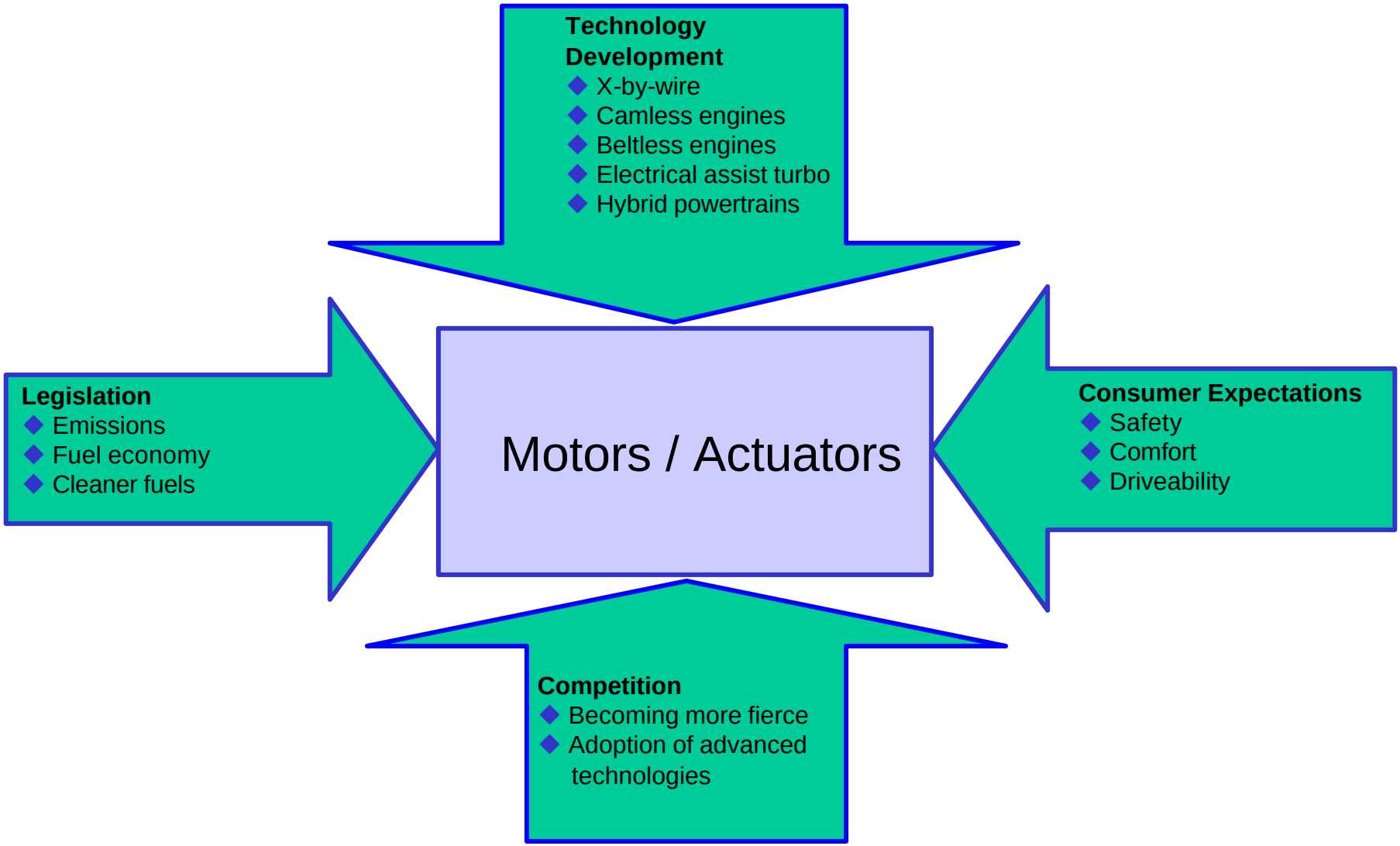
The Future of Electric Motors for Hybrids

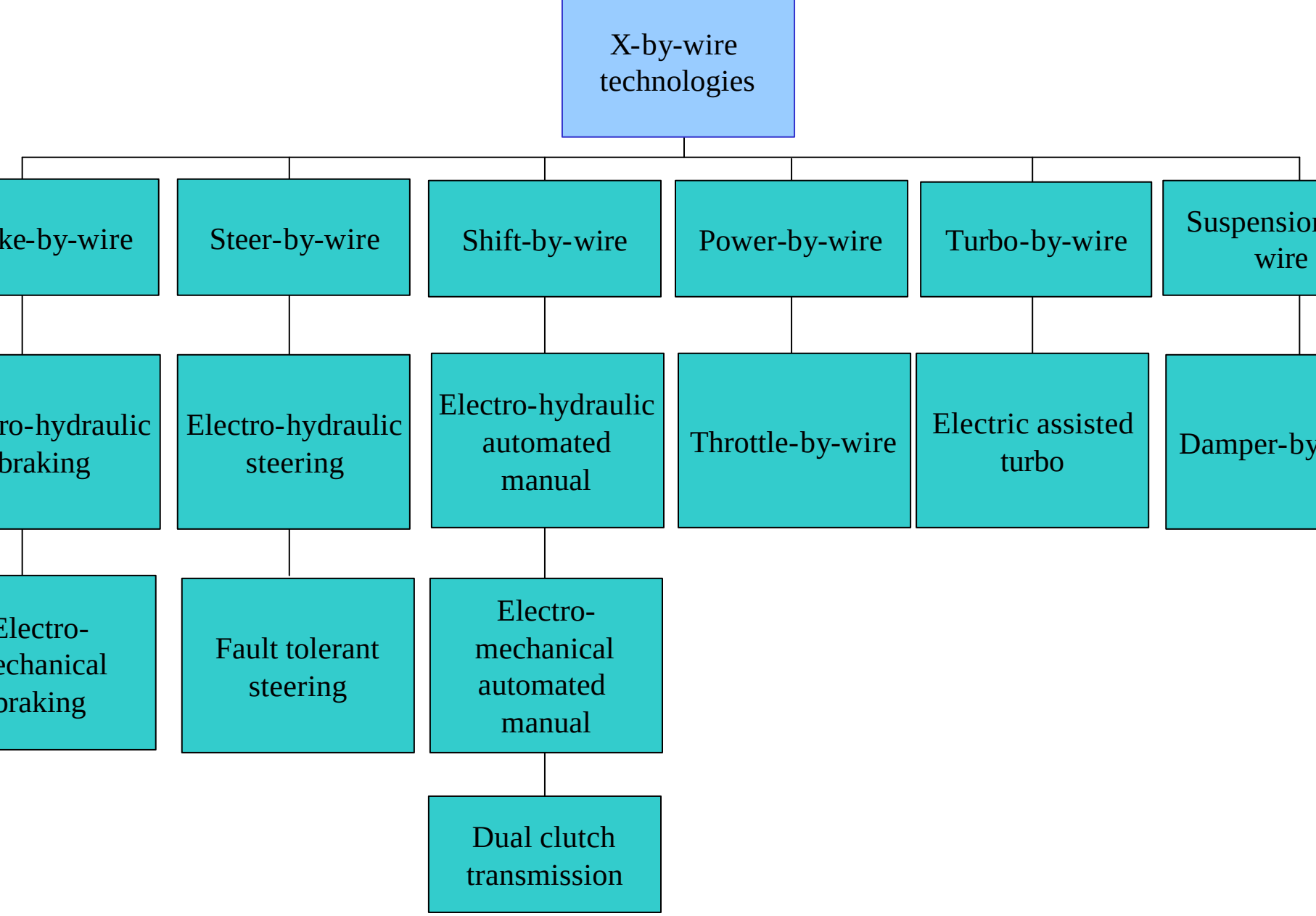
Professor David Howe & Dr Nigel Schofield

Electrical Machines & Drives Research Group
University of Sheffield

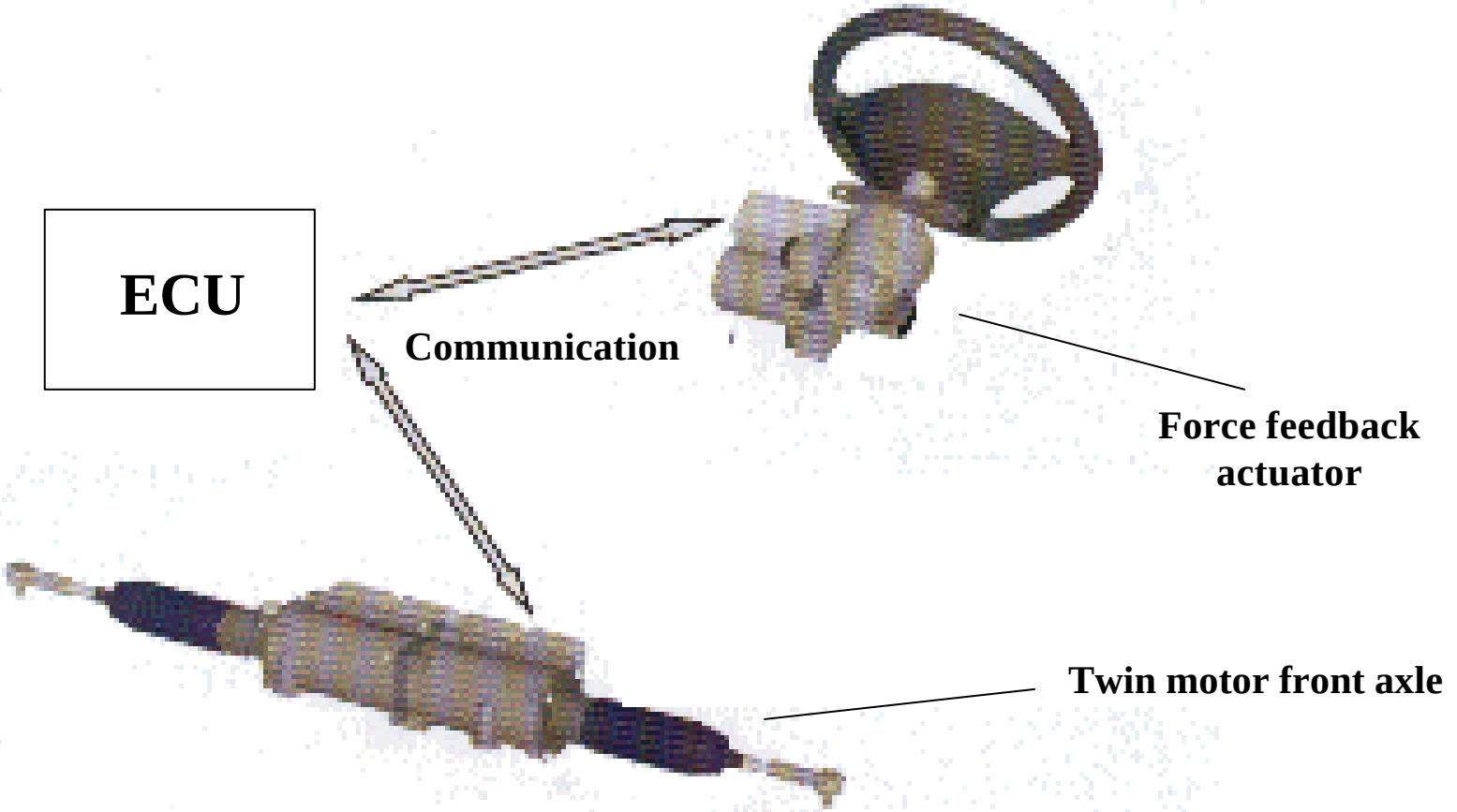
Joint UK/Japan Automotive Forum for Low Carbon Vehicles,
2nd December 2003

Drivers for More Motors/Actuators

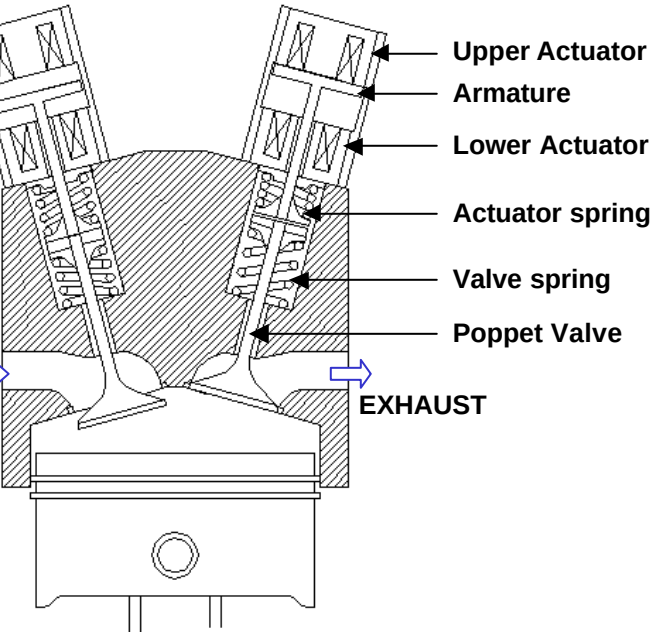


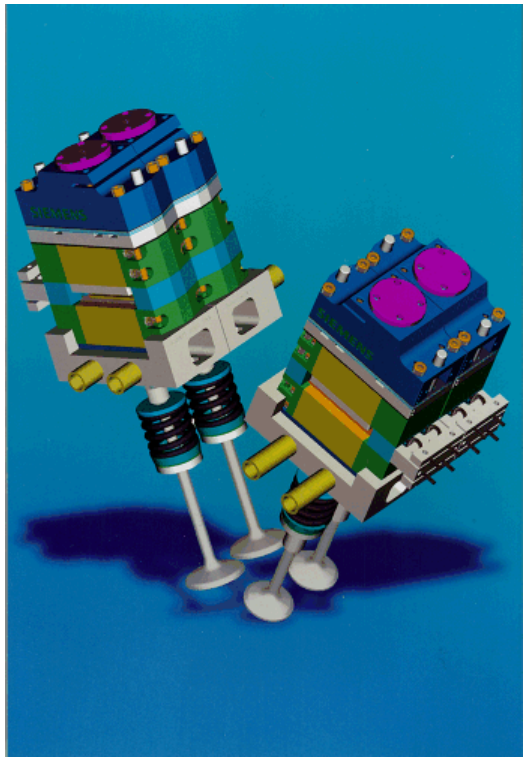

X-by-wire technologies
ke-by-wire
Steer-by-wire
Shift-by-wire
Power-by-wire
Turbo-by-wire
Suspension wire
ro-hydraulic braking
Electro-hydraulic steering
Electro-hydraulic automated manual
Throttle-by-wire
Electric assisted turbo
Damper-by
Electro-echanical braking
Fault tolerant steering
Electro-mechanical automated manual
Dual clutch transmission

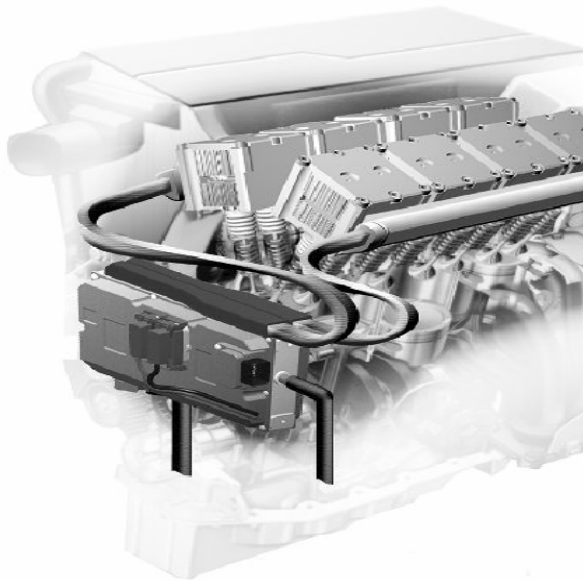
Fault-Tolerant Steer-by-Wire



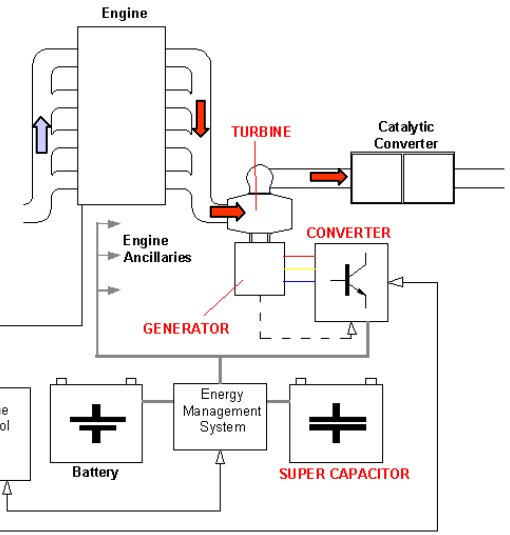
Electromechanical Valve Actuation

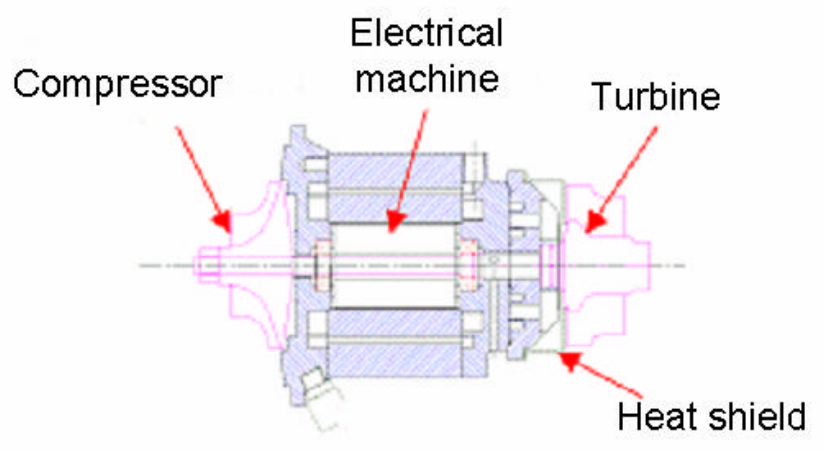




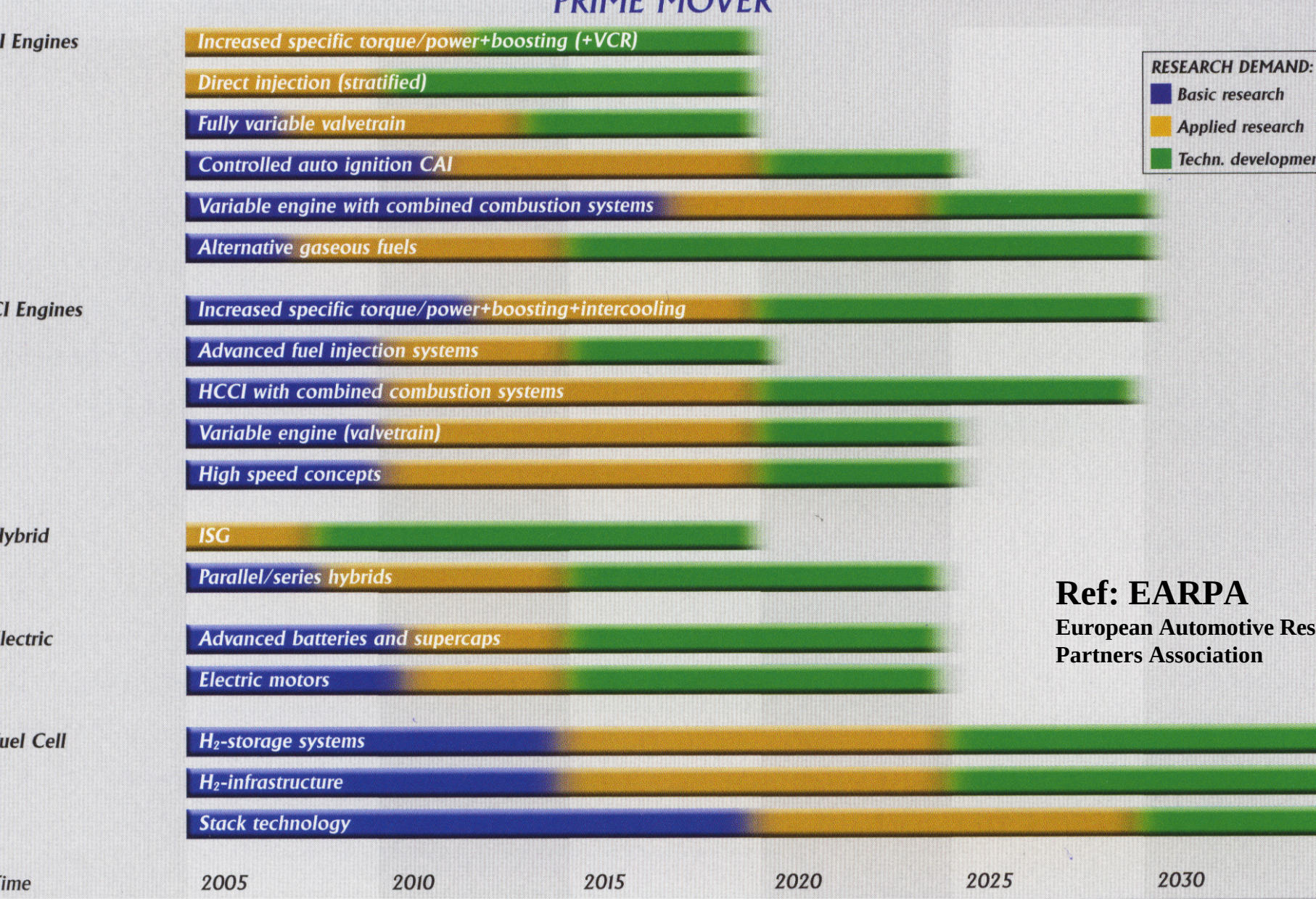


Exhaust Energy Recovery





- Turbine-driven generator reclaims waste exhaust gas energy at high engine speeds
- Electrically-driven compressor increases air flow at low engine speeds


PRIME MOVER
I Engines
Increased specific torque/power+boosting (+VCR)
Direct injection (stratified)
Fully variable valvetrain
Controlled auto ignition CAI
Variable engine with combined combustion systems
Alternative gaseous fuels
CI Engines
Increased specific torque/power+boosting+intercooling
Advanced fuel injection systems
HCCI with combined combustion systems
Variable engine (valvetrain)
High speed concepts
Hybrid
ISG
Parallel/series hybrids
lectric
Advanced batteries and supercaps
Electric motors
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H2-storage systems
H2-infrastructure
Stack technology
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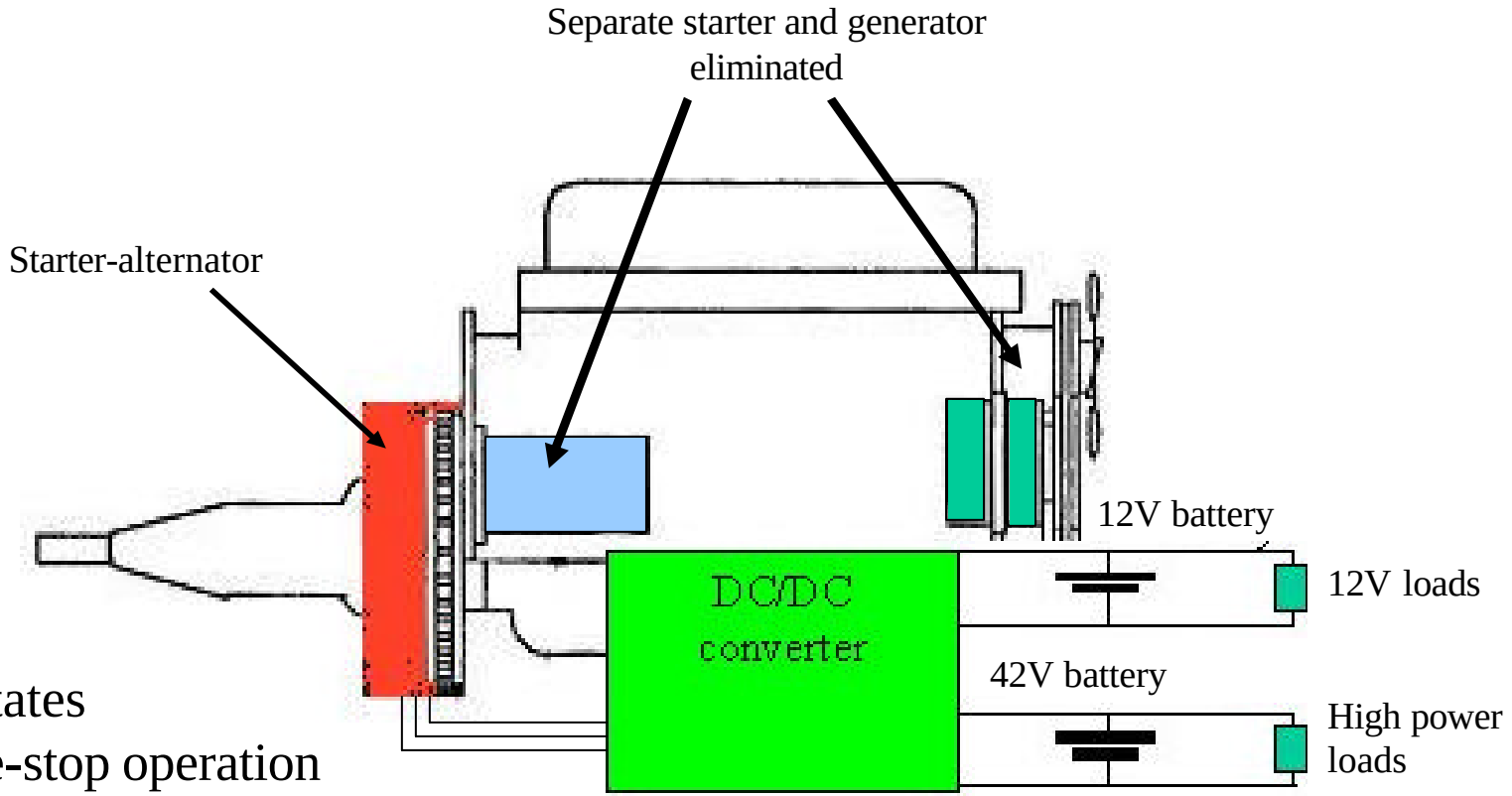
2005
2010
2015
2020
2025
2030
RESEARCH DEMAND:
Basic research
Applied research
Techn. developmer
Ref: EARPA
European Automotive Res
Partners Association

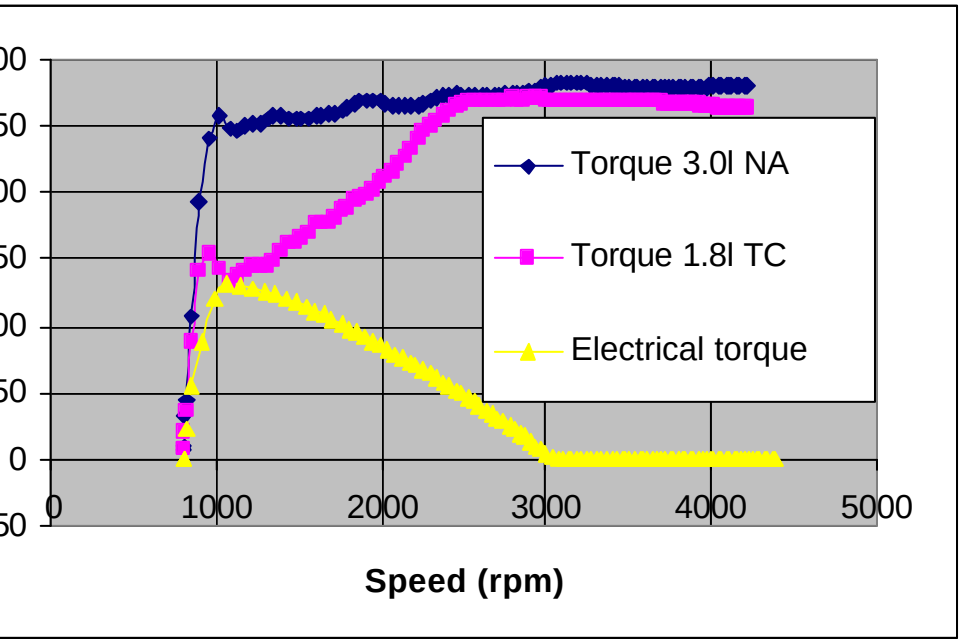
Integrated Starter-Generator/42V System

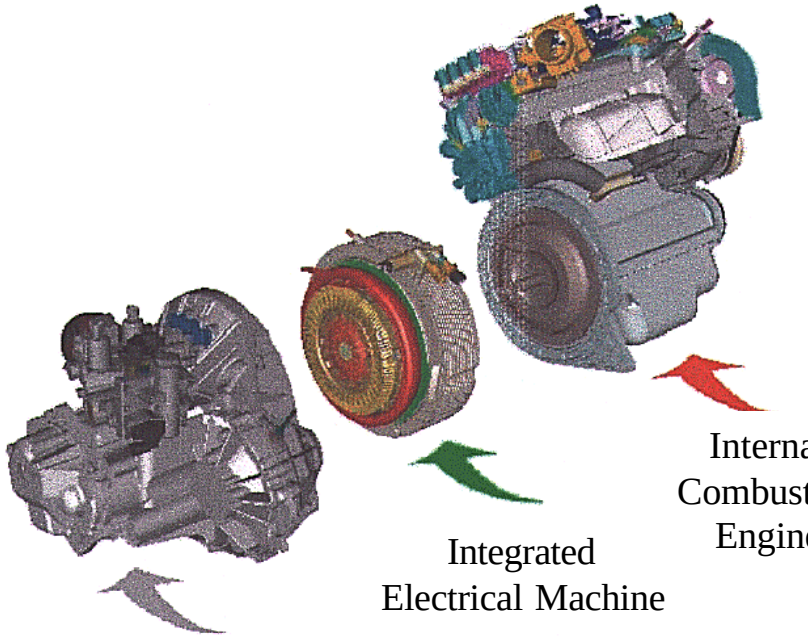


acilitates

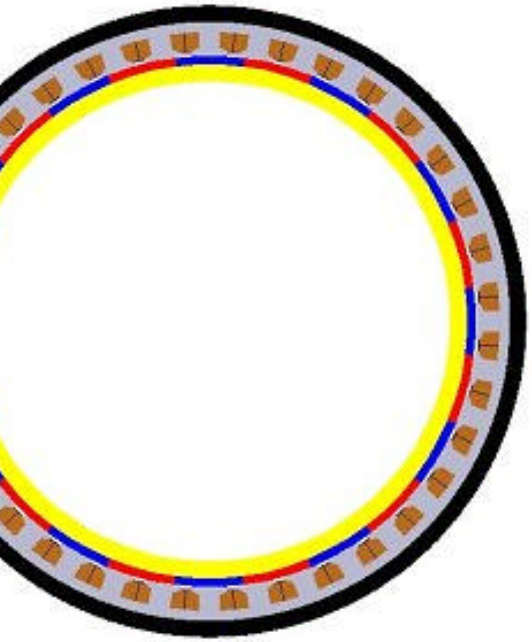
- Idle-stop operation
- Launch-assist (soft hybrid)
- Regenerative braking
- Power assist (mild hybrid)

Engine Down-Sizing

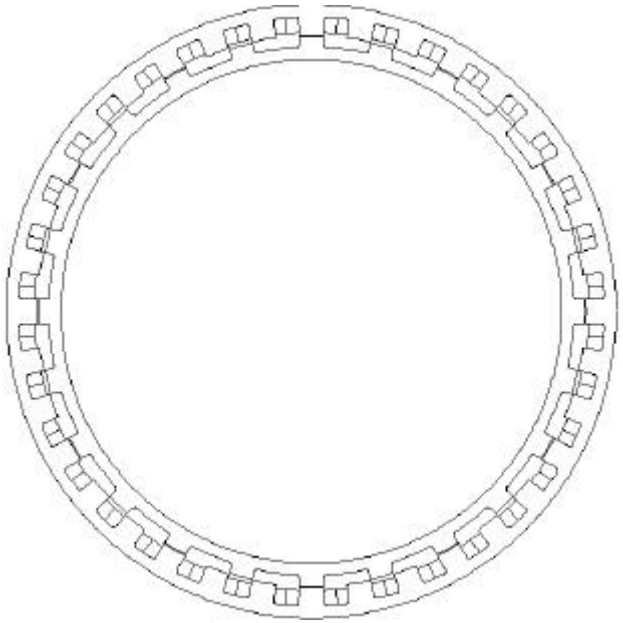




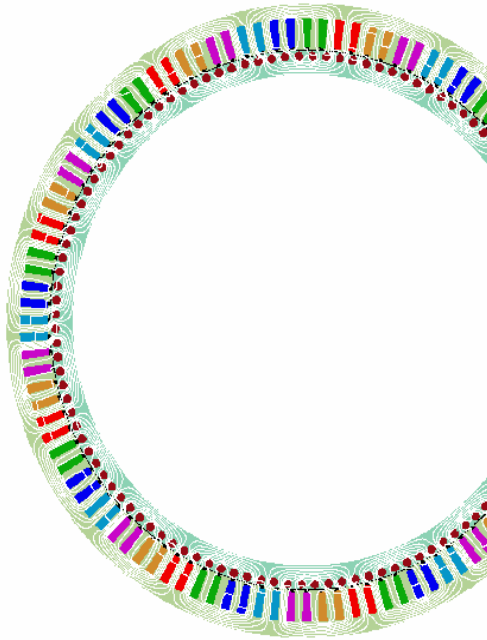
Machine Technologies



Permanent magnet machine

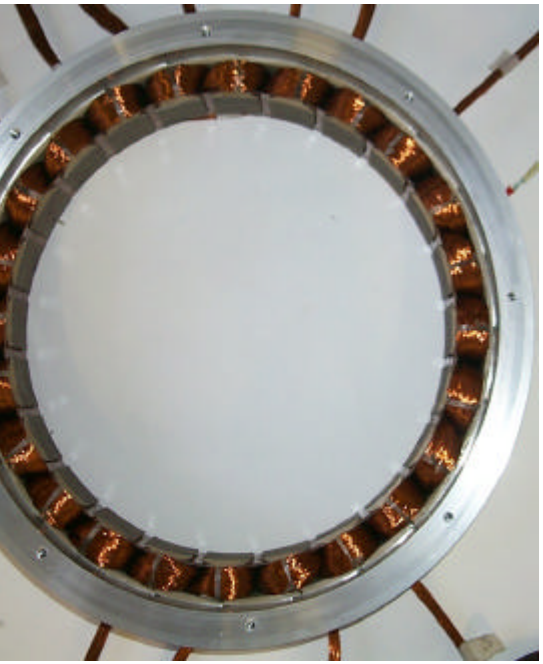


Switched reluctance machine



Induction machine

Permanent Magnet Machine

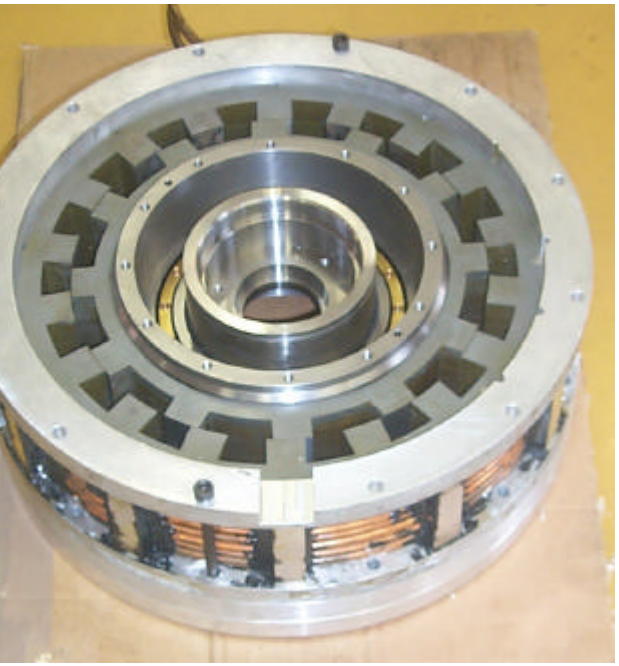


Stator

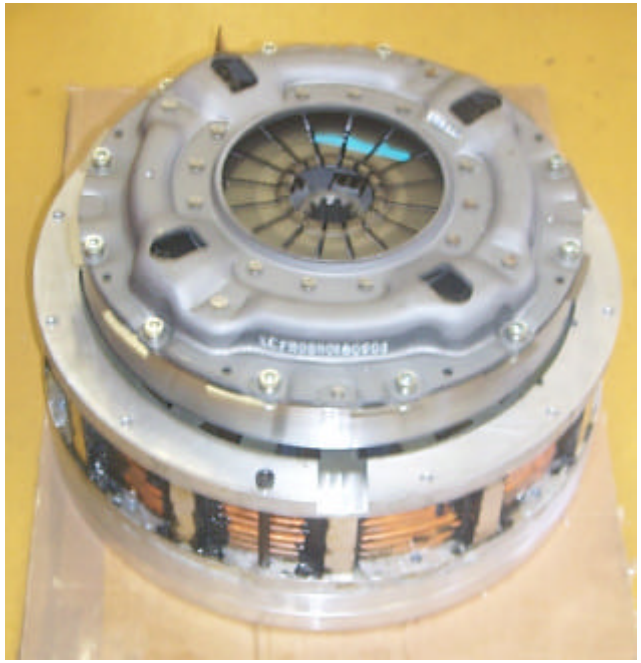
Rotor lamination

Assembled rotor

Switched Reluctance Machine



Stator/rotor

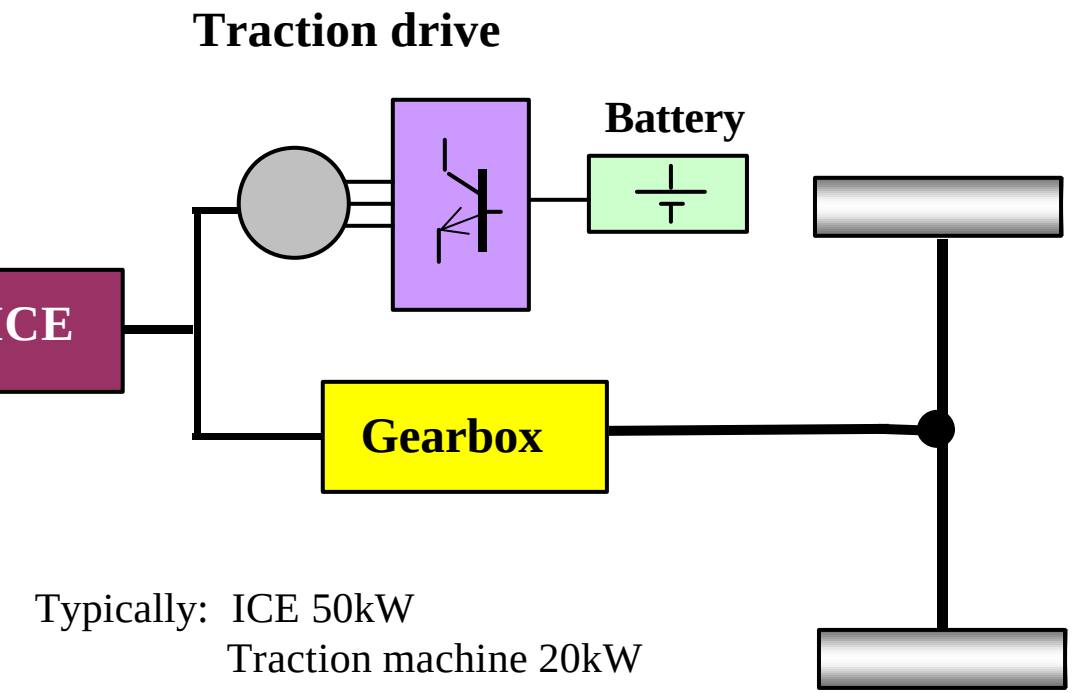


Machine integrated
with flywheel & clutch

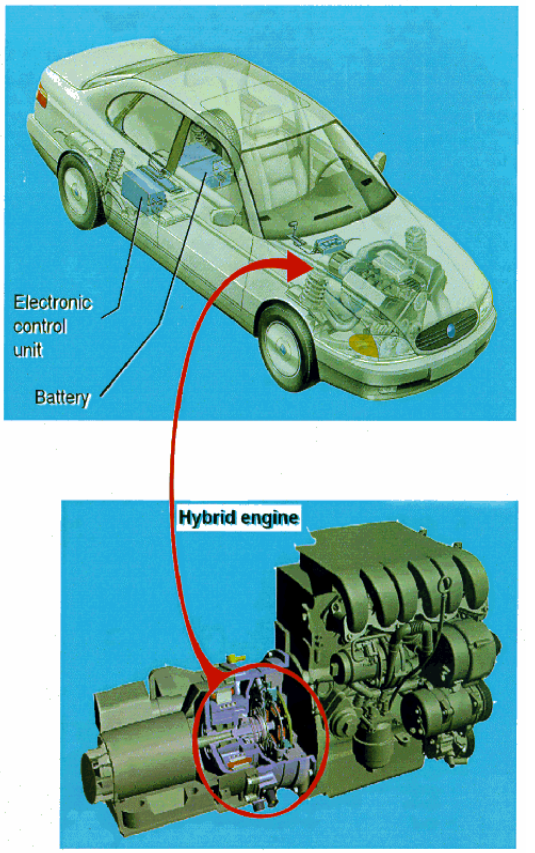
Final assembly

Basic Power-Train Configurations

Parallel Hybrid

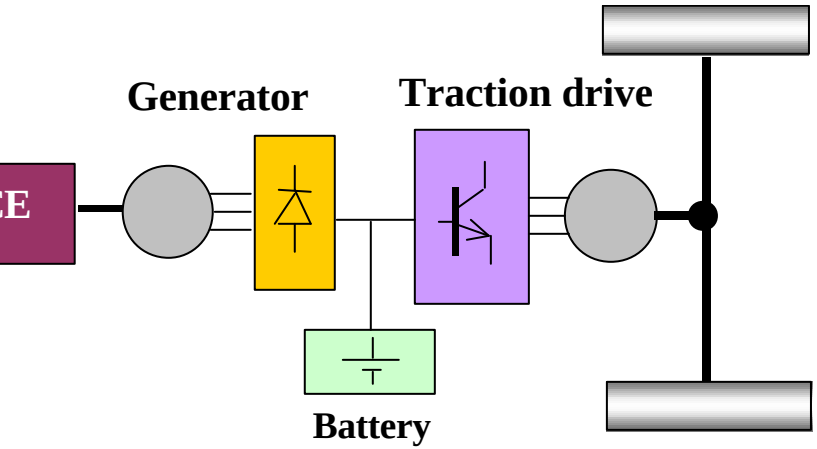


Typically: ICE 50kW
Traction machine 20kW



Basic Power-Train Configurations

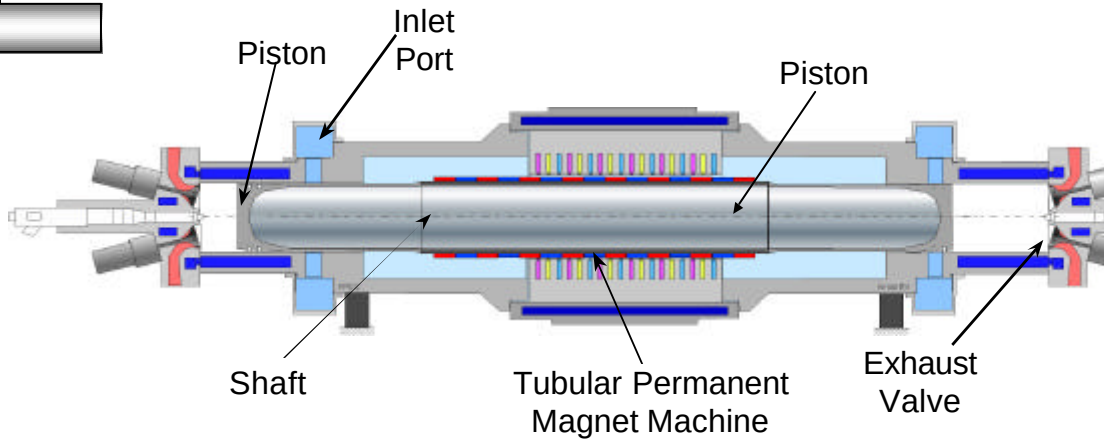
Series Hybrid



Typically: ICE 50kW
Generator 50kW
Traction drive 70kW

Free-piston energy converter (2-stroke)

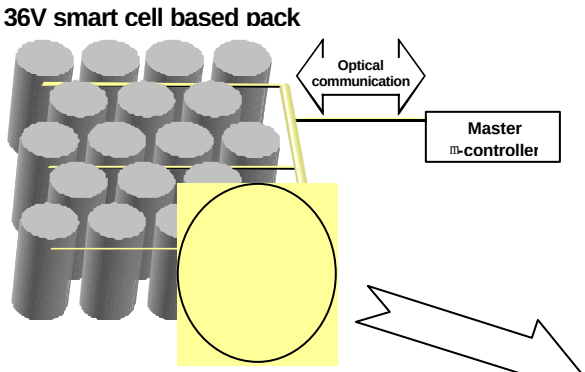
- Floating piston – eliminates crankshaft
- Piston motion controlled by electrical machine
- Facilitates optimum combustion



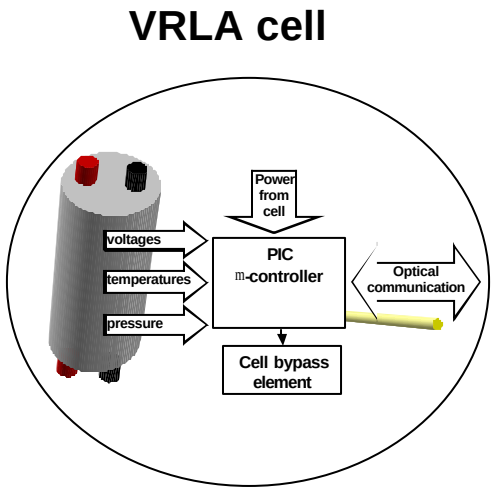
Other Key Technologies

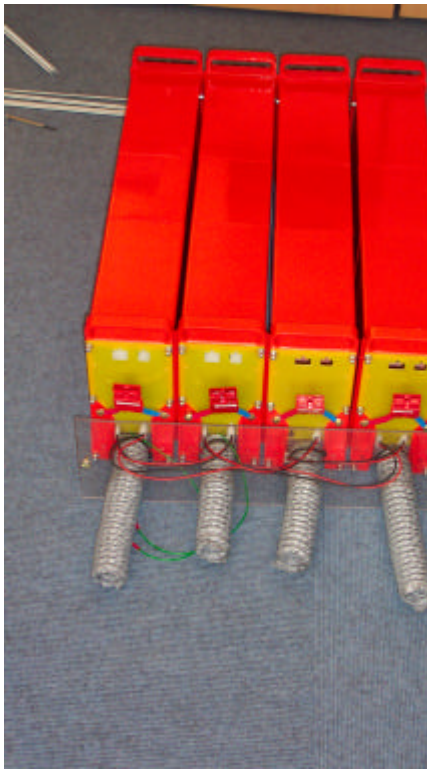
Batteries

Lead acid batteries are much lower cost than other systems (eg. NiMH)
Hybrid vehicles impose high transient power charges/discharges
To extend battery life, each 2V VRLA cell incorporates electronics
for state-of-charge monitoring and conditioning



36V battery module



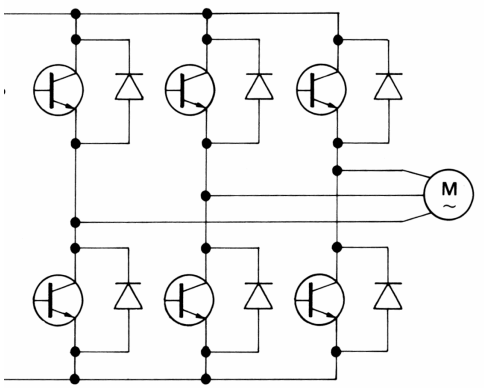


144V battery pac

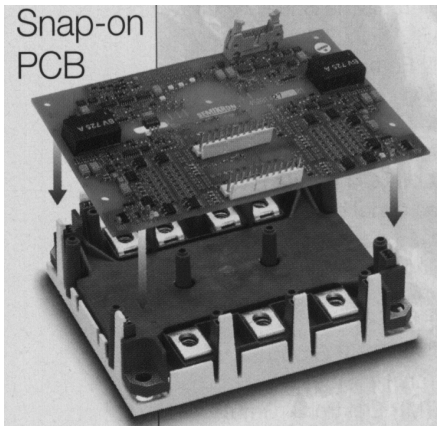
Other Key Technologies

Power electronics

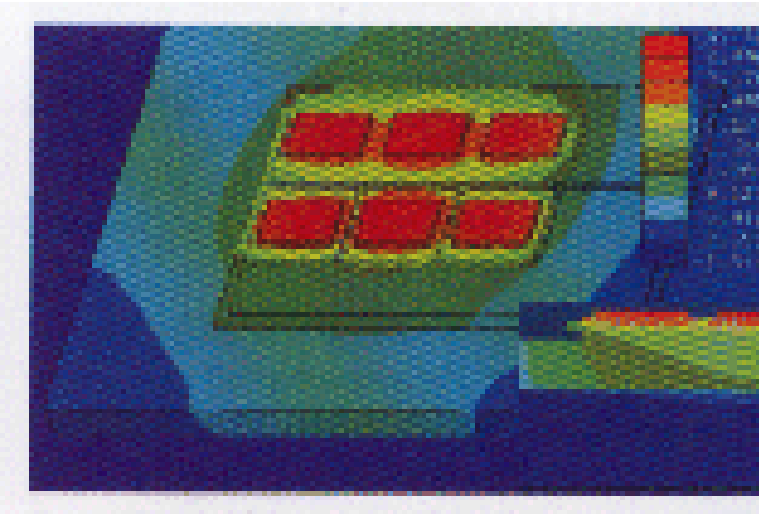
3-phase drive



integrated power module



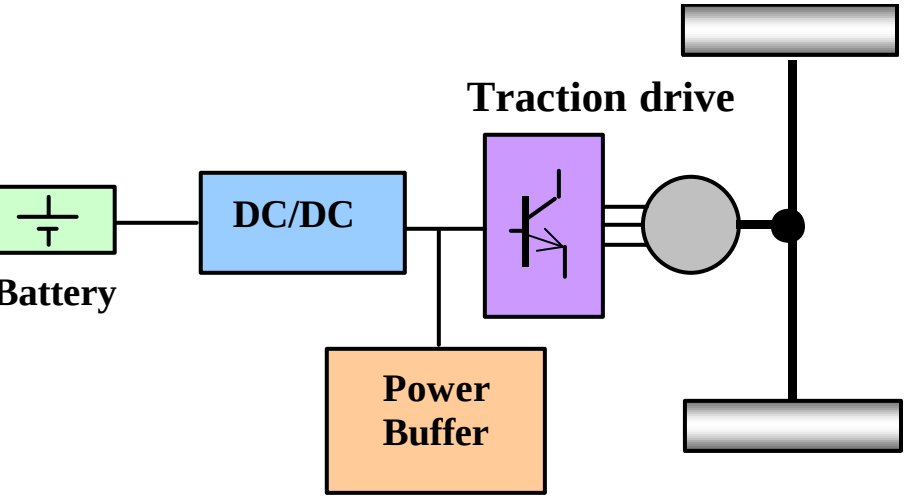
- New technologies
  - silicon dies on direct bonded copper (I



- high temperature semiconductors
  - silicon carbide
  - gallium nitride

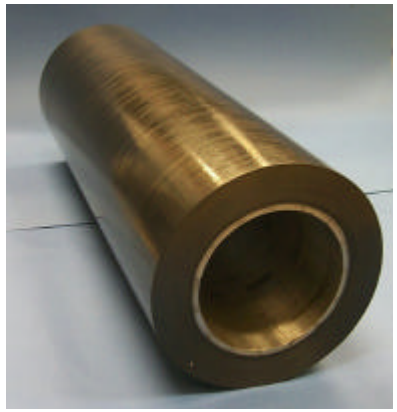
Basic Power-Train Configurations

Electric with peak power buffer

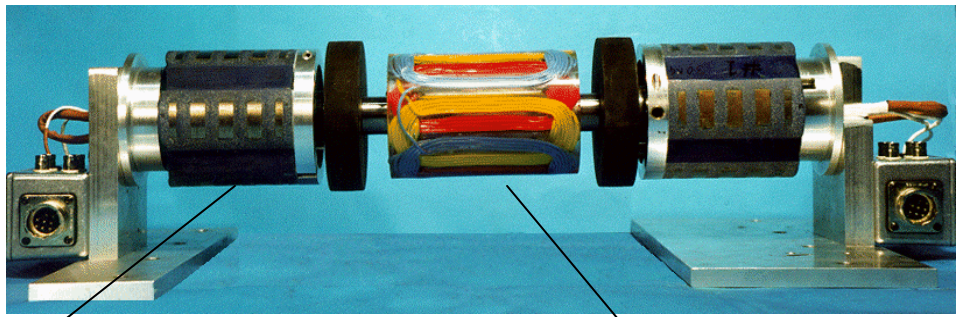


Extends battery life
Consistent vehicle performance

Flywheel buffer

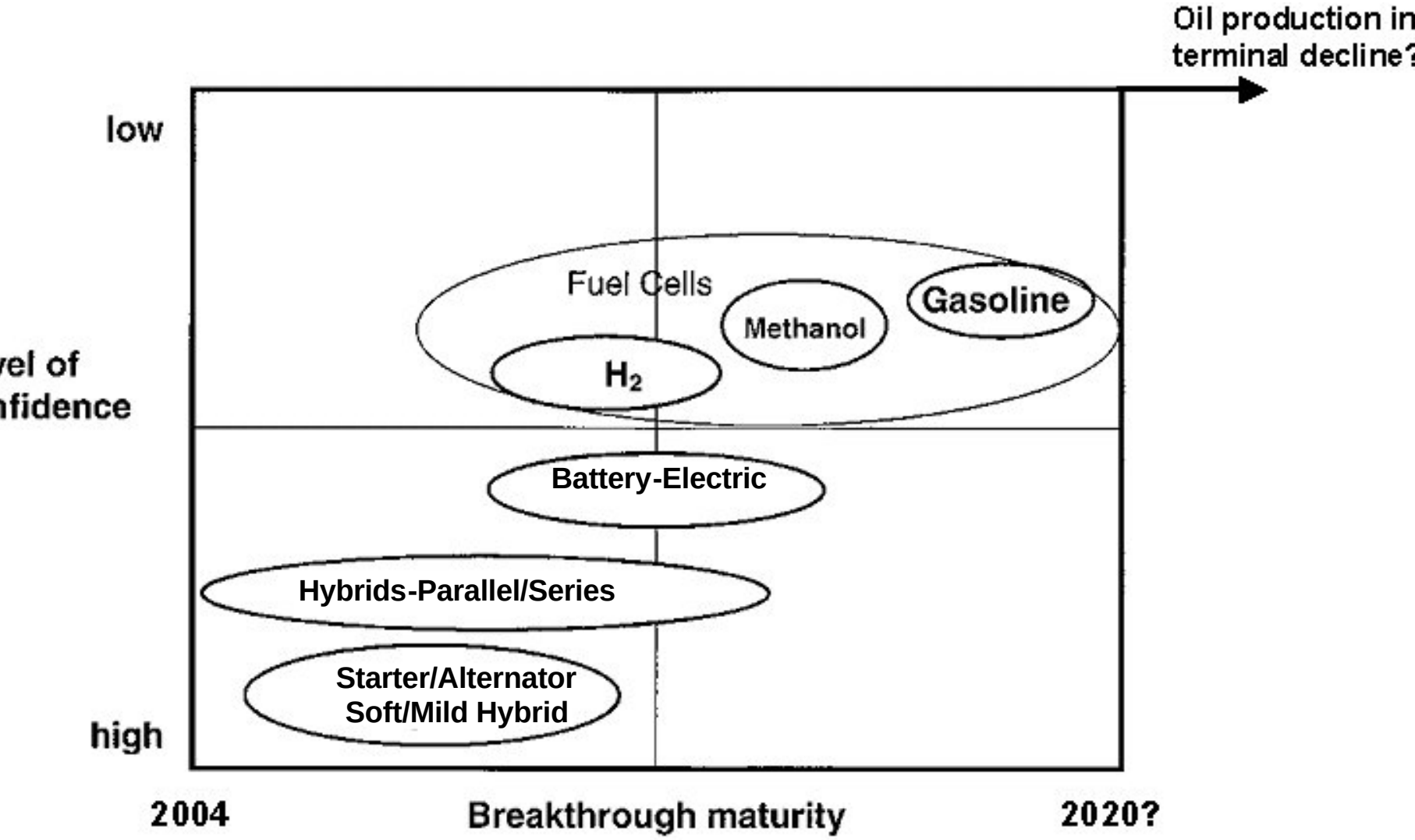


Carbon fibre flywheel
- 60,000rpm
- 1MJ stored energy



Central stato
- 30kW for

Technology Roadmap



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