Sustainable Life Cycle Management of complex products: Automobiles

- Input / material issue?
- Output / Sustainability issues
- Product Sustainability Index

Wulf-Peter Schmidt
Manager Sustainability
Vehicle Environmental Engineering
Ford of Europe
Material input vs. Emission output perspective

Peak oil depletion

Limits to Growth

Issue: Quantity (and quality) of Material used

Recycling Regulation

Resource depletion

Life Cycle Management

Limits to Growth

Issue: Quality (and quantity) of Emission

Pollution Chaos

Climate Limits to Growth

Emission Regulation

Resource depletion

Life Cycle Management

Limits to Growth

Issue: Quality (and quantity) of Emission

Pollution Regulation

Climate Limits to Growth

Emission Regulation

Resource depletion

Life Cycle Management

Limits to Growth

Issue: Quality (and quantity) of Emission

Pollution Regulation

Climate Limits to Growth

Emission Regulation
Resource Issue – depletion or economics?

EU report: Critical raw materials for the EU

Real price indices of metallic minerals (2000 = 100)

Indium

1972: 66.4 t

1989: 15 years

1989: 15 years

2007: 19 years

Refinery production

Static life time of reserves

Asia, Speculation

Production increase

EU report: Critical raw materials for the EU
Dependency issue – politics, trade, ethics, environmental, etc.

Recycling & Design as solution?

Materials & Parts | Manufacture and Assembly | Vehicle Use | End of Life

80-85% | 1-3% | 15% | 1%

Situation today (Metal recycling, organics/ceramics to landfilling)
Mechanical Recycling
Energy Recovery of organics, recycling of metals, landfilling of ceramics/glass

Impact of material differences (max-min)
Impact of increasing recycling
Impact of theoretical, extreme lightweighting (~ medium engine downsizing)

MAX and MIN are representing the range of 7 different vehicle designs/material compositions

1000 kg | 900 kg | 750 kg

* Similar for other environmental impact; Source: EU funded, ISO14040 reviewed LCA LIRECAR
Material input/up-stream issues - conclusions

- Mainly a **supply chain management** issue for manufacturers.
- Mainly a **trade and political** issue for governments.
- Mainly a **substitution** issue for research.

- “**Material ecology**“ is **too limited** in scope:
  - Efficient use of materials is a given due to costs, weight, logistics, etc. → tailored to application.
  - Recycling is done **where reasonable** / no additional relief – positive value of end-of-life vehicles.
Sustainability of Cars – The Output/Downstream Challenges

Environment

Society

Economy
Complexity of cars
Ford of Europe’s functional organisation of sustainability – combining input/output

- Main organisational functions are responsible / accountable for their bit of sustainability
- Tailored Sustainability Management Tools
### What is PSI measuring – how and why?

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Metric</th>
<th>Why Important</th>
</tr>
</thead>
<tbody>
<tr>
<td>Life Cycle Global Warming Potential</td>
<td>Climate Change gases along the product life cycle* (LCA)</td>
<td>Carbon intensity as main strategic issue</td>
</tr>
<tr>
<td>Life Cycle Air Quality Potential</td>
<td>Summer Smog gases (NOx, VOC) along the life cycle* (LCA)</td>
<td>Potential trade-off: non-CO2 emissions</td>
</tr>
<tr>
<td>Sustainable Materials</td>
<td>recycled &amp; natural materials per vehicle polymer weight</td>
<td>Resource Scarcity</td>
</tr>
<tr>
<td>Restricted Substances</td>
<td>Allergy-tested label etc. (15 point rating)</td>
<td>Substance risk management</td>
</tr>
<tr>
<td>Drive-by-Noise</td>
<td>Drive-by exterior Noise = dB(A)</td>
<td>Society concern</td>
</tr>
<tr>
<td>Safety</td>
<td>Different Safety criteria</td>
<td>Main direct impact</td>
</tr>
<tr>
<td>Mobility Capability</td>
<td>Mobility capacity (seats, luggage) to vehicle size</td>
<td>Crowded cities (future: disabled)</td>
</tr>
<tr>
<td>Life Cycle Ownership Costs</td>
<td>Price + 3 years fuel, maintenance costs, taxation - residual value</td>
<td>Consumer focus/ Competitiveness</td>
</tr>
</tbody>
</table>

*(from raw material extraction through production to use (150000 km) and recovery)*

Note: legal compliance issues (recycling) are the baseline, i.e. not a topic of PSI. Most data anyway tracked by PD / panel charts.
Tailpipe/Life Cycle CO2 down
Footprint of supply up

<table>
<thead>
<tr>
<th>Category</th>
<th>Focus I</th>
<th>Focus Econetic II</th>
<th>Future Focus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use of vehicle incl. Fuel prod.</td>
<td>32 tons</td>
<td>23 tons</td>
<td>? tons</td>
</tr>
<tr>
<td>Logistic</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supplier</td>
<td>20%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recycling</td>
<td>0%</td>
<td>99 g CO2/km</td>
<td></td>
</tr>
</tbody>
</table>

Materials, electronics, batteries,…
Product Sustainability Index – managing all aspects of vehicle sustainability
Conclusions

• Need to concentrate on **hot-spots** (vehicle level) due to vehicle complexity

• **Holistic life cycle perspective** important – environment, social and economic – not only Material Ecology

• Material issues cannot be limited to material/input perspective but need to be seen in perspective of life cycle sustainability as well as politics/trades.
Back-up
Balancing sustainability requirements in today’s vehicles

<table>
<thead>
<tr>
<th>Bi-Fuel</th>
<th>CNG/ Gasoline</th>
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</thead>
<tbody>
<tr>
<td>Bi-Fuel</td>
<td>LPG/ Gasoline</td>
</tr>
<tr>
<td>Flexifuel-</td>
<td>Bio-Ethanol/ Gasoline</td>
</tr>
<tr>
<td>Tri-Fuel</td>
<td>Bio-Ethanol/LPG/Gasoline</td>
</tr>
<tr>
<td>Econetic</td>
<td>Diesel Vehicles</td>
</tr>
</tbody>
</table>

- Bi-Fuel CNG/Gasoline: 98 g CO2/km
- Bi-Fuel LPG/Gasoline: 99 g CO2/km
- Flexifuel-Bio-Ethanol/Gasoline: 139 g CO2/km
- Tri-Fuel Bio-Ethanol/LPG/Gasoline: 189 g CO2/km
### Outlook – Electrification?

#### Transit Connect Electric

<table>
<thead>
<tr>
<th>Technical Specification:</th>
<th><img src="image" alt="Transit Connect Electric" /></th>
</tr>
</thead>
<tbody>
<tr>
<td>Range: ~ 130 km (80 mi)</td>
<td></td>
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<tr>
<td>Charging Time: ~ 6 - 8 hours</td>
<td></td>
</tr>
<tr>
<td>Energy Storage: Li-Ion Battery (~ 28 kWh)</td>
<td></td>
</tr>
</tbody>
</table>

#### Focus BEV

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<tr>
<th>Technical Specification:</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Range: ~ 120 km (75 mi)</td>
<td></td>
</tr>
<tr>
<td>Motor Power: 100 kW</td>
<td></td>
</tr>
<tr>
<td>Charging Time: 6-8 hours</td>
<td></td>
</tr>
<tr>
<td>Energy Storage: Li-Ion Battery (23 kWh)</td>
<td></td>
</tr>
</tbody>
</table>

- Electric Ford Vehicles (HEV, PHEV, BEV) developed but market introduction requires incentives, production support, infrastructure, customer acceptance
- Battery technology currently very costly
- Renewable electricity / EU Emission Trading Scheme compensates for CO2
Life Cycle Perspective for strategic questions: Extreme lightweighting: Burden shifting when looking only at tailpipe CO₂ / Fuel Economy?

- Lightweighting reduces tailpipe CO₂
- Significant light-weighting requires materials that are linked to high CO₂ in production
- Lightweighting (>300 kg) can lead to a net increase of CO₂ if not based on LC thinking

* Compared to base weight