Discussion Forum: Electric Vehicles vs Hybrid Vehicles, 20 June 2008

Hybrid Electrical Vehicles

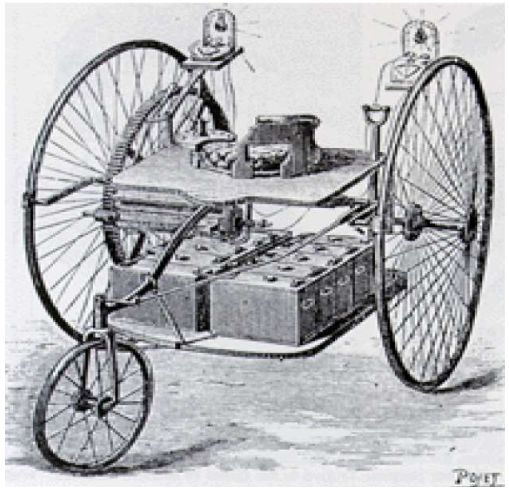
Prof M J Kamper and Dr R Wang

Electrical Machines Laboratory
University of Stellenbosch
Stellenbosch, South Africa

Overview

- History
- Vehicle Powertrains
- HEV Configurations
- Degree of Hybridization
- Plug-in HEVs
- Electrical Motor Drives
- HEV Example at SU
- Conclusions

Historic Review



- First EV (1881)

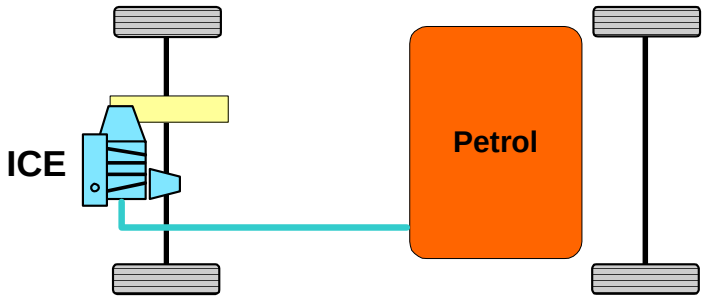
- First 4WD EV (1898)

- HEV won hill climbing race (1902)

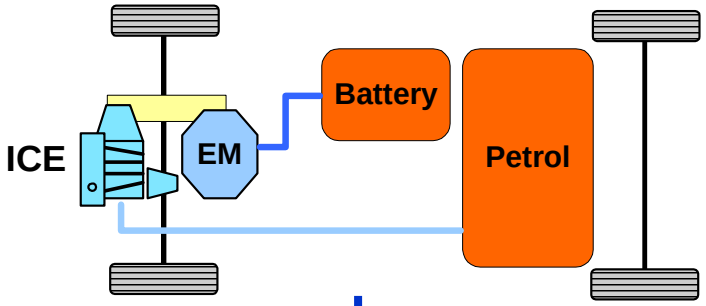
- First mass produced HEV (1997)

Vehicle Powertrains

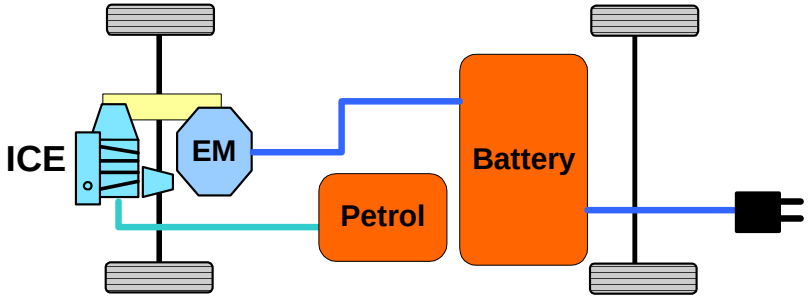
- Conventional Vehicle



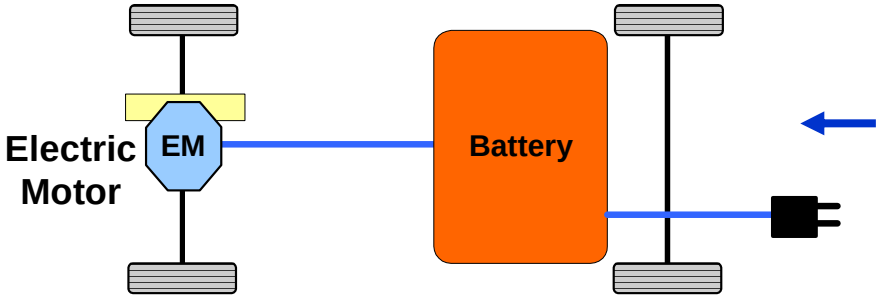
- Hybrid Electric Vehicle



- Plug-In Hybrid Electric Vehicle

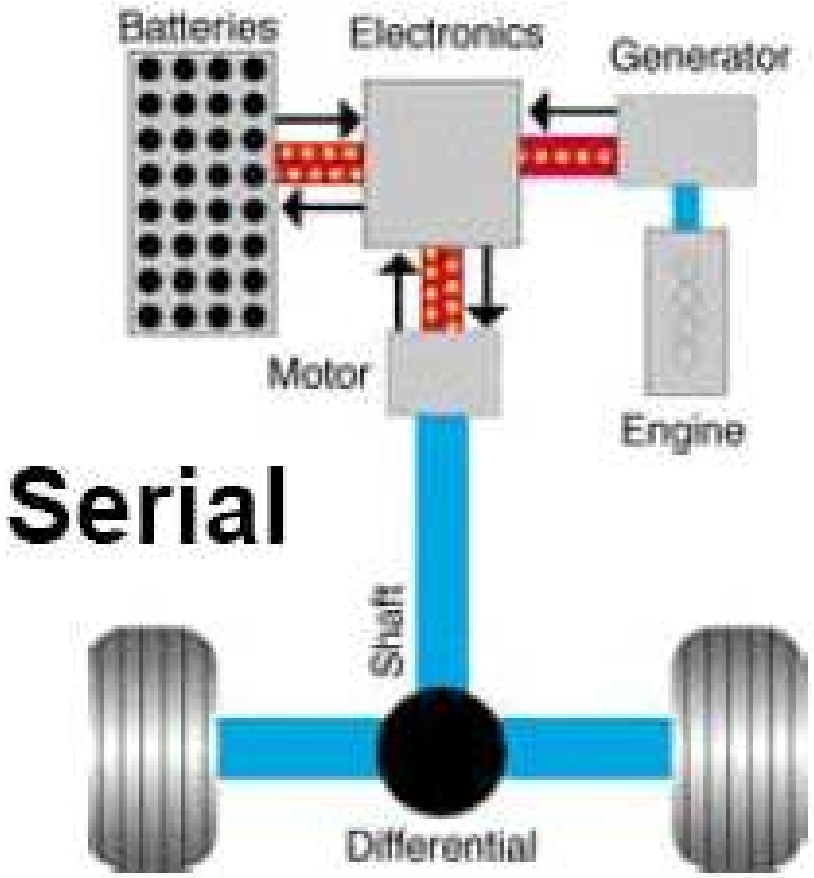


- Battery Electric Vehicle



HEV Configurations

Series Hybrid

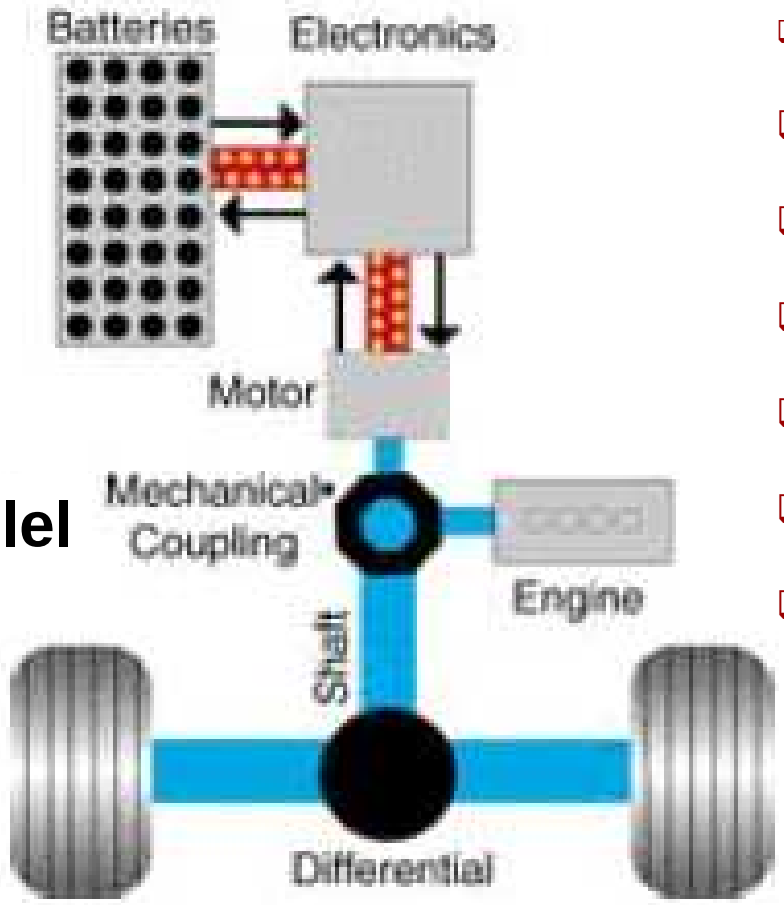


- **ICE-assisted EV**
- **Simple drivetrain (no clutches)**
- **Flexible location of ICE**
- **3 Propulsion devices**
- **Heavy-duty electrical machine**
- **Large battery pack**

HEV Configurations

Parallel Hybrid

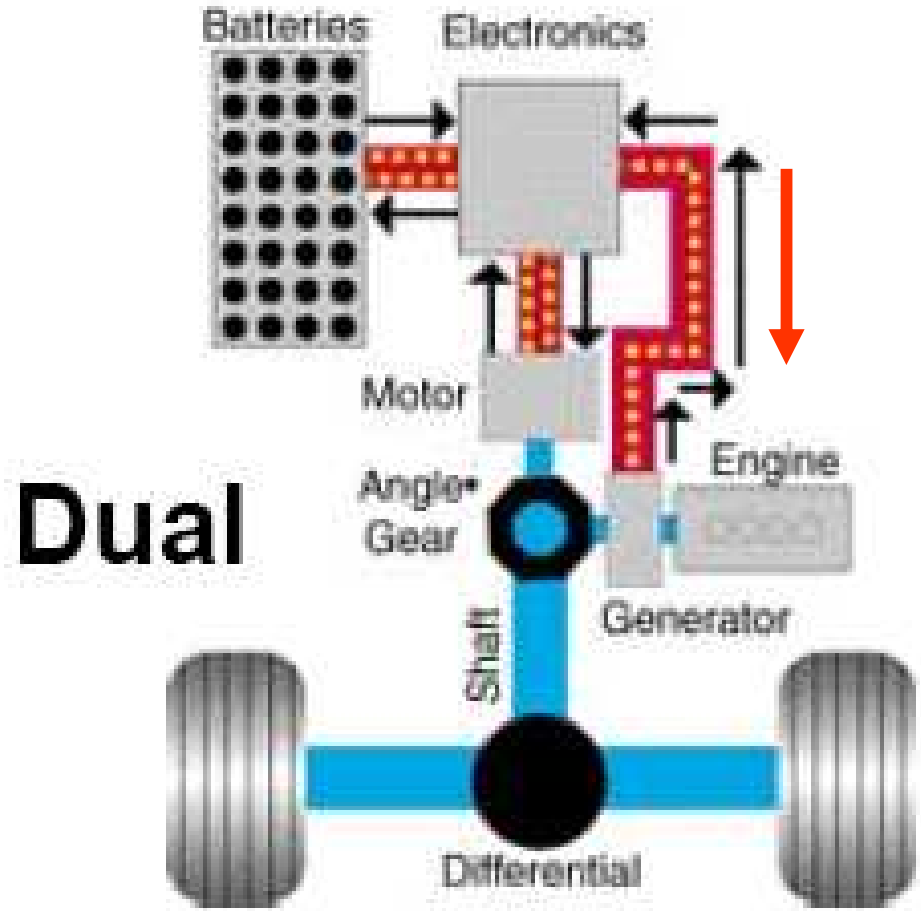
Parallel



- **ICE or Motor or both in Parallel**
- **Electrical-assisted ICE vehicle**
- **2 Propulsion devices**
- **Sizing of devices depends**
- **Simple power converter**
- **Generally two clutches**
- **Small-medium battery pack**

HEV Configurations

Series-Parallel Hybrid



- **More complex and costly**
- **3 Propulsion devices**
- **Three propulsion power**
- **Two clutches**
- **Smaller battery pack**

NB: Power Flow Control

Degree of Hybridization

- "**micro**" HEVs: stop/start and variable charging capacity;
- "**mild**" HEVs: regenerative braking, engine start/stop, electric assisted driving;
- "**full**" HEVs: full electric launch/drive capability, a higher percentage of system power from the electric motor part of the propulsion system;
- "**series**" or "**range extender**" HEVs: a full-sized electric motor drive in addition to including regenerative braking and significant "All Electrical Range" (AER).

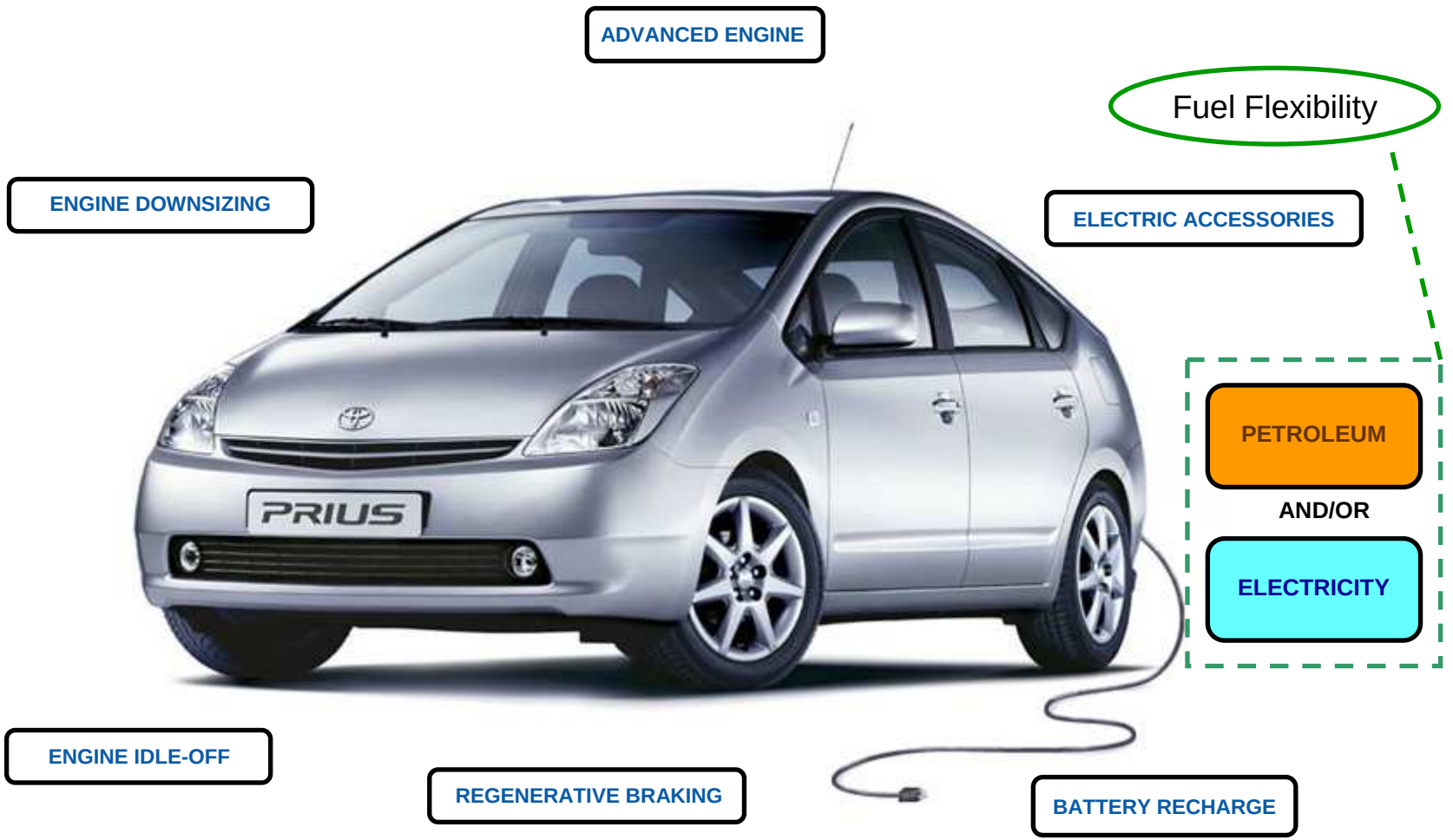
Degree of Hybridization

Full Hybrid

A Full Hybrid: 57 kW ICE, 50 kW electric motor, 1.5 kWh battery (2004)

Plug-In HEV (PHEV)

Converted Prius

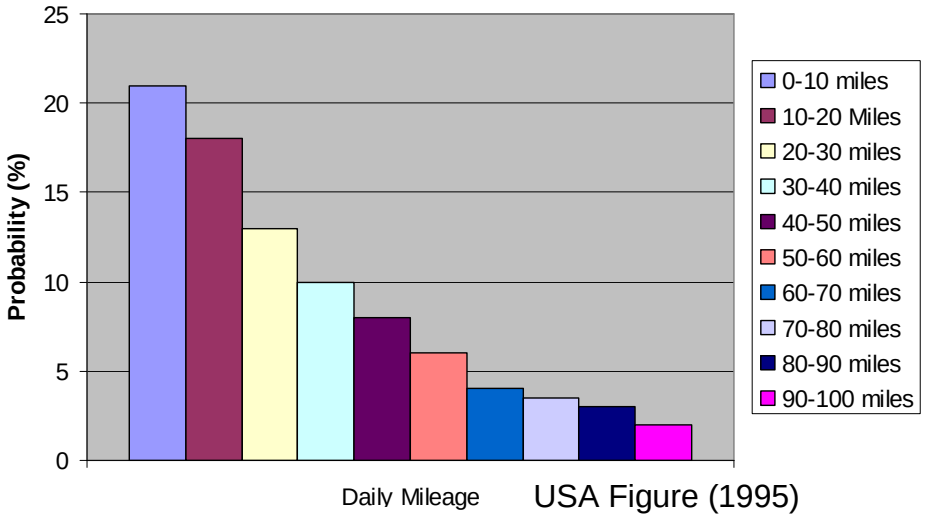


57 kW gasoline engine, 50 kW electric motor, 9.0 kWh battery (48km)

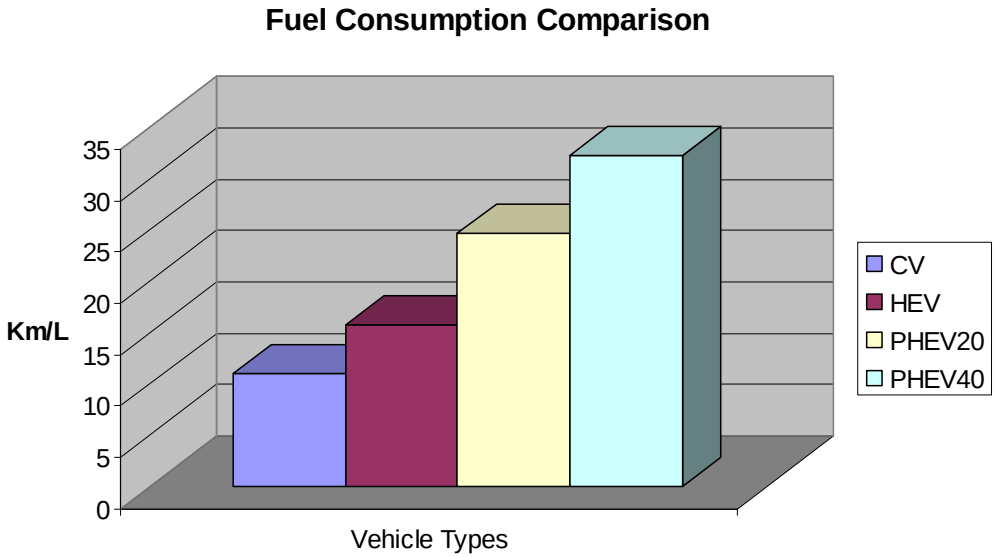
Plug-In HEV

Rational

- Matching motorist's driving habit
- Reduction of petrol usage and thus related emission

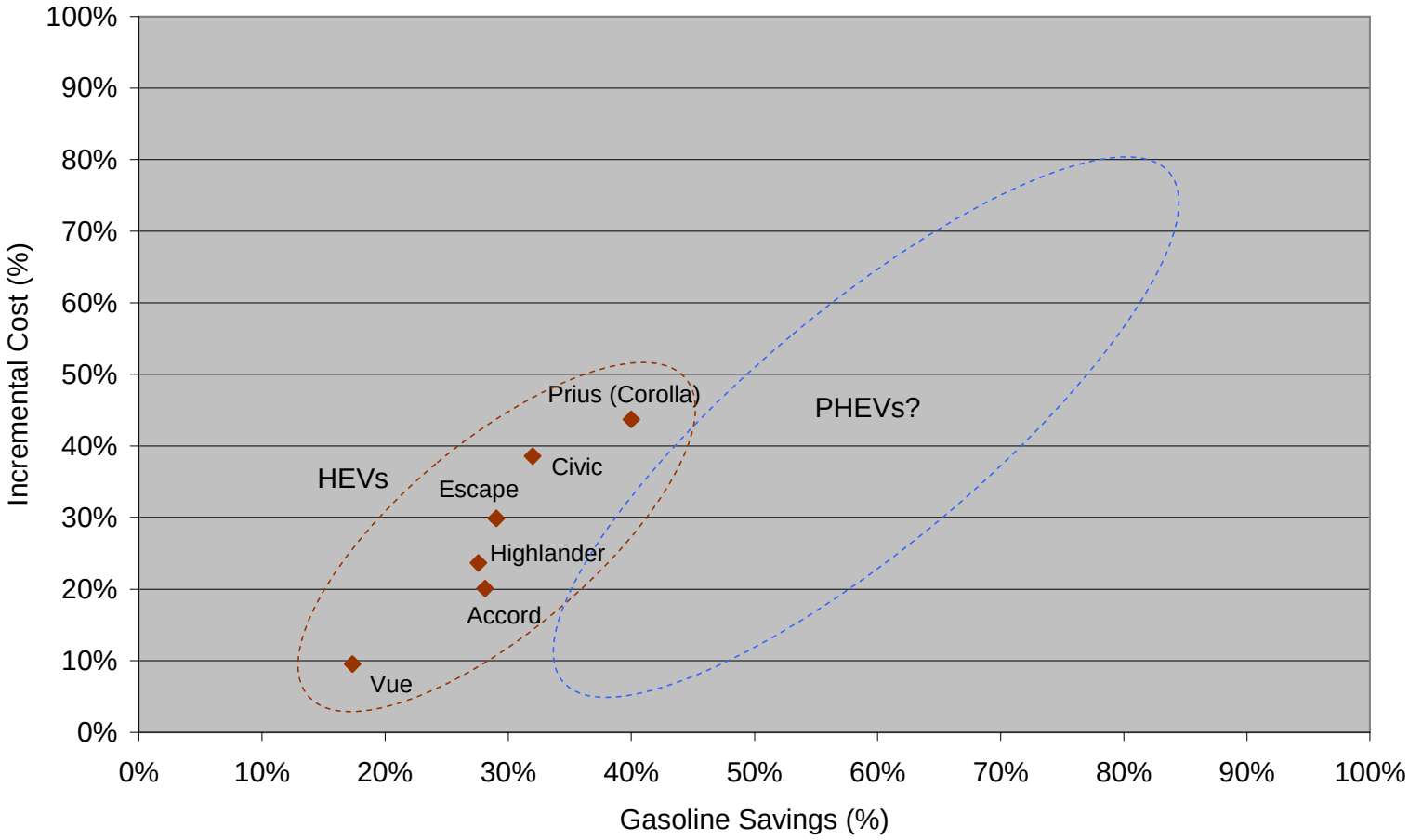


USA Figure (1995)



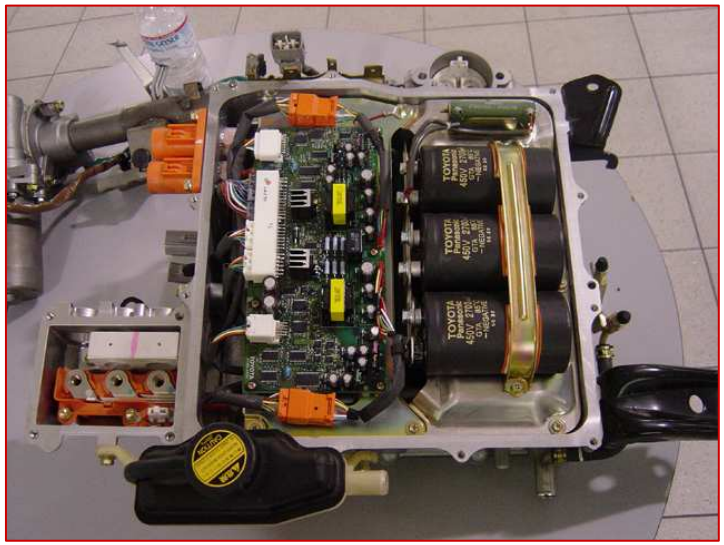
Challenge for PHEV

Cost vs fuel saving



Electrical Motor Drives

Integrated Design



Motor Design Requirements:

- Light weight / High power density
- High efficiency

Power Converter Design Considerations:

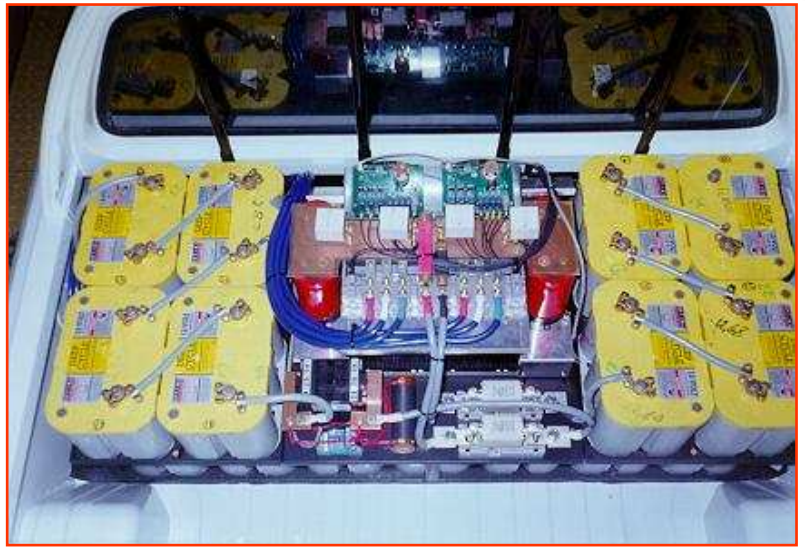
- Temperature sensitivity of bus capacitors;
- Environmental impact;
- Drive efficiency;
- EMC issues;
- Last but not the least COST.

HEV Example at SU

Parallel HEV developed by EMLab (1998)

HEV Example at SU

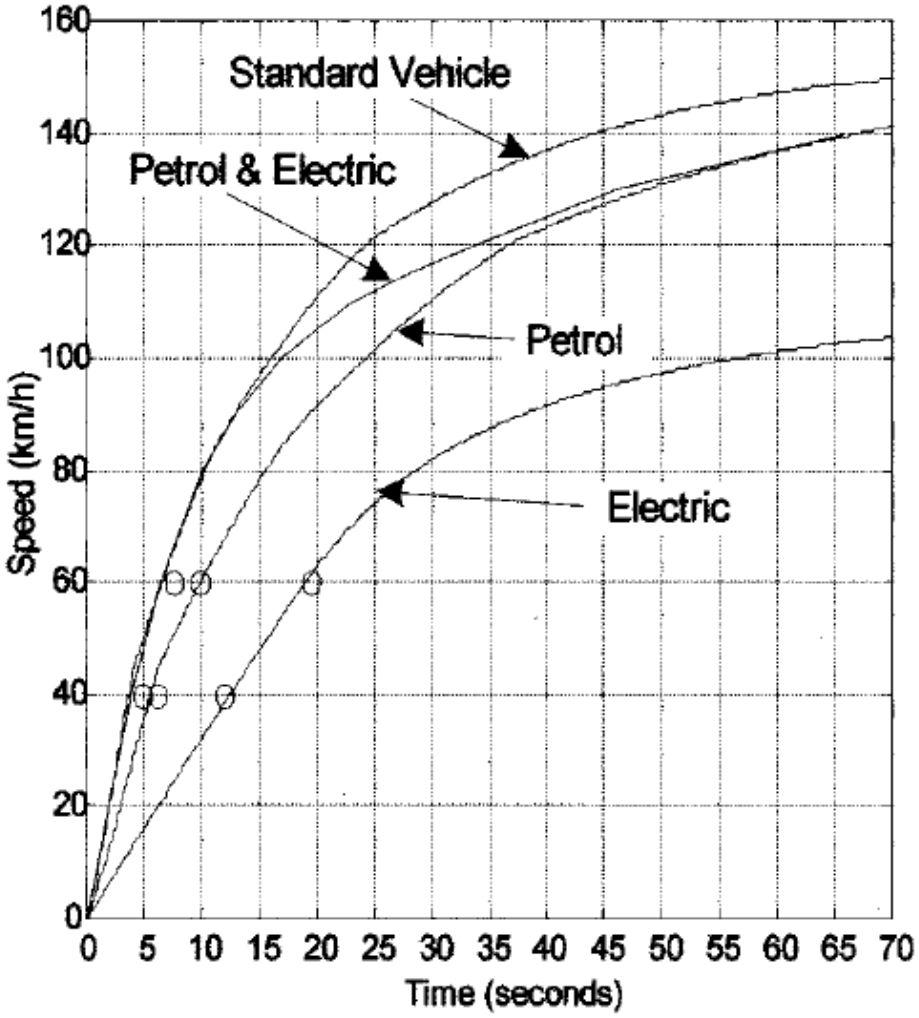
- **Power Electronic Converter and Batteries**
  60 kW Inverter with 22 x 12 V batteries (280V DC voltage bus, 420 kg, 90 km range)



- **Parallel HEV Configuration**
  30 kW peak, Reluctance Synchronous Machine and ICE

HEV Example at SU

Performance



Conclusions

- HEV is a near-term technology for improving fuel economy and emission.
- The mainstream powertrain topologies are power-split and parallel.
- There are different degrees of hybridization.
- PHEV is potentially a better system than normal HEV, but there are also challenges.
- Fuel prices vs battery cost will determine HEV configuration and user term.

Thank You

Prof M J Kamper and Dr R Wang

Electrical Machines Laboratory
Department of Electrical and Electronic Engineering
University of Stellenbosch
Stellenbosch, South Africa