the ARPRO® life cycle assessment

quantifiable and significant
environmental benefit

benefit twelve times impact

saves weight and so
reduces fuel consumption

ARPRO®
More than expanded polypropylene


quantifiable and significant
environmental benefit
benefit twelve times impact
saves weight and so
reduces fuel consumption

the ARPRO® LCA evaluates the environmental impact of the production, use and disposal of a typical ARPRO® seat-core

key findings

- Calculating a comparative global warming potential for the production of an ARPRO® seat core shows an environmental benefit to impact ratio of 12:1 :
  - The impact of the seat-core was equal to 21.9 kg CO_2(e)*.
  - The resultant fuel saving equated to 265.0 kg CO_2(e).
- If this saving is applied to the number of cars sold annually, an environmental saving of nearly 16 million tonnes of CO_2(e) could be achieved.
- Assuming a vehicle lifetime of 100,000km, just changing the seat can enable a net reduction in CO_2(e) of 2.65 g/km, over 13 per cent of the 2012 EU target reduction from 140 to 120 g/km CO_2(e).
- CO_2(e) savings result from the ability to deliver component weight reductions of up to 35 percent, achieved by replacing the heavy steel anti-submarining safety ramp with ARPRO®.
- ARPRO®'s mechanical properties enable the seat-core to be incorporated into the seating itself, replacing the traditional metal structure and contributing to a more flexible vehicle platform.
- In all of the environmental impact categories studied (except one), an environmental benefit (positive impact) is delivered. In the 'aquatic eco-toxicity' category, even the weight-saving capabilities of ARPRO® cannot overcome the environmental burden resulting from manufacture of the wireframe.
- The end-of-life stage of the seat-core impact is insignificant relative to other life cycle stages, even in the worst case (disposal). As ARPRO® is 100% recyclable there is further potential to reduce its environmental impact.

100% recyclable

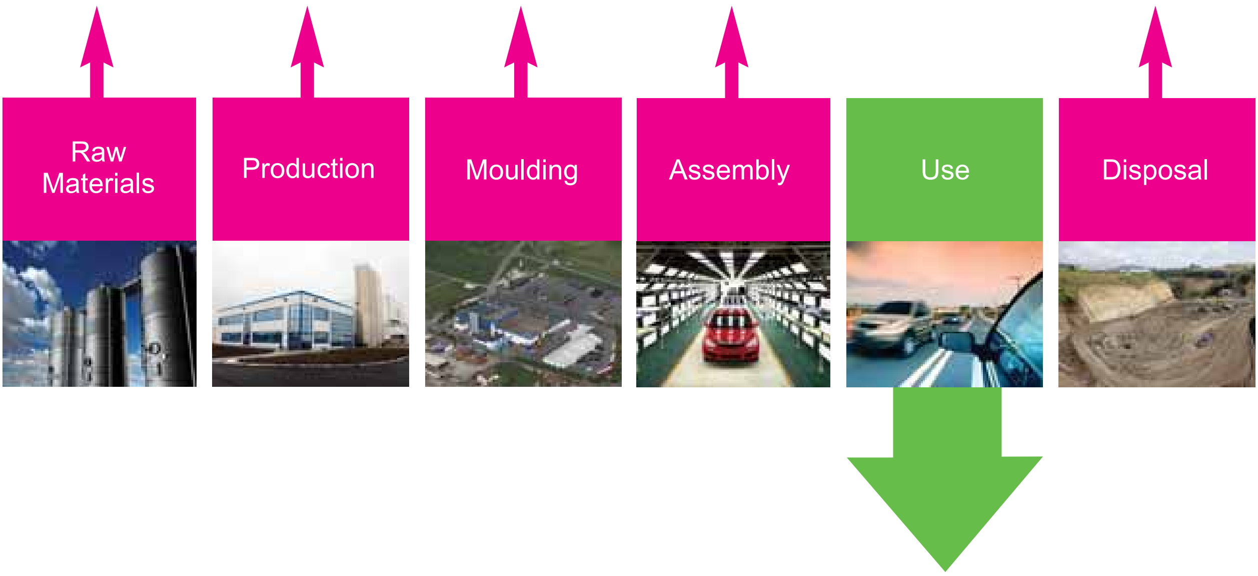
life cycle assessment

A life cycle assessment (also known as LCA, life cycle analysis, eco-balance study, and cradle-to-grave analysis) is the investigation and valuation of the environmental impacts of a given product or service.

As the focus on environmental performance intensifies, companies will be increasingly expected to demonstrate proven results for their products. To promote further use of the product and increase understanding of its environmental benefits, JSP has been pro-active in expediting a full life cycle assessment report for ARPRO®. Despite the focus of the automotive industry, few suppliers have taken such steps.

methodology

We have followed the internationally agreed procedure for performing a life cycle analysis, using the ISO 14040 environmental management standards. In order to be ISO-compliant the study requires an independently-managed, approved protocol to be followed and peer-reviewed by a second, independent life cycle assessment expert. This methodology is both rigorous and comprehensive.



life cycle assessment - an introduction

Life cycle assessment is the most widely recognised technique to assess the environmental impacts of a product or service. In the case of ARPRO®, this means assessment:

» From raw material supply,
» Through the point of use,
» To end of life (recycling or disposal)

Applied correctly, a life cycle assessment will improve environmental awareness and performance throughout the production chain, demonstrating where raw material, resource and energy consumption can be minimised as well as minimising disposal and management costs and eliminating environmental exposures and liabilities.

measuring
environmental impact

Results from each stage of production, use and end-of-life are reported for a range of categories. These measures are then quantified as equivalents of well-understood environmental impacts (see Appendix).

Both the environmental impact results for ARPRO® and the fuel savings created are proven, but the net benefit to the environment is actually greater than that stated. When using the ARPRO® seat-core, not only is fuel consumption and therefore CO_2 emission reduced, but by using the ARPRO® design rather than the traditional one, the steel construction and its associated production emissions are eliminated. Though these savings cannot be included in our calculation, it is worth noting the disproportionate environmental impact of the small amount of steel used in the wireframe of the ARPRO® seat-core, and that the amount of steel 'saved' is ten times the amount actually used.

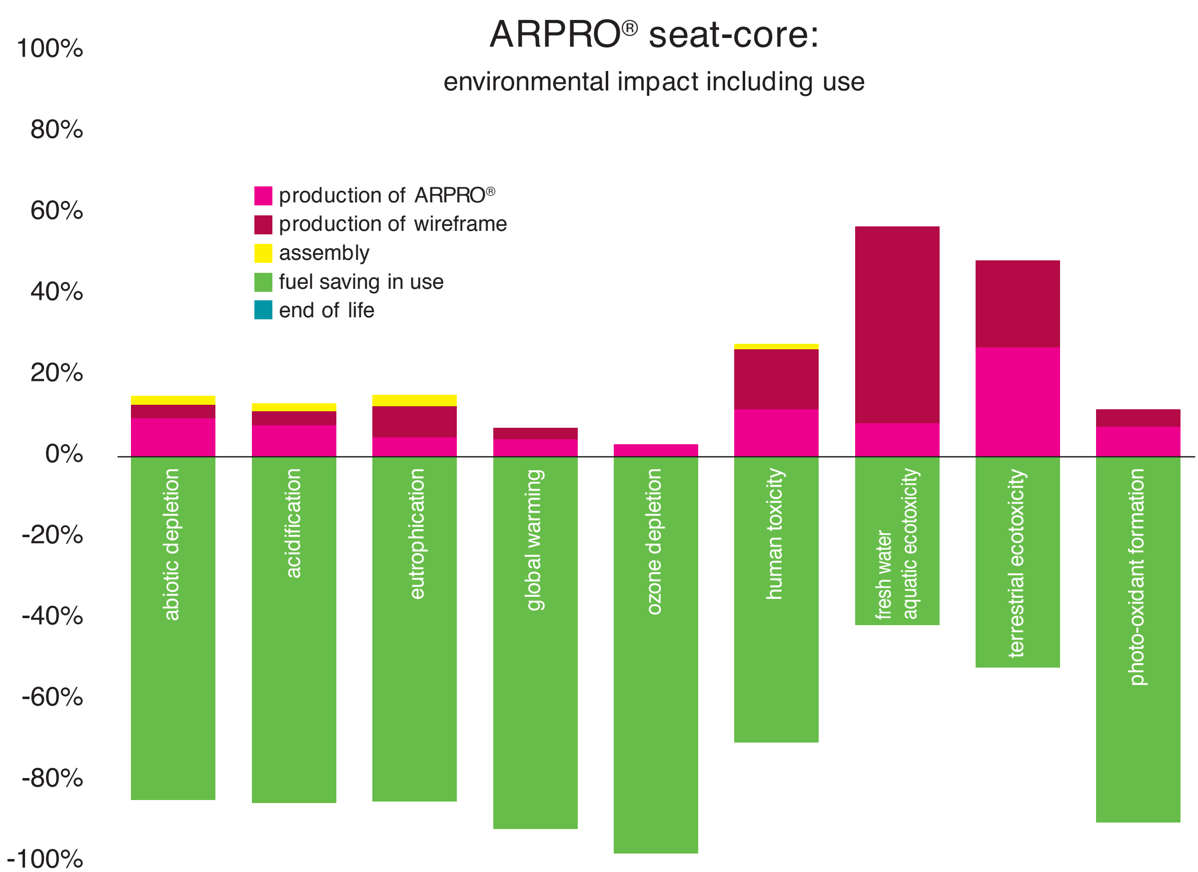


Fig. 1 results of ARPRO® seat-core LCA demonstrating positive impact

results of the life cycle analysis

The results of the impact assessment including use are displayed in Fig. 1. The ARPRO® LCA evaluates the resultant environmental impact of the production, use and disposal of a typical ARPRO® seat-core. The key findings of the report are:

- In all of the environmental impact categories studied (except one), an environmental benefit (positive impact, coloured green) is delivered. In this one category, even the weight-saving capabilities of ARPRO® cannot overcome the environmental burden required to manufacture the wireframe.
- Calculating a comparative CO_2 (global warming potential) figure for the production of an ARPRO® seat-core shows:
  - The impact of the seat-core was equal to 21.9 kg CO_2.
  - The resultant fuel saving equated to -265.0 kg CO_2.
- In the category, 'Global warming' the ARPRO® seat-core delivered an environmental benefit twelve times that of its impact.

environmental impact

summary

Almost all of the impact from ARPRO® production is the result of either ARPRO®'s raw material inputs or the moulding process. This is explained by the fact that the main material input for ARPRO® is polypropylene (propylene and therefore polypropylene is a product of "cracking" naptha - a derivative of crude oil and an energy-intensive process) and (steam-chest) moulding which requires generation of high pressure steam.

The contribution to the total potential impact of ARPRO® production (excluding material inputs and moulding) is therefore relatively small and electricity generation is responsible for the majority of the remaining potential impacts.

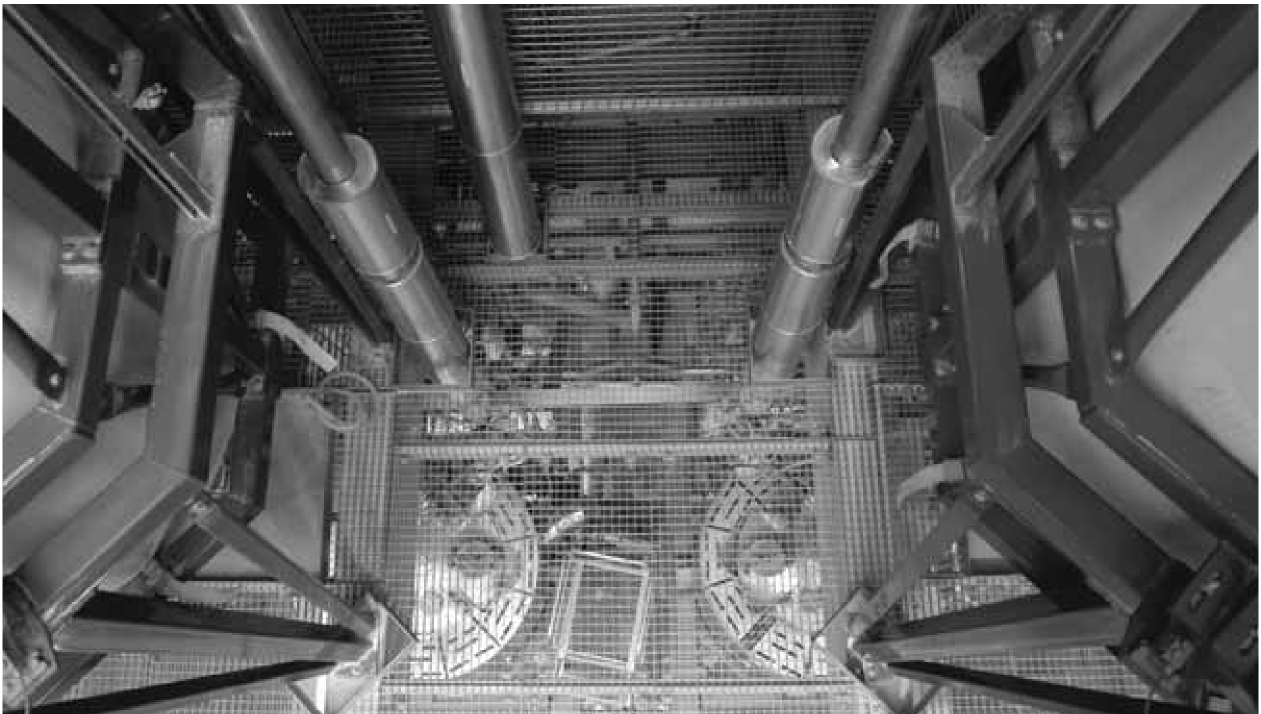
The CO_2 used in ARPRO® production is sourced from other manufacturing industries where CO_2 is a by-product and is therefore already a recovered product.

The impacts from the moulding phase are mainly due to the extraction and combustion of fuel and, to a lesser extent, the generation of electricity. Compared to actual ARPRO® production, the moulding phase is more energy intensive.

The wireframe production is responsible for the majority of the total potential environmental impact in the remaining three out of the nine impact categories presented. The production of steel and polyamide (a polymer coating on the steel frame) dominate the potential impacts of wireframe production in all categories. It should be remembered that the alternative design solution uses far more (more than 10 times more) steel.

The end of life stage of the seat core life cycle is insignificant relative to other life cycle stages. It should also be noted that ARPRO® is 100% recyclable.

100% recyclable



impact category	benefit/impact ratio
depletion of abiotic resources	4:1
acidification	6:1
eutrophication	5:1
global warming (climate change)	12:1
ozone depletion	39:1
human toxicity	2:1
fresh water aquatic ecotoxicity	1:1
terrestrial ecotoxicity	1:1
photo-oxidant formation	9:1

impact category	'real-world' description…
» depletion of abiotic resources	» using up the earth's resources
» acidification	» tendency to cause acid rain
» eutrophication	» specific chemical deposits to soil
» global warming (climate change)	» effect on rise in average temperatures, sea levels, etc.
» ozone depletion	» tendency to increase the size of the hole in the 'ozone layer'
» human toxicity	» adding to pollution that affects humans (air, water, food chain)
» fresh water aquatic ecotoxicity	» amount of water pollution
» terrestrial ecotoxicity	» amount of soil pollution
» photo-oxidant formation	» adding to smog levels

Note: Not all of these environmental impacts are of equal importance,but there is no way to compare them quantitatively.

environmental impact

results in more detail

ARPRO® LCA data is broken down in to distinct production phases and sources of environmental impacts to better explain some of the key findings and increase understanding of ARPRO®'s environmental performance.

ARPRO® production (driven by material inputs and moulding, see Fig. 2 on page 12) is responsible for the largest potential impact in the following categories: abiotic depletion, acidification, global warming, ozone depletion, terrestrial ecotoxicity and photo-oxidant formation. A reasonable result given that the seat is 'made of' ARPRO®.

Wireframe production is significant to all investigated potential impact categories however. It makes the largest contribution to the total potential impact on eutrophication, human toxicity and fresh water aquatic ecotoxicity.

The assembly stage makes a critical contribution to total potential impact on eutrophication and ozone depletion.

The end of life stage is insignificant to the total potential impact in all categories.

These results are then split further to report more detail on the different phases of the ARPRO® Seat-core production:

- ARPRO® production
- Seat-core wireframe production
- Seat-core assembly into vehicle
- End-of-life

While reviewing the results the relative importance of each phase should be considered. Please note for example the small impact of the end-of-life phase despite the worst case scenario being employed. In analysing the ARPRO® production in more detail, it is possible to determine the specific impacts of material inputs and the moulding phase.

100% recyclable

ARPRO® seat-core:

environmental impact by life cycle phase

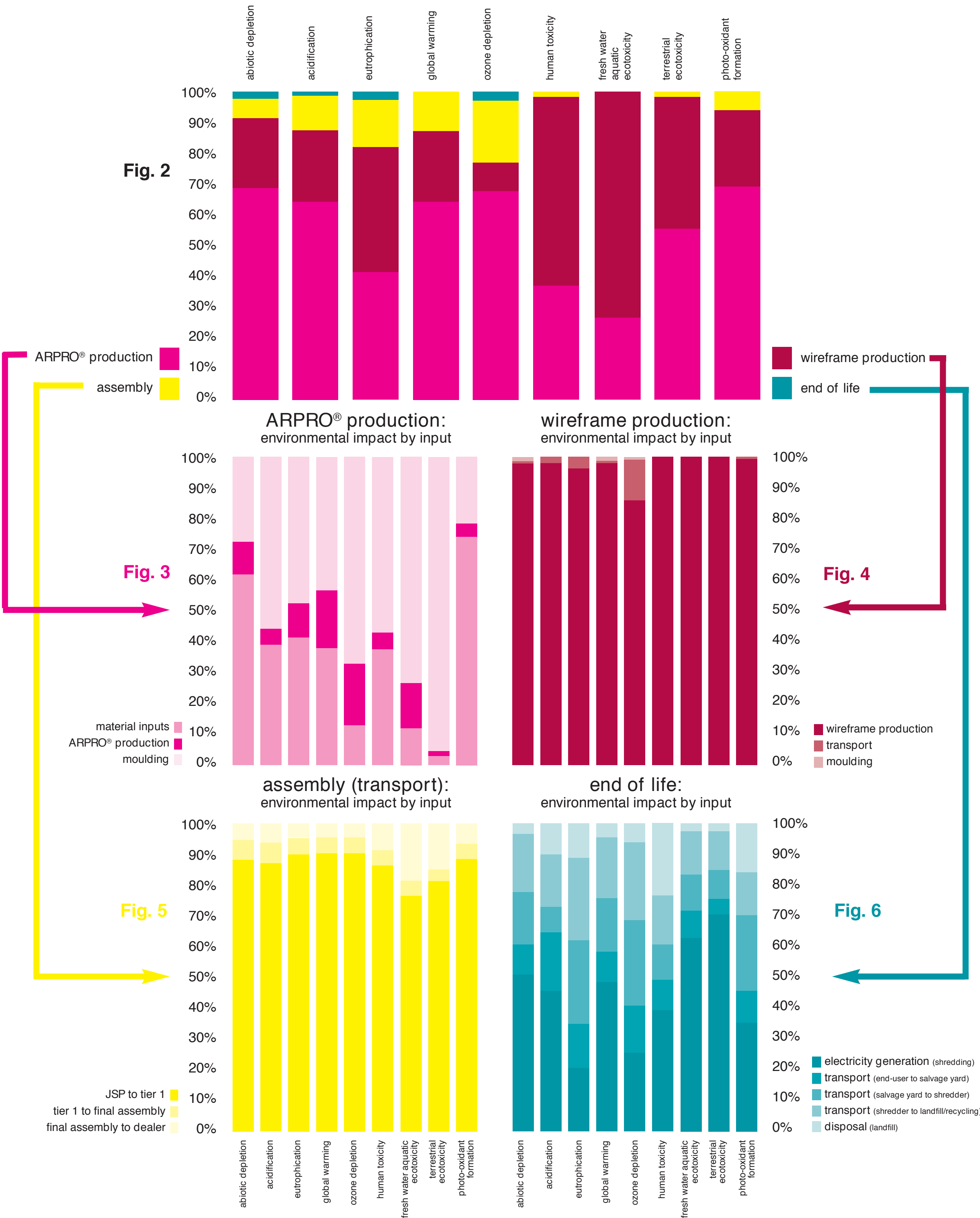


Fig. 3
Sources of environmental impact within ARPRO® production

The majority of the potential impacts of ARPRO® production on abiotic depletion and photo-oxidant formation can be attributed to material inputs (polypropylene). Material inputs are also the driver in terms of acidification, eutrophication, global warming, ozone depletion human toxicity and fresh water aquatic ecotoxicity.

Moulding is responsible for the majority of ARPRO® seat-core production potential impacts in all categories except abiotic depletion and photo-oxidant formation.

Compared to material inputs and moulding, the contribution of other manufacturing processes to total potential impacts is relatively small. Actual ARPRO® production impacts on fresh water aquatic ecotoxicity, global warming and ozone depletion due to the direct use CO_2 in the process. We believe the use of CO_2 currently provides the most environmentally advantageous mechanism across all available densities.

Fig. 4
Sources of environmental impact within wireframe production

The wireframe's steel production (though becoming increasingly efficient, is a hugely energy intensive process) is responsible for the majority of total impacts in all categories.

Coating production (for the wireframe) makes an important contribution to the following impact categories: abiotic depletion, acidification, eutrophication and photochemical oxidation.

Transport of raw materials to the production facility makes a small but important contribution to the total potential impact on ozone layer depletion.

Fig. 5
Sources of environmental impact within seat-core Assembly

The majority of potential impacts in all categories are associated with transport from moulder to Tier 1/Final Assembly plants and so the potential impacts in the assembly stage are predominantly from diesel production and emissions associated with combustion. The results use weighted averages of real production components and return 'typical' impact scores.

Fig. 6
Sources of environmental impact at end of life

Electricity generation for the shredding operation is responsible for the majority of total potential impact in the following categories: abiotic depletion, fresh water ecotoxicity and terrestrial ecotoxicity.

The transport stage includes the collection from the end user to salvage yard, from salvage yard to shredding operation, and from shredding operation to land filling/recycling. Diesel production and combustion generate the majority of the potential impact in the following categories: global warming, ozone depletion and photo-oxidant formation.

Landfill has an important potential impact in terms of eutrophication, human toxicity and photo-oxidant formation. Landfill is used as the measure in the ARPRO® LCA to provide a worst case score.

ARPRO® however is a 100% recyclable material, and as such offers a clear potential environmental benefit for use in seat-cores, for example, when vehicles reach the end of their useful life. This benefit is seen further when recycling products in accordance with the end-of-life vehicle (ELV) Regulations, as disassembly and sorting of mono-material ARPRO® parts is easier and more efficient. Efficient recycling of non-metallic parts will be increasingly required as the ELV Regulations require re-use and recovery targets to be increased from 85% to 95% by weight of vehicle.

Recycling ARPRO® at the end-of-life stage also further increases its positive environmental impact.

quantifiable and significant
environmental benefit

benefit twelve times impact

saves weight and so
reduces fuel consumption

about JSP

JSP is the world leader in the production and development of ARPRO® and its applications. An essential product for the automotive, packaging and consumer product industries, ARPRO® is a source of strength, durability and weight reduction. Designers and engineers use ARPRO® to stretch their imaginations to develop new and better solutions **www.arpro.com**. A truly global provider, JSP's application specialists help their customers increase competitive edge through the innovative use of ARPRO®. The company is quoted on the Tokyo Stock Exchange. **www.jsp.co**

about ERM

Environmental Resources Management (ERM) the independent consultancy that performed the ARPRO® Life Cycle Assessment is one of the world's leading providers of environmental consulting services. More information on ERM can be found at **www.erm.com**

appendix

environmental impact categories in more detail

global warming

Emissions of gasses such as carbon dioxide (CO_2), methane (CH_4), carbon monoxide (CO), nitrous oxide (N_2O) and sulphur hexafluoride (SF_6) increase the absorption of infra red-radiation scattered back from the surface of the earth and so increase the temperature of the atmosphere.

A 'unit of measurement', Global Warming Potential (GWP) has been developed by the IPCC (Intergovernmental Panel on Climate Change) and can be used to express the potential contribution of different gases to the greenhouse effect. GWP is a relative parameter that uses CO_2 as a reference gas. Characterisation factors are expressed as Global Warming Potential for a time horizon of 100 years (GWP100), in kg carbon dioxide-equivalents per kg emission.

Increasing global temperature may cause sea levels to rise and change the amount and pattern of precipitation. Other likely effects include increases in the intensity of extreme weather events, changes in agricultural yields, glacier retreat, species extinctions and increases in the range of diseases.

abiotic depletion

This impact category considers the proportion of the available resource (in years) for each abiotic raw material consumed by the activities in question and summing their contribution to depletion of known stocks, calculates a measure of total depletion in years. Raw materials extracted that contribute to resource depletion are aggregated according to their impact on resource depletion compared with reserves of the metallic element antimony (Sb) as a reference.

acidification

Acidification arises due to the deposition of acids that lead to:

(i) a decrease in pH
(ii) a decrease in the mineral content of soil
(iii) an increase in concentrations of potentially toxic elements in ground water

These effects are caused by acid rain and dry deposition to water and surfaces; caused by production of the associated gaseous pollutants sulphur dioxide (SO_2) and nitrogen oxides (NO_x).

Acidification Potential (AP) factors have been developed for potentially acidifying gases such as SO_2, NO_x, HCl, HF and NH_3. The AP of a substance is calculated on the basis of the number of hydrogen ions that can be produced per mole of a substance, using SO_2 as the reference substance.

Acid rain has been shown to have adverse impacts on forests, fresh water and soils, killing insect and aquatic life-forms.

photo-oxidant formation

Low level smog contains irritants that can adversely affect human health. Factors have been developed for emissions with photochemical oxidant formation potential (POCP) that contribute to the formation of photochemical oxidants (smog). The POCP is a measure of the capacity to form ozone in the lower atmosphere using ethylene as the reference substance. Impacts are expressed in kg ethylene (C_2H_4) equivalents.

Smog is especially harmful for senior citizens, children, and people with heart and lung conditions such as emphysema, bronchitis, and asthma. It can inflame breathing passages, decrease the lung capacity and cause shortness of breath. It can cause eye and nose irritation and interferes with the body's ability to fight infection, increasing susceptibility to illness

ozone depletion

Changes in stratospheric ozone will modify the amount of harmful ultraviolet radiation reaching the earth's surface with potential effects on human health. For emissions that contribute to the depletion of the ozone layer (e.g. chlorofluorocarbons), ozone depletion potentials (ODPs) have been calculated. ODPs use CFC-11 (or CCl_3F trichloroflouromethane – the first widely used refrigerant with the highest ozone depletion potential) as a reference substance (kg CFC-11 equivalent/ kg emission).

It is thought that consequences such as skin cancer, damage to plants, and reduction of plankton populations in the oceans may result from the increased UV exposure due to ozone depletion.

human toxicity

This impact category indicator represents the potential for the human body to be contaminated.

Outputs in this category include releases of metals to air and water, organic compounds to water, volatile organic compounds, nitrogen oxides, ammonia and sulphur dioxide.

Human Toxicity Potentials (HTP), are calculated. They describe fate, exposure and effects of toxic substances for an infinite time horizon. For each toxic substance HTPs are expressed as 1,4-dichlorobenzene equivalents per kg emission. 1,4-dichlorobenzene is used a pesticide and a deodorant, most famously in mothballs. It is poorly soluble in water, is not easily broken down and accumulates in fatty tissues. The International Agency for Research on Cancer (IARC) has determined that it may reasonably be considered a carcinogen, since animals given very high levels in water developed liver and kidney-tumours.

freshwater aquatic toxicity / terrestrial toxicity

The ecotoxicity scores represent the quantity of aquatic or terrestrial ecosystems potentially polluted to their maximum tolerable concentration. Outputs in this category include releases to water of metals, non metals and organic compounds.

eutrophication

This is caused by the addition of nutrients (e.g. NO_x, nitrates, phosphates and ammonia) to a soil or water system that leads to an increase in biomass. These substances are aggregated using nutrification potentials (NPs) which are a measure of the capacity to form biomass compared to phosphate ($PO_{4\text{-}3}$).

Changes in nutrient supply can dramatically affect 'primary productivity' (excessive plant growth and decay) causing a lack of oxygen and severe reductions in water quality for fish and other animal populations.

LCA report bibliography / sources

SETAC (1993) Society of Environmental Toxicology and Chemistry (SETAC): Guidelines for Life-Cycle Assessment: A "Code of Practice". From the SETAC Workshop held at Sesimbra, Portugal, 31 March - 3 April 1993. Edition 1, Brussels and Pensacola (Fl)

SETAC (2008): Hunkeler, D.; Lichtenvort, K.; Rebitzer, G. (Eds): Environmental Life Cycle Costing. SETAC, CRC Press, Boca Raton, Florida

Schmidt W-P and Butt F (2006) Life Cycle Tools within Ford of Europe's Product Sustainability Index International Journal of LCA 11 (5) p.315-322

Ecoinvent Life Cycle Inventory Database (Version 2) developed by the Swiss Centre for Life Cycle Inventories, Sweden.

European Parliament ELV Directive - An Assessment of Implementation by Member States

Jernkontorets Forskning (2007) Looking at Shredding Plant Configuration and its Performance for Developing Shredding Product Stream - An overview (Report JK 88011 2007-09-03 (ISSN 0280-249X))

ISO 14040 (2006) Environmental Management -- Life Cycle Assessment - Principles and Framework (Edition 2) International Standard Organisation

ISO 14044 (2006) Environmental Management -- Life Cycle Assessment - Requirements and Guidelines (Edition 1) International Standard Organisation

http://www.iso.org

Environment Agency statement on shredder residue (Issued 1 February 2005) http://www.environment-agency.gov.uk

http://www.jdpowerforecasting.com

http://www.vcacarfueldata.org.uk/

http://hdrstats.undp.org/countries/country_fact_sheets/cty_fs_GBR.html

http://dataservice.eea.europa.eu/PivotApp/pivot.aspx?pivotid=455

http://www.acea.be/images/uploads/ind/ind_0004.pdf

http://www.startipp.gr/automobiles-bayern.pdf

* CO_2(e) is a measure for describing how much global warming a given type and amount of greenhouse gas may cause, using the functionally equivalent amount or concentration of carbon dioxide (CO_2) as the reference

recycle

When you have finished with this publication please recycle it.
Recycling this publication means using less raw materials which in-turn helps the environment.

Invent
Inspire
Insist

ARPRO®

More than expanded polypropylene

ARPRO.com