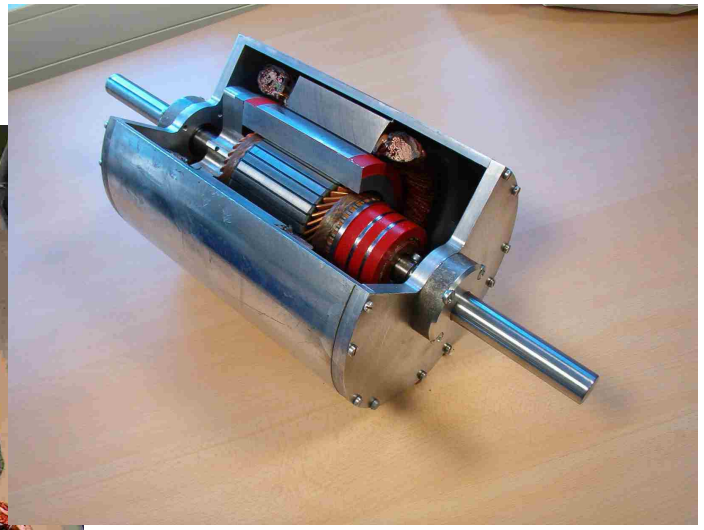
- **Passenger cars**
  - Highly efficient EVT transmission
  - Full-hybrid functionality (regen, boost, ZEV)
  - Range-extender functionality
  - EVT replaces starter, alternator and fly-wheel/clutch assembly
  - EVT replaces transmission, EM and clutch in the hybrid powertrain
- **Customer benefits**
  - Improved drivetrain efficiency
  - Reduced weight and packaging compared to hybrid powertrain
  - Drivability (no gearshifts, torque-smoothing, noise reduction)
  - Integrated emission control (ZEV, DPF-regeneration, NO_x-control)
- **Technology drivers**
  - 15% CO_2 reduction on NEDC
  - Exhaust emission reduction
  - Driveability/Fun-to-drive
  - Costs

Unique features: packaging & efficiency

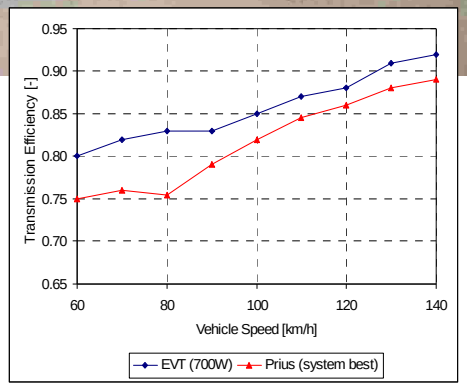
Comparison Prius (THS-II) vs EVT



110 kg, 76 L, 30 parts

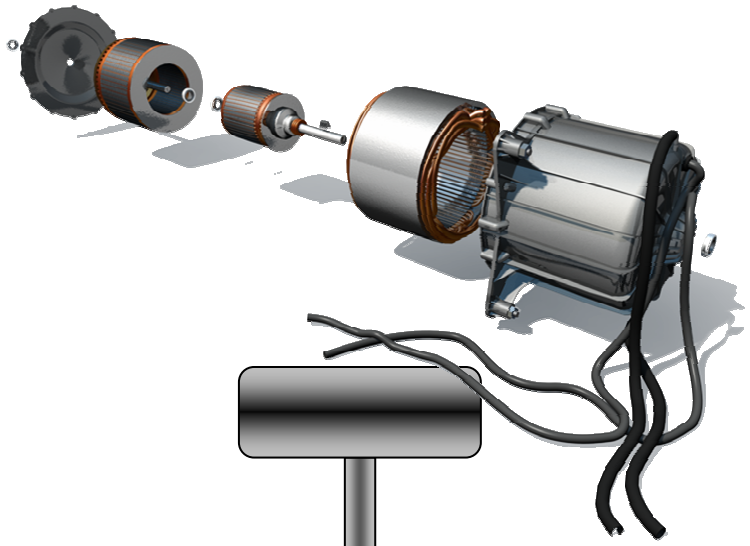


95 kg, 45 L, 16 parts

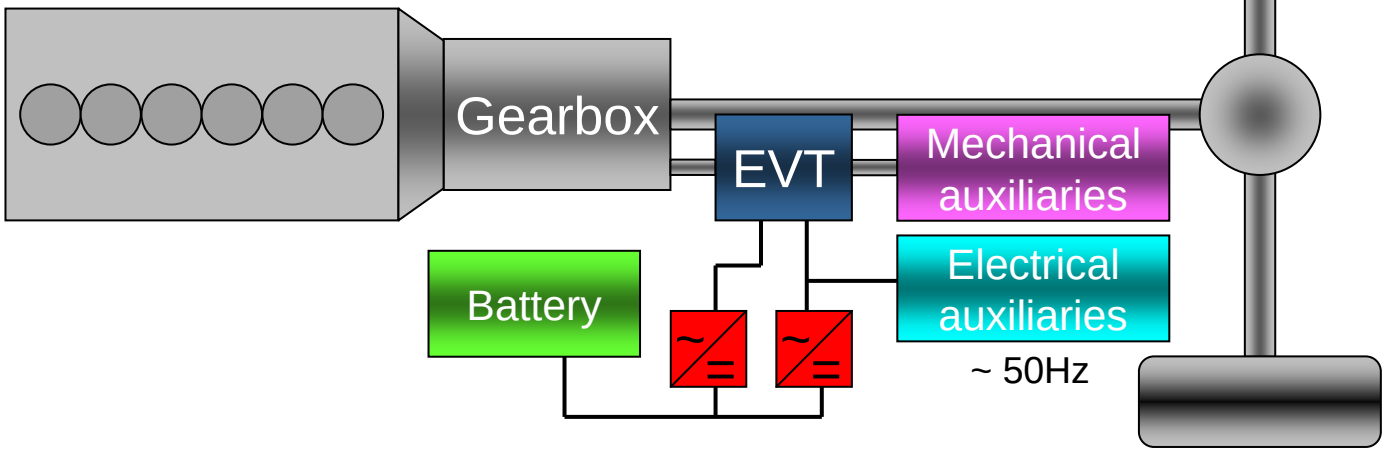


	THS-II	EVT
Mass	110 kg	95 kg
Dimensions	40 × 50 × 38 cm	Ø 38 x 40 cm
Volume	76 dm³	45 dm³

Special application - EVT in Power Take Off



- **e-PTO application:**
  - Stable AC power supply: 30kW @ 50Hz
  - Mechanical output shaft (optionally)
  - High voltage battery (optionally)



- **Possible application: garbage truck / refrigerated truck**

Applications: Heavy Duty

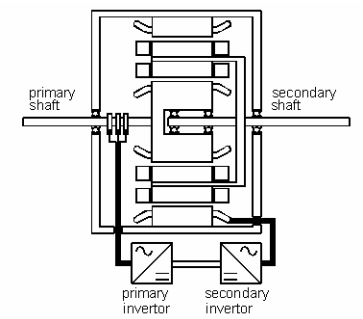
- **Busses / Distribution trucks**
  - Highly efficient EVT transmission
  - Full-hybrid functionality (regen, boost, ZEV)
  - EVT replaces starter, alternator and fly-wheel/clutch assembly
  - EVT as ePTO is separate opportunity

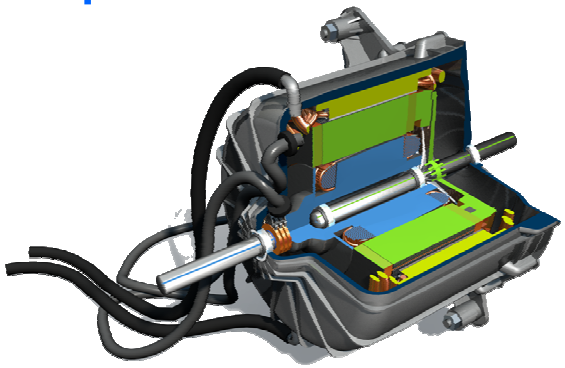
- **Customer benefits**
  - Improved drivetrain efficiency
  - Reduced weight and packaging
  - Drivability (no gearshifts, torque-smoothing, noise-reduction)
  - Integrated emission control (ZEV, DPF-regeneration, NO_x-control)
  - Low maintenance costs (no mechanical friction, electro-magnetic coupling only)

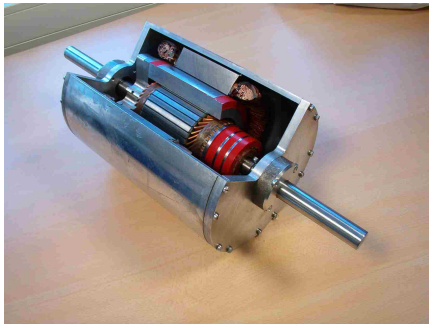
- **Technology drivers**
  - 20% CO_2 reduction on a distribution route
  - NO_x reduction
  - Driveability
  - Inner-city air-quality (PM)
  - Costs

SUMMARY: TNO's Patented EVT

- Cost effective transmission / PTO concept for reduced fuel consumption, increased comfort and performance. Ideal for hybrid powertrains
- Two mechanical axles (one to ICE, one to wheels) and one electrical input / output integrated in one device
- Continuous variable transmission & Electrical motor/ generator / starter motor in one device. Only 2 moving parts, lowest cost
- The best alternative for companies not willing to use the Toyota Prius patents
- Status: simulations done, one prototype ready
- Enquiries welcome: partners / endusers

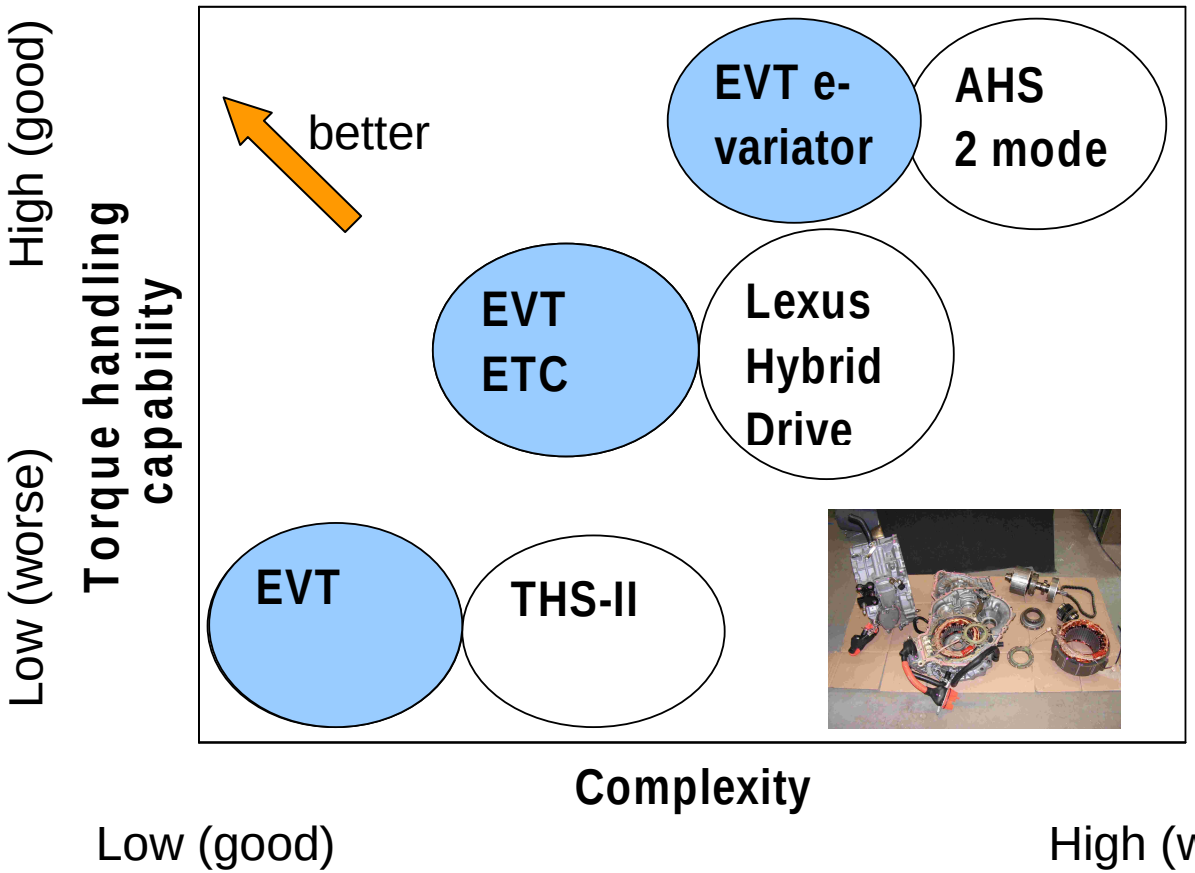


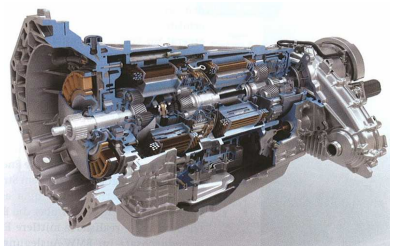




Benchmarking

Hybrid market coverage with one core technology





Benchmarking

Value of EVT compared to competitive full hybrid systems:

	Efficiency	Perfor-mance	Mass	Packaging	Cost
EVT HEV (simulated results)	+	++	0*	++	+
Prius II (test results)	+	+**	+	+	0
Parallel hybrid with DSG/DCT	+	++	+	-	0
Parallel hybrid with AT6	-	++	-	-	0
Two mode HEV	++	++	-	0	-

* reduction potential identified
** no trailer allowed

EINDE