



# FUTURE**EV**ISION

Realizing future technologies for electrified vehicles



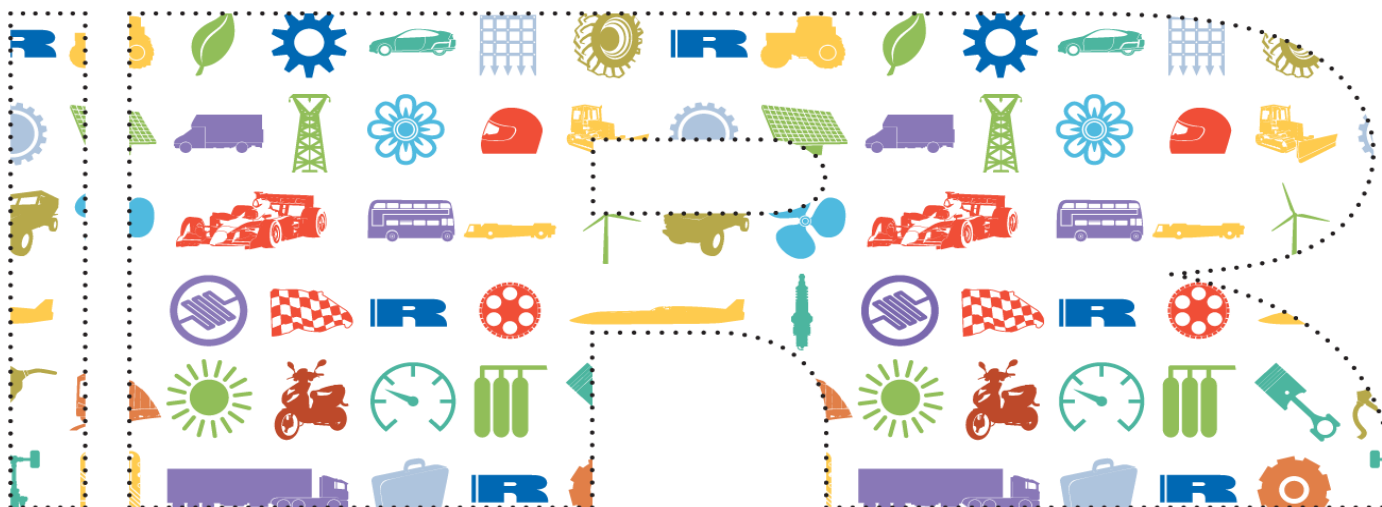
## **Ricardo:** **A View of 10 years past and 10 Years Future of Electric Vehicles**

**Commercial Exploitation of Electric Vehicles**

**Roger Atkins &  
Michael Raines**

**Ricardo**

- **Introduction to Ricardo**
- Before
- Now
- Future
- Question & Answer



## Ricardo plc

### Introduction & Overview – Q4 2011

# Ricardo Overview

Ricardo delivers world class strategy, engineering and technology programs to the global automotive, transportation, defence and energy industries



## Company

- Established in 1915 and independent
- £196.5/~\$307 million revenue (FY 10/11), up 21%  
£162.8/~\$254 million revenue (FY 09/10)
- More than 1.500 employees with more than 1.300 technically qualified and engineering staff
- Global presence in 16 locations

## Values



RESPECT • INTEGRITY • CREATIVITY & INNOVATION • PASSION

## Positioning

- Emphasis on achieving enhanced value propositions for our clients
- Multi-sector oriented with relevant domain expertise
- Global footprint with local understanding
- Strategic perspectives and consulting
- Unique holistic vehicle and powertrain experience
- Systems engineering approach that considers integrated solutions for the entire product lifecycle
- Significant self-funded R&D investment
- Technology led product innovation
- Extensive production vehicle and major sub-system introduction experience
- Delivery focused
- Specialist manufacturing and assembly capability for niche product applications

# Ricardo History

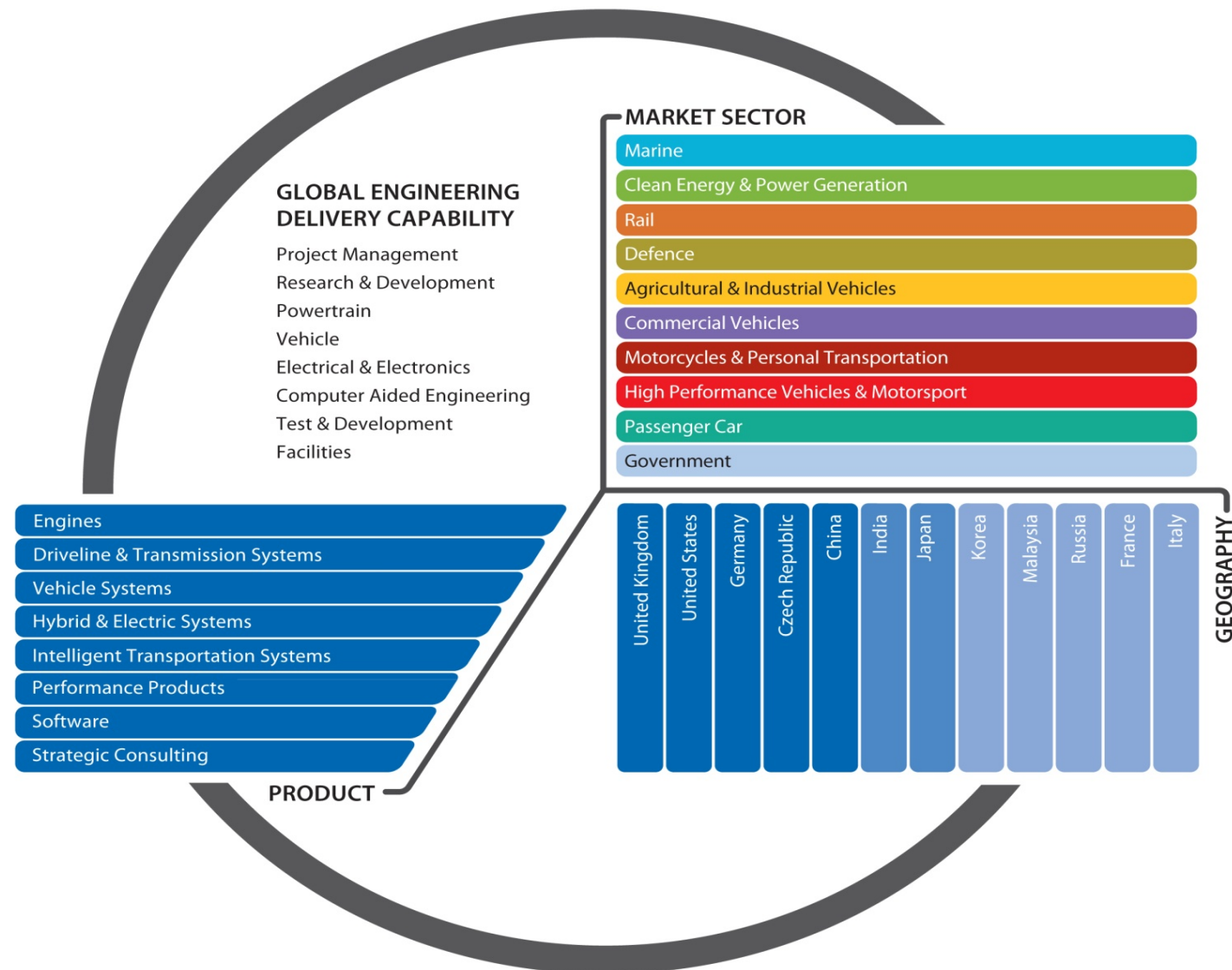
More than 90 years of successful project delivery





# Three dimensional Ricardo Core Business Model

Market Sectors provide domain expertise and ensure relevance, Product Groups provide deep content technology and delivery from global world class engineering teams



# Ricardo Client Base

Represented across a number of key market sectors each with unique drivers



## Passenger Car



## High Performance Vehicles & Motorsport



## Commercial Vehicles



## Agricultural & Industrial Vehicles



## Motorcycles & Personal Transportation



## Marine



## Rail



## Clean Energy & Power Generation



## Defence



## Government



## Introduction:

The Challenge and Contrasting Views on Electric Cars.  
Do we need them - but they do the same job – don't they?

+/- 10 Years:

### Oil v's Electricity

- Charge Times = Range Angst
- No 'back up's'
- Why 8 hr charge time c.f to a 3 min fuel fill up!

### Cost of Battery on top of the Cost of Car

- Cost of Electricity v's Cost of Oil

No Clear CHOICE – not a One Size Fits All scenario!





# What is an Electric Vehicle?

- **Energy v's Power:**
  - Combinations of:-
    - All Electricity or Petrol and Electric Engine:
      - Energy from Fuel and Energy from the grid:
    - There is more energy in 1lb of Chocolate than in a 1 lb Lithium Ion Battery
- Battery Electric Vehicle (BEV)
- Hybrid (Petrol & Electric Engine)
- Range Extended Electric Vehicle (REEV)
- **ITS ALL ABOUT:**
  - **Energy Storage and Energy for Power**

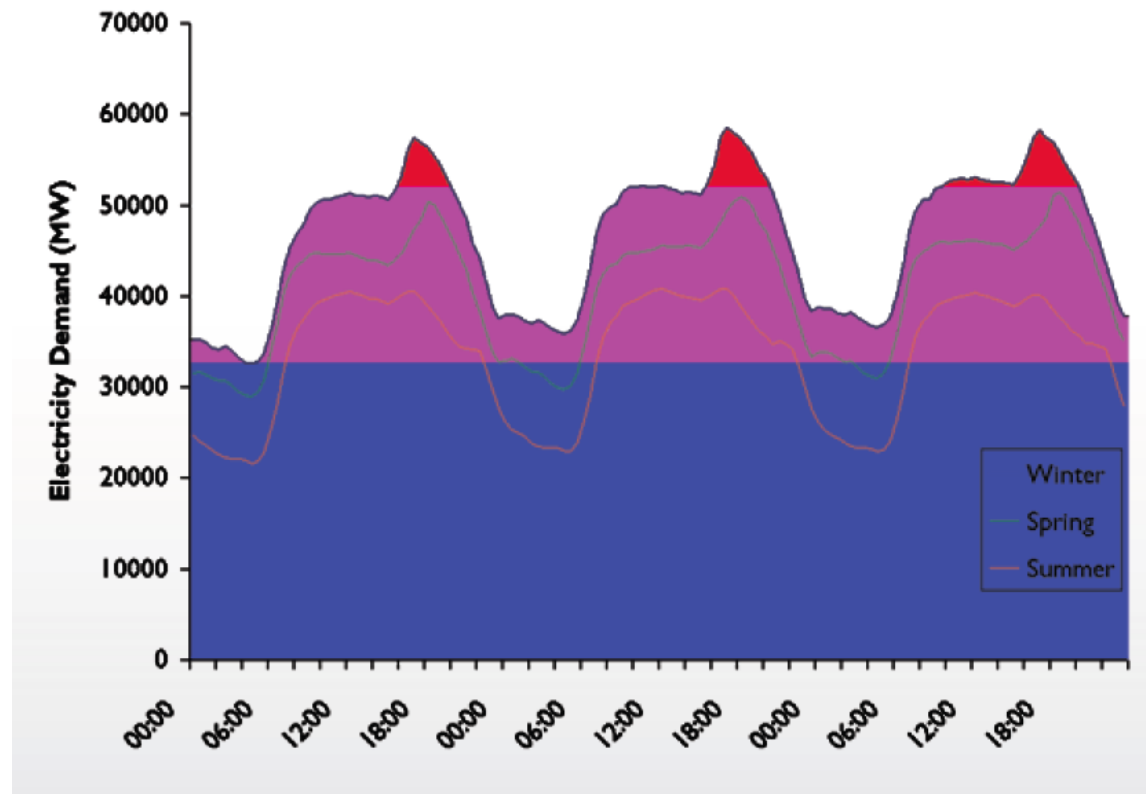


# Understand Electricity Demand

## Demand Variations

Daily, Weekly, Seasonally:

- Winter peaks
- Base load always there
- Mid merit plant (Night Charging)
- Peaking scenarios (TV effect)
- What effect will EV's then have?
- Grid Balancing



## Available Electrical Energy for Vehicles Via Renewable Sources

- Lower cost electricity @ 2c per mile
  - Fuel today is @ 13c per mile
- Surplus electricity makes hydrogen by hydrolysis
  - Hydrogen Internal Combustion Engine
  - Fuel Cells – good for EV's
- Battery drop or quick exchange business model
  - Deals with offsetting the cost of the battery
  - Requires common standards for vehicle platforms
  - Can be known as the “Duracell Model”
- Oil for the next 40 years mean business as usual?
  - Or Range extended Electric Vehicles.
  - Offers a link to the way we drive today



# Agenda



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# *i*-MoGen: c.2003

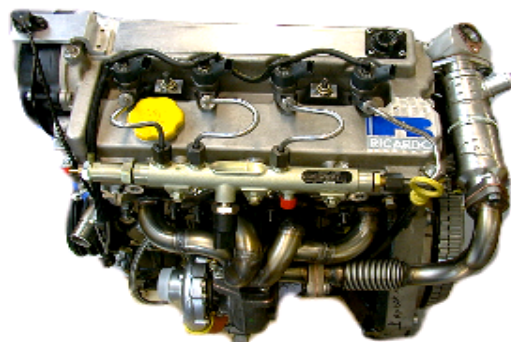
## Targets

Savings of - 20% from Downsizing Alone

- Fuel consumption of 59mpg
  - 28% FC reduction from donor 2.0L vehicle
- Breakdown as follows:
  - 20% from downsized engine, fast warm up and intelligent cooling system
  - 3% from Stop and Go
  - 5% from regenerative braking
- These include energy management savings offered by the Ricardo Supervisor Control Approach
- The vehicle is also robust:
  - ~1200 demo drives; >10,000 miles; nine countries - fault free

# *i*-MoGen Five Key Systems:

circa: 2003



**Ricardo Downsized Engine**  
1.2 L, 4cyl Diesel  
High Output - 100hp  
~30% Weight Saving  
Aftertreatment with DPF

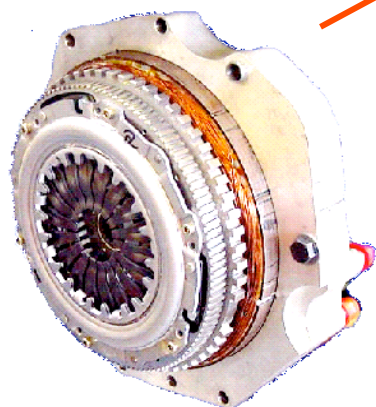
**Diesel-Electric Mild Hybrid Vehicle**



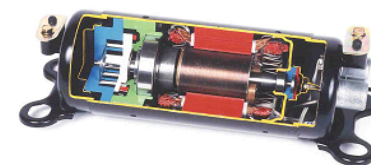
**Ricardo Supervisory Control**



**42V NiMH battery**  
just 17kg  
9kW, 620Wh



**6kW, 42V Electric Machine**  
ISA Supplied by **Valeo**  
Torque Boost  
Regenerative Braking  
Stop / Start  
Efficient Generation



**42V Ancillaries:**  
Water Pump, Fans, HVAC  
(No Fan Belts or alternator)

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## Personal Mobility – Fact Drivers

### Customer Behaviour / Legislation Mandates

- |   |         |
|---|---------|
| – Range Angst / loss of flexibility                               | - Today |
| – 30 new EV's in next 12 months                                   | - 2012  |
| – One power-train will not suffice.                               | - 2020  |
| – McKinsey - 2/3 will be EV                                       | - 2030  |
| – JD Powers - 10% will be EV                                      |         |
| – ¾ of all vehicles still have an IC Engine (conventional or APU) | - 2030  |
| – IC Engines will continue to dominate for next 40 years.         | - 2050  |
| – 80% CO2 reduction   | - 2050  |





## Early Adopters or Adapters – point to the future



Several months of real-world data offer a clearer picture of who's buying these cars and how they're using them. For example:

- 2.1 million Volt miles driven
  - 2/3 used electricity from the grid
  - 1/3 driven using the onboard gasoline powered generator.
- Leaf drivers average fewer than 60 miles a day.
- 90 percent of Leaf owners bought their cars
  - Nissan's earlier prediction was that 90 percent would lease.
  - 1/3 of GM Volt owners lease.
- 86% of Volt buyers formerly drove non-GM vehicles,
  - Including a combined 33% from Toyota and Honda.
  - The Leaf is poaching some Toyota Prius owners.
- Many people still know little about the technology.
  - Automakers need "marketing that really shows what these cars can do."

Read more:

<http://www.autonews.com/apps/pbcs.dll/article?AID=/20110620/RETAIL07/306209975/1429#ixzz1Pnr7hRpi>

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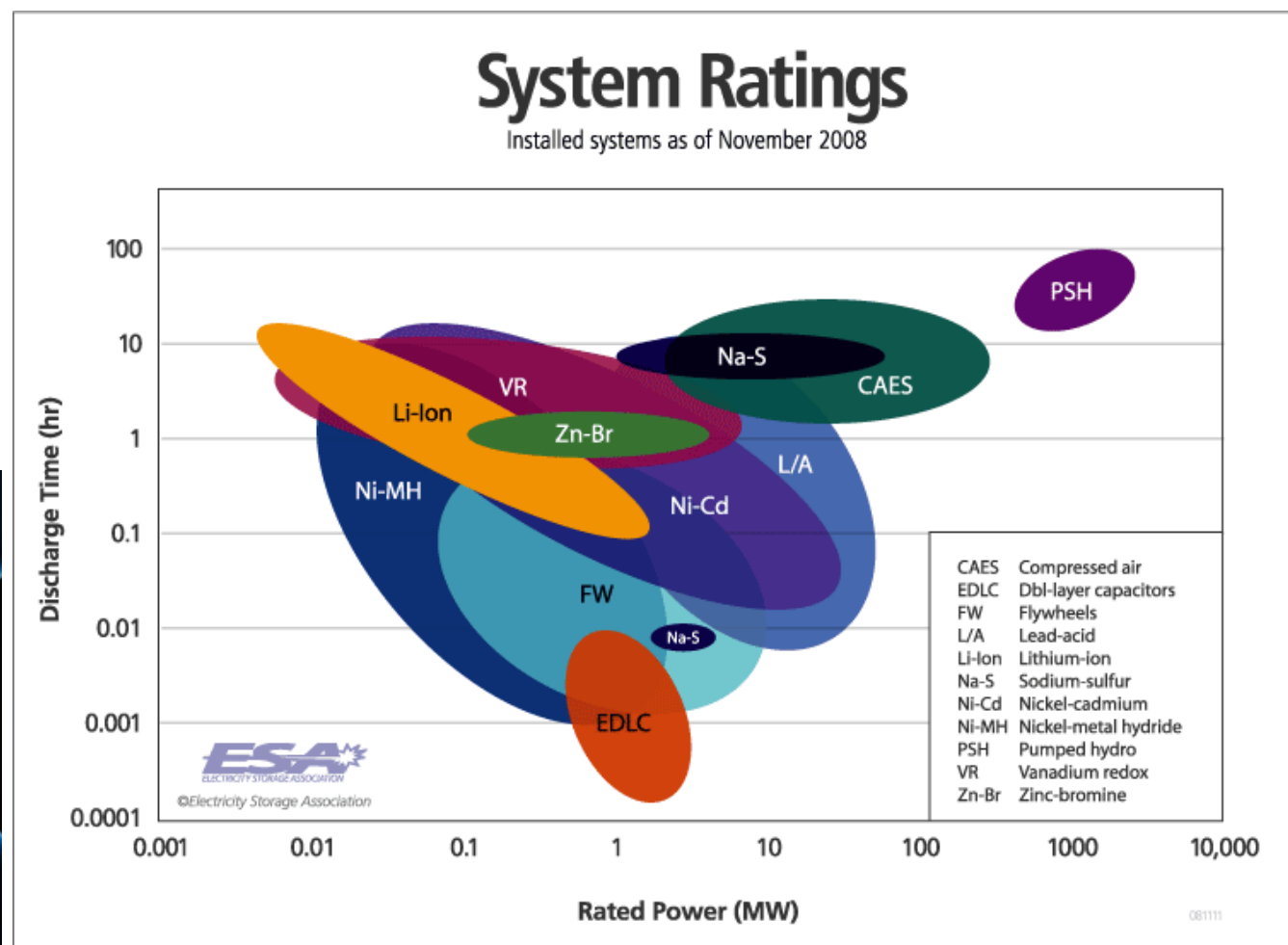
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# Renewable Energy needs Energy Storage

Efficient low cost production and storage will change the world – using wind, sun, bio-fuels and grid balancing off-sets

- Segmented by Size and Storage Time

- Super capacitors
- Flywheels
- Batteries
- Flow Cells
- Hydrogen
- Compressed Air
- Pumped Hydro



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**THANK YOU FOR LISTENING**

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*Graham Cooley (ITM)*  
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*Getty Images*





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