TOWARDS A SUSTAINABLE VEHICLE DEVELOPMENT

Wulf-Peter Schmidt

Manager Sustainability, Ford of Europe

Feel the difference

Agenda

The Challenge

Evolution of answers to the challenge – Evolution of DfX

→ Design for Disassembly

→ Design for Recycling

→ Design for Environment

→ Design for Sustainability

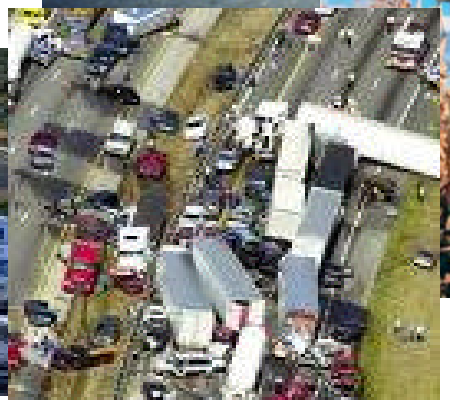
Balancing environmental, societal and economic requirements in today‘s vehicles

Outlook

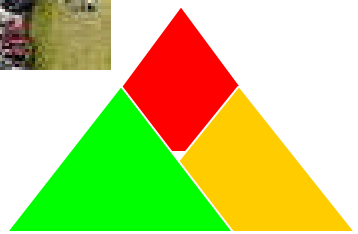
Sustainability of Cars – The Challenges

- CO2 / Climate change
- Other Pollution (e.g. Summer Smog)
- Oil dependency

- Overcrowded streets / mobility capability per car / mobility access (aging EU population)
- Safety
- Affordability/ often precondition for development
- Etc.



All dimensions of sustainability



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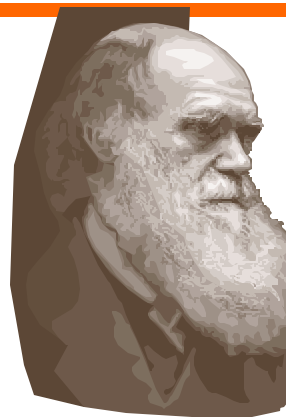
Evolution of DfX – Example vehicles

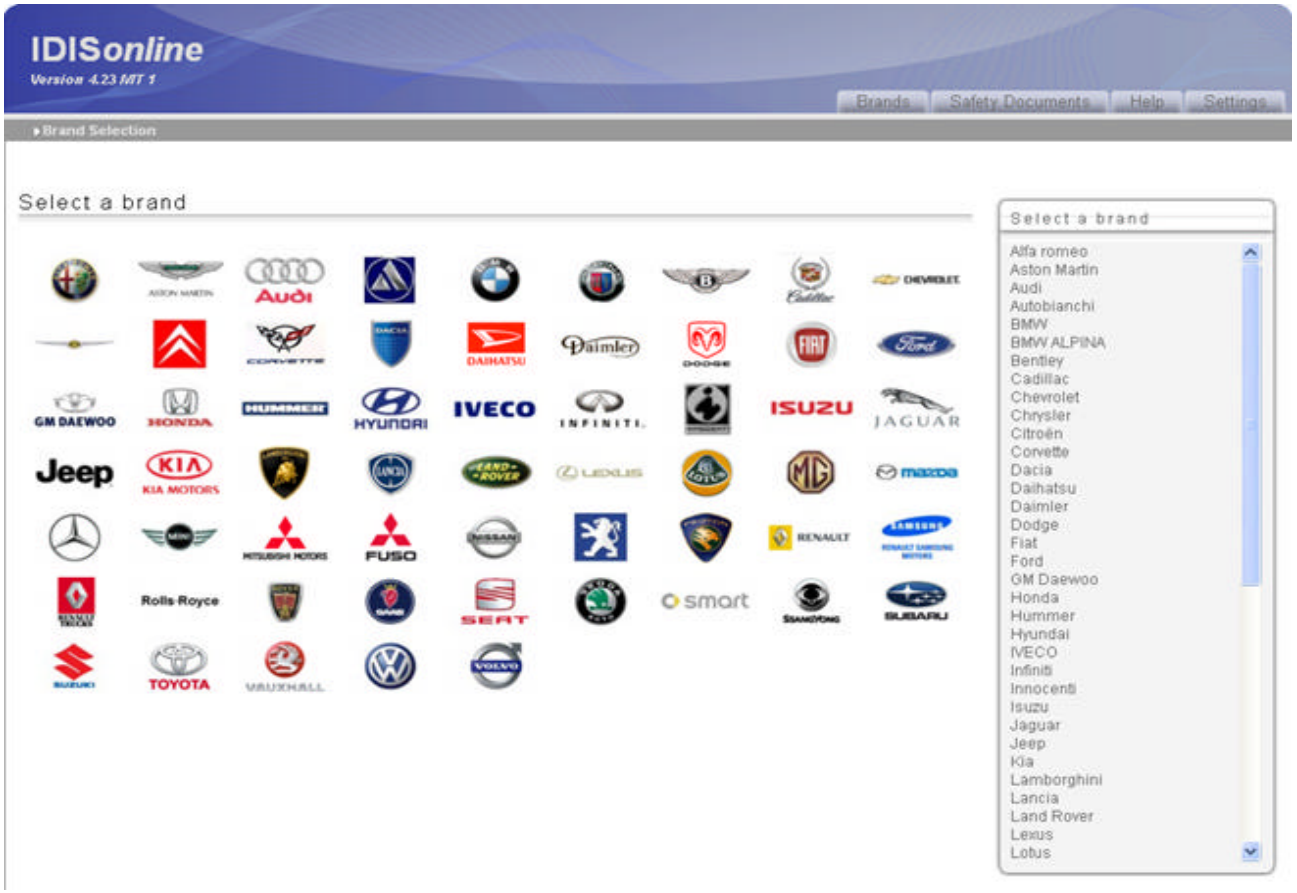


- Early 90es – Df Disassembly (Accessability, type & number of fastener, parts marking etc.)

Strategy of Manufacturers

Dismantling information

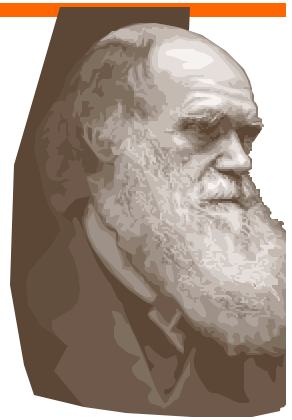
- IDIS (International Dismantling Information System) – International consortium of 24 OEM's which enables identification of component materials and hazardous materials for dismantling
- IDIS responsible Department: Vehicle Recycling
- www.idis2.com



IDIS

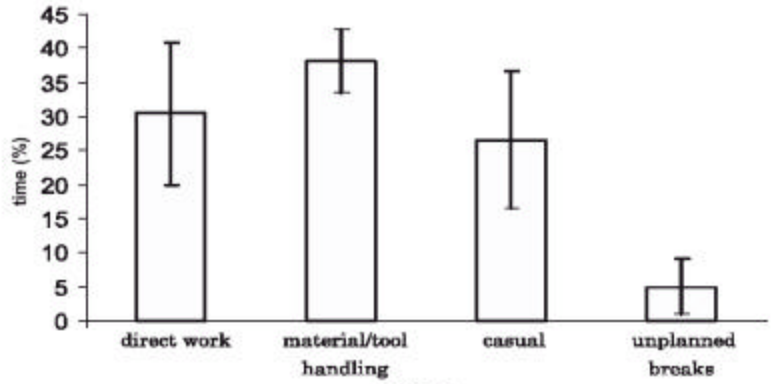
- **IDIS** was developed by the automotive industry to meet the legal obligations of the EU ELV directive and has been improved to an information system with vehicle manufacturer compiled information for treatment operators to promote the environmental treatment of End-of-Life-Vehicles, safely and economically. The information are organized in different areas including:
    - Batteries
    - Pyrotechnics
    - Fuels, AC,
    - Draining
    - Catalysts
    - Controlled Parts to be removed
    - Tyres
    - Other Pre-treatment
    - Dismantling
- **IDIS** does not contain any information to meet further requirements. It is not designed to be used for issues like recycling quota and dismantling time calculation or to be used as a replacement for manufacturers workshop manuals, for parts identification based on part numbers or stock managing purposes.

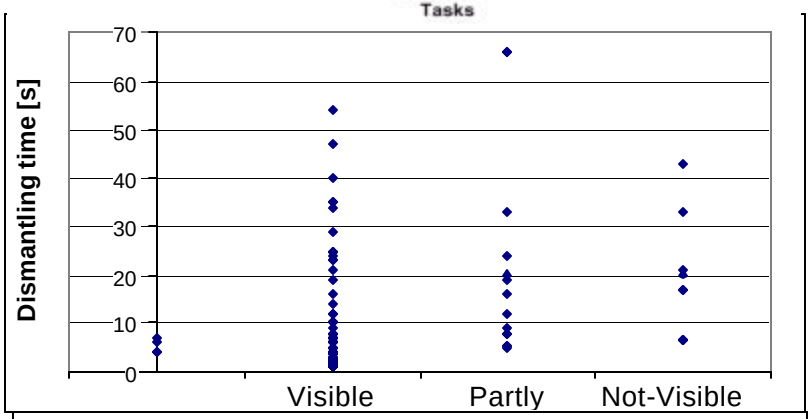
Evolution of DfX – Example vehicles

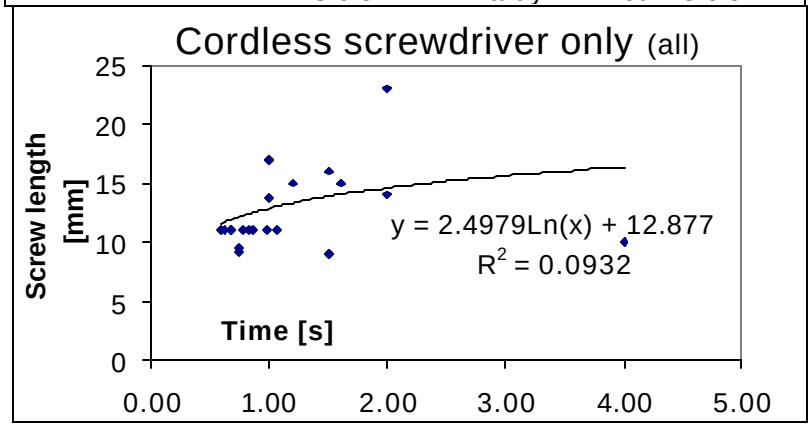


- Early 90es – Df Disassembly (Accessability, type & number of fastener, parts marking etc.)
- Mid 90es – Df Recycling (DfD + material complexity / compatibility, recycled content)

Impact of DfDismantling !?



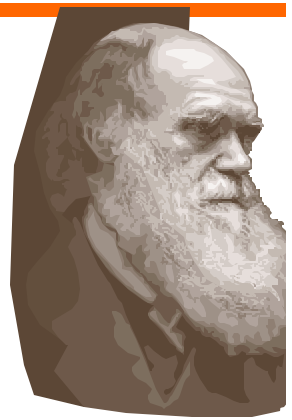




- **70 % of real world dismantling time not linked to type of design** [Kazmierczak et al 2005]
- Remaining 30 % mainly weak potential impacts.
- EU funded SEES project made comprehensive analysis of design parameters (visibility, accessibility, fastener type etc.) and dismantling time (475 dismantling actions analysed)
- SEES found **no significant correlation between design parameters and dismantling time** (besides number of previous parts).

Source: EU funded SEES project (TU Berlin (project coordination), Ford et al.)

Evolution of DfX – Example vehicles



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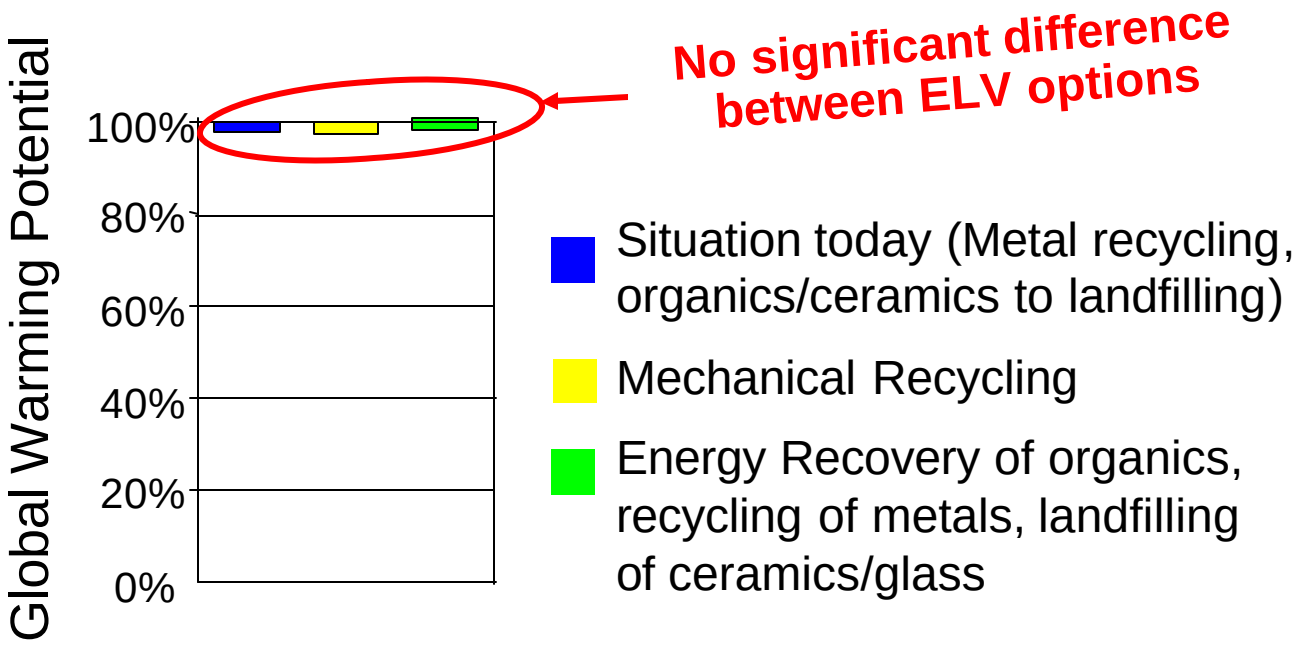
- Mid 90es – Df Recycling (DfD + material complexity / compatibility, recycled content)
  - Real world time measurements showed no significant impact of DfD/design on dismantling times
  - Life Cycle Assessment studies show minor effect of recycling for non-metals

What are the impacts of End-of-Life technology variation on the overall environmental profile ?



- Answer: No significant environmental difference between different EOL technologies
- **Similar results for other environmental impacts & resource depletion**

Source: EU funded, ISO14040 reviewed LCA LIRECAR

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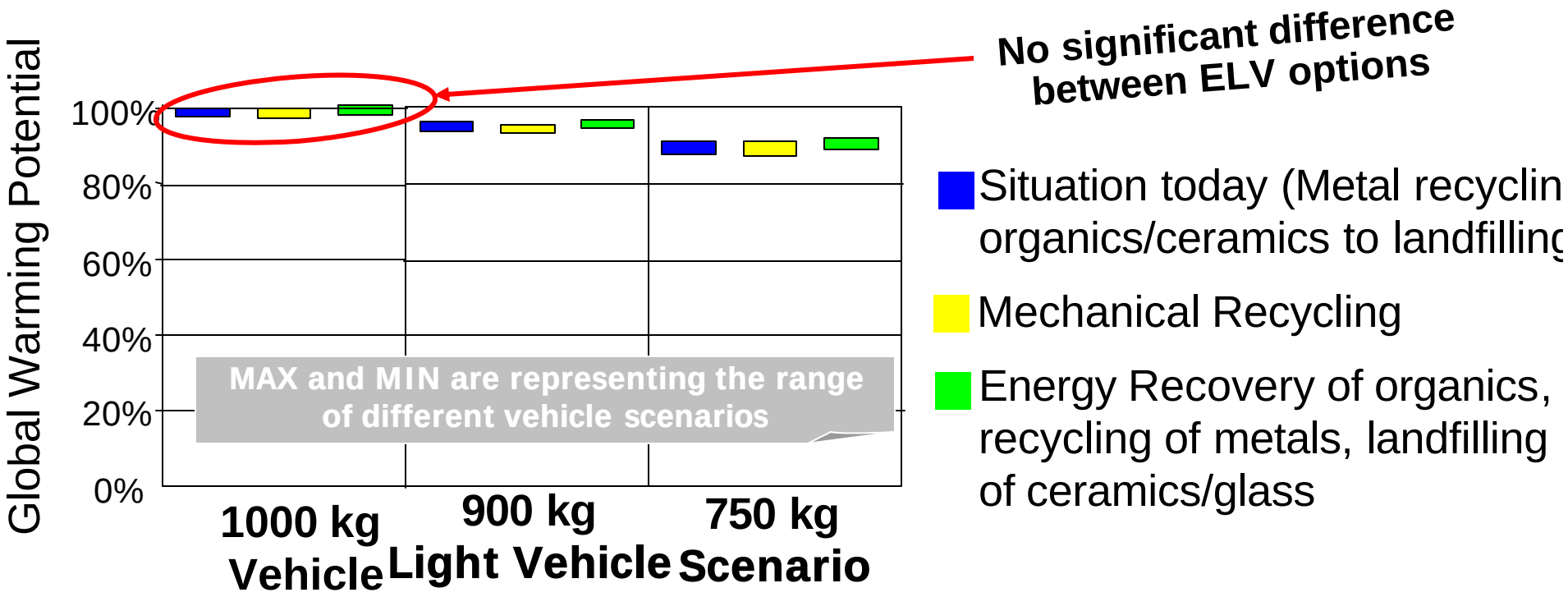
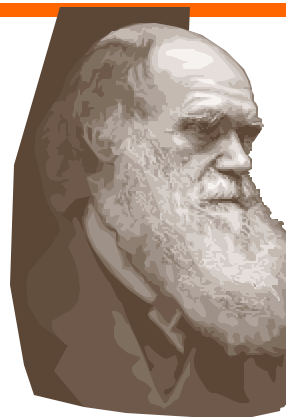


- Answer: No significant environmental difference between different EOL technologies
- **Similar results for other environmental impacts & resource depletion**
- Lightweighting is more important – but less then expected

Source: EU funded, ISO14040 reviewed LCA LIRECAR

Evolution of DfX – Example vehicles



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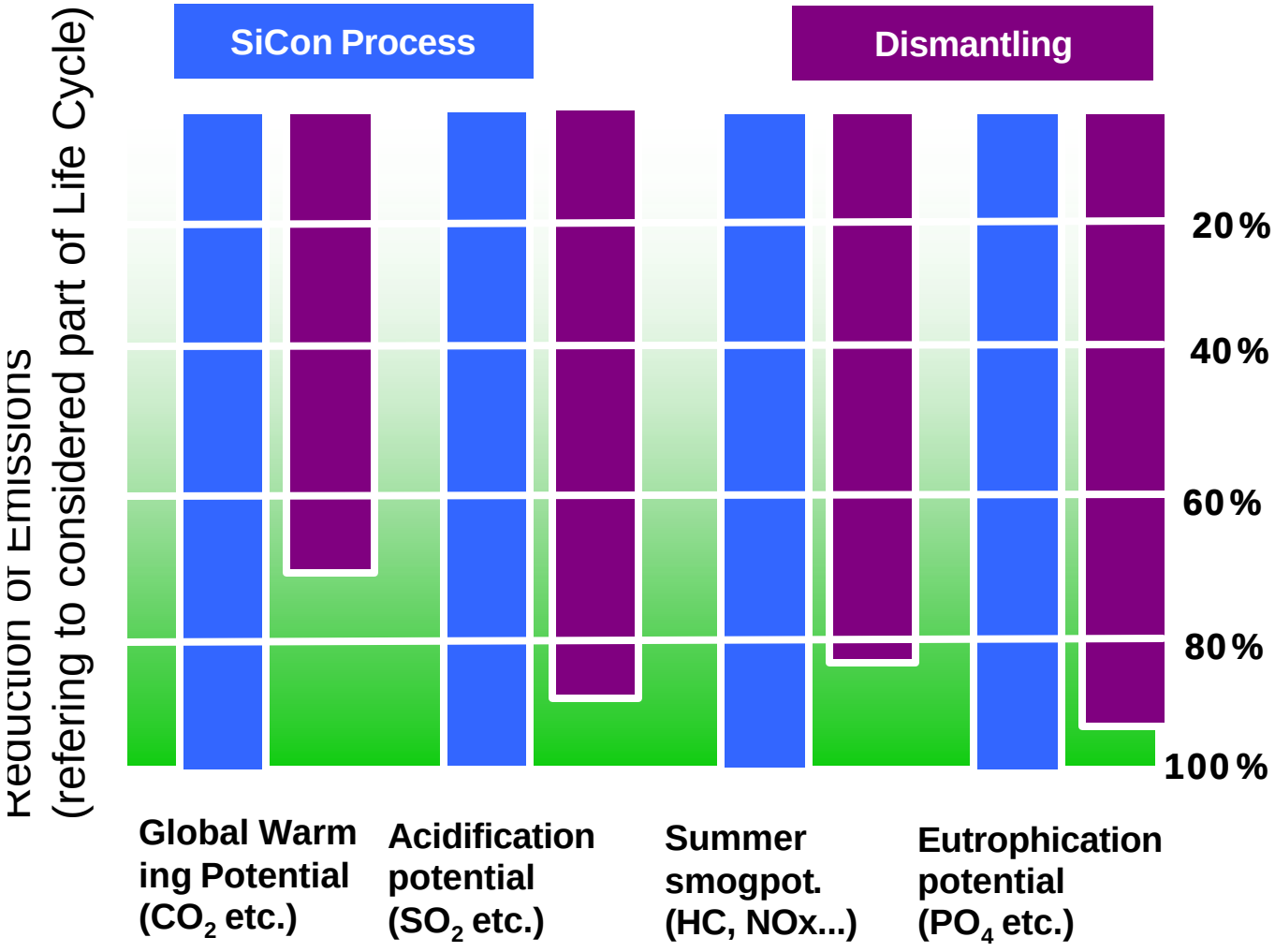
Post Shredder: Recycling/Recovery of Automotive Shredder Residue (ASR)

- Cars are shreddered, treatment of shredder residue.
- Material sorting and recycling based on
  - Density differences
  - Surface characteristics (polarity / adhesion ...)
  - Material properties (glass point / hardness / reflectivity / ...)
  - Electrostatic or electromagnetic properties (eddy current etc.)
- Feedstock recycling (substitution of virgin material)
  - Reduction agent in blast furnace
  - Back to a monomer / gaseous state
- Energy Recovery of light fraction

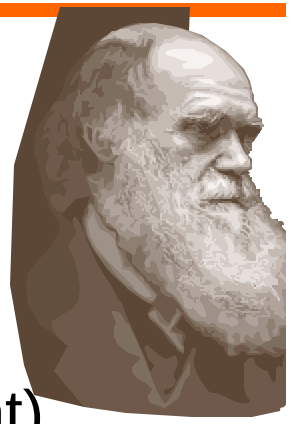
Post-Shredder Treatment (PST) vs. dismantling / mechanical Recycling



- SiCon-Process is a process where no dismantling is necessary & mainly feedstock recycling is done.
- This SiCon-Process results in more environmental credits compared to a dismantling & mechanica recycling.
- Sensitivity analysis demonstrates that this advantage remains also for bigger facilities (longer transport distances).
- Note: This advantage is mainly due to better yields

Source: ISO14040 reviewed LCA study of VW

Evolution of DfX – Example vehicles



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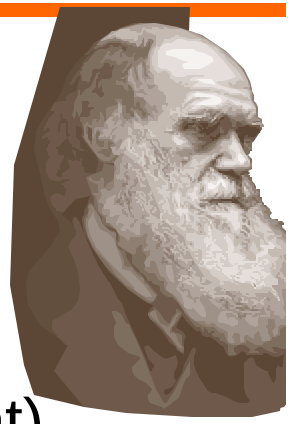
- Late 90es – Df Environment (Life Cycle Thinking based, decreasing DfD/R content due to development above – **No design changes necessary for recycling as PST can treat material mix. Recyclabiilty demonstrated based on Material composition deduced from IMDS**)

Evolution of DfX – Example vehicles



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- 2002 – Df Sustainability (e.g. Product Sustainability Index)

What is PSI measuring – how and why?

ndicator	Metric	Why Important?
.ife Cycle Global Varming Potential	Climate Change gases along the product life cycle* (LCA)	Carbon intensity as mai strategic issue
.ife Cycle Air Quality otential	Summer Smog gases (NOx, VOC) along the life cycle* (LCA)	Potential trade-off: non-CO_2 emissions
ustainable Materia	recycled & natural materials per vehicle polymer weight	Resource Scarcity
estricted Substances	Allergy-tested label etc. (15 point rating)	Substance risk management
rive-by-Noise	Drive-by exterior Noise = dB(A)	Society concern
afety	Different Safety criteria	Main direct impact
obility Capabili	Mobility capacity (seats, luggage) to vehicle size	Crowded cities (future: disabled)
.ife Cycle Ownership osts	Price + 3 years fuel, maintenance costs, taxation - residual value	Consumer focus/ Competitiveness

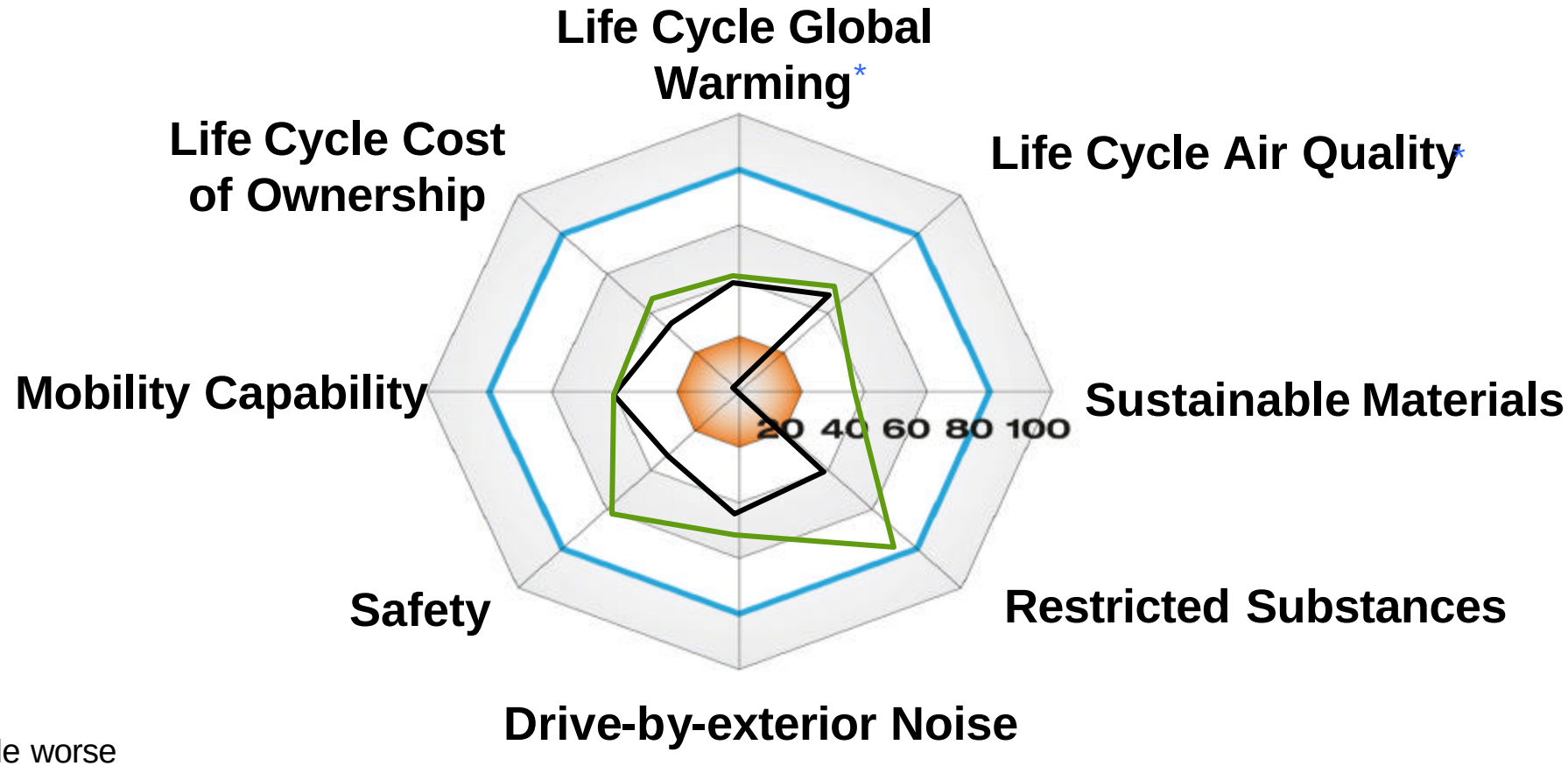
Note: legal compliance issues are the baseline, i.e. not a topic of PSI.
Also aspects decided before PD (service aspects) cannot be covered by PSI

Ford's Product Sustainability Index (PSI) – DfS / Sustainability Mgt'ment

- 2002 Senior management decision
  (all new FoE products starting with S-MAX/Galaxy)
- Used by engineering management to check target vs status at each development gateway – ensuring full ownership
- Tailored to Ford of Europe – no need for incremental resources

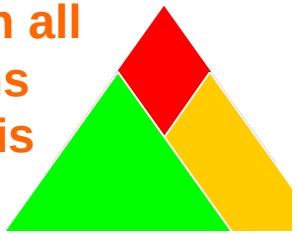
Not an after-thought but built-in the product development process

PSI – Example Galaxy diesel



Key: inside worse
outside better
Prior Ford Galaxy 1.9l TDI
New Ford Galaxy 2.0 l TDCi with DPF
80% theoretical best cross-industry
B to V segment Europe

Improvements in all three dimensions (described area is getting bigger)



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Same applies to aspects decided before/outside PD (e.g. service aspects, working conditions)

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

Balancing sustainability requirements in today‘s vehicles

Bi-Fuel
CNG/
Gasoline



Bi-Fuel
LPG/
Gasoline



Flexifuel-
Bio-Ethanol/
Gasoline




Tri-Fuel
Bio-Ethanol/LPG/Gasoline

Econetic
Diesel
Vehicles




98 g CO2/km | 99 g CO2/km | 139 g CO2/km | 189 g CO2/km

Outlook – Electrification?

Transit Connect Electric

Technical Specification:

Range: ~ 130 km (80 mi)

Charging Time: ~ 6 - 8 hours

Energy Storage: Li-Ion Battery (~ 28 kWh)

Focus BEV

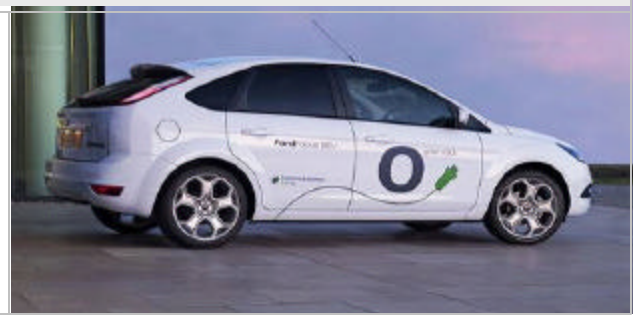
Technical Specification:

Range: ~ 120 km (75 mi)

Motor Power: 100 kW

Charging Time: 6-8 hours

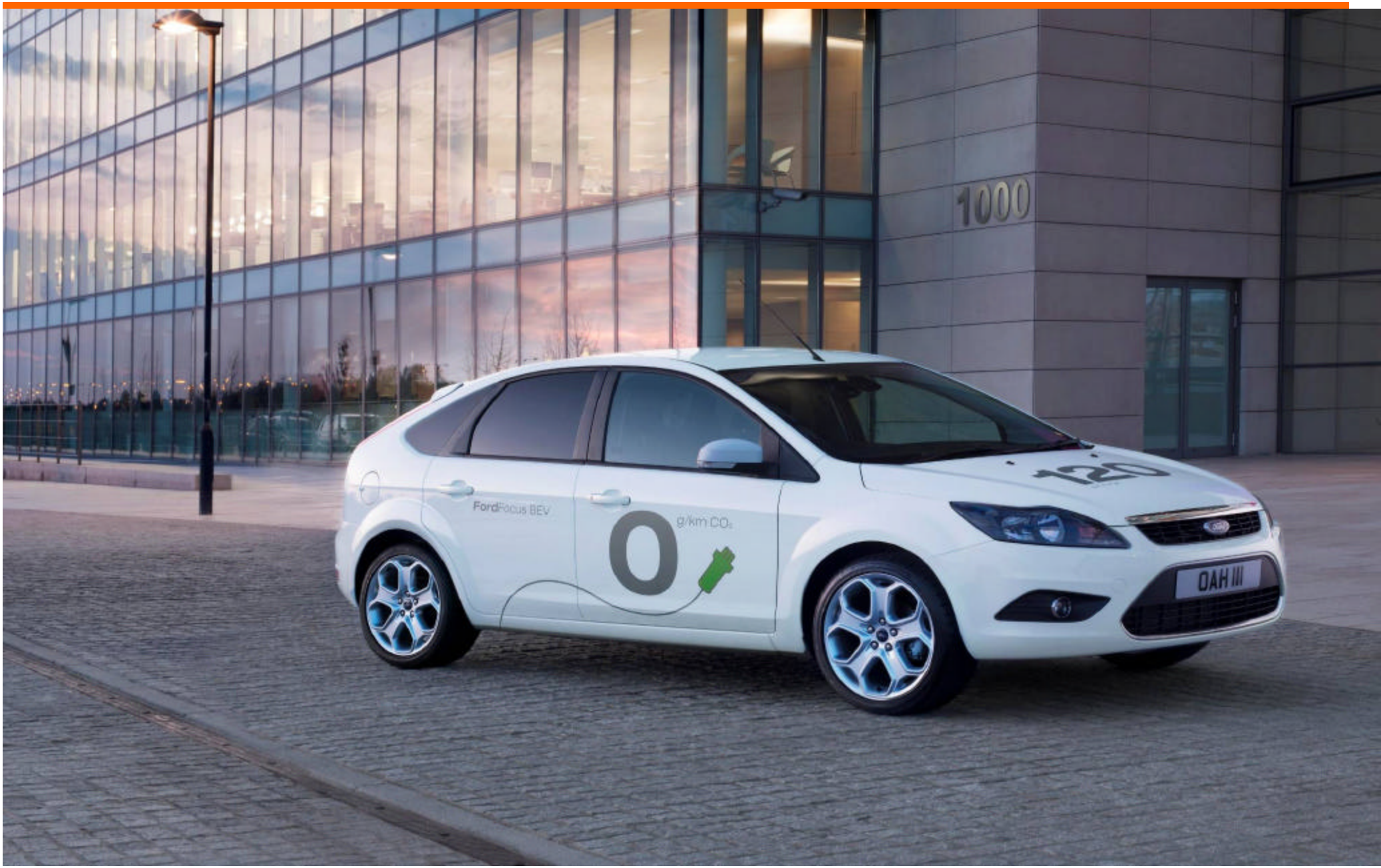
Energy Storage: Li-Ion Battery (23 kWh)



- 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

Summary

- Increasing challenges for individual mobility based on vehicles
- Learning curve led to new answers over time:
  - Design improvements little impact on real-world dismantling time
  - Recycling of non-metals minor environmental credit
  - Focus on Environment only does not address all sustainability issues and opportunities
  - Holistic and balanced design approach needed covering environmental, societal and economic needs.
- Balancing environmental, societal and economic requirements in today‘s vehicles is key



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