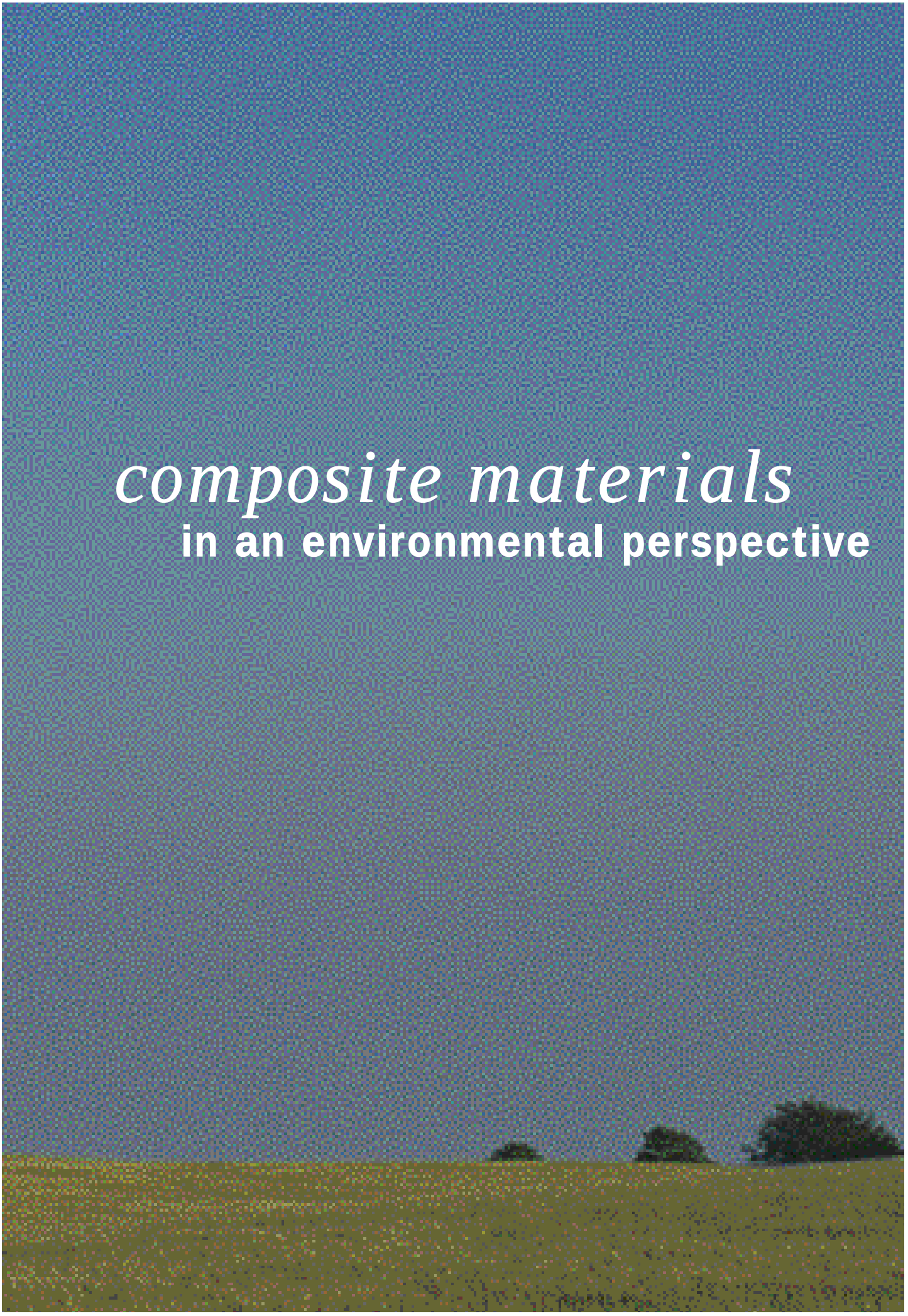
composite materials
in an environmental perspective



A study of the environmental impact of composites

Concern for the environment is an issue of increasing importance for our society. In order to assess the environmental impact of composites, a thorough study of the entire life cycle of the product was conducted. A comparison between propane cylinders made of aluminium, steel and composites showed that composites had the least burden on the environment. This was due mainly to their low weight in transports and the fact that composites have a long working life in corrosive environments.

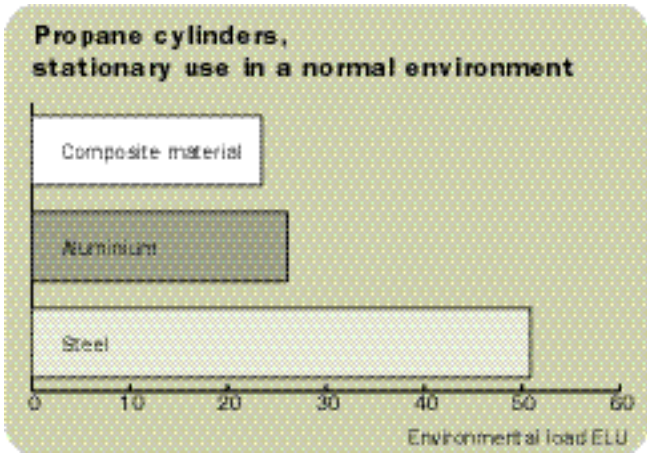
To gain a clear understanding of environmental impact of a product, it is necessary to view its entire life cycle, from the production of its raw materials until it is finally discarded.

Environmental work must be characterized by a holistic approach so that all relevant information is considered.

Life cycle assessment

Through life cycle assessment or analysis (LCA) we obtain quantitative values of a product's impact on the environment.

An LCA comparison of propane cylinders made of different materials conducted by the environmental consultancy ASSESS Ecostrategy Scandinavia AB emphasizes the importance of the holistic approach. All of the propane cylinders were used in the same way, but they differed with respect to weight, material and manufacturing methods. The environmental effects were apparent. The method used in the study, EPS, which stands for Environmental Priority Strategies in Product Design, has been developed within the Swedish Federation of Industries and is managed by CPM, Chalmers University of Technology. Results are given in the measurement unit ELU.



Strong, light products can be made from composite materials. When they are transported, or used in transport applications, the total environmental load is often considerably lower than that of corresponding heavier alternatives.

Because composites are corrosion-resistant, products made from them last longer.

Recycling of metals has a positive effect, since it partly compensates for the high environmental impact of virgin metal production.

The advantage of composite materials is that environmental impact from both their manufacture and use is normally low, which, from an environmental point of view, makes them a very good alternative.

Tools for assessing and minimizing environmental impact

We have long been accustomed to assessing and quantifying the costs, performance and quality of a product. Now there is also a need to assess and minimize its environmental impact.

One way of doing this is by means of life cycle analysis. There are several effective methods, one of which is EPS. EPS meets the requirements of ISO 14040 and is used in the environmental work of, among others, Volvo, e.g., for establishing environmental product declarations.

The method is based on calculations of impacts from the different phases:

- Production
- Use
- Scrapping and recycling

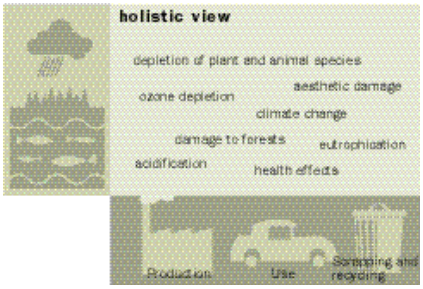
Each phase is subdivided into a number of separate activities and assigned an environmental load value according to the calculation principle:

Environmental load = Environmental load index x Quantity

Environmental load is expressed in ELU, Environmental Load Units.

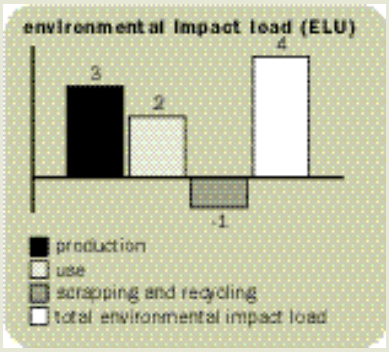
The index is a numerical value that corresponds to the degree of environmental load that a certain delimited activity is thought to cause, for example, the use of a specific raw material or consumption of specific energy resources.

The size of the environmental load index depends on how the so-called 'safeguard subjects' are influenced, see page 4.



Example

3.85 kg of fibreglass is used to manufacture a propane cylinder of composite material. The environmental load index for producing fibreglass is 0.185 ELU/kg. The total environmental impact load for the raw material, fibreglass, is thus: 3.85 x 0.185 = 0.712 ELU. In an LCA the environmental loads for all constituent materials, processes, handling, etc., for the different phases during the life cycle of the product are added together. In this way, a total environmental impact load value, expressed in ELU, is obtained.



LCA of propane cylinders

An LCA* has been conducted, the results of which are applicable in the design of propane cylinders with low environmental impact. Here, it is demonstrated how chosen material, method of use, length of working life and recycling influence the total environmental load.

The study includes comparisons of three material alternatives: steel, aluminium and composite material. Both stationary and mobile use have been compared, as well as use in a corrosive environment.

It is apparent that the weight and working life of the propane cylinders are the parameters that have the greatest influence on total environmental load. The low weight of composite cylinders and their long life in a corrosive environment explain why they generally display the lowest environmental load.

In a corrosive environment the life expectancy of the metal products is limited to 5 years, while the working life of composite vessels is still 30 years.

Recycling of metal cylinders is positive from an environmental point of view, but does not compensate for the heavy environmental load resulting from their manufacture and use.

	Stationary			Mobile		
Results, use in normal environment						
	Composite	Aluminium	Steel	Composite	Aluminium	Steel
Production	5.98	18.00	53.30	5.98	18.00	53.30
Use	17.40	19.80	53.00	35.00	39.60	98.30
Scrapping/recycling	0.09	-11.90	-39.40	0.09	-11.90	-39.40
Total	23.45	26.00	50.90	41.05	45.00	84.30
Results, use in corrosive environment						
	Composite	Aluminium	Steel	Composite	Aluminium	Steel
Production	5.98	108.00	320.00	5.98	108.00	320.00
Use	17.40	19.80	53.00	35.00	39.60	98.30
Scrapping/recycling	0.09	-70.90	-233.00	0.09	-70.90	-233.00
Total	23.45	56.90	140.00	41.05	76.90	173.30

The analysis shows that it is important to study the entire life cycle of a product in order to obtain all relevant environmental data. Merely considering recycling gives only a partial view, and can even be misleading. The study also demonstrates that composite materials offer significant advantages, in an environmental context, especially in applications in which their unique properties are used to full advantage.

International consensus for environmentally sustainable development

Based on discussions following the UN Earth Summit at Rio de Janeiro in 1992, five safeguard subjects have been defined. They are used as a basis for measuring environmental impact.

Bio-diversity	A greater diversity of species reduces the risk of serious disruptions in nature and its eco-systems.
Human health	Including physical and psychological well-being and freedom from disease and suffering.
Bio-productivity	Sustainable biological production of food and raw materials is necessary for our survival.
Resource consumption	The natural resources we use must also be available to coming generations.
Aesthetic values	Short-term economic gain must not be allowed to jeopardize cultural and recreational values.

Based on this and other considerations, the Swedish Government passed a bill to establish 15 National Environmental Quality Objectives in April 1999.

• Clean air • High-quality groundwater • Sustainable lakes and watercourses • Flourishing wetlands • A balanced marine environment, sustainable coastal areas and archipelagos • No eutrophication • Natural acidification only • Sustainable forests • A varied agricultural landscape • A magnificent mountain landscape • A good urban environment • A non-toxic environment • A safe radiation environment • A protective ozone layer • Limited influence on climate change

Extensive efforts are being made to set up international databases in which material, manufacturing processes, etc., are assigned environmental impact indices. For example, the impact on the five safeguard subjects caused by the production of 1 kg of steel of a given quality can be quantified according to these indices. Corresponding values are available for composite materials.

Composite materials

Composite materials, or fibre-reinforced plastics, are light and strong materials that withstand damp and corrosive environments better than many other materials. Boats are one of the most common applications.

Photo: Ryds Båtindustrier

In leisure-craft, fibreglass and polyester are normally used. Fibreglass is the most widely used reinforcement material in composite products. Other fibres including carbon and aramide fibres are also used, particularly in applications demanding a high degree of rigidity in relation to weight. Examples of such applications can be found in the aviation industry and, more and more, in the manufacture of sports equipment. Golf club shafts, fishing rods and rackets are just a few common products in which the unique properties of high-performance composites are utilized.

Polyester is the most common plastic, or "matrix", and its purpose is to bind the fibres together to form a dense structure. Other common matrix materials are vinylester, epoxy and polyurethane.

- Low weight
- Corrosion-resistance
- Long life
- High specific rigidity
- High specific strength
- Fatigue resistance

The demand for lighter, stronger components is increasing in many sectors.

The automotive industry is looking for new ways to build light, fuel-efficient cars. Composite materials are an alternative for producing light, corrosion-resistant products that have a longer working life.

The composites industry is advancing all the time. New grades of fibres and matrix materials are being introduced, manufacturing processes are being developed and optimized. In product development, it is important to choose concepts that are both technically and commercially viable. Now, more than ever before, greater emphasis is placed on environmentally advantageous solutions. If a holistic approach with life cycle assessment is adopted, composite materials will take on an even more important role in the future. Analyses conducted in the vehicle sector, on entire vehicle concepts, as well as on many components, point clearly in this direction.

* The study was conducted in 1999 within the framework of the programme Composite Industries in Collaboration. Participants in the project include the following companies: ABB Plast AB, APC Composit AB, Composite Scandinavia AB, Glasfiberprodukter i Trehörningsjö AB, Skellefteå Plastcisterner AB, SQS System AB, Sandström Innovation AB, SICOMP AB. Information about the manufacture and use of propane cylinders (fibre composite cylinders) has been provided mainly by Composite Scandinavia AB. This brochure has been produced in consultation with ASSESS Ecostrategy Scandinavia AB.
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