Università degli Studi di Firenze
Dipartimento di Meccanica e Tecnologie Industriali

Ecomondo 2011 - "LCA in Italia: dall'ecodesign alla gestione del fine vita"

Rimini, 09.11.2011

LCA and ecodesign applications in the automotive field

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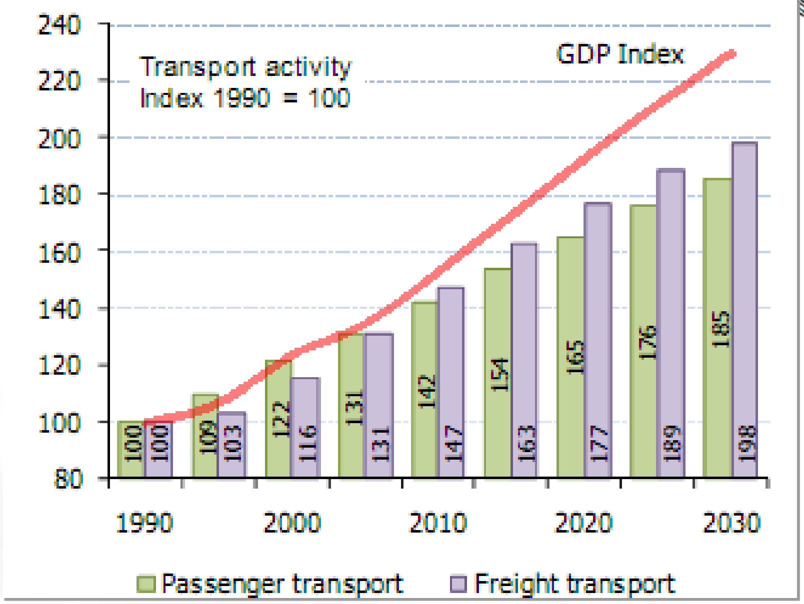
EcoDesign Innovation Team

Outline

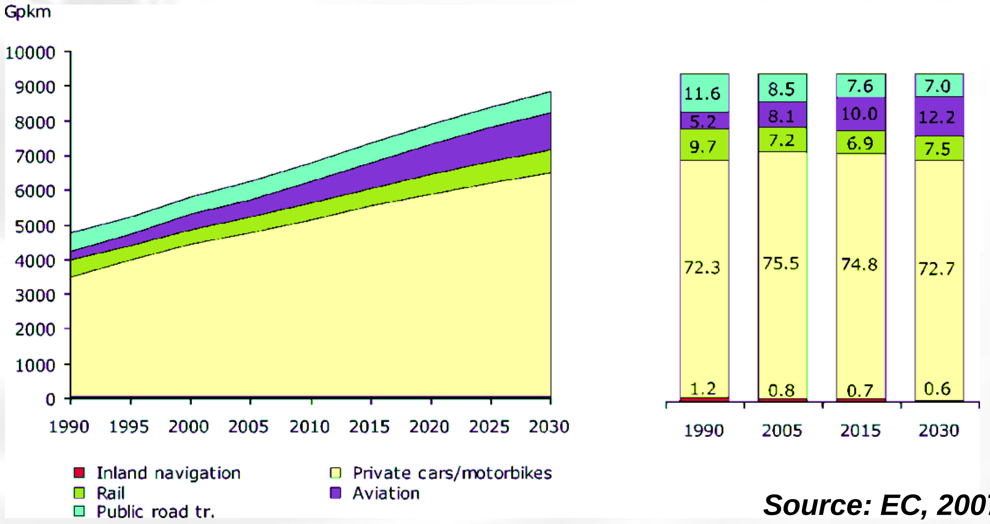
- Introduction
- Main actors in vehicle design
  - Customer needs, regulation, business strategies
- Factors influencing eco-vehicle design
  - Approach to EcoDesign, LCA of vehicle
  - Technical Factors
- Conclusions

Introduction

- Increasing transport demand vs GDP
  - Strong correlation with economic development
  - 2030+ scenario: Growth of transport demand (passenger)
  - Private vehicles: >70% of passenger transport activity



Source: EC, 2007

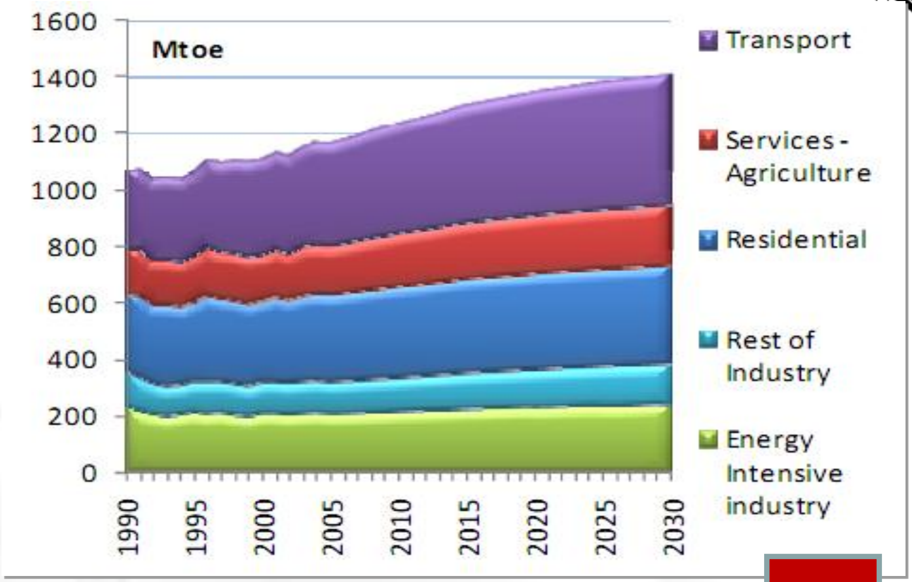


Source: EC, 2007

Introduction

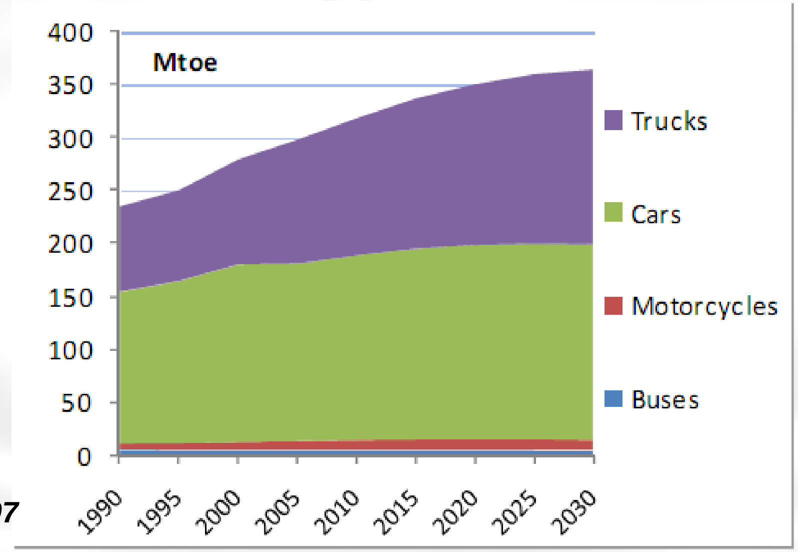
- Increasing energy consumption

– Transport: ~25% of total energy consumption in Europe



Source: EC, 2007

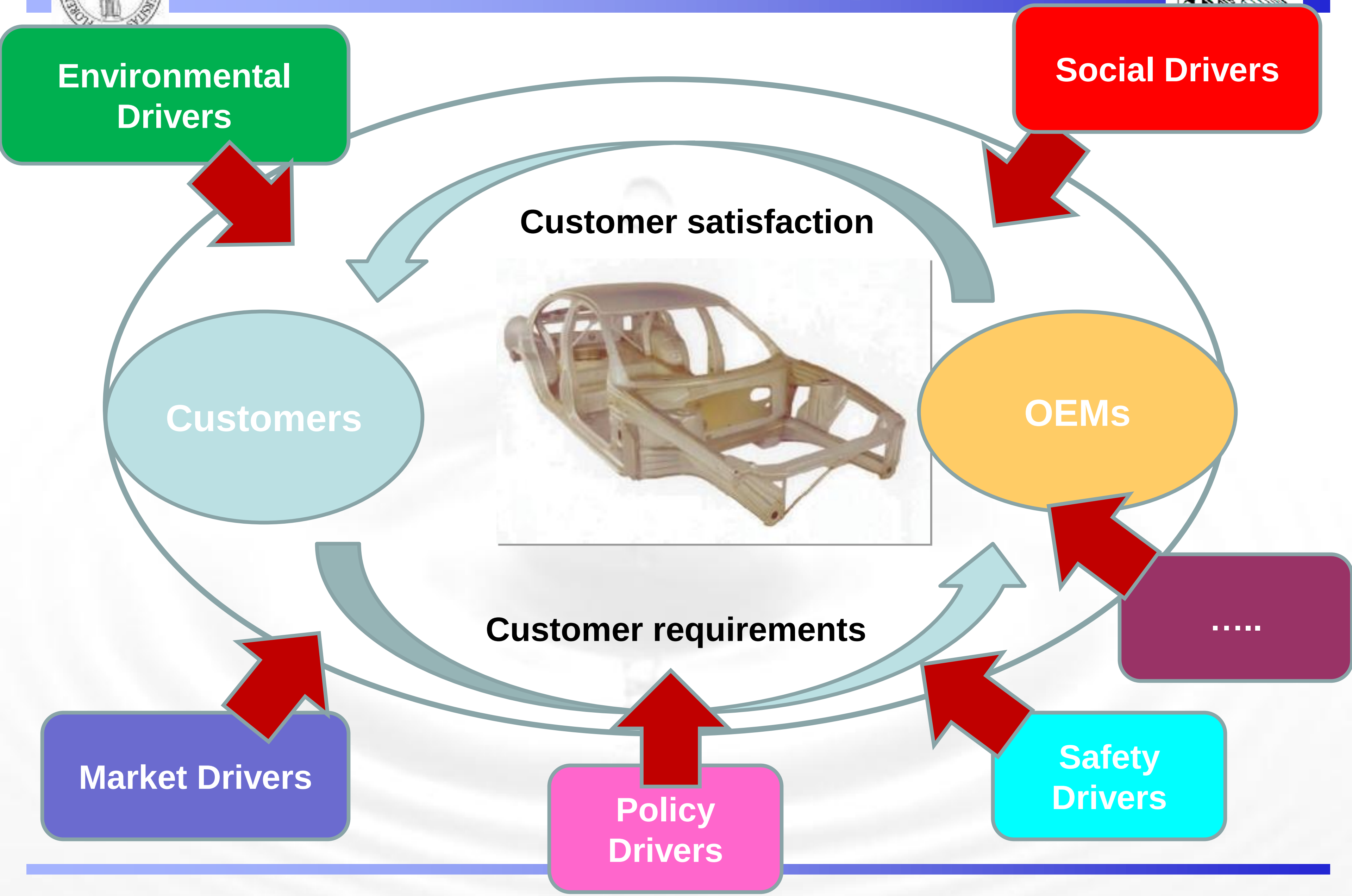
- Relevance of car consumption



Source: EC, 2007

~ 20% of total EU GHG emissions and ~30% of CO_2 emissions are linked to the transport sector

Main actors in Vehicle design

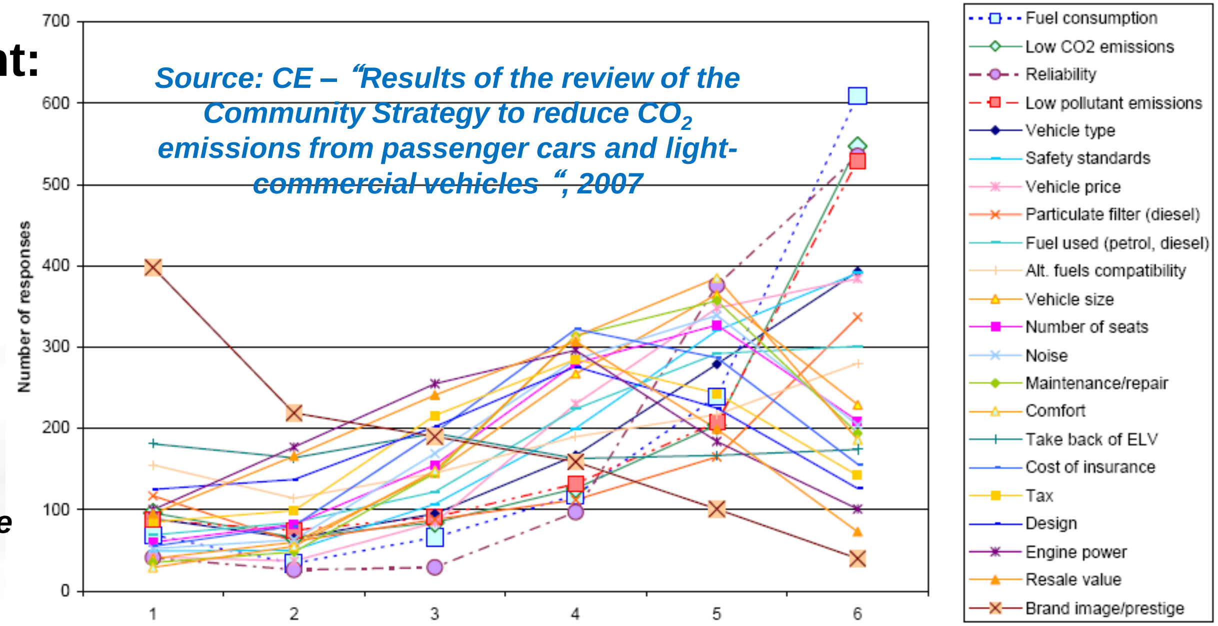


Customer awareness and needs

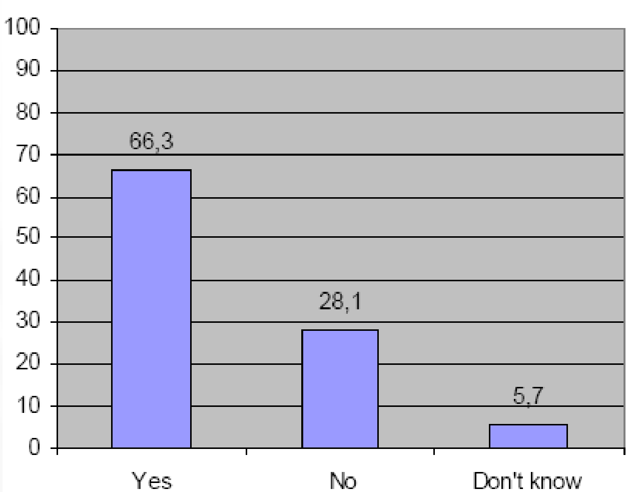
Criteria when buying a car and how people rank them

Criteria perceived as important:

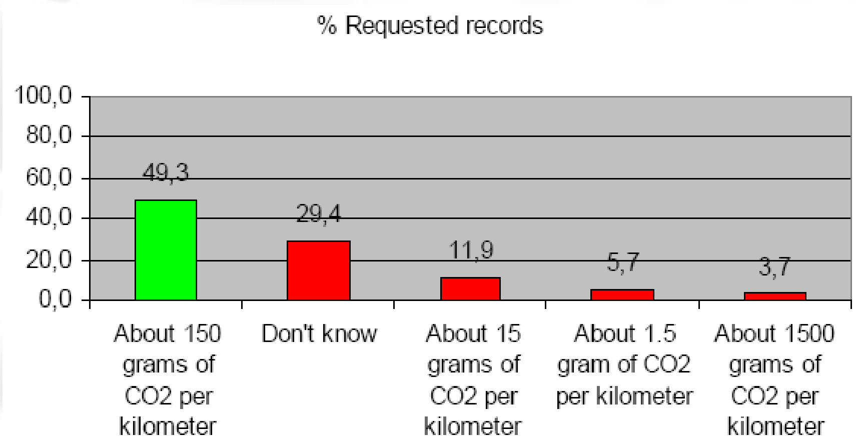
- Fuel consumption
- Low CO_2 emissions
- Reliability
- Low pollutant emissions
- …



"Do you feel well informed about the climate change impacts of road transport? "



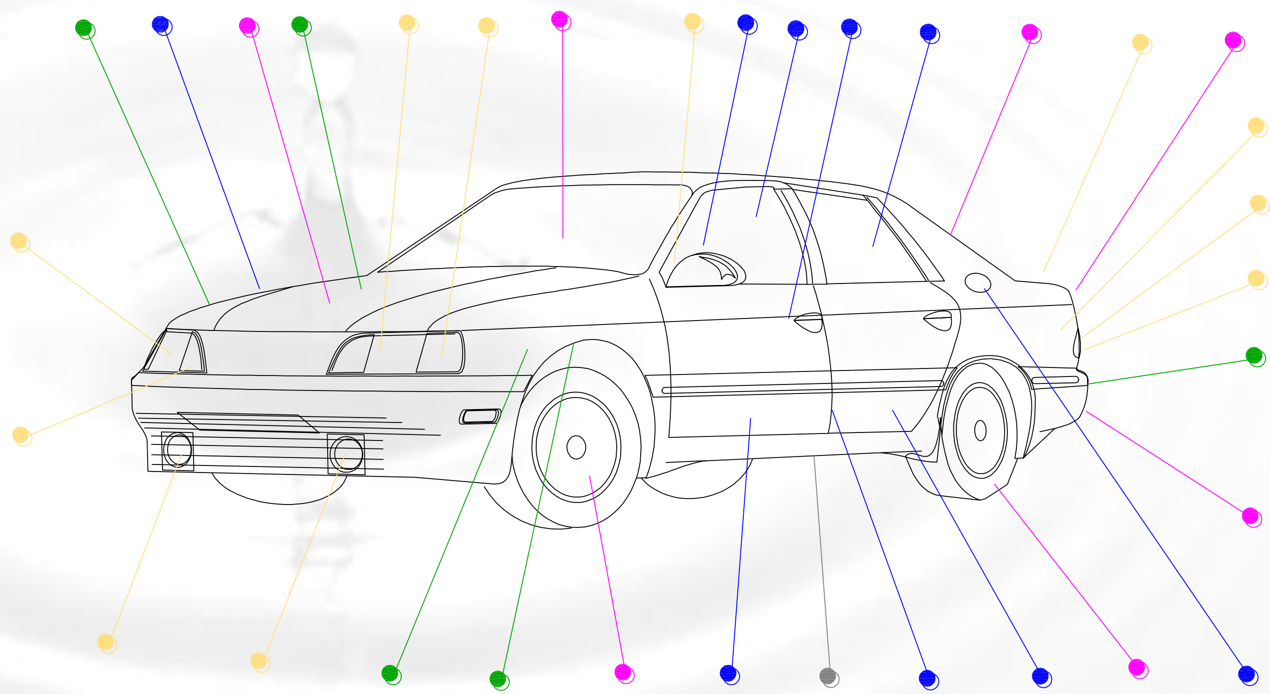
"How much CO_2 would you think a car emits if it consumes 6 litres of fuel per 100 km?"



Vehicle regulation

- Vehicle type approval is strictly regulamented!
  - Compliance needed for more than 45 EU Directive and Regulations
  - High cost for development of new vehicles

- Environment
- Active safety
- Passive safety
- Other
- Lighting and signaling



Source: ACEA, 2009

Business Strategies

Two possible different OEMs approaches to demand for sustainable development:

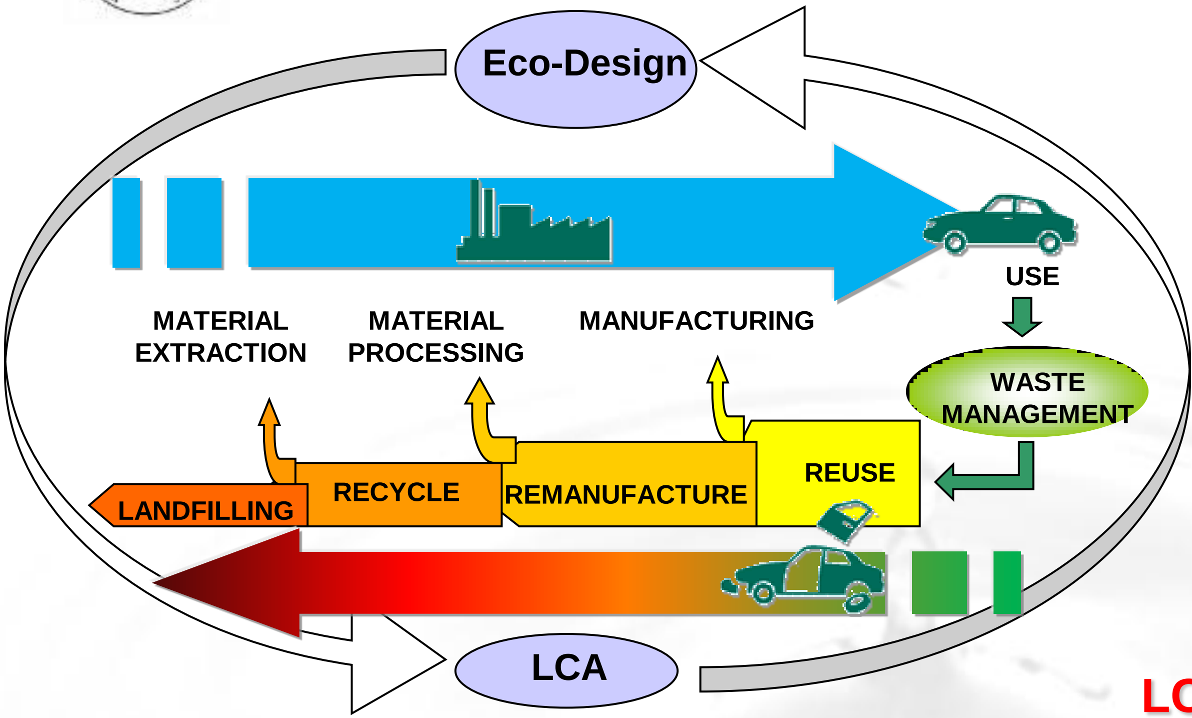
1. **Reactive**: Fulfilling existing laws, directives and perhaps standards

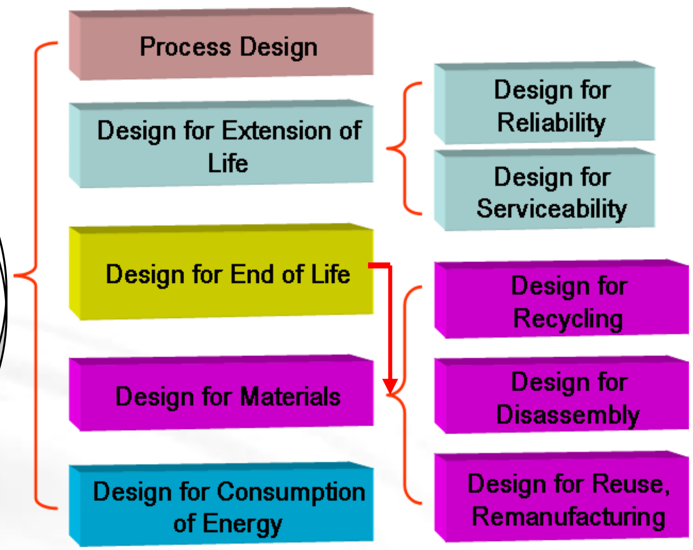
2. **Proactive**: Go beyond existing regulation to become leader and use sustainability aspects as business opportunities

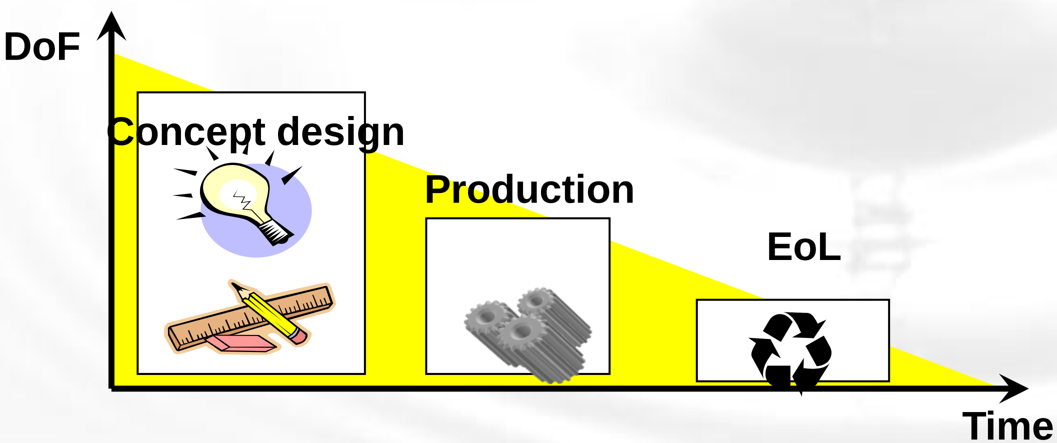
Integration of EcoDesign in product development

- **Eco-Design**: "*Integration of environmental aspects into product design and development with the goal to reduce negative environmental impacts of products along their entire life cycles*"

EcoDesign integrated approach





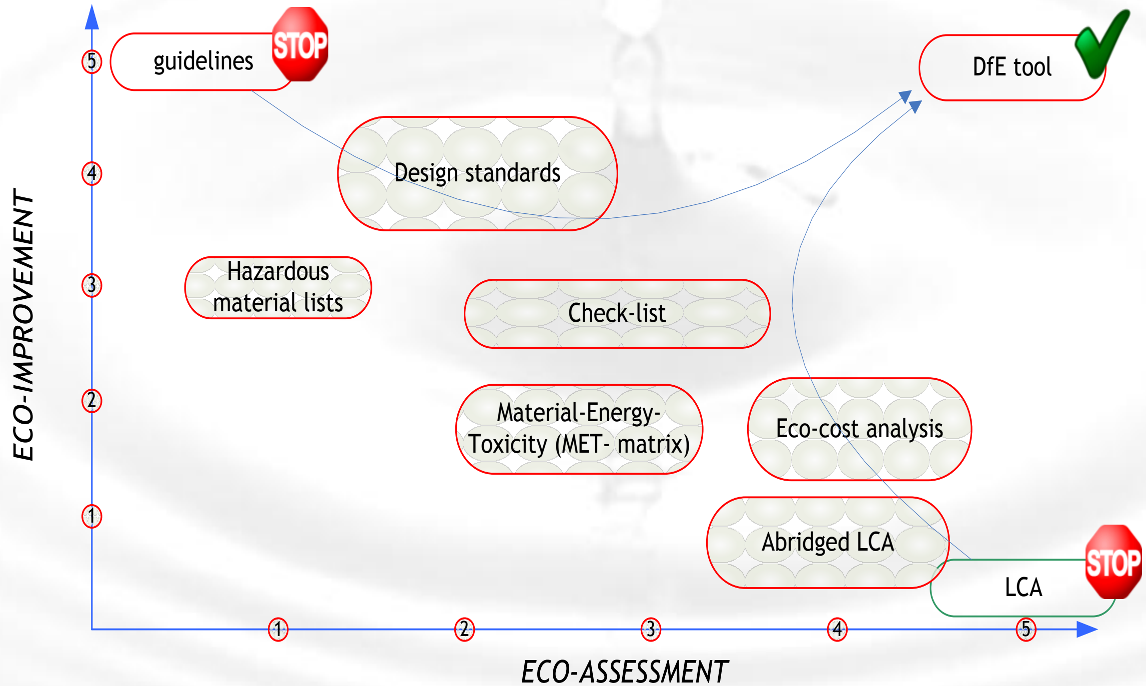


LCA issues:

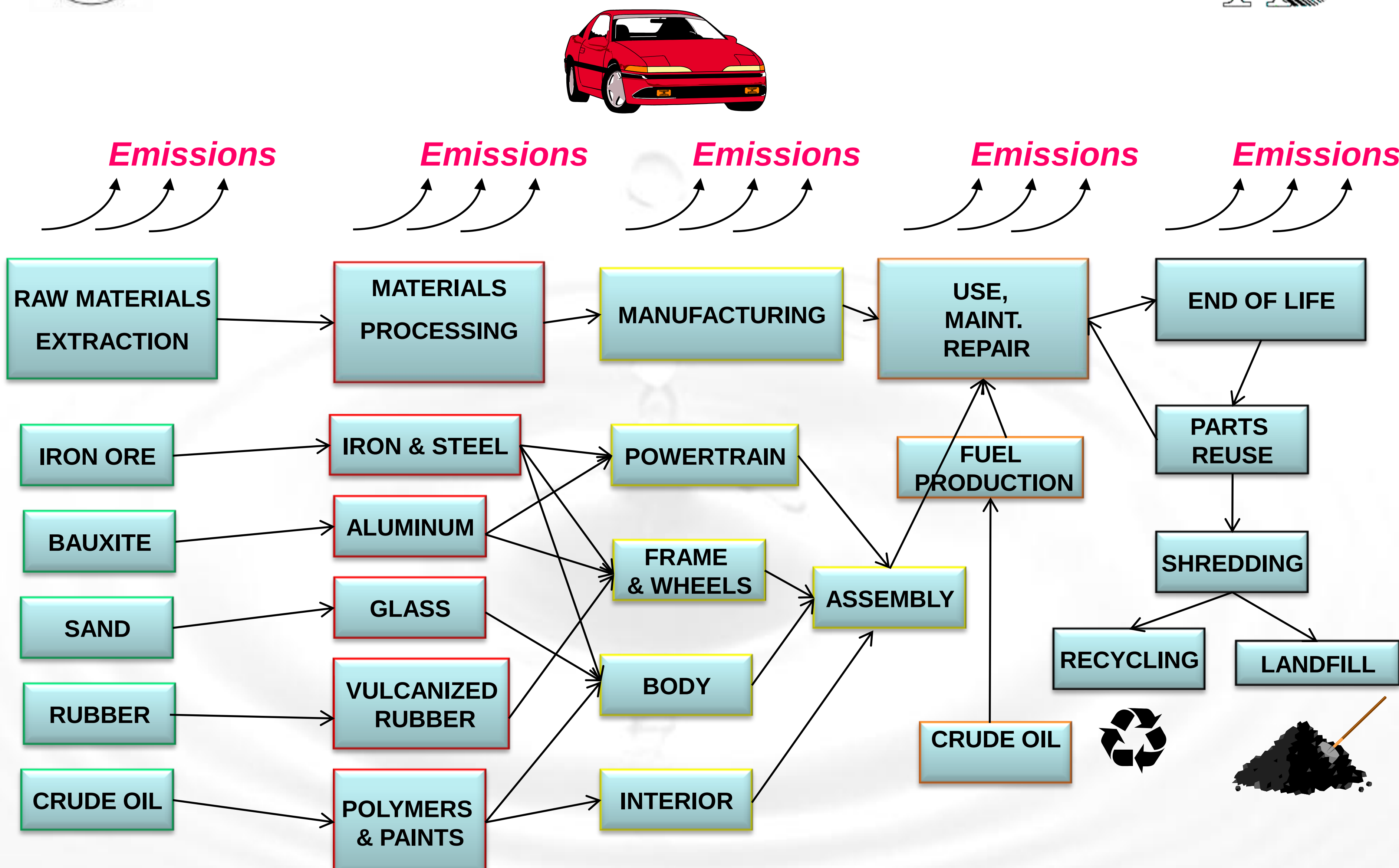
- ✓ Data intensive
- ✓ Detail level
- ✓ High time and costs
- ✓ Environmental educated engineer is needed…
- ✓ Green-product is a requirement, but not the only one

EcoDesign integrated approach

- Partially depends on a set of preliminary studies on products (pilot-projects)
- Involves innovation process at all stages (both early stages and late stages)
- Involves strategic management view
- Comprehends cultural tuition
- Requires specific tools and indicators

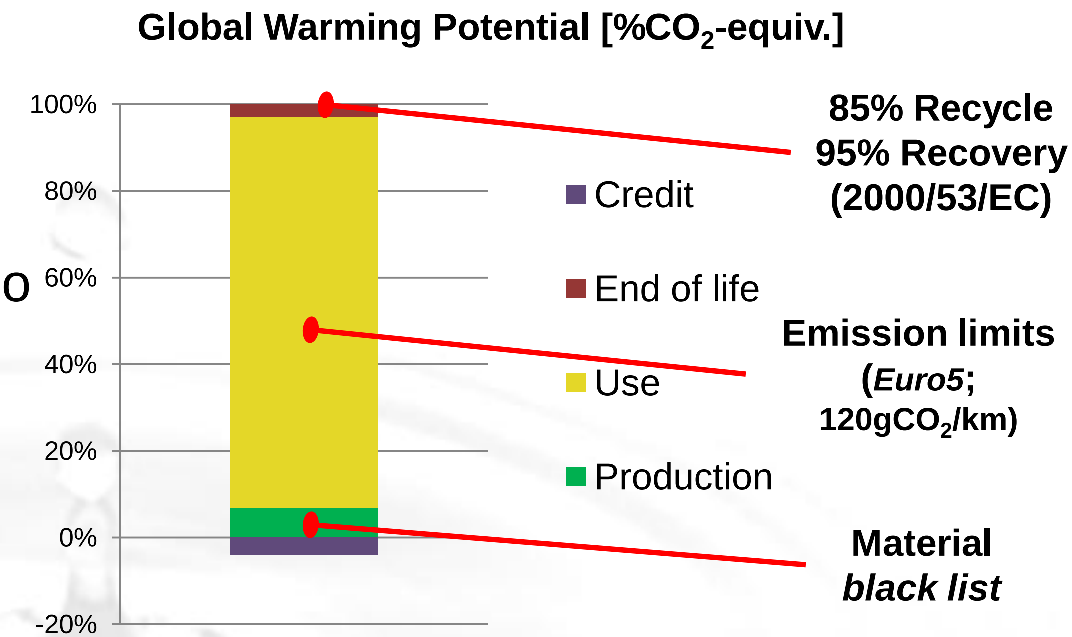


Vehicle Life Cycle

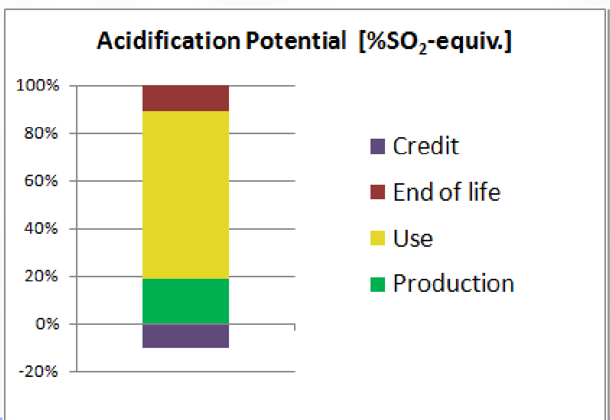


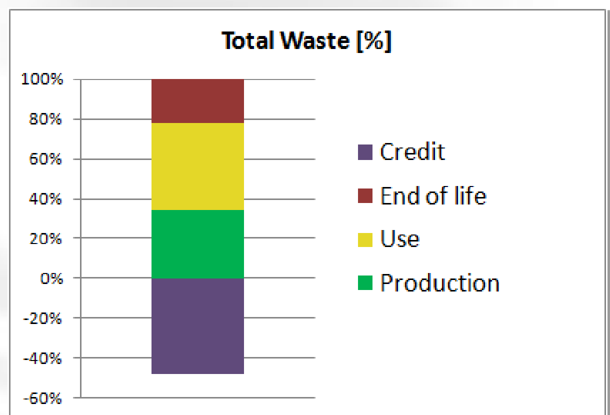
Vehicle LCA: an example

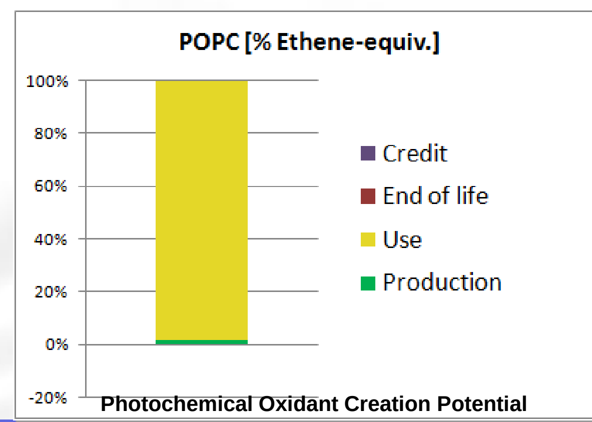
- USE phase causes main GHG Emission
- Other impact categories are also important
- *Regulations affect vehicle design on every phase!*



Source: Schmidt et al, 2004

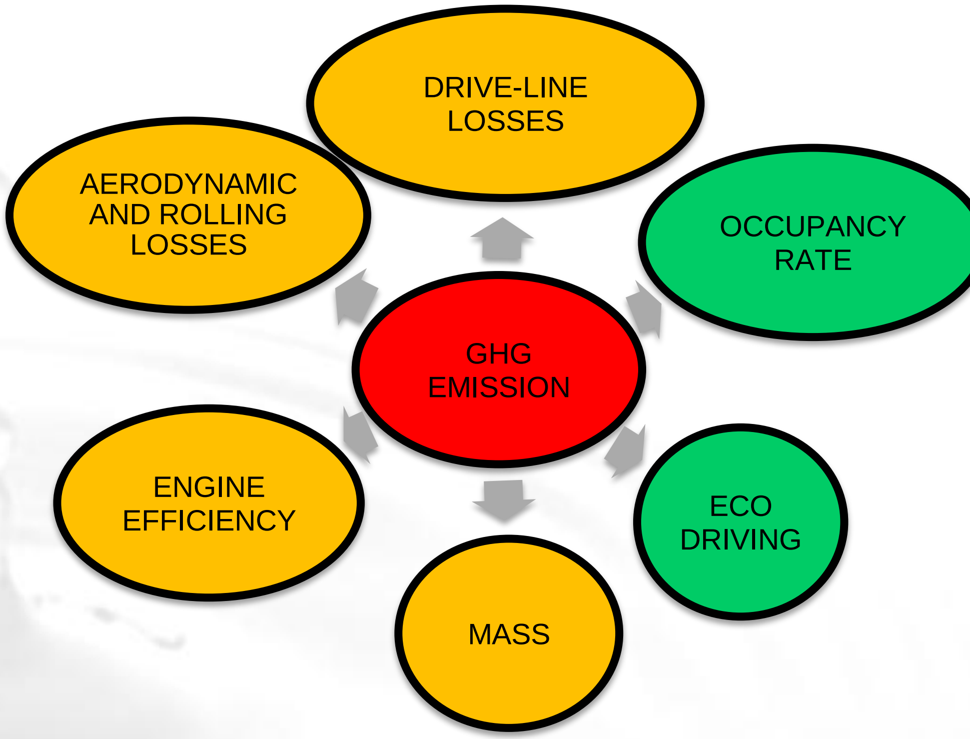






Factors influencing GHG Emission

- USE phase causes main GHG Emission (90% on total life cycle)
  - 2009, new vehicles: 153,3 gCO_2/km (*Source: T&E 2009*)



How to reduce impact?

- 2012 target: 120 gCO_2/km limit

Regulation

- Energy supply
- Energy consumption

Technical factors

- Optimized use of fleet
  - Eco-driving behaviour
  - Increase vehicle occupancy rate

Social factors

GWP reduction for different technologies

CO_2 in g/km: NEDC* WTW for the vehicle and LCA for the e-energy source			
	Well to Tank (batteries)	Tank (batteries) to Wheels	Total CO_2 emissions
Conventional ICE Car	25 – 35	120 – 180	145- 215
Electric Vehicle 11% nuclear, **20%** renewable, 69% fossils (Italian mix 2010)	120-140	0	120-140
Electric vehicle 27% nuclear, **20%** renewable 53% fossils (EU-27 mix 2010)	85-105	0	85-105
Electric vehicle 75% nuclear, **20%** renewable, 5% fossils (French mix 2010)	20-25	0	20-25
Electric vehicle 30% PV on-board , 60% other renewables, 10% fossils.	18-22	0	18-22
Electric vehicle **Carbon free communities** Energy 50% PV + 50% wind	8 5km per kWh and 40g/kWh	0	8 ***Source: Ertrac, 2009***

*** New European Driving Cycle**

Design options VS key factors and constraints

- **Energy supply**

- **“Clean” sources**
  - Renewable
  - No-Carbon intensive
  - CH_4
  - …
- **“Clean” vectors**
  - Biofuels
  - Electricity
  - H_2
  - …

KEY FACTORS & CONSTRAINTS:

✓ Availability
✓ Cost
✓ Technologies
✓ Storage technologies
✓ Supply infrastructure
✓ Recyclability
✓ Performance
✓ Internal space
✓ Vehicle size
✓ Reliab/Maintain.
✓ Safety
✓ **Materials**
✓ **…**

- **Energy conversion & consumption**

ELECTRIFICATION

ICE
HEV
PHEV
BEV

- **“Clean” Engines**
  - High eff. ICE
  - Electrification
  - FCV
- **Transmission**
  - CVT
  - shifting schedules
  - …
- **“Clean” Vehicle**
  - Weight reduction
  - Aerodynamic shape
  - Low rolling resistance tyres
  - Regenerative braking
  - …

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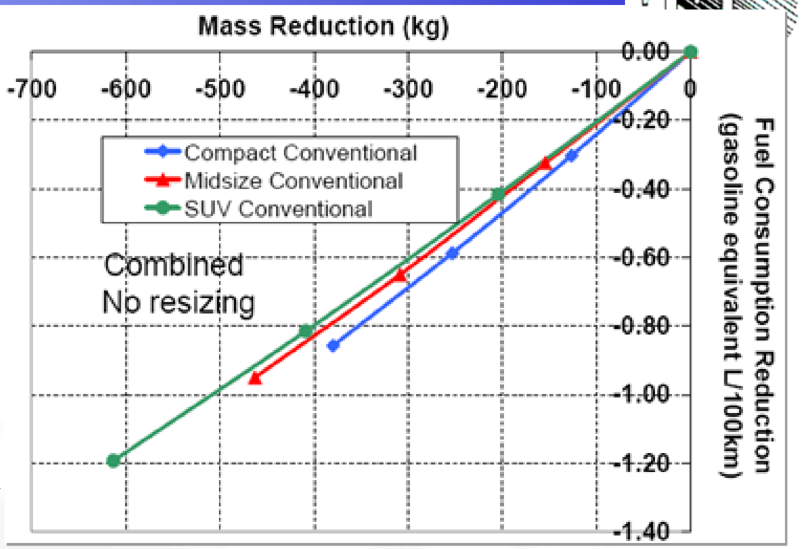
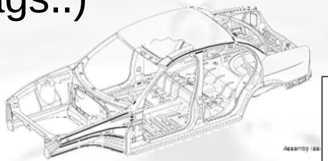
Mass: the importance of materials

- 10% mass reduction → ~4% fuel consumption reduction
- Problem: vehicle mass increasing due to
  - Costumers expectations (size, comfort, accessories…)
  - More and new components (EES, batteries)
  - Safety reasons (severe crash-test approval for occupants & pedestrians; supplementary systems such as ABS, airbags..)

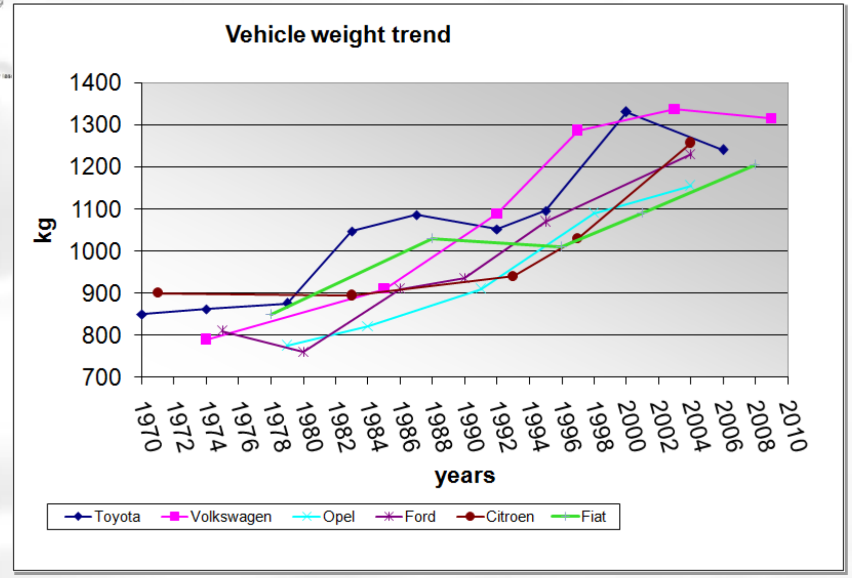


Source: Argonne, 2006



- Possible solutions
  - Ultra High Strength Steel (thinner, lighter bodies)
  - Lightweight metal: Aluminium, Titanium, Magnesium
  - Plastics, Composites, Nano-reinforced materials, Ecomaterials
  - New technologies
  - …

But…

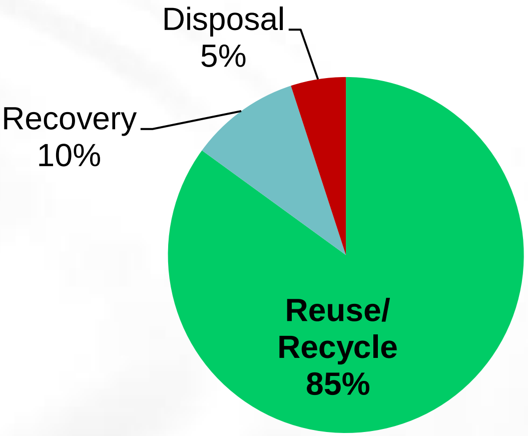


Mass: the importance of materials

..but, ELV...

- 2000/53/EC Directive: regulation for End-Of-Life Vehicles (ELVs)
  - 2015 target: < 5% ELV mass to Disposal
  - 95% Recoverability: limitations on material choice
  - Non-metal materials: “car fluff” production (~25% vehicle mass)

Materials	2003 ELV (% mass)	2015 ELV (% mass)	2030 ELV
FE-Metal	68%	66%	?
NF-Metal	8%	9%	
Plastics	10%	12%	
Rubber	5%	5%	
Glass	3%	2%	
Batteries	1%	1%	
Fluids	2%	2%	
Textiles	1%	1%	
Other	2%	2%	
Total	100%	100%	



Source: GHK, 2006

Design for End of Life

- Encourage "Mechanical recycling"
  - Design for Dismantling
    - Easy removal of non-metallic parts
    - Easy removal of fasteners
    - …
  - Design for Recycling
    - Mono-material components
    - Avoid gluing for different polymers
    - …
- Optimize material choice in new vehicles
  - Reduce use of thermosets materials
  - Reduce number of polymeric families
  - Reduce PVC
  - Recyclability
  - Cost increasing?
  - Degradation of mechanical behaviour?
  - Loss of perceived quality?

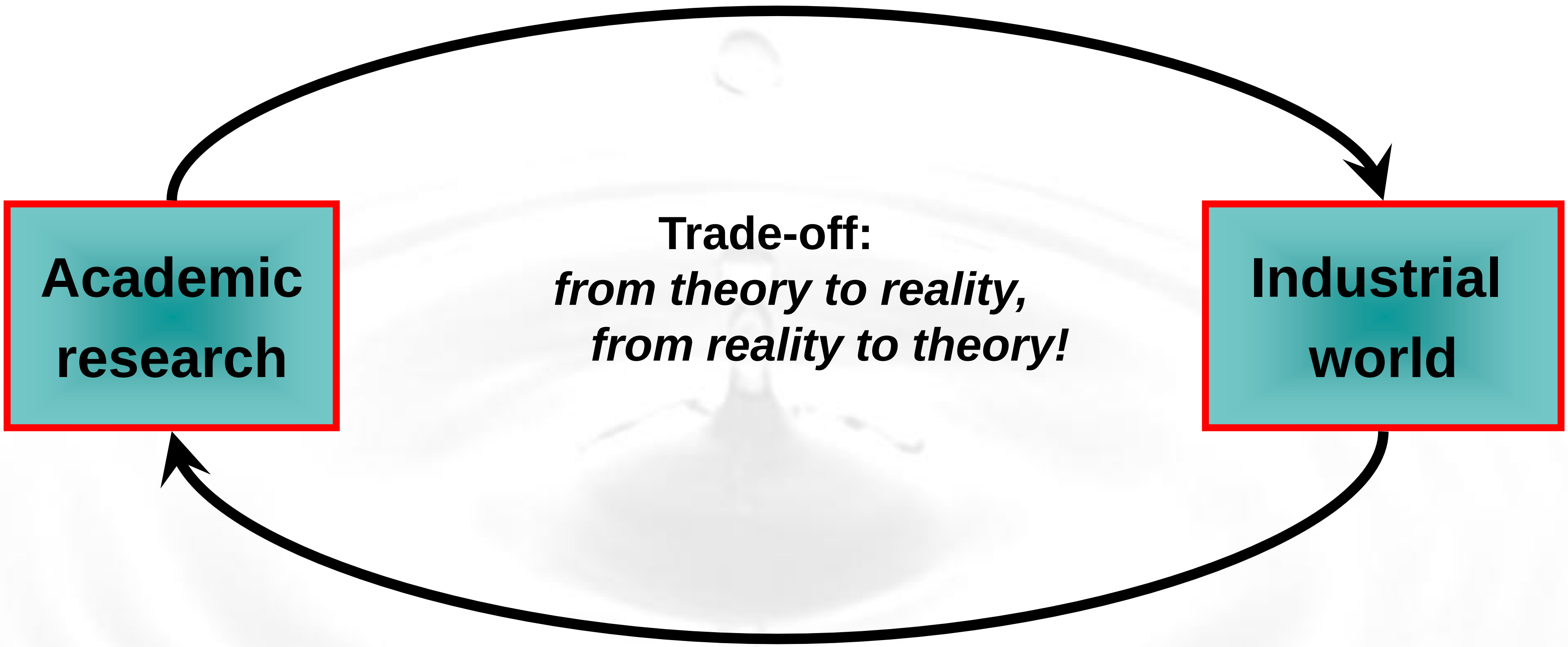
Component	Polymers	kg [%]
Bumper	PP, ABS, PC	10
Seats	PUR, PP, PVC, ABS, PA	13
Dashboard	PP, ABS, PA, PC, PE	15
Fuel systems	PE, POM, PA, PP	7
Interior trim	PP, ABS, PET, POM, PVC	20
Electrical comp.	PP, PE, PBT, PA, PVC	7
Exterior trim	ABS, PA, PBT, ASA, PP	4
Lighting	PP, PC, ABS, PMMA, UP	5
Upholstery	PVC, PUR, PP, PE	8

Source: APME

Conclusion

- Many different drivers are involved in the improvement of vehicle sustainability
- Integration of Ecodesign in the product development is needed
- The use phase of vehicles is the most relevant but the others should not be neglected
- The challenge is to obtain the best compromise among tecnhical solutions, key factors and constraints

Cultural considerations



Factors influencing eco-vehicle design

Thank you for your attention

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