Environment oriented light weight design in steel

Oliver Hoffmann, Hannover, 25.4.2012

ThyssenKrupp Steel Europe

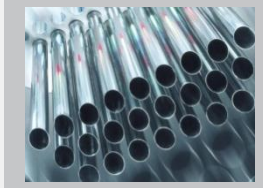
ThyssenKrupp Group Structure
7 business areas including Steel Europe

ThyssenKrupp

Steel Europe

Steel Americas

Materials Services



Stainless Global *)

Division Materials

Elevator Technology

Plant Technology

Components Technology

Marine Systems

Division Technologies

*) Discontinued operation (as of September 30th, 2011). Carved-out new entity is called Inoxum.

Business Area Steel Europe

Company profile

Key figures 2010/2011

Sales	€ 12.8 bn
Employees (30.9.)	28,843

Operating Units

ThyssenKrupp Steel Europe AG
Volumeplayer

Processing
Nicheplayer

Key strategic elements

- Focus on premium flat carbon steel products
- Optimum realization of economies of scale and differentiation potential through “large-scale, multiple niche” approach
- Systematic strengthening of the well acknowledged technological competencies in processes and products
- Continuous development of innovative steel grades to achieve technology leadership in all relevant product groups

Internationalization of ThyssenKrupp

Expansion of relationships with international customers

Lightweight Design & innovative Steels

R&D activities at ThyssenKrupp Steel Europe

High-strength grades

- Today's steel grade portfolio
- Future developments

Hot stamping

- New Boron steels with higher strength (MBW® 1900) or higher elongation
- Optimized processes & technologies
- GammaProtect®: cathodic corrosion protection for direct hot stamping

Sandwich materials

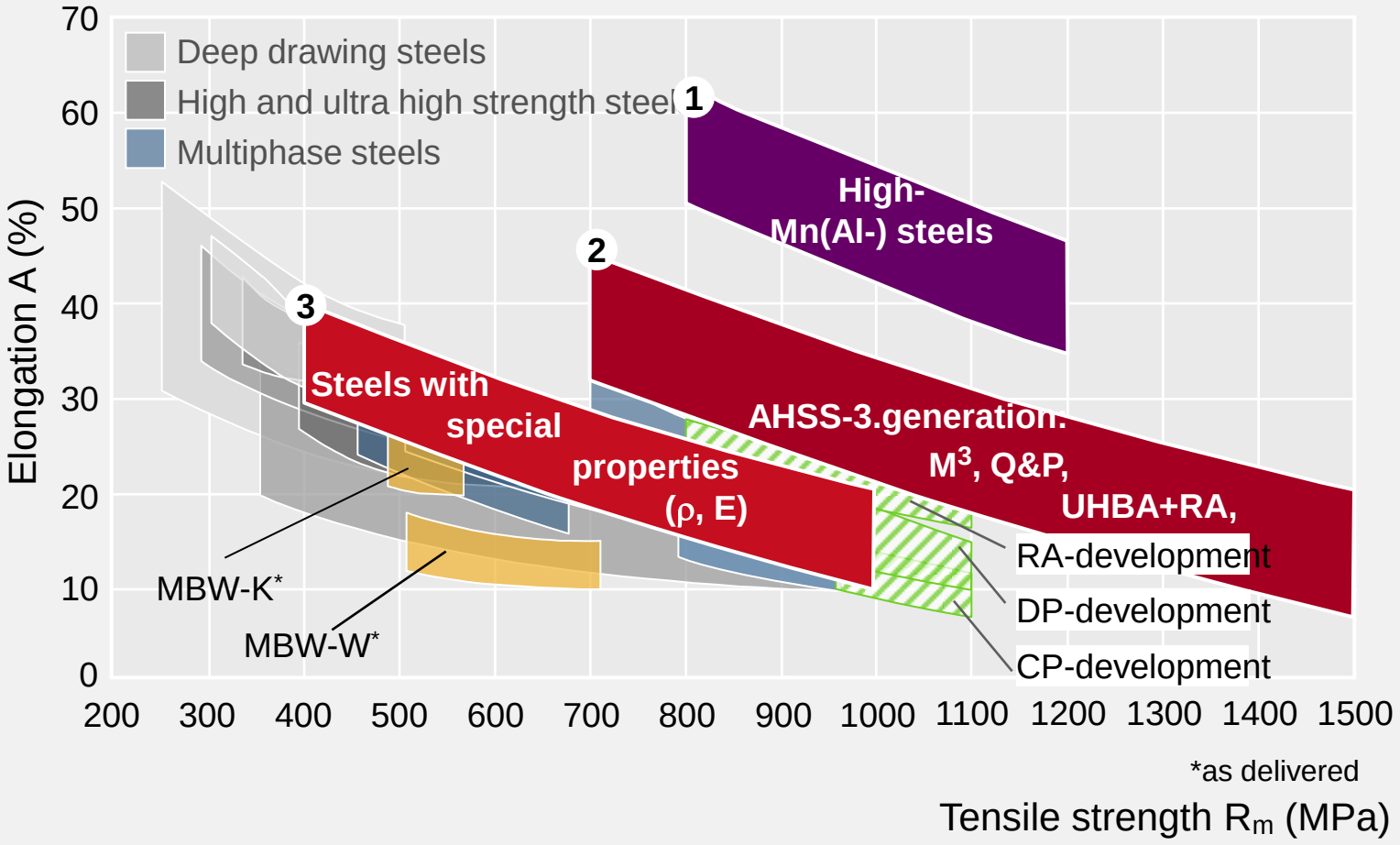
- LITECOR®
- Massive weight saving at extremely attractive lightweight costs
- Innovative material for automotive lightweight design

Life cycle assessment

- Evaluation of the environmental impacts throughout the product life cycle
- Extraction – material – manufacturing – use phase – recycling

Innovative steels for the automobile industry

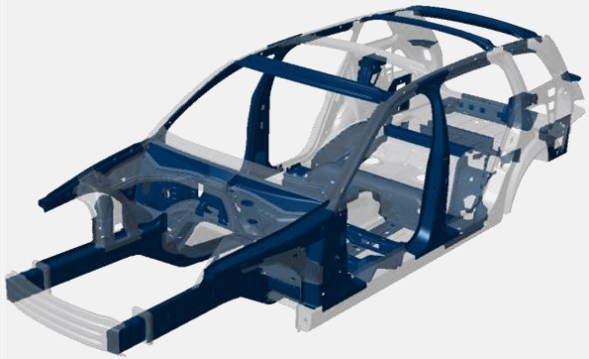
Time horizon today … 15 years



Density reduced (particle strengthened) steels

Pre-development

- **Chemical composition:** high alloyed steel with light elements and low carbon content
- **Microstructure:** ferritic matrix with a fine distribution of particles
- **Properties:**
  - high yield strength (350-500 MPa) and tensile strength (Rm = 450-650 MPa) by solid solution hardening and particle strengthening
  - significant reduced density ($\Delta \rho$ = 8-13%) compared to conventional steels
- **Application:** BIW components with reduced weight and improved Eigen frequencies
- **Status:** laboratory developments carried out; due to the chemical composition specific process facilities and parameters necessary, industrial production trials in preparation



InCar®-BIW: Several Components,
Weight reduction: -13 kg (-13 %)

Lightweight Design & innovative Steels

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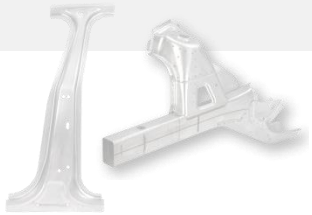
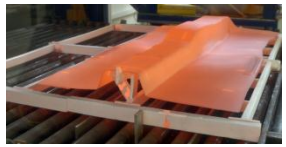


- Today's steel grade portfolio
- Future developments

Hot stamping



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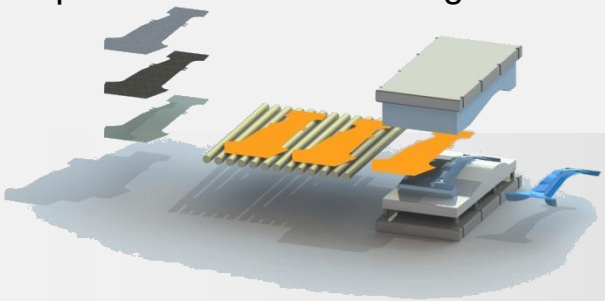
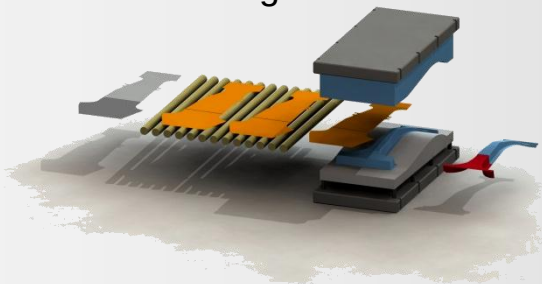
Materials and manufacturing strategies for hot forming applications

Challenges and solution statements

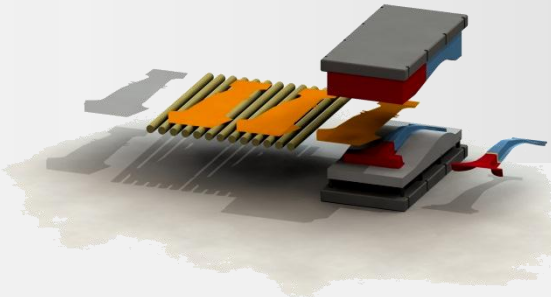
Material ➔ development of different steel grades and coatings



Hotform Blanks ➔ different steel grades or thickness

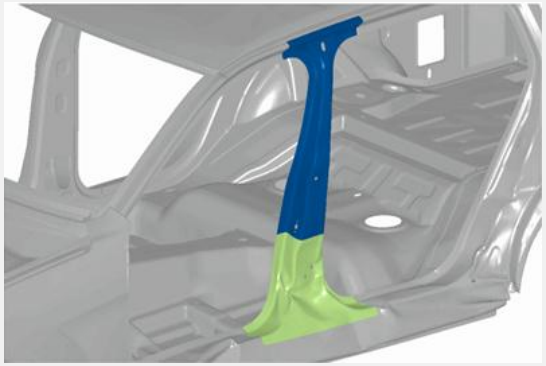


Tailored Tempering ➔ adjusted heat treatment for varying strength level



Challenge

- Optimization of functional properties for modern steel based lightweight design structures



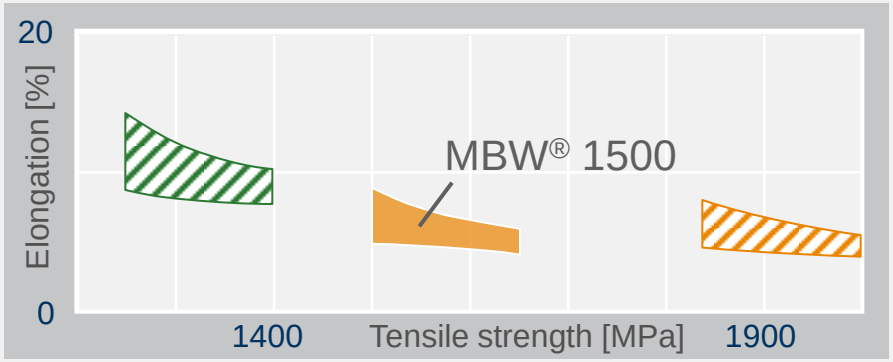
Realization

- Implementation of lightweight strategy by new materials and manufacturing technologies

Material trends in hot stamping

Development of new manganese-boron steels MBW®

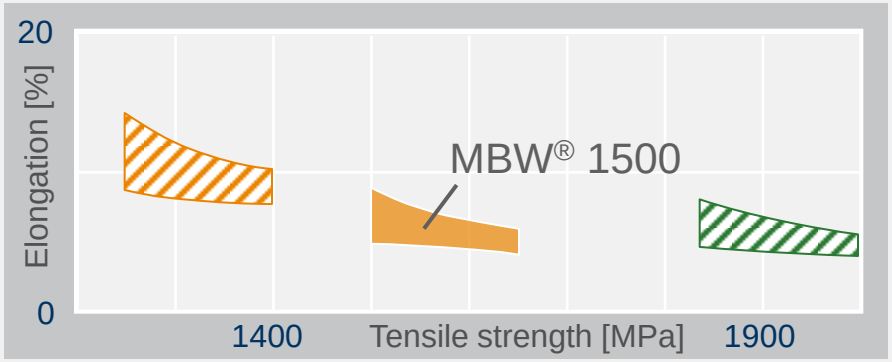
Elongation ↑



- Increase in elongation at moderately lower strength level, e.g. R_m=1400 MPa
- Higher energy absorption capacity
- New joining partners for Hotform Blanks with strengths around 800 MPa

Series	to be defined

Tensile strength ↑



- Increase in tensile strength up to 2000 MPa,
  e.g. MBW® 1900
- High potential for automotive lightweight engineering, especially for safety-related parts like bumper or door beams

Series	2010	2011	2012	2013	2014	2015

➔ Tailor-made material properties possible by using Tailored Tempering

GammaProtect® from ThyssenKrupp Steel Europe

Cathodic corrosion protection for hot stamping

- Cathodic corrosion protection
- Outstanding forming properties in direct and indirect hot stamping process
- No alloying necessary
  - ➔ Rapid heating possible
  - ➔ Shorter process times
- Easy to process using methods typical for auto parts
- Suitable for Hotform Blanks
- Components have already been stamped under production conditions

Hot-stamped B-pillar with cathodic corrosion protection

➔ Now available: cathodic corrosion protection for the direct process

MBW® 1500 in 0.5 mm thickness

Further weight reduction due to reduced blank thickness

Customer benefits

- Further weight reduction by application of thinner blanks
- Enhancement of the MBW® 1500 +AS dimensions
- New possible applications for thin walled parts

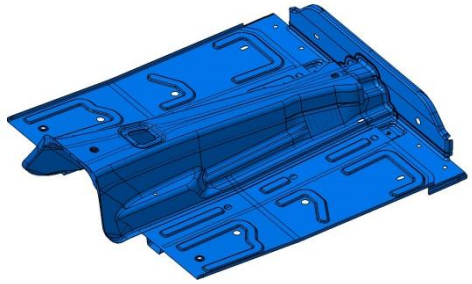
Investigation results

- First field test successful (0.5 x 1250 mm)

Current status

- Suitability for series strip production will be tested by further field tests, width enlargement is planned
- Further coils under production trials
- First test material available

MBW® 1500 +AS, 0.50 mm



Possible Applications: Floor Panel, Tunnel, Firwall

Cost	Weight	CO_2/km
To be analyzed by further tests		

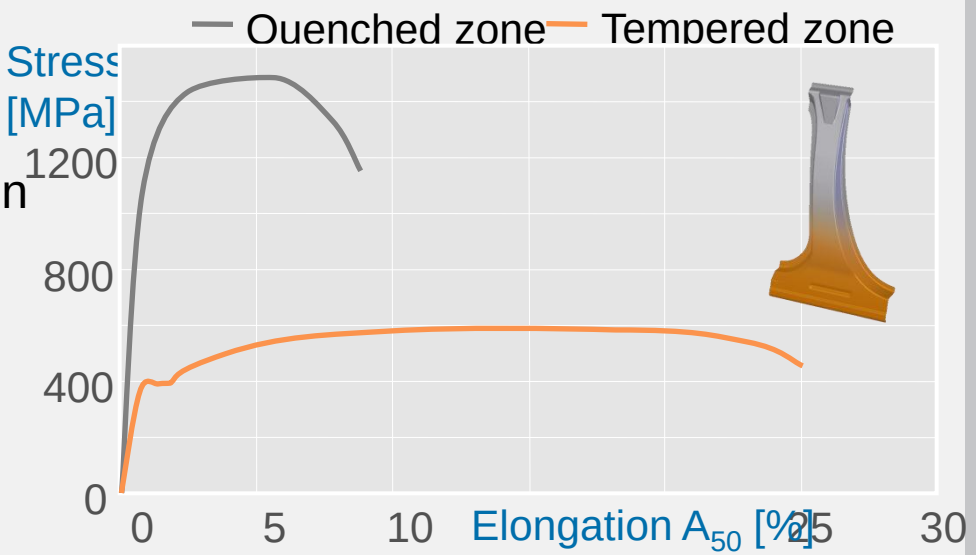
Series	2010	2011	2012	2013	2014	2015

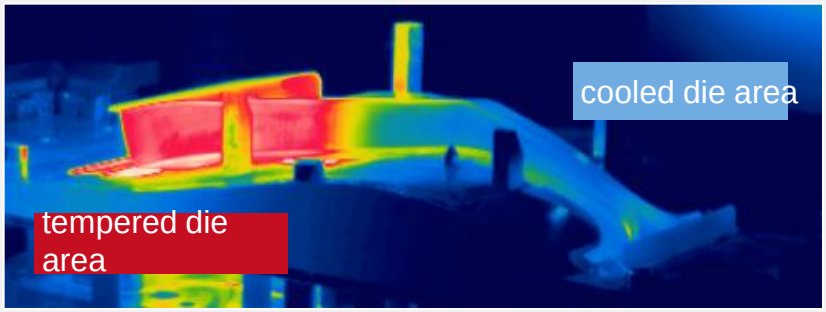
➔ Weight reduction by use of thinner blanks is possible

Extended applications for hot stamping

Tailored Tempering

- Tool with different temperature zones for defined cooling rates
- Increased part complexity in comparison to cold stamping, yet at the same time extremely high material strengths
- Elimination of components (lower B-pillar reinforcement) and the upper/ lower welded assembly B-pillar
- Targeted increase in deformation reserve in lower area of B-pillar reinforcement
- Soft transition between strength zones has positive impact on crash behavior





➔ For different local properties in monolithic parts

Lightweight Design & innovative Steels

R&D activities at ThyssenKrupp Steel Europe

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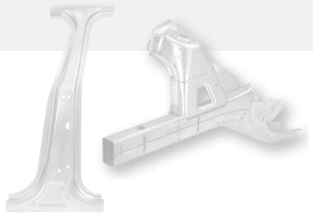

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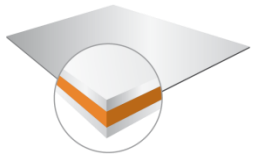
Sandwich materials



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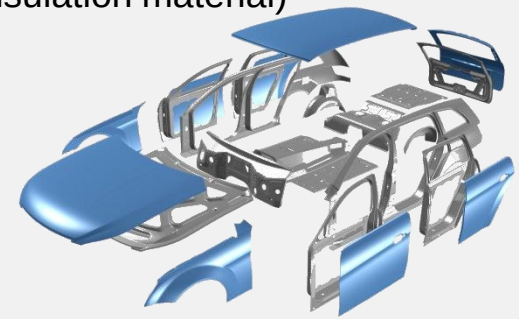
Stiffness Optimized Sandwich Material

Product overview

- Alternative Lightweight design solution to Aluminum
- Very thin outer panels
- Polymer core made of PE/PA-Compound
- Core layer / cover sheet composite with high shear stiffness
- Very high bending stiffness
- Structure borne noise damping properties existing (Potential to reduce secondary acoustic damping and insulation material)



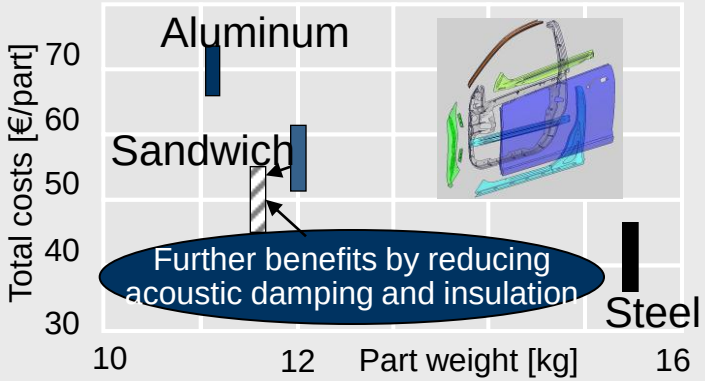
Outer panel parts
Inner panel parts

Steel sheet (0,20 - 0,30 mm)

Polymer core (PE/PA-Compound)
(t_k = 0,4 … 1,0 mm)

Steel sheet (0,20 - 0,30 mm)

Lightweight design potential – e.g.: Door



➔ Goal: at least 30% cost benefit compared to an Aluminum application, maximal 10% weight penalty compared to an Aluminum solution

Part production from Stiffness Optimized Sandwich Material

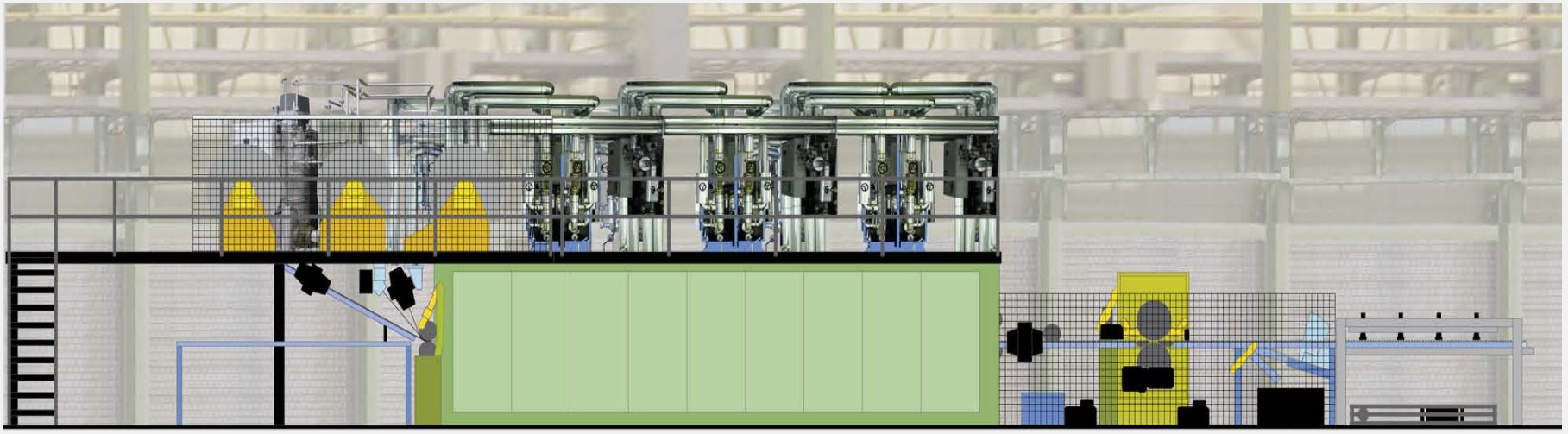
Test results - summary

Forming	✔
Stiffness	✔
Dent resistance (Hailstorm), Snowload	✔
Cold joining technologies	✔
Thermical joining technologies	✓ under construction
Deformation before/after KTL-painting	✔
Deformation at operating temperature (Dilatometric)	✔
Dynamic	✔
Corrosion	✔
Acoustic	✔ / under construction
Crash	✔

Stiffness Optimized Sandwich Material

Taking Off with Pilot Plant 09/2011

Schematic illustration: Pilot plant for stiffness optimized sandwich material



- Plant Capacity: ca. 2.500t Lightweight Sandwich per year
- Dimensions: (0.7 – 1.5mm) x max. 1600mm width*
- Low volume series from 12/ 2011
- High volume series (capacity of 40.000t/a) planned from 2nd half of 2014

* Depending on availability of steel layer

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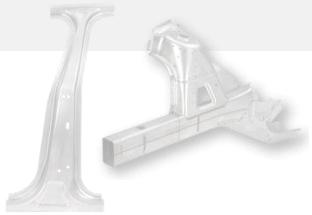

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Life Cycle Assessment

What is Life Cycle Assessment?

I Production

Raw material

Energy

Information

Casting

Energy

Information

Semi-Product

Energy

Information

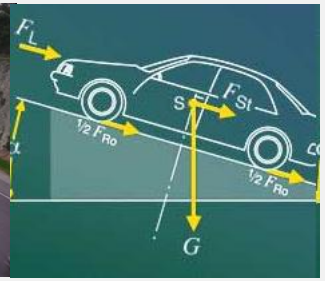
Manufacturing

Energy

Information

Assembly

II Use Phase



Gesamtfahrwiderstand.

F_L Luftwiderstand,
F_{RO} Rollwiderstand,
F_{ST} Steigungswiderstand,
S Schwerpunkt,
G Gewichtskraft,
α Steigungs-/Gefällwinkel.

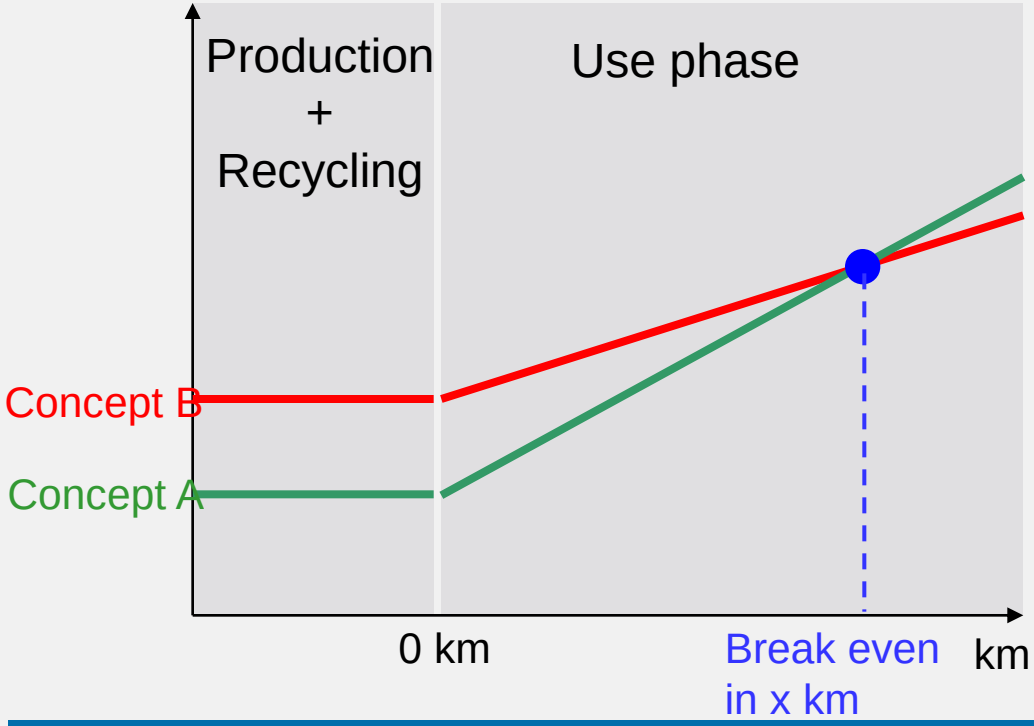
III Recycling

Sources: Internet

➔ Evaluation of the environmental impacts of a product throughout its life cycle

Benefits of LCA

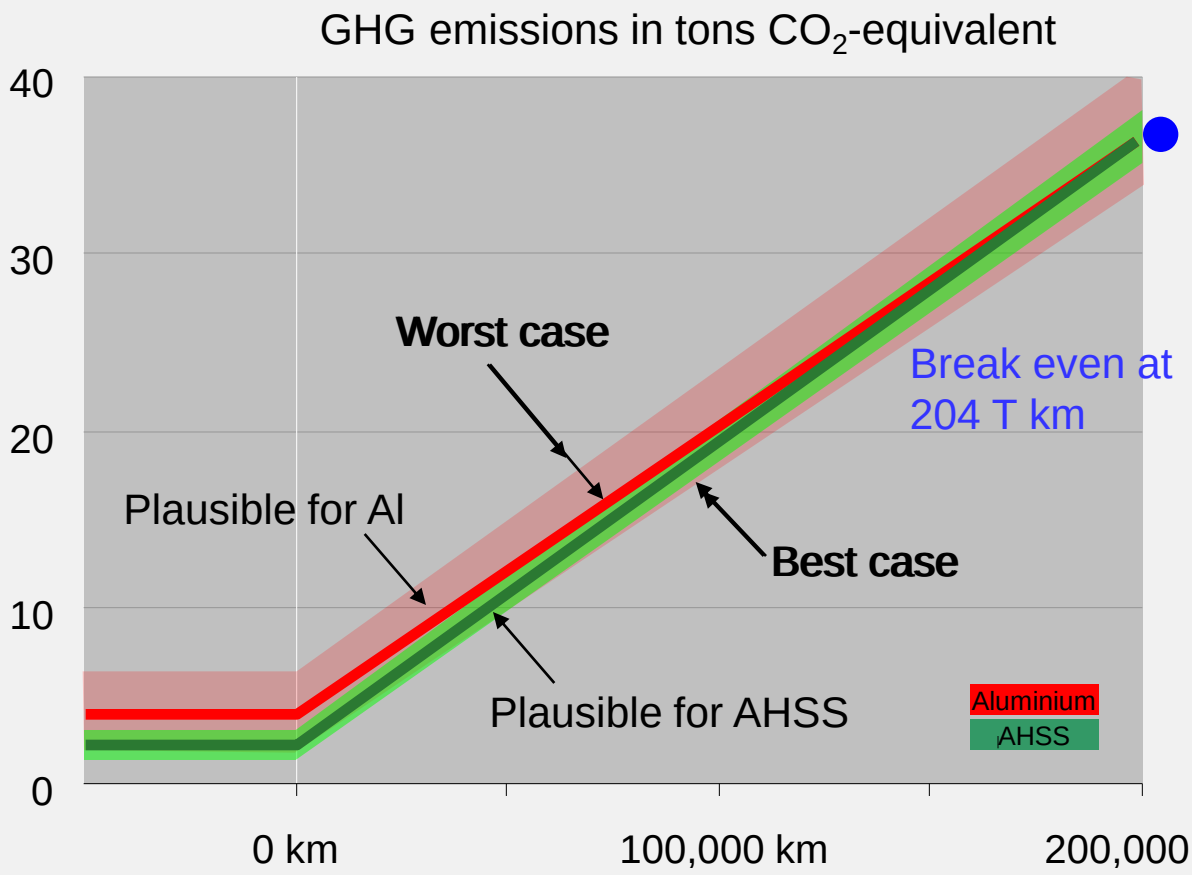
Greenhouse gases (GHG) in tons CO_2-equivalent



- GHG emissions over the life cycle phases of a product
- Shift of environment burden from one phase to another can be recognized
- It promotes objective evaluation of a product's environmental performance

➔Our LCA analysis is based on the certified phase 1 model of Dr. Roland Geyer University of California, Santa Barbara

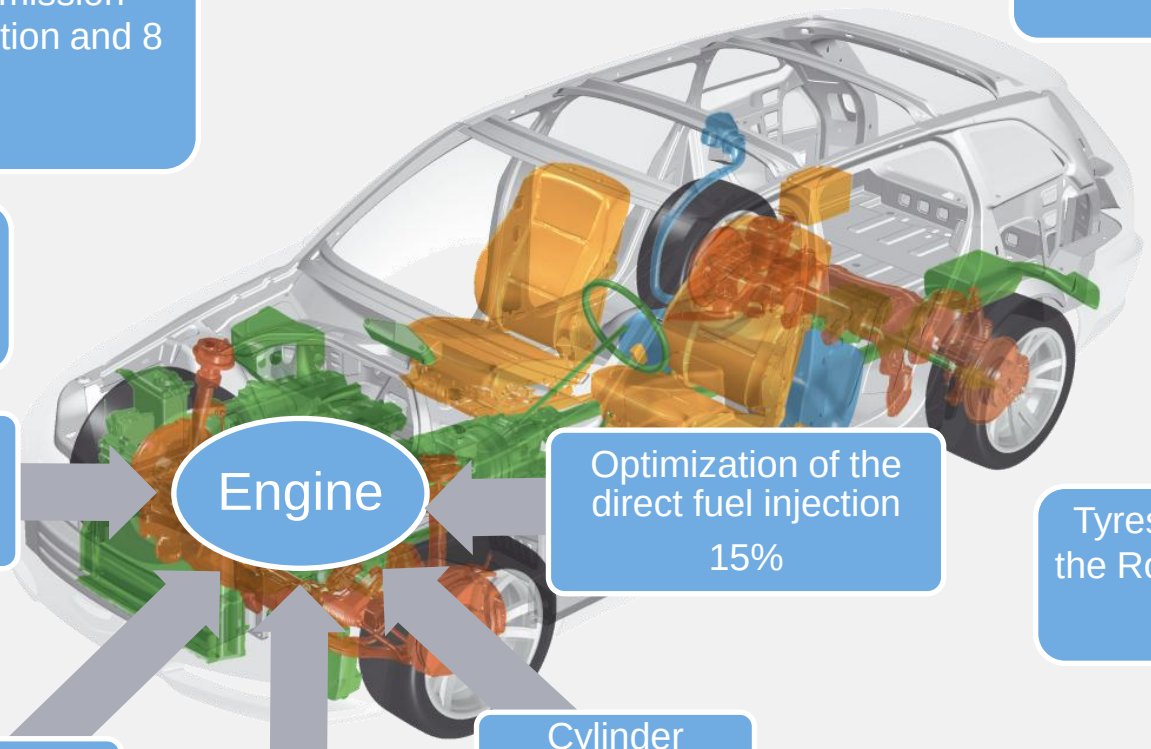
Comparative LCA for BiW Materials
Scenario SE-AG



Fuel Reduction Value l/100km/100kg	0,30
Allocation of recycling credits	50/50
Weight reduction: AHSS vs. conv. steel	-15%
Weight reduction: Aluminium vs. conv. Steel	-40%

➔With plausible assumptions, same level of GHG emissions over the lifecycle

Technologies to reduce Fuel Consumption



Source:
Wirtschaftswoche

Conclusion

- Based on the currently available steels and in light of future developments there is a high potential for an innovative lightweight design
- For the design of BIW, hot-stamping technologies become more important
- Steel-plastics-composites such as LITECOR® provide additional solutions for lightweight design
- The Life Cycle Assessment assures sustainable lightweight solutions