Green Engine Technologies

Overview, Key Challenges, Opportunities and Trends
Overview

• The world has a need for energy efficient solutions that lower the greenhouse gas emission and reduce fossil fuel dependency.
• Forced by regulations, car manufacturers are now seeking ways to comply with the required ultra-low CO2, NOx, UHC, CO and PM levels.
• Four focus areas:
  – Alternative fuels
  – Vehicle improvements
  – Electrification
  – Engine improvements
Overview continued

• Australia has a great opportunity to play a major role in future green car technology development and applications.

• There is a push towards “Green” and RMIT should get involved.

• RMIT’s engine or engine related research facilities are being set up to be amongst world class green car research.

• Still, there is need for cooperation / use of other research facilities: Cross RMIT, Car manufacturers, Research organisations, Other Universities (national and international).
3 Major Concerns / Global Challenges

- Global warming (Green house gases like CO2)
- Population growth (energy consumption and vehicle number)
- Energy consumption (fossil fuels and natural assets)
- Emissions (air quality)
Global Challenges
Global Warming

Cause and Effect of Climate Change

Carbon dioxide levels related to Global temperatures

Temperature anomaly correlates to CO₂ increase
Global Challenges

Green house gas emissions

Greenhouse Gas Emissions from Transportation Sector

- **13 percent** of Global GHG Emissions from Transportation Sector in 2004 (27.5 Gt CO₂ Eq.)
- **81 percent** of transportation GHG emissions in the United States from “onroad” vehicles

*Source: IPCC Study 2007

Global Challenges
Population Growth

World Population Growth, Actual and Projected, 1950-2050


7-8 Billion yr 2020!!
Global Challenges
Fossil Fuel Reserves

Global oil production of resources of 1800 / 2200 / 2600 billion barrels

Source: World Resources Institute

Oil scarcity is already a fact today

Billions of Barrels per Year

Source: World Resources Institute
Air quality now and then

NYC 1988

First Smog Alarm in Germany 1985

NYC 2000

Beijing after and before rain
Older vehicles
Developing countries
Consequences

- CO2 legislation
- Emissions legislation
- Common awareness
- Increased prices
Consequences
CO₂ Legislation

Governments Act to Reduce CO₂/Fuel Consumption
Requirements standardized to the NEDC-Cycle (New European Driving Cycle)

1.5 – 2.5 % y-o-y CO₂ reduction is required to stabilise CO₂ @ 550 ppm yr 2100

*California AB 1493 decided by CARB, litigated by US mfgs. Source: U of California, U of Michigan, Argonne, PEW Center for Global Climate Change, Dec 2004

Source: VCC
## Consequences

### Emissions Legislation

**Legislated Emission Levels (GRID)**

(light duty vehicles)

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<thead>
<tr>
<th></th>
<th>CO</th>
<th>HC</th>
<th>NMHC</th>
<th>NOx</th>
<th>PM</th>
<th>PN</th>
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<tr>
<td></td>
<td>g/km</td>
<td>mg/km</td>
<td>mg/km</td>
<td>mg/km</td>
<td>mg/km</td>
<td>#/km</td>
<td>mg/km</td>
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<td>EURO 4*</td>
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<td>100</td>
<td>80</td>
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<td>100</td>
<td>68</td>
<td>60</td>
<td>5</td>
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<tr>
<td>EURO 6**</td>
<td>1.0/0.5</td>
<td>100</td>
<td>68</td>
<td>60/80</td>
<td>5</td>
<td>TBD</td>
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<td>LEVII/ULEV</td>
<td>1.3</td>
<td>34</td>
<td>43</td>
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<td>6.8</td>
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<td>34</td>
<td>19</td>
<td>6.2</td>
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<td>PZEV</td>
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<td>12.4</td>
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<td><strong>Japan</strong></td>
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</table>

* Gasoline standards
** Diesel slightly lower CO but higher NOx allowed in EU
Consequences
Common awareness

We ruin the World every Year. BMW.
Unsere 3er Modelle stoßen bis zu 243 g CO₂ pro km aus. Damit ruinieren wir das Klima weltweit. Versprochen haben wir, den CO₂-Ausstoß bis 2008 auf 140 g/km zu senken. Dieses Ziel werden wir verfehlen. Vereinbaren Sie ein Informationsgespräch unter 0600 0887766 (gebührenfrei).
Consequences
Increased prices

Current Gas Prices and Price History

Regular Gasoline Price In Today’s Dollars (3/10/08)

- $3.29, March 1981
- $3.28, Sept. 2005
- U.S. Invades Iraq
- OPEC Oil Embargo
- Iraq-Iran War Starts
- Iraq Invades Kuwait
- 9/11

$3.50
$3.00
$2.50
$2.00
$1.50
$1.00
$0.50
$0.00


zFacts.com

(maybe not an effect of decreased fossil fuel reserves)
4 Major directions

- Improving the internal combustion engine
- Improving the vehicle
- Alternative fuels
- Electrification
Examples of Various Technology Choices for CO₂ Reduction / Sustainable Mobility / Emissions leg.

Car Manufactures (Volvo)

Advanced Internal Combustion Engines, e.g. - Downsized SI Engines - Advanced Combustion - Clean Diesel

Advanced Transmission Technologies

Vehicle Drag and Weight Reduction

Hybridized Powertrain

Vehicle Energy Management

Advanced Electric Energy Storage - Batteries - Supercaps

Exhaust Energy Recovery

Alternative Clean Fuels

Rolling Resistance Reduction
Examples of Various Technology Choices for CO₂ Reduction / Sustainable Mobility / Emissions leg.

Consultants (Ricardo)

Powertrains will evolve through downsizing of combustion engine, electrification and use progressively lower carbon fuel

<table>
<thead>
<tr>
<th></th>
<th>Today</th>
<th>2015</th>
<th>2025</th>
<th>2030?</th>
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<td>ICE Swept Volume (litres)</td>
<td>1.8</td>
<td>1.2</td>
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<tr>
<td>Engine Power (kW)</td>
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<td>75</td>
<td>70</td>
<td>65</td>
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<td>Electric Power (kW)</td>
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<td>40</td>
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<td>Boost Pressure (bar)</td>
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<td>2.5</td>
<td>3</td>
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<tr>
<td>Battery Capacity (KWh)</td>
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<td>2</td>
<td>4</td>
<td>6</td>
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<tr>
<td>Electric Only Range (km)</td>
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<td>15</td>
<td>35</td>
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<tr>
<td>City Economy (l/100 km)</td>
<td>6</td>
<td>3.5</td>
<td>5.2</td>
<td>0*</td>
</tr>
<tr>
<td>Highway Economy (l/109km)</td>
<td>5</td>
<td>3.5</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Highway CO₂ (g/km)</td>
<td>140</td>
<td>90</td>
<td>70</td>
<td>40</td>
</tr>
</tbody>
</table>

* Assumes Plug-in electric power use only
Examples of Various Technology Choices for CO₂ Reduction / Sustainable Mobility / Emissions leg.

Suppliers (Bosch)

Drivetrain technologies for passenger cars – timeline

- Gasoline
- Diesel
- Alternative fuels
- Hybrid
- HCCI
- Diesel
- Alternative fuels
- Range extender
- Electric/Fuel cell
- Electric/Battery
- Electric (Battery/Fuel cell)

Timeline:
- 1997
- 2015
Green Car Learning Clusters Project

• A framework for collaborative research based on three learning clusters:
  – Vehicle life cycle design
  – Alternative vehicle power-trains
  – End-of-live vehicle treatment

• Virtual (web-based) environment to facilitate knowledge base creation, linkages to relevant online resources worldwide, communication, e/learning and sharing of ideas among all participating stake-holders.

• Resources generated through this project will be used in teaching and learning, professional development, research and research training.

• Focus: capacity building and workforce development for the emerging green car economy.
More Opportunities
Conclusion

• The world has a need for energy efficient solutions that lower the greenhouse gas emission and reduce fossil fuel dependency.

• Car manufacturers are seeking technological solutions to comply to regulations

• The future vehicle will go through a transformation from conventional to a combination of all feasible technologies implemented by the readiness of the state of the art of those technologies, to eventually completely be sustainable, green and independent of fossil fuels.

• RMIT is involved.