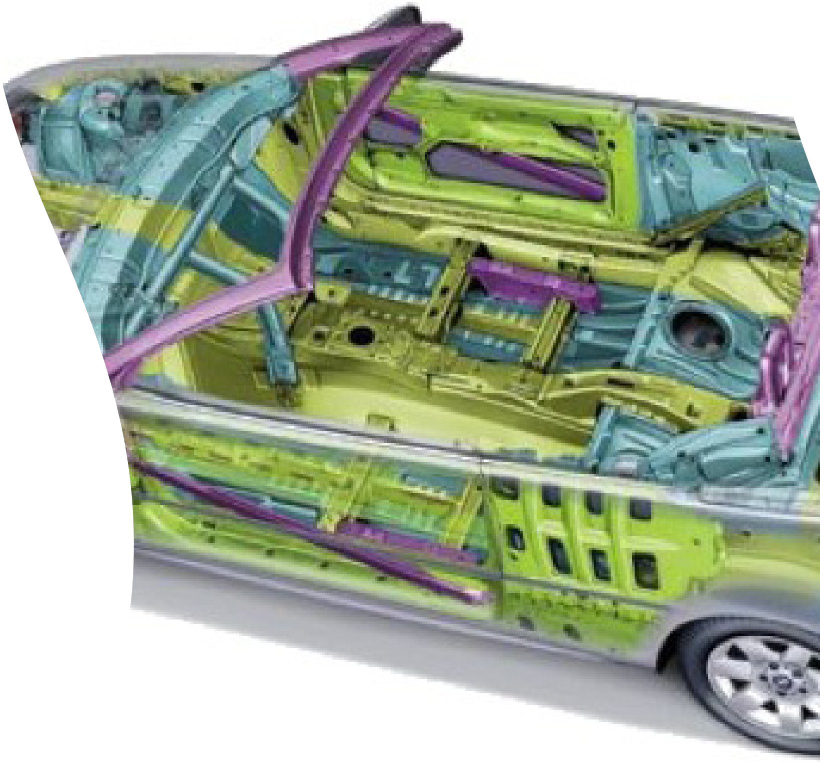
ECO-DESIGN PACKAGE

TAILOR WELDED BLANKS



EUROFER
The European Confederation of Iron and Steel Industries

ABOUT EUROFER AND THE ECO-DESIGN PACKAGE

The European Confederation of Iron and Steel Industries, EUROFER, is committed to advancing sustainable development throughout the European steel industry.

This Eco-Design Package has been developed to promote the environmental credentials of steel and provide downstream users with environmental performance information. It demonstrates:

- the importance of life cycle considerations during product development
- the closed loop, material to material recycling of steel
- the availability of steel life cycle inventory data and information on the steel industry's sustainability development

This document follows the key philosophies of Eco-Design as described in ISO 14062 "Environmental Management - Integrating environmental parameters into product design and development".

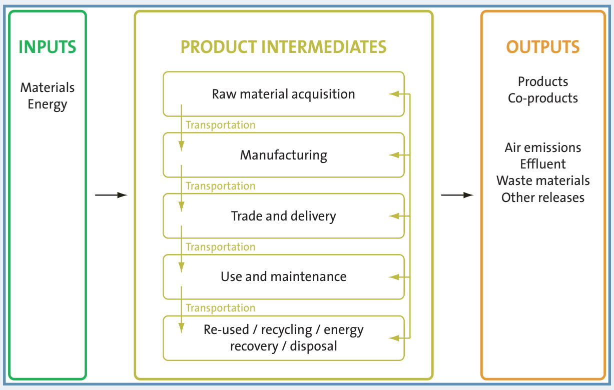


Figure 1: Scope of a life cycle consideration

In this Eco-Design package, life cycle considerations are integrated into the industry's product development and design environment. This provides product-specific environmental decision-making support for new and improved designs in early development phases and thereby assists with compliance of legislative requirements.

Discussions on Eco-design should be incorporated into the very early stages of product design to ensure optimum benefit to environmental, technical and economical performance.

TAILOR WELDED BLANKS

This Eco-Design package focuses on the application of tailor welded blanks (TWBs) in the automotive industry.

TWBs are steel sheets of different thicknesses and grades which are laser welded into a single flat blank prior to pressing to achieve optimal material arrangement and weight reduction for vehicles. Their use/production also increases process efficiency and machine flexibility.

Figure 2: Example of a tailor welded blank application **/1/**

The benefits of using TWBs are vehicle weight savings, part-count reduction, an improved stiffness/weight ratio, enhanced crash energy management, and an overall reduction in manufacturing costs.

A generic TWB part has been analysed to highlight the environmental benefits of such a product. The generic TWB part represents a part of the vehicle chassis with a weight of 12.3 kg.

Tailor welded part:

The generic tailor welded part consists of four different steel grades. In this application they are galvanised high strength sheets:

Thickness:	0.67 – 1.47 mm
Weight of steel sheet input:	16.5 kg
Weight of resulting part:	12.3 kg
Pre-consumer scrap:	4.2 kg

Conventional part:

For a corresponding conventional part, the thickness of the steel would be constant. The overall weight of this part would be 16.1 kg. This results in the TWB equivalent part having a reduced weight of 25 % compared to the conventional part.

The advantages of the tailor welded blank can be attributed to the use of different sheets of varying thickness: thicker sheets for areas requiring greater strength, with larger areas of thinner steel sheets for the main panels. A weight reduction of 25% compared to the conventional part is achieved, supporting the efforts of the automotive industry to minimise fuel consumption and air emissions during the use phase. This weight reduction is in line with the overall weight savings achieved in the Ultra Light Steel Auto Body (ULSAB) project **/2/**.

In addition, the TWB part leads to a significant reduction of steel input to the manufacturing process, which supports the initiative of safeguarding material resources for future generations within the product development process.

Identifying the most environmentally-sound product design alternative requires tracing the ecological effects of each choice.

Life Cycle Thinking / Assessment

According to ISO 14044 'Environmental management – Life cycle assessment – Requirements and guidelines', Life Cycle Assessment (LCA) provides a systematic approach to integrated environmental analysis. Emissions to air, water and soil, as well as resource intensity along a products' life cycle, can be analysed, aggregated and assessed.

The **Life Cycle Inventory (LCI)** phase represents the compilation and quantification of inputs and outputs for a given product system throughout its life cycle. The **Life Cycle Impact Assessment (LCIA)** phase involves interpreting and evaluating the magnitude and significance of potential environmental impacts on the basis of the LCI results.

For the tailor welded blank, the impact on the environment is displayed in the table below, characterised by a number of these well-renowned LCI and LCIA categories **/3/**. For a selection of indicators, the impact is shown for each of the life cycle stages, as well as the total life cycle impact. Further information can be obtained from EUROFER. LCI data from IISI has been utilised for the various steel products, and where necessary, data from the GaBi 4 software and database is incorporated.

Since the TWB part offers a weight advantage of 4.1 kg compared to the conventional part, fuel consumption is reduced, which can be expressed by 370 MJ of primary energy (equivalent to 8.8 kg of 42.1 MJ/kg crude oil) or 26.7 kg CO_2 emissions **/4/**.

This outstanding strength of tailor welded blanks shows the great potential behind weight reduction of steel parts in a range of 15 - 35 % **/2/** and demonstrates the enormous efforts of the steel industry to provide highly innovative materials to minimise the environmental impacts of steel products. The use of advanced high strength steels (AHSS) together with efficient part design offers further opportunities for weight reduction **/5/**.

End of Life phase

The end of life phase includes collection, separation and shredding (scrap processing) of the TWB part as well as the recycling of steel scrap at the end of the product's life. The ease of disassembly is therefore very important in improving the recyclability of the end of life vehicles.

Of high importance for the end of life phase is the effective recyclability of steel without loss of material properties (figure 3). Within the automotive industry steel materials are recovered with a recovery rate of 95 % **/5/**.

Environmental impacts	Units	Life cycle phases					Total
		Production		Use	End of Life		
		Materials	Processing		Scrap processing	Recycling	
Life Cycle Inventory (LCI)							
Primary energy demand	MJ	554	57		7.6	-235	384
Carbon dioxide (CO_2)	kg	41.9	2.4		0.3	-25.2	19.4
Life Cycle Impact Assessment (LCIA)							
Global warming potential	kg eq CO_2	43.1	2.6		0.3	-25.5	20.5
Acidification potential	kg eq SO_2	0.12	0.02		0.003	-0.052	0.094
Eutrophication potential	kg eq PO_4	0.011	0.001		0.0001	-0.004	0.008
Photo-chemical oxidant formation potential	kg eq ethylene	0.025	0.002		0.0002	-0.012	0.015

Production phase

The production phase for TWBs covers steel production, manufacturing steps (cutting, welding etc) and transportation (processing). The LCI result shows that the contribution of transport and product manufacturing is significantly less than that for material production. Overall, the production of steel is generally characterised by highly resource efficient production stages, with minimal potential for further improvement, and additional benefits of steel further demonstrated in the product's use phase.

Due to the nature of tailor welded blanks being produced from a combination of different types of steel sheets, the manufacturing of the resulting products is characterised by an increase in the amount of welding required compared to conventional blanks. Nevertheless, this additional effort is of minor relevance in comparison to the great benefits of TWBs during the use phase.

Use phase

The main impact of vehicles is within their use phase. As the TWB makes up part of the whole vehicle, it is not practical to include specific vehicle use phase data within this package and therefore the use phase is not calculated in absolute figures; the TWBs are compared with conventional parts in relative terms.

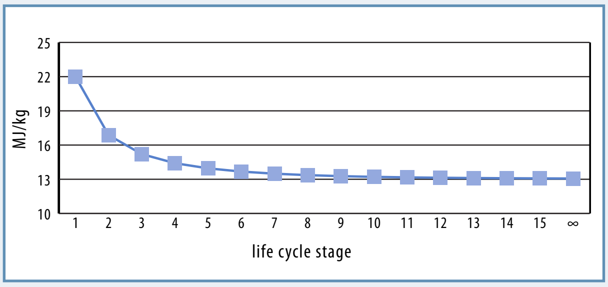


Figure 3: Multiple recycling reduces the average energy requirement per kg of steel **/6/**

The end of life is characterised by the additional burdens (7.6 MJ) of preparing the scrap, and by the credit for the recovered material which can be used within a subsequent life cycle. Focusing on primary energy demand, this credit is 235 MJ (equivalent to 5.6 kg of 42.1 MJ/kg crude oil).

The recycling of scrap closes the loop of the material (steel) flow in the steel production process. Input of steel scrap to the steel production process can be up to 100 %, depending on the process route for steel production. Europe recycles 101 million tonnes of steel scrap per year, which represents 54% of total steel production **/7/**. This saves 190 million tonnes of CO_2 emissions which is equivalent to saving CO_2 emissions generated by 34 million households **/8/**.

General information on material flows in steel making

Material flow analyses for steel products demonstrate that material-to-material recycling of post and pre-consumer scrap is already common practice. The fact that steel is 100% recyclable back into new steel products without loss of quality ensures that the material loop is closed.

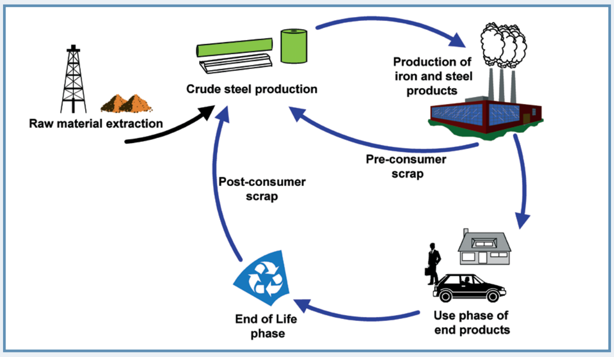


Figure 4: Flow of material through society **/9/**

Modern steel making is dominated by two principle process routes:

- **Iron ore-based production** where hot metal (pig iron) is produced by the reduction of iron oxide in the blast furnace, followed by refining in the basic oxygen furnace to produce steel. In the refining process, excess heat is produced, allowing steel scrap to be added to the melt.
- **Scrap-based production** where steel is produced by melting steel scrap in the electric arc furnace, sometimes followed by refining. Highly alloyed steel grades, like stainless steel and tool steels, are generally made from scrap. Alloying elements utilised, such as chromium and nickel, depend on the type of scrap used as well as from extra additions to the melt.

Energy efficiency has always been a priority within the steel industry and thus both process routes operate in a very energy efficient way. Continuous improvements to further develop this are ongoing **/10/**.

Steel product information

High strength steels (HSS), also known as micro-alloyed steels have yield strengths between 280 and 550 MPa. They are specially adapted to endure specific stresses and have a high energy absorption capacity, which makes them very beneficial for use in the automotive industry. In terms of environmental impact, similar properties, as identified for other cold rolled carbon steels have been observed.

Galvanised steel sheets are produced either by electro-galvanising or hot-dip galvanising of cold rolled sheets (conventional or high strength steels), resulting in an additional zinc layer of 5-15 µm thickness on one or both sides.

Galvanised steel has excellent forming properties, paintability, weldability, and is suitable for fabrication by forming, pressing and bending. Applications include domestic applications, building applications (e.g. wall elements, roofing applications), automotive applications (e.g. body in white for vehicles, underbody auto parts), lighting fixtures, drums and various kinds of sections applications, profiled sheets, etc.

Galvanised steel sheets are most commonly available within the following dimensions:

Typical thickness ranges between 0.3 and 3 mm
Typical width ranges between 600 and 2100 mm

Further information

The steel materials e.g. galvanised steel sheets support existing legislation within the automotive industry such as:

- the EU Directive on End-of-life vehicles (2000/53/EC)
- ISO 22628 on calculation of road vehicle recyclability and recoverability
- the "Restriction of Hazardous Substances" (RoHS) Directive within the electronic industry is effectively fulfilled by steel products

All steel grades commonly used within the automotive industry are included within the International Material Data System (IMDS).

Eurofer has LCI data available for galvanised steel sheets and other steel products, together with the methodology report and advice on use of the data and product applications. Contact lca@eurofer.be or visit www.eurofer.org.

Further information relating to steel in the automotive industry can be obtained from the following locations:

- Steel applications in the automotive industry – www.worldautosteel.org
- Steel University - www.steeluniversity.org
- International Iron and Steel Institute, IISI - www.worldsteel.org.
- EUROFER - www.eurofer.org

References & used data

/1/ Thyssen Krupp Stahl
/2/ ULSAB: www.worldautosteel.org/ulsab/
/3/ Impact methodology CML 2001 based on Centre for Environmental Studies (CML), University of Leiden, 2001
/4/ Eberle, Franze: Modelling the use phase of passenger cars in LCI, SAE conference, 1998
/5/ IISI: www.worldsteel.org/
/6/ Eurofer: Steel Recycling, 2006
/7/ Eurofer: Annual Report, 2005
/8/ Office for National Statistics: The impact of UK households on the environment through direct & indirect generation of greenhouse gases, 2004.
/9/ LBP, University of Stuttgart, 2007
/10/ IISI: Energy use in the steel industry, 1998

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EUROFER
European Confederation of Iron and Steel Industries

European Confederation of Iron and Steel Industries
Avenue Ariane, 5 - E3
B-1200 Brussels
BELGIUM
Tel. +32 (2) 738 79 20
Fax +32 (2) 736 30 01
www.eurofer.org
eco-design@eurofer.be