VOLKSWAGEN
AKTIENGESELLSCHAFT

Environmental friendly vehicle design throughout the life cycle

6. Ökobilanz Werkstatt, Darmstadt 30.9.2010

Dr. Stephan Krinke

Head of Environmental Affairs Product

Agenda

- Environmental aspects of vehicles
- Life cycle assessment: Internal and external applications
- Life cycle assessment: Success factors for application in industry
- Examples for application
- Resource risk assessment
- Conclusion

Environmental aspects of vehicles

- Manufacturing
- Consumption and emissions
- Environmental impacts of fuel extraction and production
- Maintenance
- Recycling

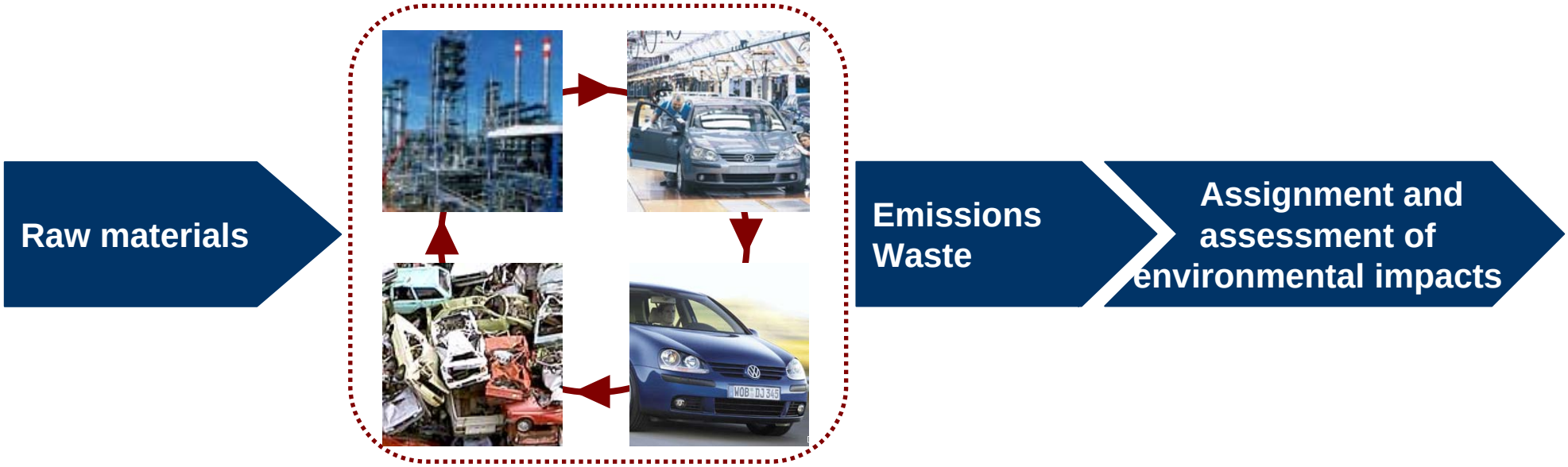
The assessment of a product has to cover all aspects of the life cycle !

Life cycle assessment

The life cycle assessment is a method to evaluate all potential environmental impacts throughout a product lifecycle.

Life cycle assessment
Method

- Analysis of the environmental performance over the entire lifecycle.
- Assessment of all relevant environmental impacts to soil, water and air.

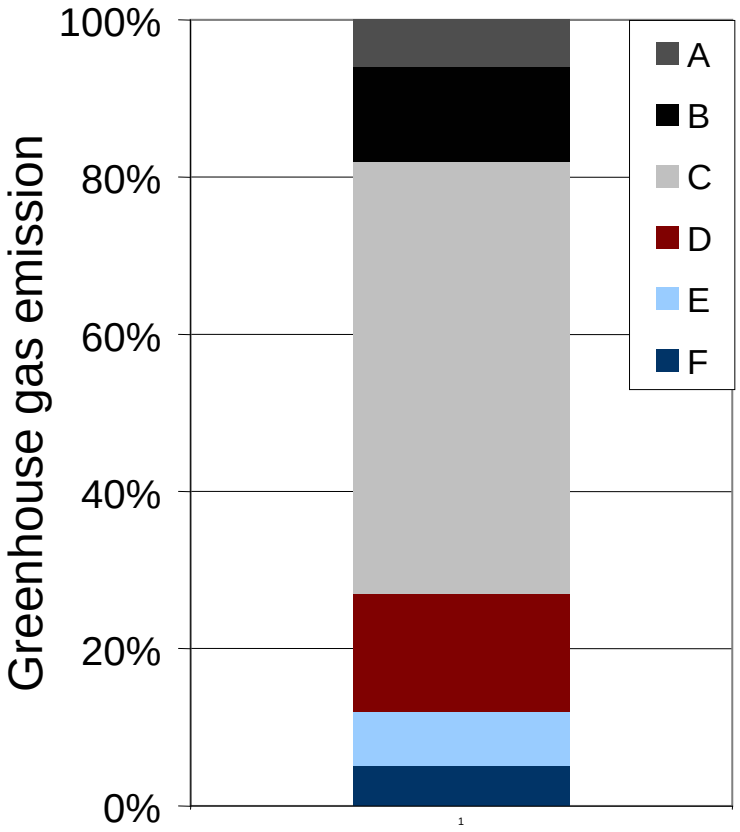


Life cycle assessment

Internal application in companies

- Results are based on data and facts and will be a used to support the decision process.
- Assessment of the complete value chain including suppliers.
- Investigation and assessment of all potential environmental aspects.

The environmental impacts of different technologies can be compared and assessed prior to the decision process and market introduction.



Life cycle assessment

Application for external communication

- International recognized method for environmental assessment (ISO 14040).
- Firm basis for the environmental dialogue with stakeholders.
- Increasing relevance in politics and legislation.
- Part of company ratings.

Environmental Commendation

TÜV NORD
TÜV NORD CERT GmbH
Geprüfte Produkt-Ökobilanz
gem. DIN EN ISO 14040

Environmental challenges for the future

Climate Change

Health & Local Air quality

Resources

Environmental Strategy Volkswagen Group

Individual ecological mobility

Environmental Affairs Product

Environmental Affairs Product
K-EFUP
(Mr. Dr. Krinke)

Environmental Analysis Product	Environmental Control Product	Material Controlling and Data Systems
➢ Life Cycle Assessment	➢ Supervision of vehicle projects	➢ Global material legislations
➢ Environmental commendations	➢ Environmental product management	➢ Material prohibitions
➢ Analysis of raw materials	➢ Sustainability assessments	➢ REACh
➢ Strategic environmental topics	➢ Environmental product information	➢ Material data acquisition

Success factors for the application in industry

- **Integration in internal processes**
- **Reasonable time and resource demand**
- **Reliable and stable recommendations**

Life Cycle Thinking as Core Principle for the Product Development

VOLKSWAGEN
AKTIENGESELLSCHAFT

Volkswagen Group
Environmental Principles Products

The Volkswagen Group's Environmental Principles serve as a guideline for all the Group's marques and regions, taking into account the regional possibilities. To live up to our responsibility towards customers, society and the environment, we have made the continuous improvement of the Group's products in respect of their environmental compatibility and resource conservation an integral part of our corporate policy. Our activities and processes are shaped by a prudent approach to ecological challenges.

In line with this approach, we have defined the following objectives:

1. Climate protection
- reduce greenhouse gas emissions
- reduce fuel consumption in the driving cycle and over the vehicle's service life with the customer
- support fuel-efficient styles of driving

2. Resource conservation
- improve resource efficiency
- attain optimum recyclability by taking account of innovative recycling technologies
- use renewable and secondary raw materials
- develop and make available alternative powertrain technologies
- enable the use of alternative fuels and other energy storage systems, taking account of regional circumstances

3. Healthcare
- reduce regulated and non-regulated emissions
- avoid the use of hazardous and harmful materials – wherever possible in line with the world's strictest materials legislation
- minimise interior emissions including odours
- attain best possible exterior and interior noise levels

In future, we will develop each model in such a way that, in its entirety, it presents better environmental properties than its predecessor. As we do so, we will make sure that improvements are attained over the entire product life cycle.

In this process, the Volkswagen Group will take particular account of the changes in mobility and environmental aspects resulting from growing levels of urbanisation.

The environmental objectives set out above also serve to differentiate us from the competition to the benefit of our customers. The Volkswagen Group aims to rank among the leaders in respect of environmental matters.

Prof. Dr. Martin Winterkorn
Chairman of the Board of Management of Volkswagen AG

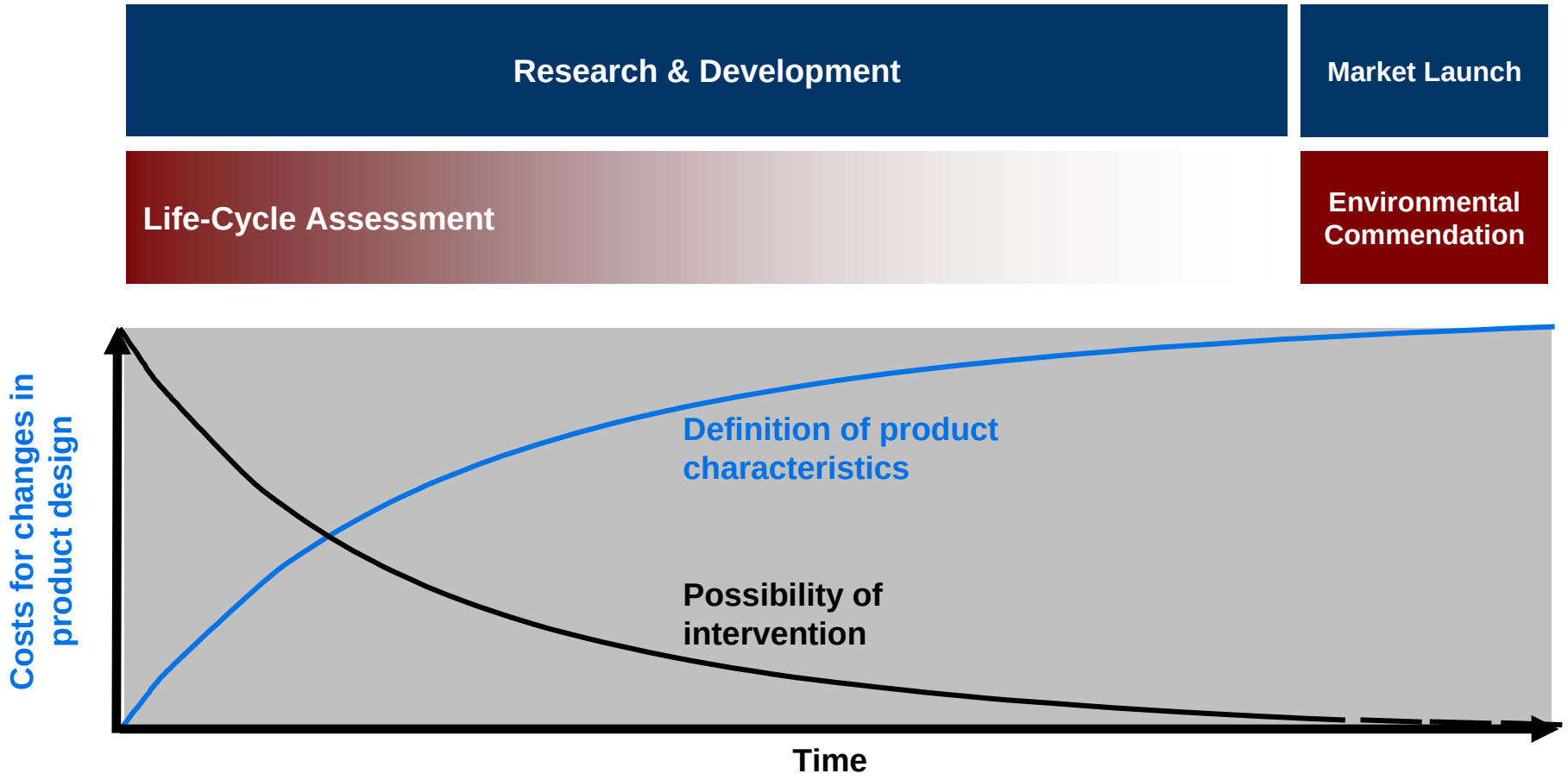
01.12.2008

Volkswagen is the high-volume brand that stands for innovation and engineering excellence.

Dr. Martin Winterkorn, Chairman of the Board of Management of Volkswagen AG

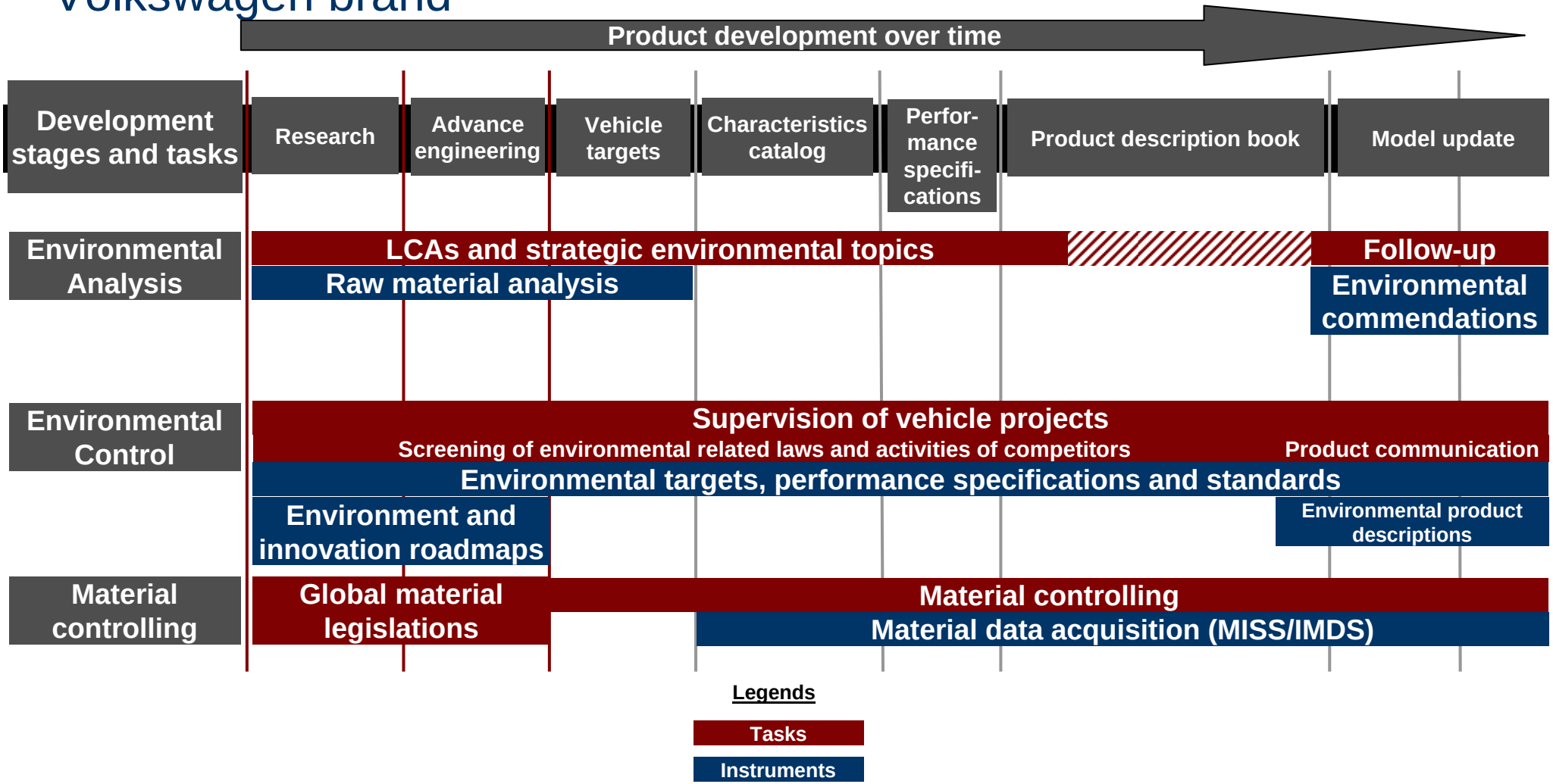
In future, we will develop each model in such a way that, in its entirety, it presents better environmental properties than its predecessor. As we do so, **we will make sure that improvements are attained over the entire product life cycle.**

Integration of LCA in the Product Development



Environmentally compatible product development

Volkswagen brand

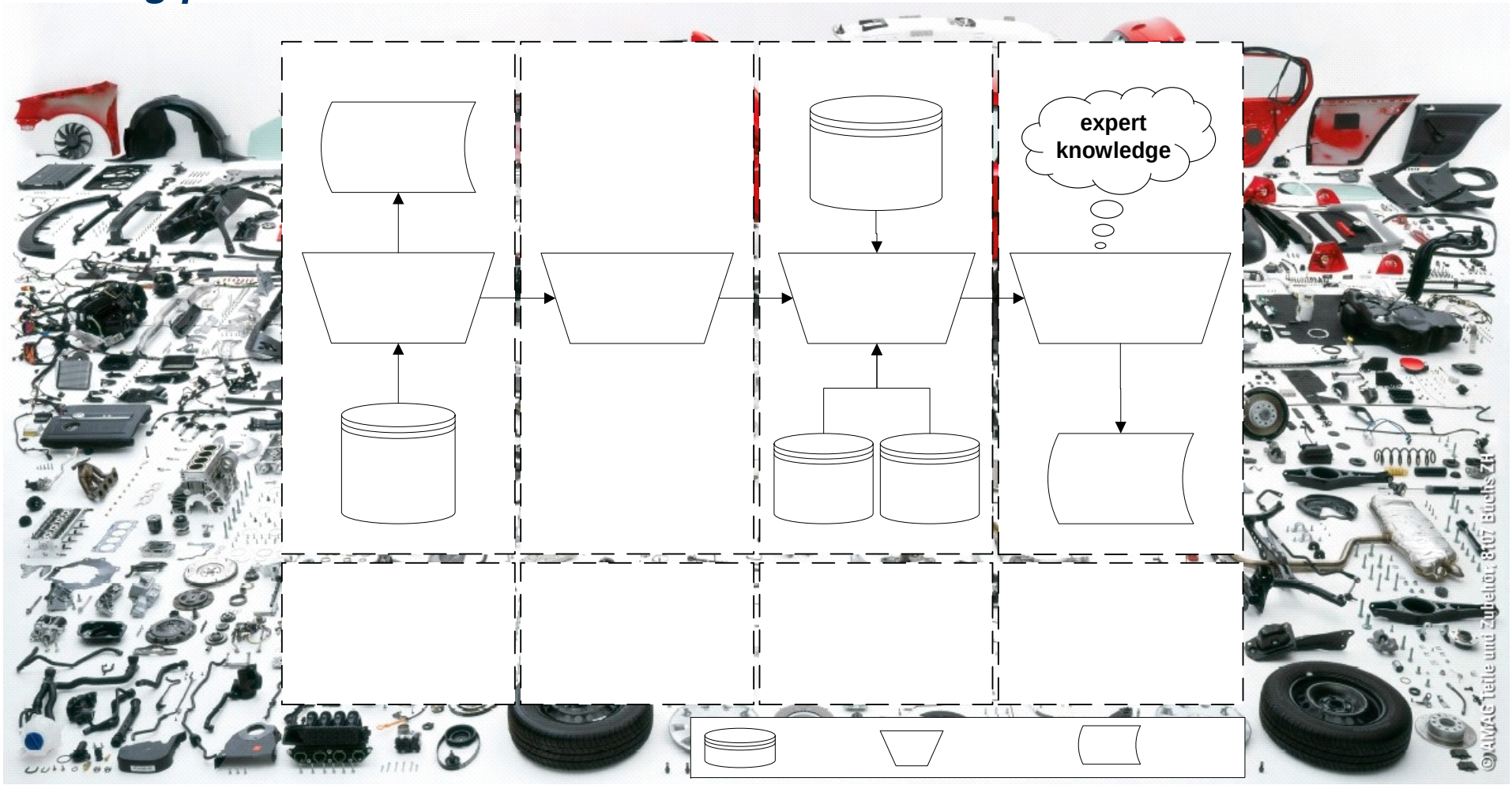


Time and resource demand for LCA of cars

Starting position in 2000

Time and resource demand for LCA of cars

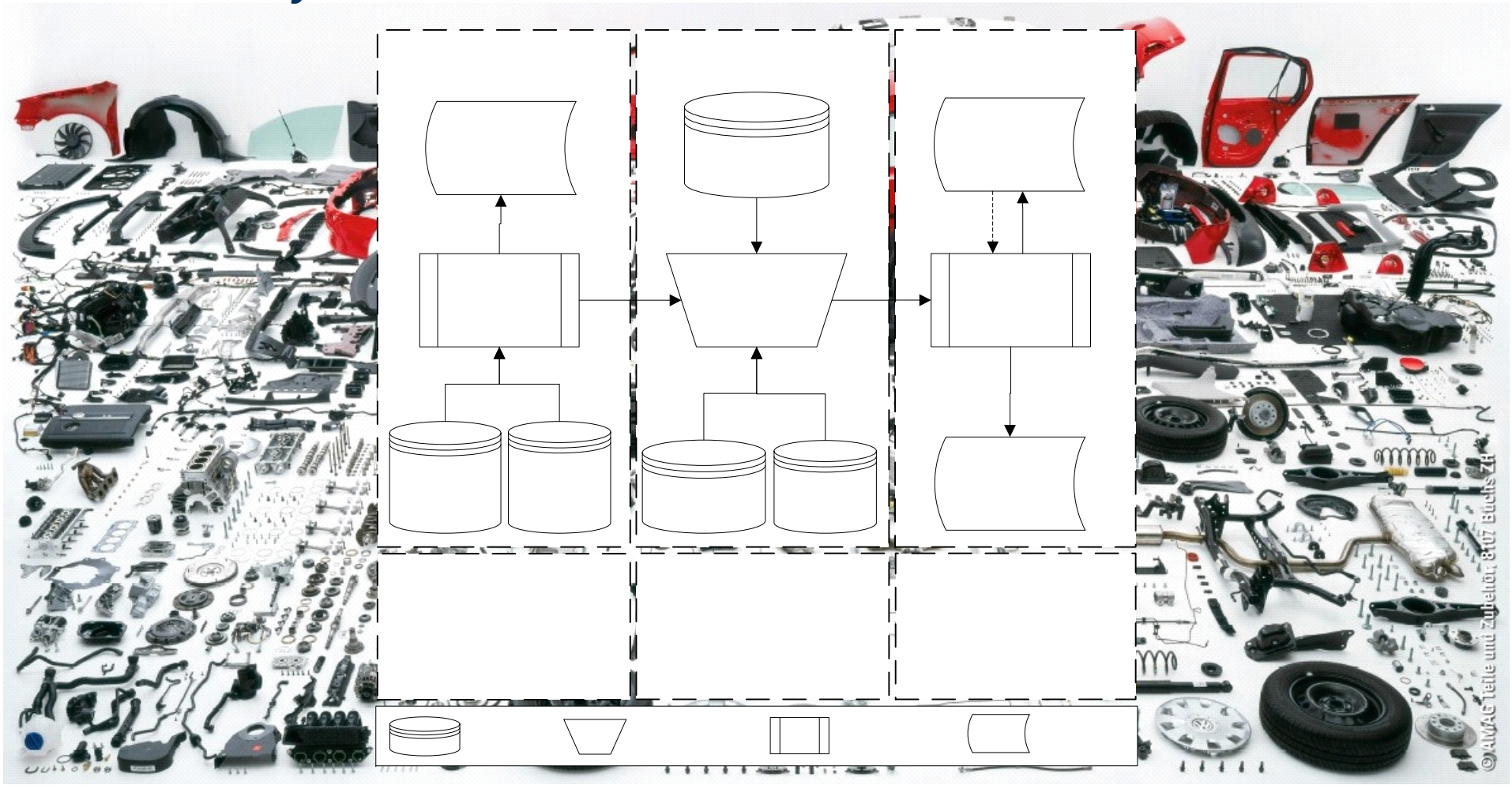
Starting position in 2000



~ 1 day

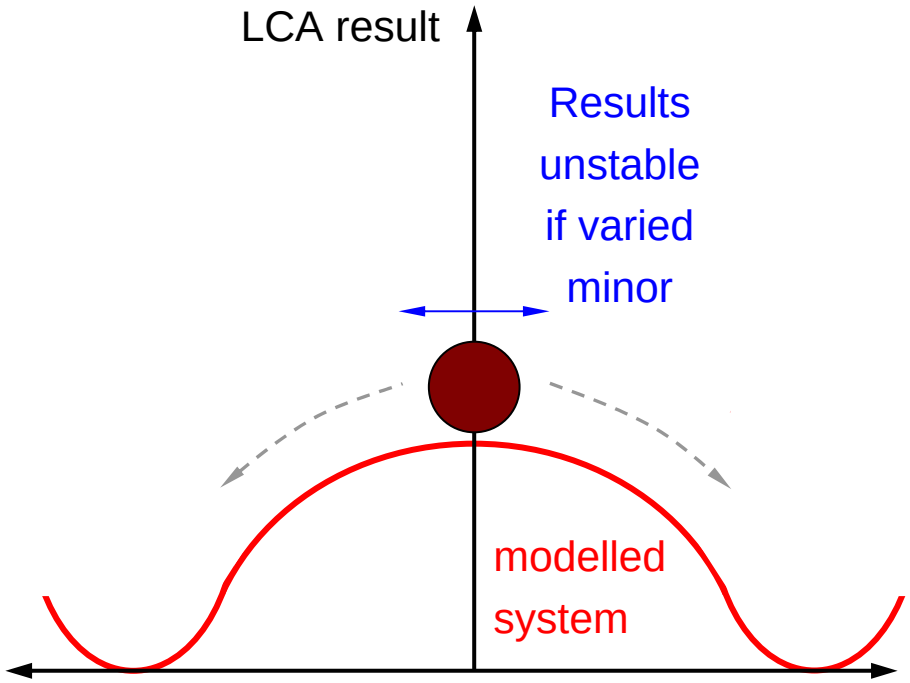
Time and resource demand for LCA of cars

Situation today

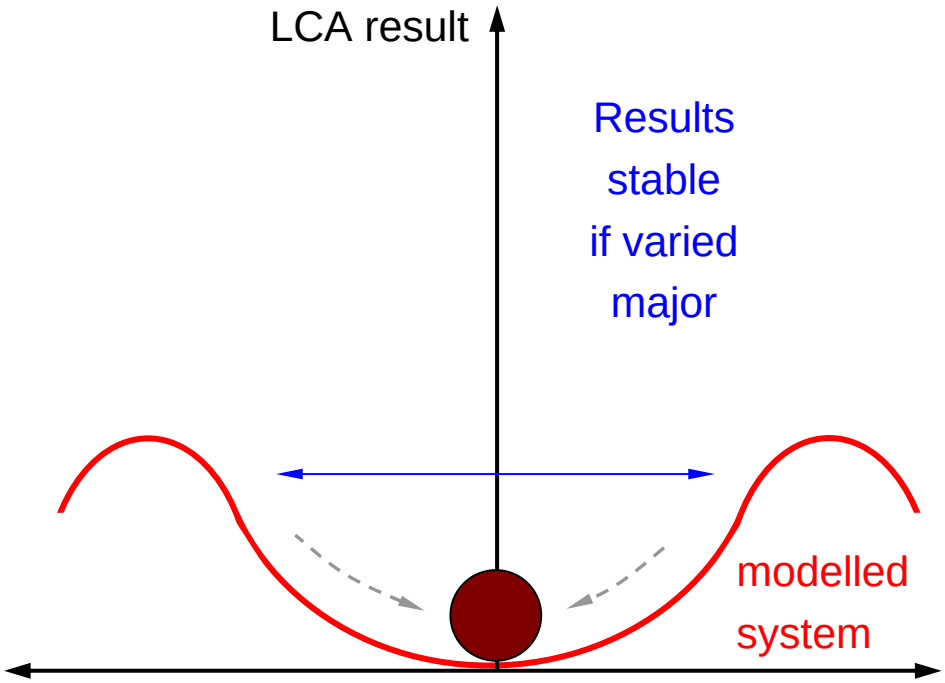


Life Cycle Assessment

Quality check



Study ***without*** sufficient sensitivity analysis



Study ***with*** sufficient sensitivity analysis

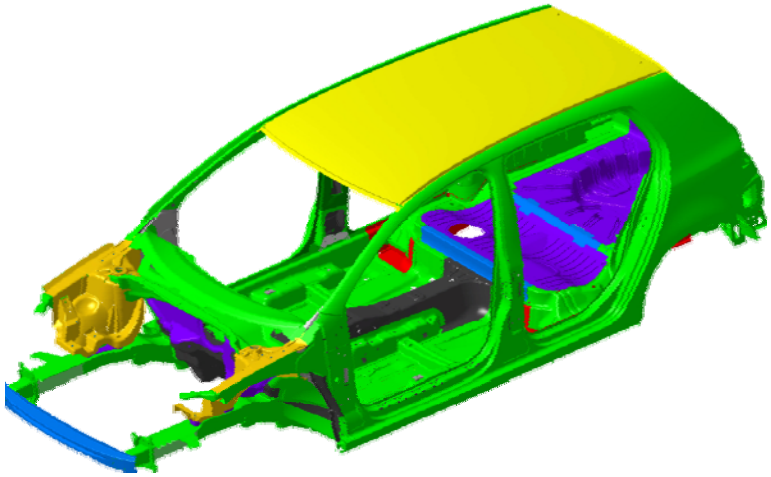
Life Cycle Assessment
Quality check

To derive reliable recommendations the following items have to be checked

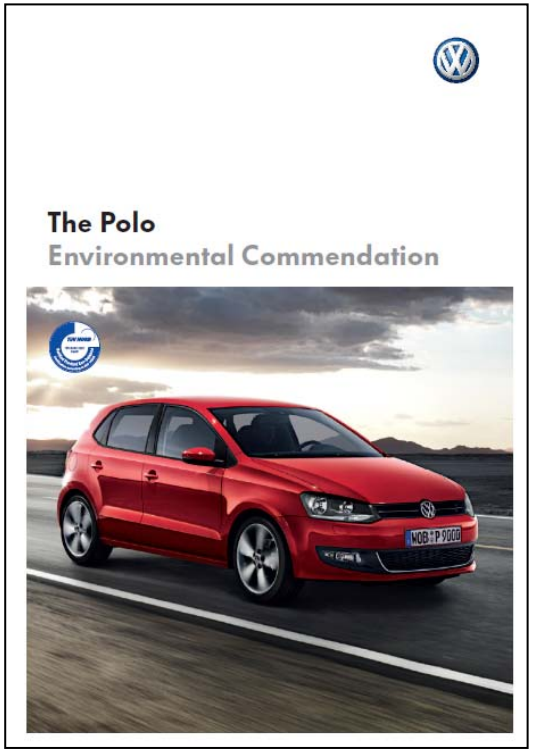
- Which factors are dominating the environmental profile ?
- Which measures can be derived ?
- Is the direction of recommendation the same while varying different parameters ?
  - Yes: Congratulation !
  - No: How can you assure that the dominating parameters will be achieved in reality ?
- Which stakeholders are responsible for the realisation of the measures ?

Applications of Life Cycle Assessment

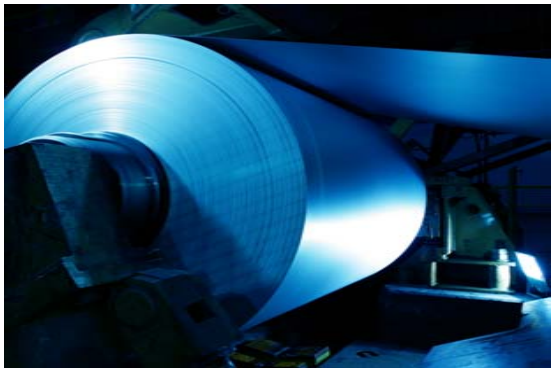
Product development



Communication & Customer information



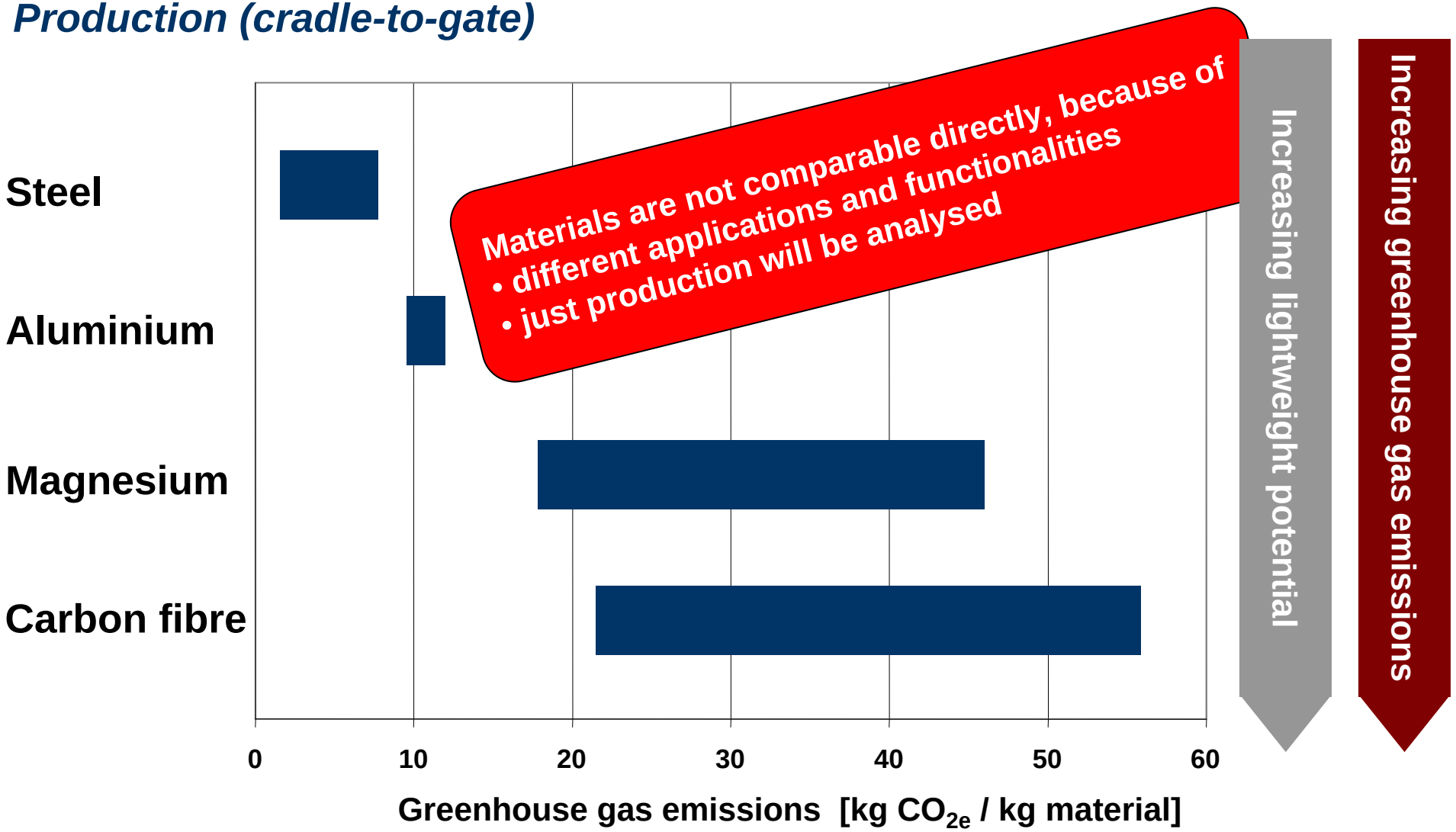
Application in the product development
Lightweight design



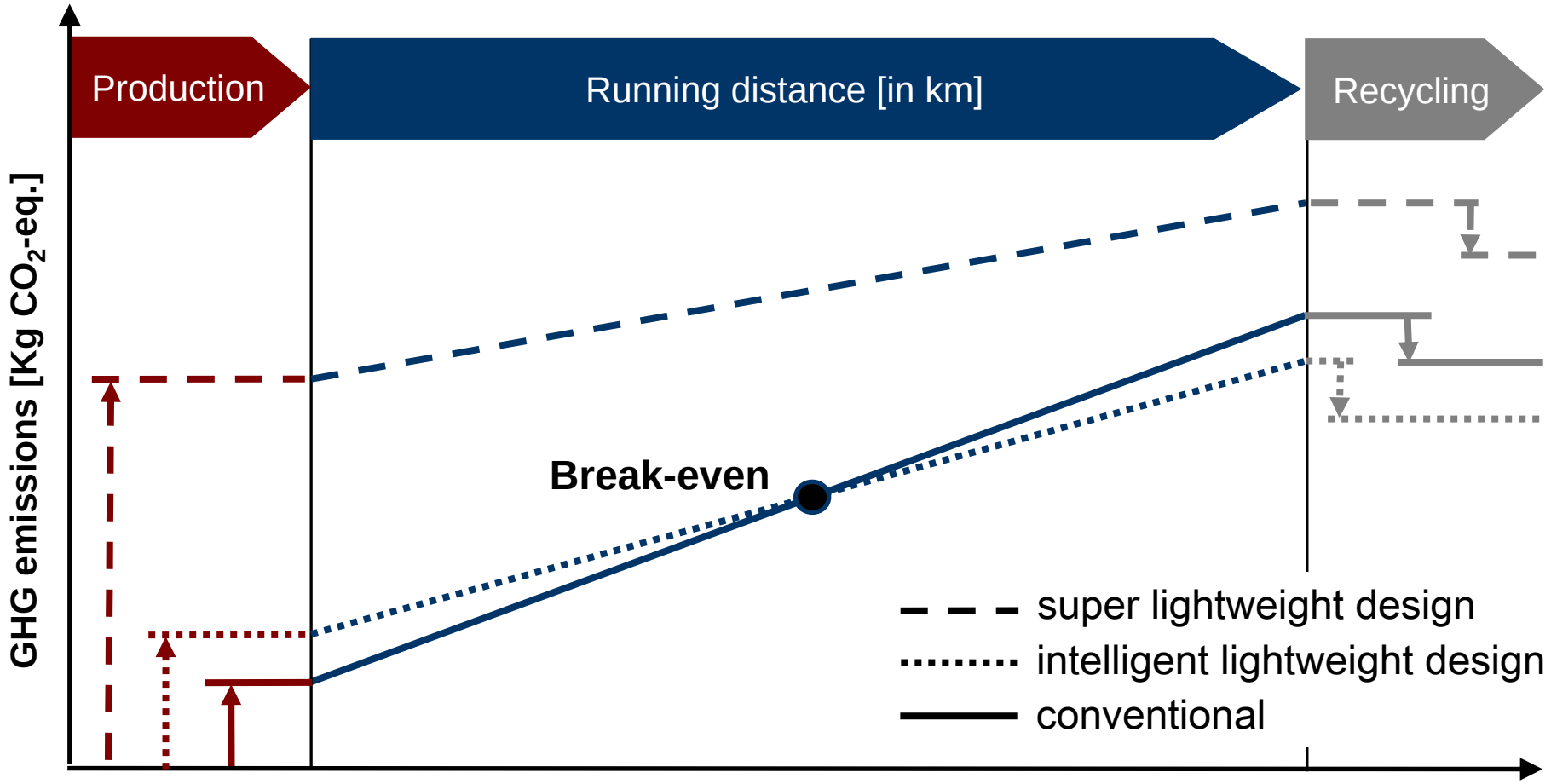
Is lightweight design always a good measure for the environment?

Comparison of the greenhouse gas emission of materials

Production (cradle-to-gate)



Lightweight design throughout the lifecycle



→ **Intelligent lightweight design leads to less emissions during the lifecycle**

Environmentally friendly lightweight design

Life Cycle Phase and Main Actors	Aspects	Measures
Production **(Supply Chain, OEM)**	▪ Energy demand ▪ Energy mix ▪ Secondary materials ▪ Process specific aspects	▪ Reduction of energy demand ▪ CO_2 reduced energy mix ▪ Enhanced usage of secondary materials ▪ Optimized protecting agents

Use Phase
 	
(OEM, Customer)
	▪ Realized fuel reduction by lightweight design
	  ▪ Weight induced effect
	  ▪ Secondary measures (e.g.engine downsizing)
		▪ Lightweight measures have to be assessed always in the context of the **realized** fuel reduction

End-of-Life **(Recycling Industry)**	▪ Recovery of materials ▪ High quality recycling	▪ Collection systems ▪ Separation technology ▪ Enhanced quality of secondary materials

Life cycle assessment as an environmental management tool

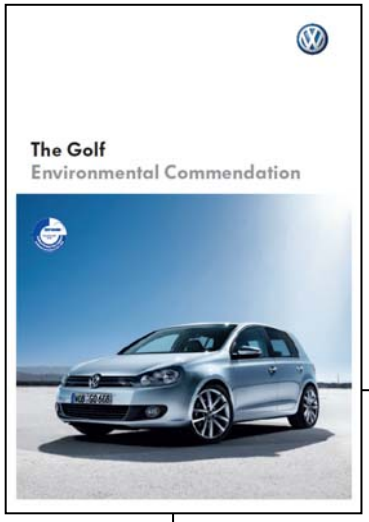
Lightweight design

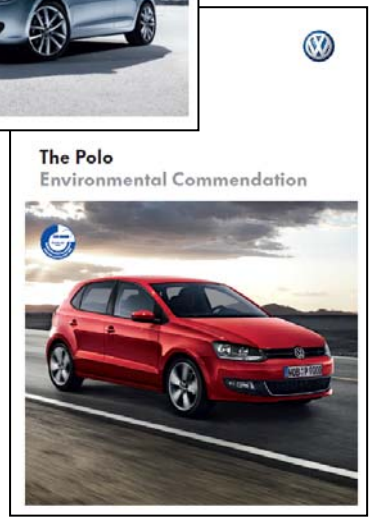
LCA is able to derive measurable technical targets for environmentally friendly light weight design, like e.g.

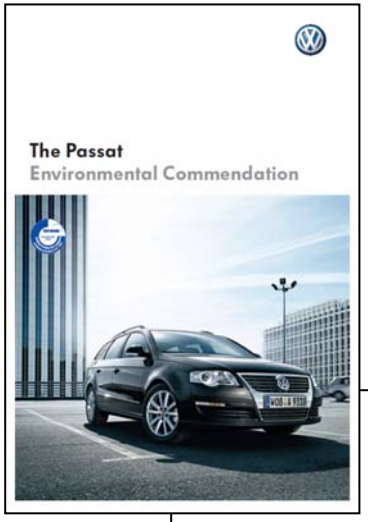
- What weight reduction has to be realized in comparison to a reference car to achieve the ecological break even point during the use phase ?
- How much CO_2 can be saved during the production e.g. with closed-loop recycling ?
- How much CO_2 can be saved by lightweight secondary measures ?
- Which amount of CO_2 can saved with increased use of secondary materials ?

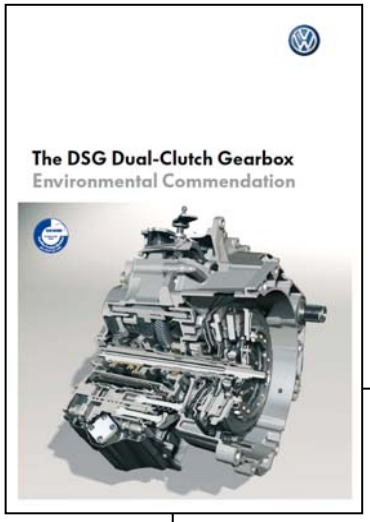
Communication and customer information

Environmental commendations of the brand Volkswagen









Environmental commendation for the brand Volkswagen

Concept

- Profile of the environmental performance over the entire life cycle
- Point out the improvements in comparison to the predecessor
- Specific technological highlights related to the environment

Requirements of the target groups

- Reliable: Certification according to ISO 14040/44.
- Clear and understandable message: Environmental commendation
- Comprehensive and transparent: Background report

Environmental Commendation Polo

Highlights for our customers

Fuel-saving measures on the new Polo
Weight reduction (W), lower energy consumption (E), drag reduction (D)

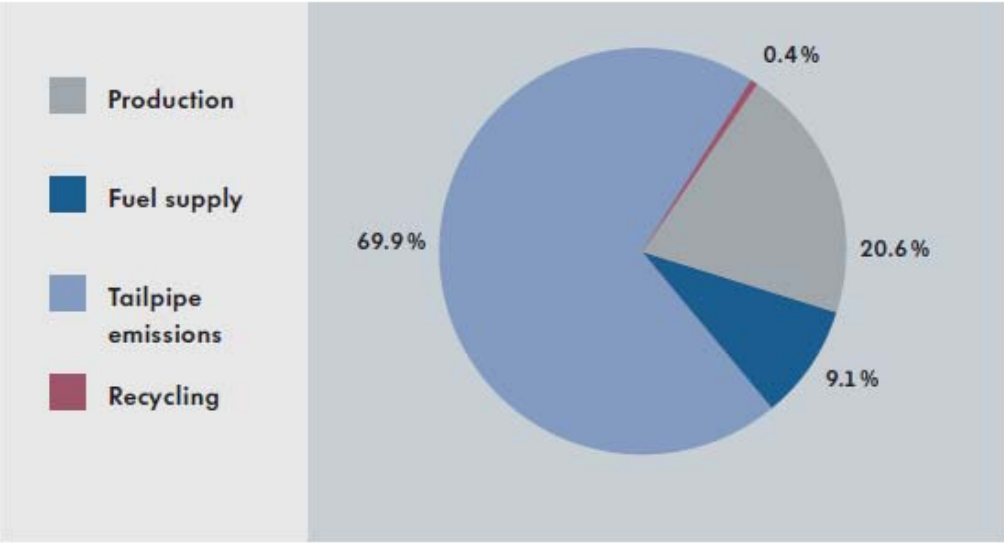
1. Optimized material thickness: rear axle subframe and transverse links (W)
2. Standard tyre repair kit (W)
3. Use of aluminium, high-strength steel, composite materials and magnesium (W)
4. Electro-hydraulic power-assisted steering (E)
5. Reduced idle current (E)
6. Timer for rear window heating (E)
7. Efficiency-optimized generators (E)
8. Tyres with optimised rolling resistance (D)
9. Optimised drag coefficient: front spoiler, underbody tray, wheel spoilers, door mirrors (D)
10. Start-stop system (BlueMotion Technology)
11. Braking energy recovery (regenerative braking) (BlueMotion Technology)

Environmental Commendation Polo

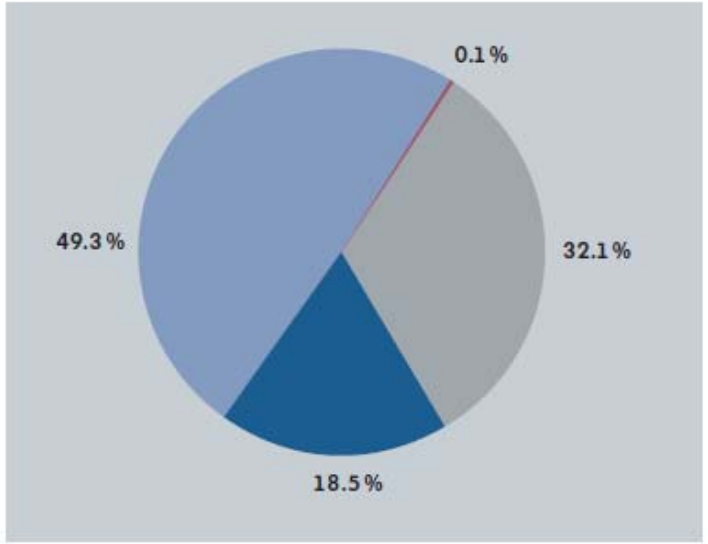
Results of the life cycle analysis

Environmental Commendation

Life cycle contribution to greenhouse effect
Polo 1.6 TDI

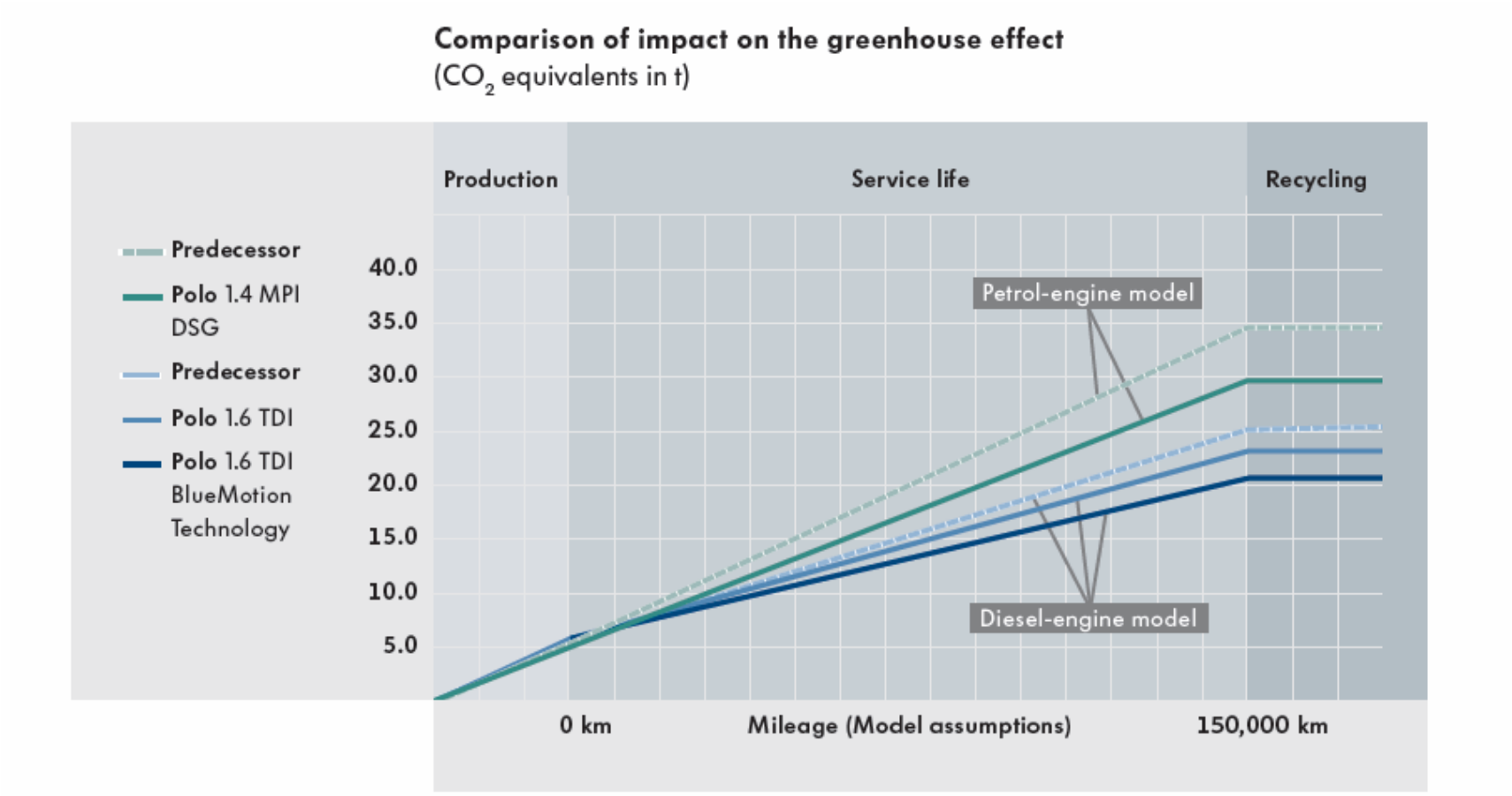


Life cycle contribution to summer smog
Polo 1.6 TDI



Environmental Commendation Polo

Comparison with the predecessor



Environmental commendation

Executive summary

Environmental Description, Polo

Generally improved environmental profile throughout the vehicle life cycle compared with the predecessor model due to lower fuel consumption and reduced emissions

Greenhouse effect – less CO_2 emissions overall*
- Diesel-engined models: -7 % and -16 % (BlueMotion Technology)
- Petrol-engined models: -12 %

Reduced contribution to formation of summer smog*
- Diesel-engined models: -4 % and -6 % (BlueMotion Technology)
- Petrol-engined models: -13 %

Reduction of driving emissions (CO_2)*
- Diesel-engined models: 109 g/km and 96 g/km (BlueMotion Technology) compared to predecessor's 119 g/km
- Petrol-engined models: 135 g/km compared to predecessor's 159 g/km

Reduction of fuel consumption through:
- Use of tyres with optimised rolling resistance
- Intelligent lightweight design (use of high- and very-high-strength steels, hot stamping, use of aluminium and magnesium components, composite materials)
- Use of Volkswagen DSG® dual-clutch gearbox (petrol-engined models)
- Use of high-efficiency electric modules
- Use of start-stop system, regenerative braking (BlueMotion Technology)

Resource conservation through:
- Use of long-lasting components (maintenance-free particulate filters and catalytic converters, longlife lamps)
- Lifetime fill with oil for electro-hydraulic steering

Materials with less environmental impact:
- Use of recycled plastics (e.g. for noise insulation materials)
- Use of renewable raw materials (e.g. for filter materials and floor mats)

* Applies to the actual vehicles assessed in this commendation

Environmental commendation
Communication

- Environmental commendation as print media (english/german)
  - Dealernet in Germany/Europe
  - Fleet customers / Importers
  - Hotline: 0049 800-8977277

- Online Platform (English/German)
  - ***www.environmental-commendations.com*** and ***www.umweltpraedikat.de***

Conclusions for life-cycle assessment

Environmental friendly product development over the entire life cycle

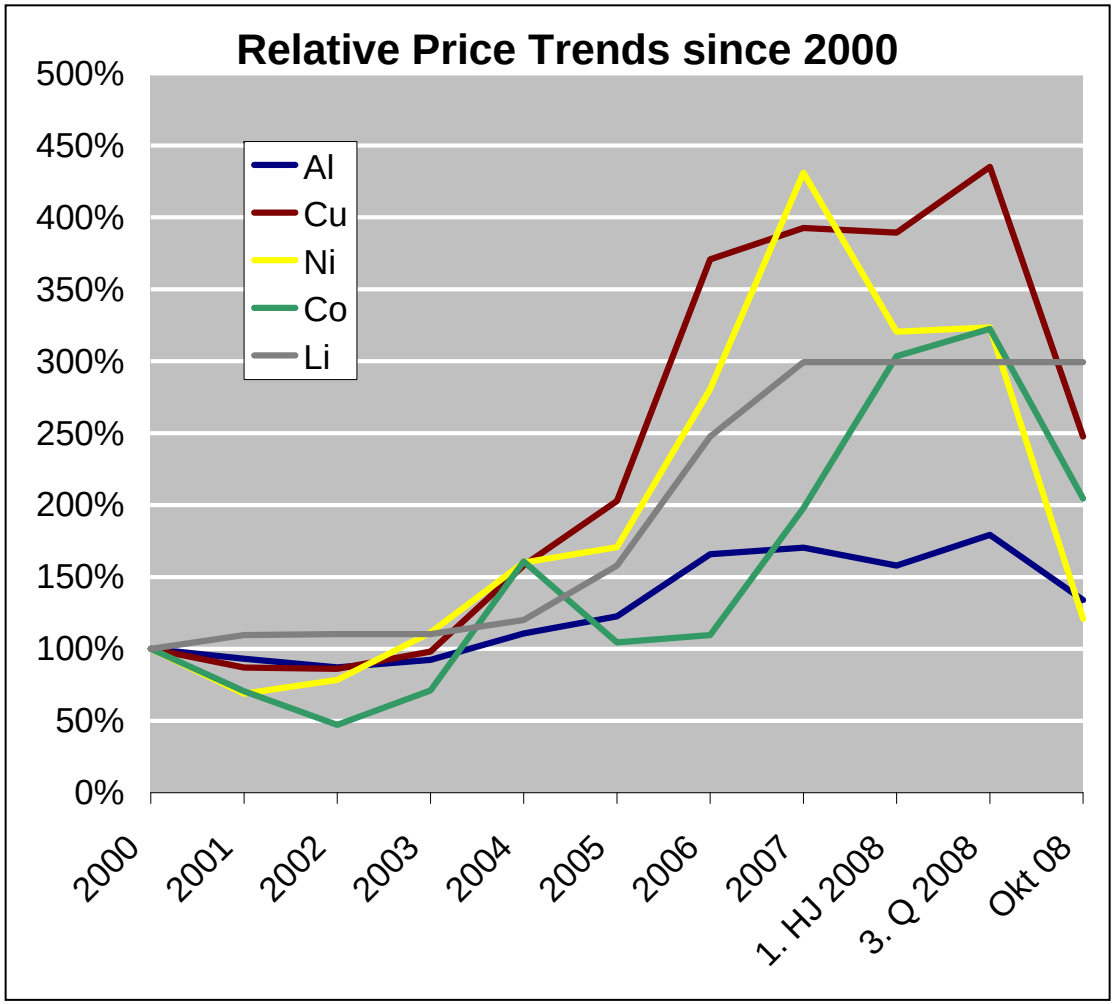
- has to be integral part of the company environmental policy.
- must be applied in the early phase of the product development.
- supplies information for a technology comparison to support the decision-making process.
- considers beyond climate change other environmental impacts to air, water and soil.

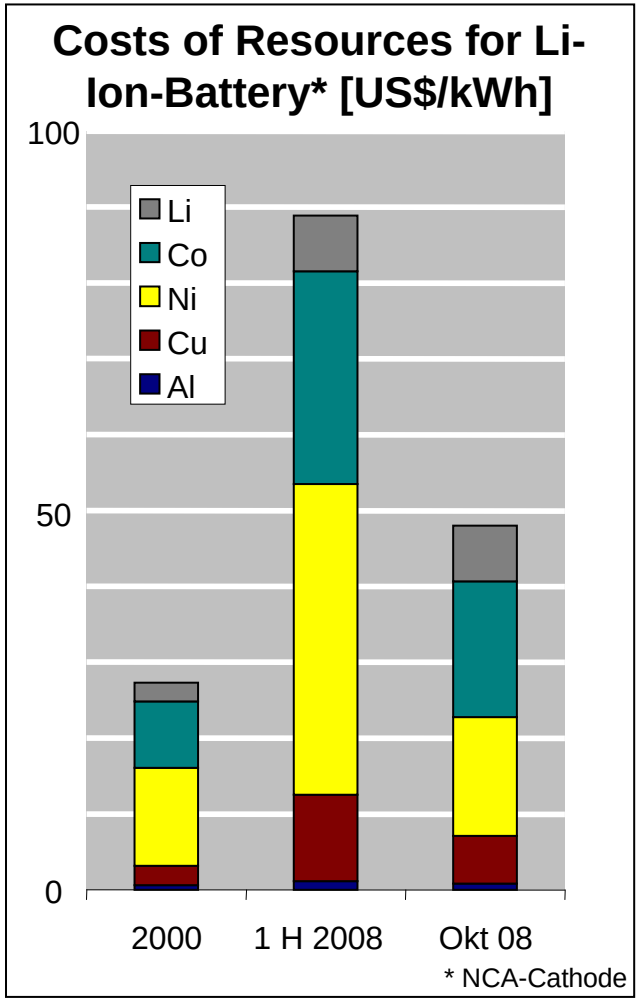
Life cycle assessment as an environmental management tool

- is able to derive measurable targets for the product development.
- can derive reliable and stable recommendations.
- is a useful basis for communication and customer information.

Resource risk assessment of metals

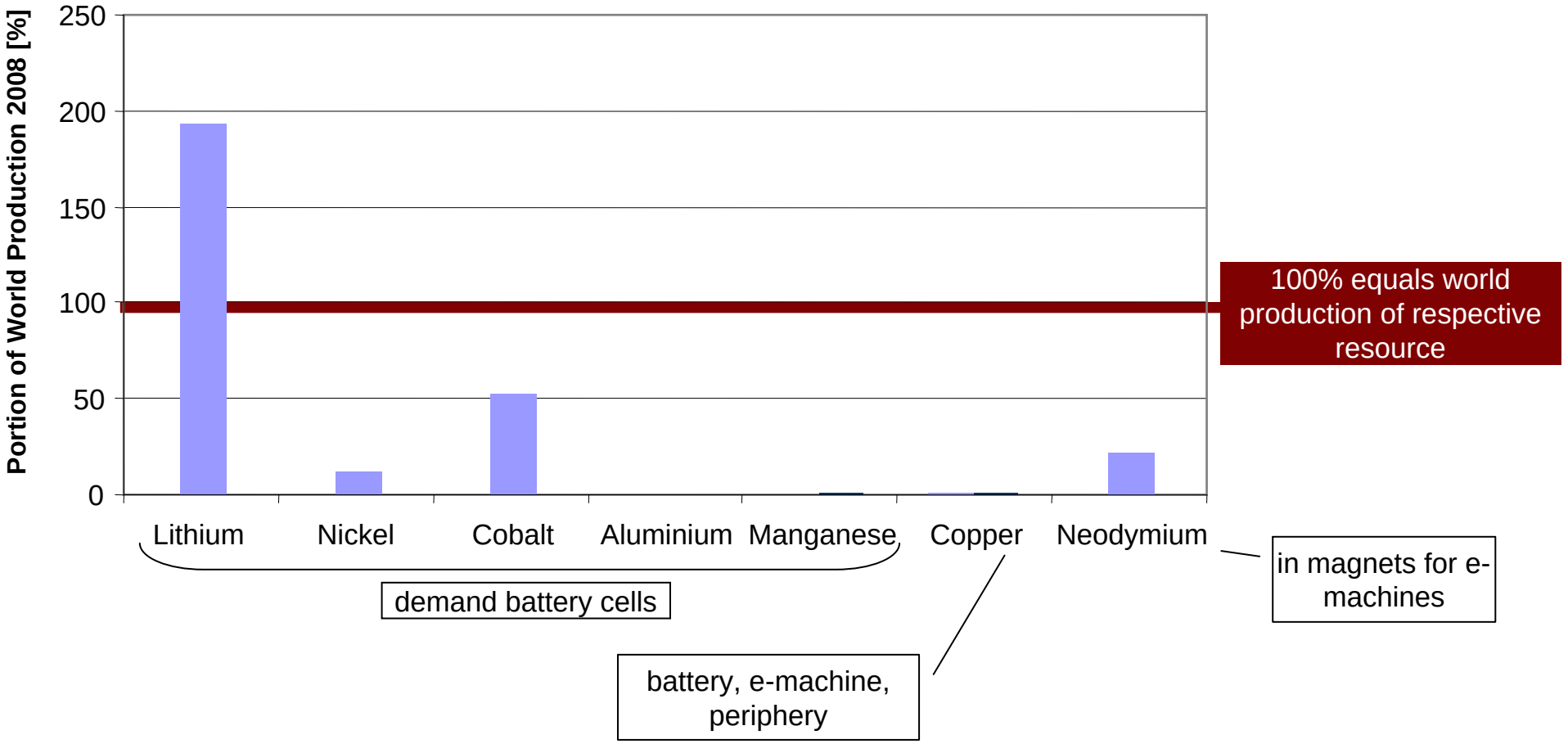
Motivation – up- and downturns of resource prices





Impact of New Technology on Resource Demand

Demand of 6 Mio Electric Vehicles relative to World Production of 2008 [%]*



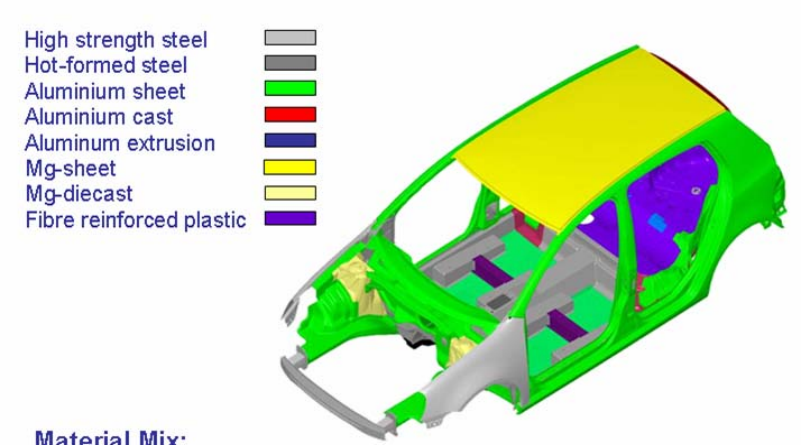
*22 kWh-battery

Goals

Method for detailed and long-term risk assessment of resources

→ particulary saving new technologies like

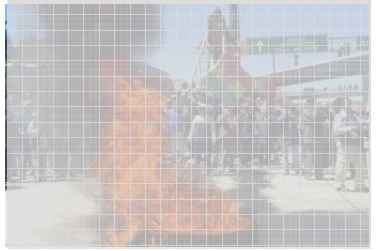
- Light weight construction
- E-mobility

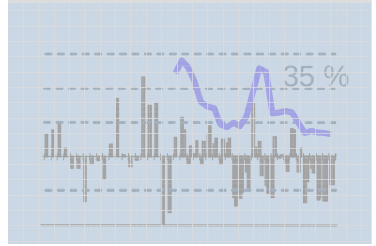


Indicator system for resource risk assessment

Goal: Identifying price and supply risks

1	2	3	4	5
Supply and Demand	**Cash Costs**	**Geostrategic Risks**	**Market power**	**Supply and demand trends**
Market supply Stocks Utilization ratio of refinery / mines		Geographic distribution / Country-specific risks	Company concentration (oligopoly)	Exploration Invest Market supply scenarios





** Federal Institute for Geosciences and Natural Resources*

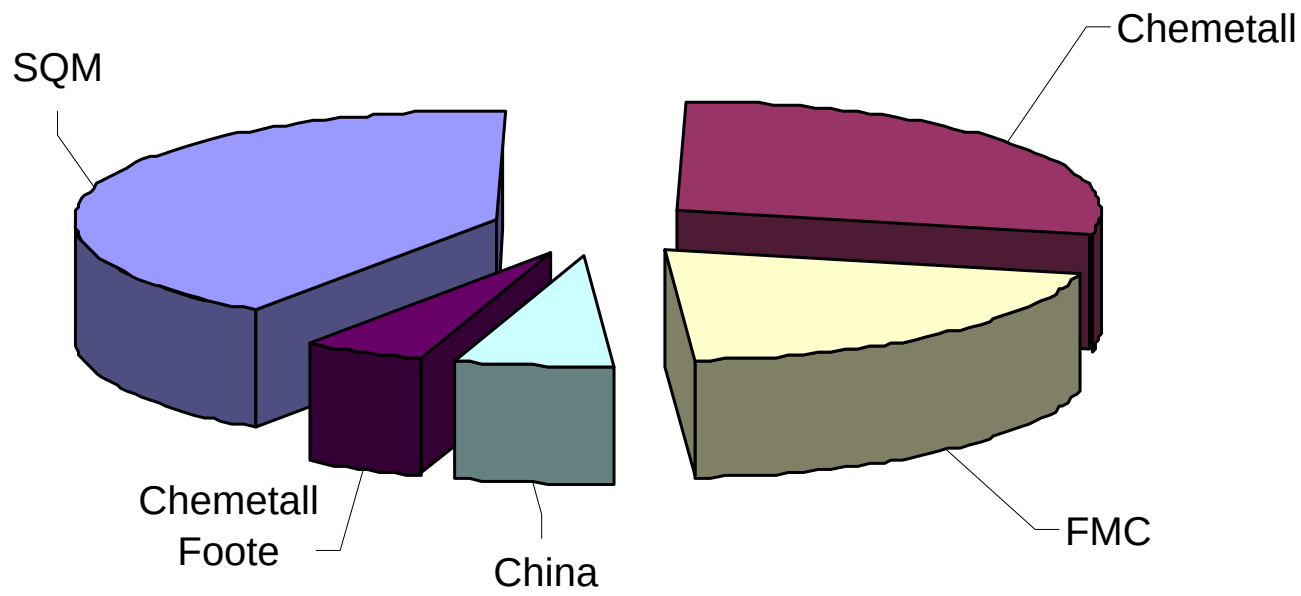
Case study: resource risk assessment of E-mobility

Indicator	Lithium	Cobalt	Neodymium
1. Supply and demand – current status			
2. Cash costs			
3. Geostrategic risks			
4. Market power			
5. Supply and demand trends			

Assessment scale: uncritical | moderate | alarming

Lithium production from brines

Market shares of lithium producers



Only 3 companies produce almost 90 % of all Lithium-Carbonate

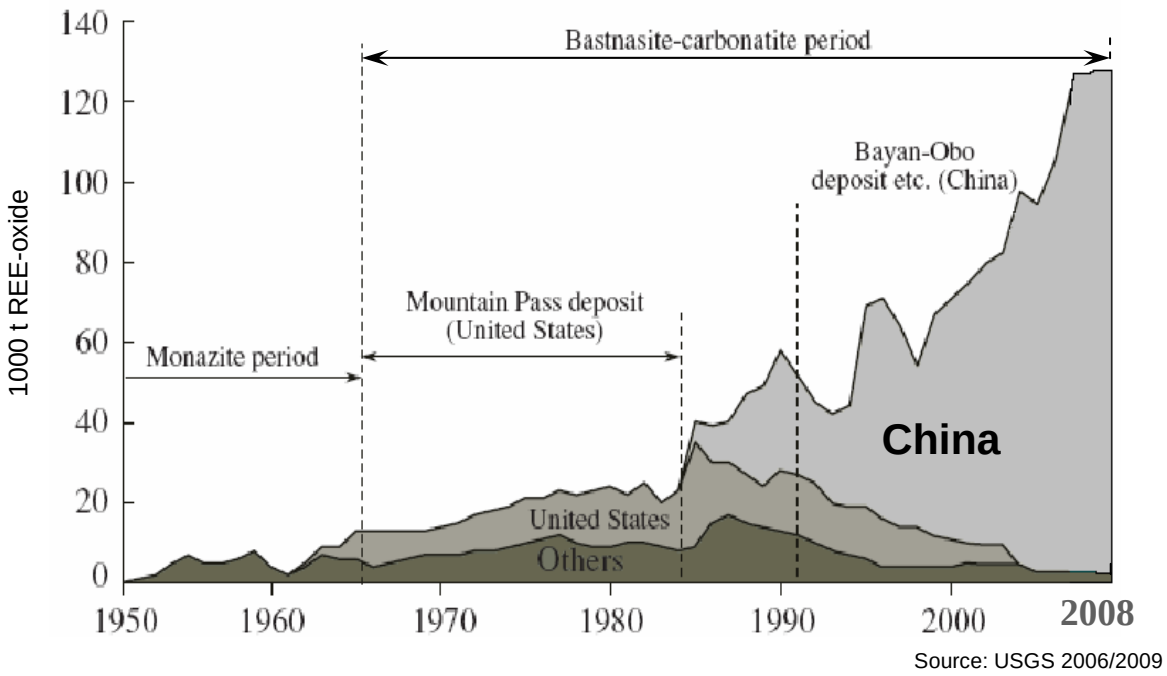
Case study: resource risk assessment of E-mobility

Indicator	Lithium	Cobalt	Neodymium
1. Supply and demand – current status			
2. Cash costs			
3. Geostrategic risks			
4. Market power			
5. Supply and demand trends			

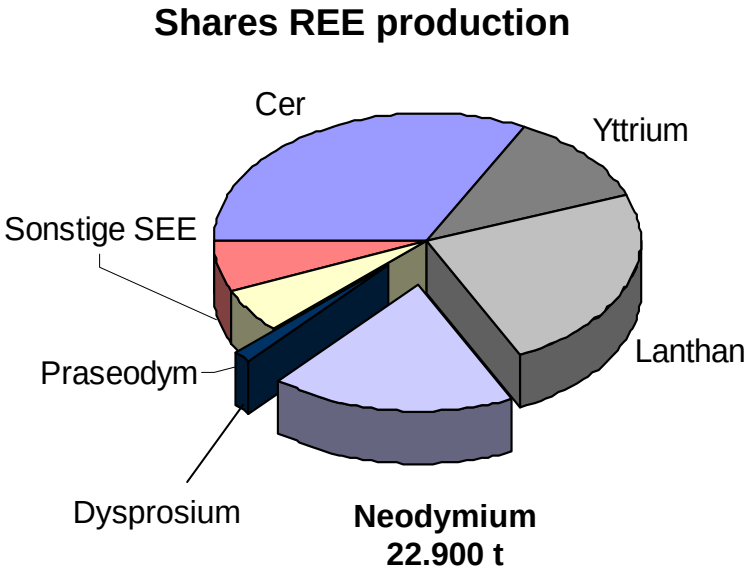
Assessment scale: uncritical | moderate | alarming

Geostratecic risk for neodymium

Neodym is part of the Rare Earth Elements (REE)



Source: USGS 2006/2009



Source: USGS2006, Asian Metal Ltd. 2008, BGR 2009

95% of current production comes from China
China imposes export quotas

Conclusions for resource risk assessment

Resource risk assessment

- has two different targets
  - reduction of economical and supply risks
  - reduction of ecological risks
- has to be managed by different tools dependent on the target (economy or ecology)

Ressource efficiency

- is defined in different ways dependent on the target

Conclusions for resource risk assessment

… and finally

- current LCIA methods for resource risk assessment such as ADP show strong linear correlation to other categories such as GWP and therefore gives NO added value
- geological shortage of resources is relevant for energy resources whereas for mineral resources there is no geological shortage
- economic risks are based on 4 areas
  - demand and supply
  - cash costs
  - geostrategic risks
  - market power

Contact

Volkswagen AG

Dr. Stephan Krinke

Head of
Environmental Affairs Product

Letter box 011/1774

38436 Wolfsburg

stephan.krinke@volkswagen.de