Comprehensive View of Environmental Impact

Since the early 1990s, businesses have increasingly shaped their environmental efforts and reports with reference to product life cycles. In many cases, studies involving formal life-cycle assessment (LCA) have been carried out. In SAS to date, LCA has been applied to the choice of inflight disposable and reusable crockery and of seat covers. But what, in fact, is LCA? What is its purpose, what forms can it take, and in which direction is it developing? We requested an overview from one of the international authorities in the area.

BY LARS-GUNNAR LINDFORS

Does anyone remember the washable-diaper wave a few years ago? Environmentally aware parents, reluctant to add to the garbage mountain by using some 5,000 disposable diapers per child, sought to act responsibly toward the environment by opting for washable, cloth diapers instead.

Why is this outstanding example of environmental work at grassroots level no longer discussed? It is because life-cycle assessment eventually showed that the washable diapers cause at least as heavy an overall impact on the environment as disposable ones, owing to aggregate use of electricity, water and washing-machine detergent.

Life-cycle assessment is based on a comprehensive view of the environmental impact of products or services. As opposed to the former exclusive focus on manufacture, products are now examined "from the cradle to the grave" – from raw materials to garbage dump or recycling plant *(Fig. A, p. 29)*.

Even by the early 1990s, few Scandinavians had come across "LCA". The term is still relatively unfamiliar to the general public. But in the business sector, especially manufacturing industry, LCA is now a well-established concept that has generated many different applications – especially in conjunction with various instruments of environmental management.

References to LCA in the U.S. often concern the need to make the life-cycle approach universal in the industrial sector. In Europe we regard this approach as already broadly established, and in referring to LCA we mean a specific set of tools, rather than a general philosophy.

The basic idea of LCA dates back more than 25 years. Back in the first half of the 1970s, cradle-to-grave analyses of energy flows were being carried out in the U.S. Owing to the energy crises of that time, interest was focused solely on total energy use. Emissions of various kinds were regarded as irrelevant, and interest in energy-flow analyses soon waned as well.

After a decade on the shelf, however, the idea was dusted off in the mid-1980s and its development gathered momentum. This culminated in what we nowadays associate with LCA: a method of gauging environmental impact and resource consumption from raw-material extraction through production, use and ultimate disposal as waste, including all transportation and other logistic flows. One factor contributing heavily to this revival of interest was the growing role attributed to the market – usually in the form of consumers – as the driving force in environmental matters. And since consumers were assumed to hold the view that the use of a product and its disposal as waste very often cause more impact on the environment than the emissions from plants where it is manufactured, designing products in such a way as to reduce environmental impact throughout their life cycles began to be deemed important. Industry, in particular, therefore needed an instrument for describing the overall environmental impacts of its products and the distribution of these impacts over their life cycles.

Initially, this descriptive instrument was applied mainly to short-lived consumer products. Many people regarded packaging, for example, as an unnecessary contribution to the garbage mountain. Tetra Pak, one the world's biggest manufacturers of disposable cartons for the food industry, carried out quasi-LCA studies in the early 1980s to help focus discussion on the environmental characteristics of entire packaging systems. Such comparisons show that the choice between disposable and reusable packaging is not always self-evident. Not only does disposable packaging often require less transportation than the reusable kind, but its energy content can sometimes be recovered or its materials recycled.

Today, LCA is under way for virtually all types of product and service, including those with a very long life, e.g. as systems of electricity production and transportation, roads and real estate.

COMPARISON OF USES

Everyday references to life-cycle assessment as pertaining to individual products are, in fact, incorrect. Using current LCA methods, it is seldom possible to compare

Contd. p. 29 ►

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Market Demands and Framework of Aviation Policy

The framework for SAS's environmental efforts is defined not only by the market and the company's own goals, but also by government agencies and civil aviation bodies. How this framework is defined may determine our further development. We are therefore active in the various national and international forums engaged in discussing constraints on aviation.

Current forecasts for global economic growth in the years ahead show an expected rise in demand for air travel averaging 4–5% p.a. In certain regions, e.g. the Pacific, the annual increase in traffic may even amount to nearly 10%. For the airline industry to meet this demand, both more aircraft and enlarged airport capacity are needed.

However, this kind of expansion cannot take place without reference to another global trend: the growing intensity of environmental efforts. Increasing public environmental awareness has, above all in the past decade, obliged the business sector and public agencies alike to reduce their overall environmental impact. In the business sector, as a result, environmental hazards are now regarded as a self-evident part of owners' and investors' total risk; the financial market is, in its valuation work, showing ever keener interest in companies' environmental status; and environmental parameters have become natural key statistics in e.g. insurance and risk management.

All in all, this means that the airline industry is being allowed to expand only if it does so within the framework of international endeavors to achieve more sustainable development. Data for SAS and other carriers show clearly that our biggest environmental impact is that exerted in our core business – aviation operations. If we want to make expansion possible, we must therefore continue – in cooperation with aircraft manufacturers – to develop technology that is both environmentally sound and cost-effective. Other forms of collaboration, too, may help to reduce the environmental impact of aviation. Cooperation with government agencies to develop and improve the efficiency of air-traffic control up to the level permitted by modern navigation technology, one benefit being shorter flight routes, is one example.

On the one hand, then, the airline industry's environmental work is propelled partly by forces of sheer market economics, and governed by both individual companies' own ambitions and joint agreements in the industry's international associations. On the other, the preconditions for companies' environmental efforts also include politically imposed requirements from national agencies and international bodies. It is important for these framework conditions arising from transportation policy to be so designed as to collaborate with the forces of market economics.

Creating business incentives for airlines to invest in environmental modification of their aircraft fleets also means giving aircraft manufacturers incentives to invest in the requisite technological development.

two products fairly. Most LCAs therefore compare not different products, but different alternative ways of fulfilling a particular function or providing some specific benefit. In comparing different paints, for example, one investigates what is required to cover a square meter of wall for ten years. The comparison takes into account the varying

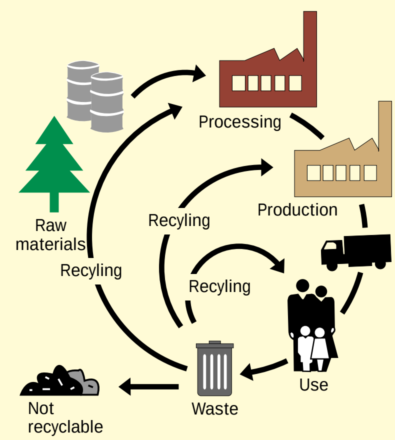


***FIG. A:* LIFE-CYCLE ASSESSMENT – A "CRADLE-TO-GRAVE" APPROACH**
The environmental impact of a product or service is exerted not only during the consumption phase. By studying the whole life cycle, from raw-material extraction to waste management, a company obtains a basis for applying resources to reduce environmental impact where they yield most effect.

quantities of paint that may be needed to cover the surface, and also the variable durability of the painted surface.

Function as the basis for comparisons is one of the strict, original requirements imposed on an LCA. The other is that all activities – from cradle to grave – required to fulfill the function must be included. However, the depth or degree of detail of the analysis is not stipulated, as long as the entire system is included. An LCA is a simplified model of a real-life phenomenon that is usually highly complex, and it is a matter of finding a balance between clarity and thoroughness (Fig. B, p. 31).

Each study is therefore valid only for the particular issue studied, i.e. is a "case study". Far-reaching, general conclusions may seldom be drawn, as they unfortunately still are. Liberal general-

Contd. p. 31

Noise charges are a reasonable means of covering an airport's costs of reducing noise problems, but they must then be earmarked and also related to aircraft's noise characteristics.

SAS GUIDELINES

SAS is, of course, actively engaged in developing this framework. As a starting point, we have drawn up an internal policy with a number of guidelines to which we wish future environmental regulations to conform. There are two paramount considerations that, in our view, should influence the regulations.

■ First, aviation is a capital-intensive business that requires long-term planning in order for the often heavy investments involved to provide satisfactory returns. For an aircraft manufacturer, developing an entirely new airplane costs in the region of 30–50 billion SEK. The manufacturer must therefore find buyers for 400-500 units in order for a new aircraft model to be profitable. An airline's purchase cost of e.g. ten medium-haul jets is in the order of 3–4 billion SEK, which means that a service life of at least 20-25 years for new aircraft is required. *The instruments of transportation policy must therefore also be so designed as to be predictable in the long term*.

■ Secondly, aviation is an international business that causes not only local, but both global and regional environmental impacts. *The instruments selected must therefore be competitively neutral and impose obligations across national borders*, in order to have any beneficial effect on the environment. Otherwise, the consequence would be that airlines in countries that apply stringent environmental requirements lose market shares to carriers in countries imposing less strict laws; thus, airlines with ambitious environmental programs would be deprived of the chance to obtain a return on their investments that would permit them to continue investing in environmentally sounder technology.

One example of predictable regulation with international effect is the phase-out of Chapter II aircraft in the EU by the year 2002. On the other hand, local noise charges introduced from one year to the next, often based on varying criteria, have only a limited environmental effect.

Basically, there are two kinds of instrument for further reducing energy use and environmental impact in aviation: 1) regulations/agreements and 2) taxes/charges. It seems clear that the trend – both in Scandinavia and throughout the EU – is toward increased utilization of taxes and charges. SAS's view, however, is that the present-day tax and charge systems entail a number of grave weaknesses:

■ Taxes and charges are often introduced at very short notice, and do not afford the airlines reasonable scope for adapting their fleet plans.

■ Since taxes and charges are not internationally harmonized, they may cause environmental problems to be "exported" to other countries and airports.

■ Taxes and charges levied are difficult to relate to environmental effects attained, since different countries apply different methods of classifying aircraft's environmental characteristics.

■ Taxes and charges may counteract their own environmental purpose, in that they may weaken an airline financially so that it has even more difficulty in defraying the heavy costs of environmentally modifying its fleet.

■ A larger increase in the overall pressure of taxes and charges in Scandinavia than in competing countries will sharply reduce SAS's capacity to compete internationally.

SAS therefore wishes to work for a shift toward *negotiated environmental agreements* and/or *long-term international environmental regulations* to supplement environmental taxes and charges.

To the extent that taxes and charges are nonetheless used for environmental purposes, the paramount consideration in our view is that the tax and charge systems should reward airlines that invest in a better environment. Accordingly, the systems must be harmonized internationally, and here in Scandinavia they must be based on a redistribution of – not a rise in – the overall burden of taxes and charges. In addition, the systems must be measured and documented to ensure that the environmental control aimed for is genuinely attained.

WORK IN PROGRESS

In broad outline, SAS's picture of reality is described above. What, then, is the nature of current development?

The EU has raised the subject of the "internalization principle" for discussion. This means that indirect social costs due to environmental impact – through e.g. infrastructure development, business operations and accidents – are to be quantified and, to a larger extent, paid for by those who cause them. Many present-day landing fees in aviation are based on this principle.

In the long run, comparisons between different modes of transportation are also required, so that the size of environmental charges imposed on each mode can be brought into line with its real environmental impact. Today, aviation is the only public mode of transportation that defrays its entire infrastructure and its own indirect costs by paying traffic charges and fees for use of facilities. Analyses carried out by the Norwegian Institute of Transport Economics show that aviation pays 120% of its own social costs, while gasoline-powered vehicles pay only 90% and other modes of transportation pay an even smaller share of their real social costs. This is one of the main arguments underlying the request from AEA's Assembly of Presidents to the EU in 1996 to carry out an objective survey of the utility, energy use and environmental impact of the various modes of transportation.

SAS respects the social endeavor to implement the "polluter-pays principle" – the principle that those who cause an environmental problem should pay for it to be remedied is, of course, correct – but emphasizes that, in discussing the environmental impact of aviation, it is important to distinguish between two categories. Noise is a *local* impact in the vicinity of airports, while emissions from fossil fuel are a *regional and global* environmental problem. This distinction must be reflected in the regulation and control of these phenomena.

Regarding noise, it is primarily European countries that have introduced noise-related landing fees as instruments of environmental control. Such charges cannot be imposed on a standardized national basis, since noise is a local problem around airports. Instead, they are of two kinds:

■ At several European airports – notably in Norway, The Netherlands, France and Switzerland – SAS pays *direct noise charges*. SAS's view is that these are reasonable in cases where an airport incurs direct costs for reducing noise problems, but they should then be clearly related to aircraft's noise characteristics and also earmarked for special noise-reducing measures.

■ Especially in Germany and Sweden, but also in the United Kingdom, The Netherlands, France, Belgium and Switzerland, airports also apply *noise-differentiated landing fees*, i.e. higher landing fees for noisier aircraft. These do not boost the airport's total income but, rather, redistribute it in such a way that airlines with older fleets have to pay more than those with more modern fleets. The purpose is to constitute an incentive for airlines to replace old aircraft. But it has not yet been possible to demonstrate that these fees, imposed at short notice, have accelerated airlines' replacement of old aircraft. The major environmental improvements achieved in civil

izations of this kind were one reason why, in the early 1990s, LCA was called in question. Different users were able to design their analyses quite freely, and different analyses of what was basically the same topic therefore yielded contradictory results. Given also the tendency to interpret LCA findings as more generally applicable than they actually were, the criticism is readily understandable.

Today, LCA methods are highly harmonized, especially thanks to the work carried out in the interdisciplinary European-American organization SETAC and ISO's ongoing work on standards for tools of environmental management (the ISO 14000 series, which also includes standardization of LCA methods). Another important contribution was made by the Nordic Council of Ministers' 1995 Nordic Guidelines on Life-Cycle Assessment, a set of recommendations that has gained broad international acceptance and influenced the work of ISO (Fig. C, p. 33).

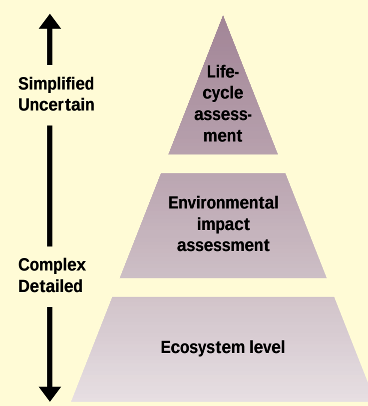


***FIG. B:* OBTAINING AN OVERVIEW**
Detailed analysis of the environmental impact of an activity at ecosystem level would require such large-scale resources that few could implement it. Simpler and more widely applicable analysis, even at the cost of more uncertain results, is preferable.

NUMEROUS EXAMPLES

Today, LCA is used mainly as an independent instrument in contexts where a comprehensive approach is important. In the near future, LCA will probably also come to be used as the basis for other

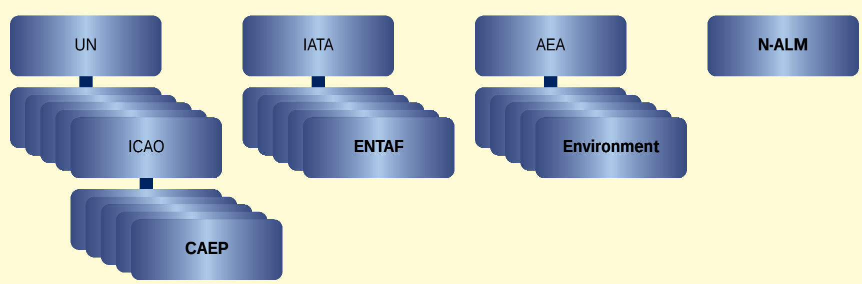
Contd. p. 33

aviation to date have, instead, been attained mainly by means of official requirements with long-term effects, i.e. compulsory certification and phase-out of aircraft. Moreover, the development of increasingly efficient and silent engines in the endeavor to attain better overall economy has also resulted in improved environmental performance (see p. 38).

Regarding emissions, environmental charges cannot be levied at an airport since local emissions around an airport are a minor problem. The EU has drawn up a proposal for a joint CO_2 tax, and is currently working on a system of levying excise duty on all forms of energy that would be acceptable to all its member states. At present the "mineral-oil directive" – e.g. preventing individual member states from levying excise duties based on fuel used in commercial air transportation – is in force. Excise duties of this kind would not constitute any incentive for the airline industry to develop techniques of reducing CO_2 emissions per volume unit of fuel consumed. Instead, they would merely distort international competition to the disadvantage of carriers in countries applying these excise taxes. The Union's current work includes a proposal for amending the mineral-oil directive to permit environmental charges on jet fuel, provided the directive can otherwise be made competitively neutral. This is also an issue affected by the scope for amending existing agreements between ICAO members.

SAS deems it essential for such regulation and/or imposition of charges to be based on a *comprehensive approach* and have *international application*, in order to prevent distortion of competition either within the aviation sector or between aviation and other modes of transportation. The latter means that if a certain form of energy produced by fossil-fuel combustion – in our case jet fuel – becomes subject to environmental charges, the same should apply to electrical power produced by combustion of oil, coal or gas, and also to energy generated by means of hydropower and nuclear power. After all, all energy sources entail various kinds of environmental impact, environmental hazards and waste problems.

FIG. 1: SAS'S INTERNATIONAL COOPERATION



SAS is actively engaged in several international environmental forums.

CHANNELS OF PRESSURE

In SAS's objectives for 1996, emphasis was laid on strengthening proactive cooperation within the industry and with government agencies so as to create a more efficient framework for competitively neutral environmental control of aviation. We are pursuing this goal in the following industry-wide, national and international forums.

International

■ ICAO The *International Civil Aviation Organization*, has general responsibility in the U.N. for issues relating to air transportation, and is the organization that develops standards and recommendations for civil aviation. Within ICAO, there is a technical committee with the task of developing and establishing regulations and recommending measures to reduce the environmental impact of aviation. This *Committee on Aviation Environmental Protection* (CAEP) consists of 15 members, who are experts nominated by ICAO member states (including Sweden), and four observers – from the aircraft and engine manufacturing industry, the airports, the EU and airlines respectively. The airlines are represented by the International Air Transport Association (IATA), and since the end of the 1980s SAS has taken part as an IATA representative.

CAEP has four subject-area working groups (Noise, Airports, Emissions, and Economic Analysis & Coordination), in which the committee members and observers carry out the work. The work programs normally run for 4–5 years, and at the end of each such period the members and observers convene for a meeting to decide on any measures and recommendations. Two working groups are charged with assessing requisite measures, taking stock of technically feasible options and calculating the potential costs of further reducing the environmental impact of noise and atmospheric emissions. The principal issue during the current working period has been that of tightening up certification standards for new aircraft and engines. Land-use planning around airports to protect residents from unacceptable noise has also been discussed.

CAEP/2 (the second formal meeting), held in 1991, decided to make the certification requirement for nitrogen oxides (NO_x) 20% more stringent. Since all newly manufactured and planned new engines meet the old standard with a margin exceeding 20%, this new limit was in practice already complied with. For the CAEP/3 meeting in December 1995, there was a proposal to raise NO_x limits by a further 16%, but no unanimous decision could be reached. ICAO therefore opted to consult all its member states on the issue, which is expected to be settled in 1997. Regarding the need and scope for tightening up noise-certification standards over and above the present Chapter III, CAEP/3 entirely failed to reach an agreement.

The next CAEP meeting is expected to take place at the end of 1997 or in 1998. Meanwhile, the four working groups continue to work in their respective areas of concern.

■ IATA The *International Air Transport Association*, organizes 254 carriers throughout the world, and participates in CAEP as an observer. In IATA there is a working group that concentrates particularly on environmental issues, the Environmental Task Force (ENTAF). Since the end of the 1980s, SAS's member of ENTAF has also represented IATA in CAEP's working groups. In 1996, SAS was also involved in developing an IATA policy on environmental charges on noise, and this policy largely coincides with the standpoint SAS has described above. Through its work in IATA ENTAF and ICAO CAEP, SAS can contribute Scandinavian experience to international environmental efforts and, at the same time, stay well informed about current environmental problems and measures.

■ AEA The *Association of European Airlines*, has special responsibility for monitoring environment-related aviation issues that arise in Europe and, in particular, the initiatives taken by the EU, e.g. the directive prohibiting Chapter II aircraft as of 1 April 2002, and the ongoing work of developing a joint Union CO_2 tax. AEA also has an environment working group, to which SAS belongs. This group monitors development in Europe in particular, and coordinates and safeguards the European airlines' interests in environmental matters.

■ N-ALM The *Nordic Working Group for Environmental Issues in Aviation*, was established in 1991. It consists of representatives of the Nordic civil aviation administrations, ministries of transportation and communications, ministries of the environment and environmental protection agencies; Copenhagen Airport (which, unlike other airports in Scandinavia, is not owned by the national civil aviation administration but is, instead, an independent corporation); and Finnair and SAS (other carriers have been invited but have refrained from participating, as has Iceland).

N-ALM's main functions are to inform the Nordic government agencies on current issues and to coordinate them in conjunction with international conferences and meetings. Thanks to substantial unity in the Nordic area, N-ALM's coordination gives Nordic views a higher international profile.

■ ICC The International Chamber of Commerce: SAS has undertaken to develop its environmental work and measures in accordance with ICC's 16 principles of environmentally aware leadership, and is represented in ICC's Swedish section.

National

■ Norway SAS belongs to the reference group for the environment within the framework of the Civil Aviation Administration's long-term plan, and discusses future environmental regulation of civil aviation with the Ministry of the Environment.

■ Sweden SAS belongs to the Civil Aviation Administration's working group for charges relating to noise and emissions (BARLA), which is listing alternative environmental regulations and charges to supersede the environmental tax on domestic air traffic that was abolished on January 1, 1997.

Industry cooperation

■ Partners' Forum Environmental collaboration with our partners (Lufthansa, THAI, United Airlines, Air Canada and Varig) has taken place since 1996 in a partners' forum for environmental issues. South African Airways is also taking part. At the statutory meetings in Frankfurt in May and June, the decision was taken to embark on work to develop joint key environmental statistics, and also to inventory potential synergic effects, e.g. development of environmentally sounder concepts for cabin operations, the purchase and operation of joint equipment for ground operations, and coordinated engine maintenance. Both Lufthansa and SAS are in the same phase of evaluating the option of endorsing an international standard for environmental management and auditing.

■ Suppliers In cooperating with various suppliers, SAS has ample opportunities of influencing its own environmental impact, especially in ordering new aircraft. By ordering the Boeing 737-600, we actively encouraged development of the new engine technology relating to the double annular combuster (DAC), which reduces formation of nitrogen oxides (NOx); and in ordering the McDonnell Douglas MD-90 our noise criteria were central in the procurement. In our purchases for cabin and ground operations, too, SAS's environmental criteria determine final environmental impact, especially of waste management.

environmental tools, e.g. as documentation for environmental labeling. The key environmental statistics and the methods currently being developed to label products and services in terms of their environmental profile differ from, for example, the Nordic "Swan" label. Instead, they amount to a complete and objective quantitative statement on all the environmental characteristics of a product, with no opinions expressed on whether these are good or bad – like nutrient declarations for food.

Let us now take a closer look at how LCA has mainly been used to date (Fig. D). The greatest strength of LCA is as a means of distinguishing between major and minor phenomena. This may be a matter of identifying the type of environmental impact that one can modify through choice of option, thereby also

Contd. p. 35

***FIG. C:* FROM A TO Z**
The work of SETAC, and subsequently ISO, has laid down a defined structure for LCA methods. This involves dividing LCA into four main stages:
- **Objectives and scope of the study** Description of objectives, purpose, scope and limitations.
- **Inventory analysis** Analysis of material and energy flows in the systems studied. The inventory summarizes all material flows, e.g. raw materials, products, waste and emissions to air and water.
- **Environmental impact assessment** This also includes resource use, and is divided into three subsidiary stages:
  – classification of resources and outward flows into impact categories
  – characterization (quantitative or qualitative) of contributions to each category
  – valuation (i.e. use of valuation methods) of the contributions from various categories, which are weighted to attain an estimate of total impact.
- **Interpretation of results** Results from the foregoing stages are interpreted in relation to the objectives of the study, taking uncertain and limiting factors into account.

The inventory analysis and the two first subsidiary stages of the environmental impact assessment are regarded, broadly speaking, as scientifically based elements. The objectives and scale of the study necessarily include subjective elements as well, and the valuation contains political and ethical considerations.

For an analysis to be correctly termed "LCA", it must include both classification and characterization. Some studies are confined to inventory analysis, possibly also including classification, and are then termed "life-cycle inventory" (LCI).

How Can a Flying Restaurant Spare The Environment?

By far the greater part of an airline's environmental impact is exerted by the aircraft's fuel consumption, emissions and noise. This does not mean that other parts of the business may be neglected in environmental work. The cabin operations involve extensive service work, including food production and disposal of waste. This must, obviously, be designed to spare the environment as well.

With several hours' flying ahead, you can take a drink and read the newspaper in peace before the meal is served. On the tray are a tempting small scampi kebab, an attractively grilled chicken breast with fresh vegetables, and a delicious fruit dessert – all agreeably arranged, and accompanied by warm bread and your favorite drink. Last come the coffee and liqueur. Then you ask for a blanket, lean back and relax until the plane lands.

Altogether, you will have come into contact with some 40 different disposable and reusable products. But to give you this service – adapted to your wishes and destination, the timing of your trip and your ticket type – SAS has purchased some 4,600 different products and services from over 600 different suppliers, and 3,500 people have been involved in large-scale development, preparation and production work. Some have designed the cutlery, crockery and food boxes. Others have designed the packaging, e.g. butter packets, jam pots and fruit-juice cartons. Culinary artists have prepared various menus and dishes that have then been prepared in the flight kitchen for further transportation out to the aircraft, where they have been stowed in the cabin kitchen. Finally, the flight personnel have placed the hot food, straight out of the oven in the cabin kitchen, on the prelaid trays and rolled the specially designed tray trolley into the aisle to serve the meal.

The people responsible for selecting the materials used and how they are disposed of subsequently are, to say the least, engaged in a challenging task.

RAW-MATERIAL CONSUMPTION AND WASTE MANAGEMENT

Many products and foods are packaged in plastic, aluminum, cardboard or paper. The reasons fall into three categories: hygienic, practical and aesthetic. In some cases, none of these reasons weighs more heavily than concern for the environment, and passengers who have queried the existence of packaging in these cases are quite right to do so – so has SAS.

Over a year, the many disposable products included in the serving concept exert a heavy impact on the environment, during production and transportation as well as disposal. The latter stage is the most visible, since food scraps are then mixed with packaging of various materials. Waste causes an ever growing load on the environment and should, of course, be reduced wherever this is feasible and make sense.

While the entire flow of food, beverages, newspapers and magazines, etc inside the aircraft is channeled through SAS and

specifying what should not be modified. Alternatively, it may be a question of identifying the phase in a product's life cycle that accounts for its principal contribution to a particular type of environmental impact. The phase pinpointed may then be studied in detail, using other tools – e.g. technical and financial – as well. Potential future changes can also be simulated and evaluated.

The Swedish State Power Board (Vattenfall) has recently concluded a major LCA study (in fact, a limited form known as "life-cycle inventory", LCI; see Fig. C) focusing on its own system of electricity generation. One purpose of the study was to obtain documentation for improvement measures; another was to enable customers to be provided with relevant information on Vattenfall's electricity production. The in-depth knowledge of the in-house system and the boost to internal environmental efforts resulting from the LCA study itself were, however, regarded as highly significant results. For the same reason, Statoil in Norway has published LCA data on its petroleum products.

The Federation of Swedish Industries and 16 businesses have, in cooperation with IVL, developed the EPS (Environmental Priority Setting) system. This

Contd. p. 37

FIG. D: THE BENEFITS OF LCA

Life-cycle assessment is used as the basis for both short-term and long-term decisions.

- Comparisons of alternative raw materials, production methods, energy-supply and transportation systems, etc for a product, with the purpose of reducing environmental impact.
- Identification of the phases in a product's life cycle that account for its primary environmental impact, e.g. for the purpose of concentrating improvement measures where they yield optimum effects, or as a basis for choice of suppliers.
- Analysis of the in-house product system to obtain and be able to disseminate knowledge of its properties within the company, and to identify gaps in knowledge.
- Support for product developers in their detailed choice of materials etc.
- Provision of data for long-term strategic planning with respect e.g. to future product design or recycling systems, and subsequently documentation of these choices.
- Provision of data for customers, who can then in turn use the data for analyzing their own products.

SAS's catering suppliers, the outward flow from the aircraft is less readily surveyed. Part of what is served and distributed leaves with the passengers. Large quantities of waste are collected in the aircraft's garbage bags. And much is returned to the catering supplier, who sorts out packaging and disposable items as waste and sends reusable articles for washing.

To date, the main characteristic of this outward flow from the aircraft been that sorting of waste has taken place only on a negligible scale. There are several reasons for this, including practical and time limitations, concern for the work environment and hygienic requirements. It would, perhaps, be simplest to collect aluminum, glass and newsprint for recycling. But even this would require substantial resources, both on board and in ground collection.

However, since it is not yet possible to sort or reuse all the waste, there are good reasons for evaluating all the disposable material supplied. Can SAS, in cooperation with its customers, suppliers, partners and personnel, make its whole catering concept more customer- and environment-oriented?

In the work of evaluating which products and types of packaging cause least environmental impact, the contexts are not always obvious. In some situations, for example, disposable materials may be preferable to reusable crockery, since use of electricity, hot water and detergent, and also the aircraft's increased takeoff weight – with consequently raised fuel consumption – due to heavy reusable crockery, cause more aggregate environmental impact than e.g. a disposable, low-weight product (read more about "life-cycle assessment" on page 27). This paradox may be illustrated by a theoretical comparison between the options of "disposable items only" and "reusable items only" in the crockery used on SAS's aircraft fleet. The difference is 300 grams per tray: in a year, that makes more than 7,000 tonnes of jet fuel. The lighter disposable articles would thus represent a fuel saving of close to 20 MSEK, and a reduction in CO_2 emissions of more than 22,000 tonnes.

During 1996, SAS initiated a project conforming with the environmental criteria that are applied to cabin operations, both in production and in the logistic flow: reduction in emissions to air, energy use, water consumption and waste volumes. This project is, in organizational terms, the responsibility of Product & Services, but for SAS's overall environmental impact to be reduced, every link in the cabin operations' production chain is important, from product development and purchasing through catering and waste management, including suppliers, manufacturers, transporters, station and flight personnel.

SPECIFIC ENVIRONMENTAL PROJECTS

Within the cabin operations' environmental projects, 50 subprojects were initiated during 1996. Most of these are continuing in 1997, when many more subprojects are also to start. Regular progress reports will be given in future environmental reports.

The main strategic features of the cabin operations' environmental projects are aimed at ensuring that all purchases undergo environmental evaluation, all main suppliers are examined in the light of the environmental policy and action plan, and environmental criteria are integrated into all agreements with suppliers, both new and old. Environment and financial improvements are the two main aims. The environmental effects are reported in more detail below; the net financial contribution of subprojects in 1996 is expected to be of the order of 1 MSEK.

At operational level, SAS dealt with a numerous disposable products in 1996. One aspect of work that affects many of them is the development of products and packaging in a single, environment-friendly and recyclable material, unlike the present-day composite plastic and aluminum materials, which are both harder and more expensive to recycle. Other examples are that, with effect from January 1, 1997, all plastic film in contact with food is to be PVC-free, and on-board blankets cleaned with special chemicals to date are now being washed in water, with regular detergent.

The complete list of the 50 subprojects under way in 1996 is available under the cabin operations' project Improving Environmental Performance in the Cabin Operations, on page 16. A detailed description of some of the most extensive subprojects is given below.

■ Coffee packaging Coffee for serving on board is delivered to the flight kitchens from the supplier packaged in cardboard boxes, on large pallets. Stacked in the boxes are cartons, containing the bags that are finally used on board.

During 1995, the aluminum content of the bags decreased by 12% and the plastic volume by 34%, and the packaging cardboard was entirely replaced by recyclable cardboard. In terms of SAS's annual consumption, approx. 2.3 million bags, this represents a significant reduction in environmental impact.

This project continued in 1996, when

Some 4,600 different products are handled in the cabin operations.

work started on replacing cardboard boxes and cartons with returnable boxes of hard plastic. During 1997, the last of the aluminum in the coffee bags will be replaced by an entirely recyclable material. The measures taken are expected to reduce SAS's packaging and transportation costs by more than 15% while, at the same time, environmental impact is reduced at both the manufacturing and the removal stage.

■ Domestic gate buffet During 1996, catering in the form of gate buffets was introduced at three Swedish domestic stations (Karlstad, Kiruna and Kristianstad). Instead of having meals on board, passengers help themselves to food and beverages from a buffet adjacent to the departure-lounge exit leading to the aircraft, and take it on board with them. The advantages are the scope for offering a larger range of refreshments, and also the passengers' freedom of choice and reduced waste in the form of leftover merchandise. Another positive effect is customers' direct involvement in a specific environmental project.

On the Stockholm-Karlstad route, where the pilot project has been under way longest, waste volumes have decreased by some 60%, and at the purchasing stage a corresponding decrease has also been achieved. Not only are environmental criteria being fulfilled, but customer satisfaction and punctuality have improved – without any increase in total costs. This concept will be developed further in 1997, with an expanded range and a switch to portion packs that are even more environment-oriented, and packaging modification at the same time. In another phase, the goal is to introduce gate buffets for several domestic flights in Sweden and South Norway.

■ SAS Express During 1996 the SAS Express, a concept developed for short routes where there is hardly time for a traditional meal, was introduced between Oslo and Stockholm. Ticketless travel (passengers book their own seats through an automatic answering service, and pay at the gate using a smart card) and one fixed exit at each airport make the journey easier for the customer. Since the serving of meals to EuroClass passengers has been moved from the cabin to a buffet at the exit, these passengers gain access to a larger range of food and beverages than on board, and cabin personnel have more time to provide extra service during the actual flight. Tourist-class passengers receive a ready-packed meal to take on board with them.

Environmentally, the benefits are that all the meal trays and most of the individual packaging needed for meals on board can be eliminated, and EuroClass passengers simply take with them the food they really intend to eat, which yields considerable reductions in resource consumption and waste volumes. Natural materials and sorting of waste at source bring further favorable environmental effects. Financially, breakeven will be attained in 1997 and the net effect thereafter will be positive.

In a development of the SAS Express concept there should be further environmental gains to be made, and an extension to more cities from 1997 is planned.

■ Cabin waste Altogether, on all SAS's flights in a year, more than 110 tonnes of aluminum cans are used on board. With efficient routines for sorting at source, the collection potential corresponds to the quantity of aluminum required to make four new MD-90 aircraft.

Limited on-board sorting at source has been tried in SAS since 1994/95, when special disposal of aluminum cans was introduced on Norwegian and Swedish domestic flights. However, since the equipment on board was not adapted for this purpose and some type approvals for routines and the requisite equipment were lacking, fully satisfactory sorting has not been feasible.

Nevertheless, under an agreement concluded with the authorities, SAS in Norway was exempted from paying almost 9 MSEK in packaging charges. However, the target is an even higher percentage return rate for aluminum (see comments on "Catering Waste", p. 15).

Environmental projects in 1996 included a sorting-at-source concept including a specially developed waste trolley that took into consideration both the limited space on board and requirements concerning the cabin personnel's work environment. This concept will be tested on Norwegian domestic flights and evaluated in 1997. Sorting at source of aluminum on other routes will then be considered. Routines for collection of newspapers and magazines are also to be developed further.

■ International garbage-sorting standard Within the framework of cooperation in AEA, SAS has taken the initiative for setting up a working group with the function of trying to adapt and standardize garbage-sorting routines internationally, so as to collect and remove waste in mutually compatible systems. For example, the systems on board must be coordinated with the recipients' systems on the ground.

Through the work of the group, which includes representatives of the major European airlines, the goal is to find solutions usable at all European airports and on board the relevant aircraft models, and also to reduce total costs. Manufacturers of on-board and ground equipment will be important business associates in this project.

system's most important component is a method of weighting various forms of environmental impact and resource use to arrive at a single figure. An EPS study – unlike the studies carried out by Vattenfall or Statoil, for example – provides no detailed information but, on the other hand, yields very clear and intelligible results. In The Netherlands a corresponding method has been developed, which suggests that quick overview calculations are sometimes needed. Perhaps the greatest benefit of EPS has been as an internal educational tool. Connections between a designer's choice of materials and the environmental impact of the product are easy to demonstrate when, for the sake of simplicity, the description has been reduced to a single figure.

In cooperation with five companies, the Danish IPU (the Institute for Product Development at the Danish University of Technology) has developed an LCA method of a completely different type. Here, no attempt is made to weight different kinds of environmental impact to attain a single figure. Instead, IPU confines itself to evaluating each impact category – i.e. effects on acidification and the climate – separately without, in a concluding summary, expressing any opinion on the seriousness of the acidification problem in relation to climatic impact. The resulting information is more detailed and lacks unclear value judgments but is, of course, less easy to grasp as a whole.

The capacity of LCA to pinpoint where in the product life cycle heavy environmental impacts arise is being utilized to identify possible improvements. The Swedish National Board for Industrial and Technical Development (NUTEK), for example, has commissioned a study comparing waste-based fuel ethanol with diesel. The production process for fuel ethanol was then undergoing development, and the study showed where improvements were required to make it an environmentally competitive alternative. When LCA is used in this way, the results are often surprising. A study for the Swedish National Road Administration, surveying the cradle-to-grave environ-

Contd. p. 39

The World's Least Noisy Large Commercial Aircraft

A meter is a meter and a kilo is a kilo. But "noise" is defined in completely different terms, depending on who is experiencing it and under what circumstances. For a person who has just gone to bed, the barely audible drip of a faucet can sabotage a whole night's sleep, while the fortissimo of a symphony orchestra – close to the pain threshold – is regarded as a pleasure by the concertgoer.

The nature of the sound can also mean more than its actual intensity. Sudden, unexpected sounds are more unpleasant than regular noise – which may even, in some cases, be perceived as soothing, e.g. waves washing in over a beach. On the hand, the constant drone of a ventilation system or whirr of a fan can cause fatigue and impair a person's performance.

Perception of aircraft noise includes other factors as well, For example, surveys have shown that people's fear of accidents makes aircraft noise more irritating than noise from such sources as road traffic. Such comparisons with other modes of transportation involve weighing noise intensity against the number of people exposed to it. Aircraft noise affects only those who live immediately adjacent to airports, and then only during takeoff and landing, while road and rail traffic cause noise throughout their respective networks, which, for those who live near a major highway, continues virtually 24 hours a day.

Most of a jet airplane's noise is produced in three ways. First, the rapidly expelled hot air from the engine collides with stationary, cooler masses of air behind the engine. The second source is the turbulence that arises around the wings, fins and landing gear. Thirdly, there are mechanical vibrations in the engine itself. Reducing noise from these sources is the task of the aircraft manufacturers. Their efforts have culminated in SAS's latest aircraft, which is illustrated on this page.

Airport owners and operators – often the aviation authority of the country concerned – also help to reduce the surrounding residents' noise annoyance. One means of doing so is, using traffic restrictions and noise charges, to limit the use of older, noisy aircraft. Others are to restrict flight density (especially at night) and to regulate the approach for landing and climb after takeoff (e.g. regulations on reducing thrust at a particular altitude during ascent from an airport).

The airlines are committed – in accordance with international regulations, e.g. EU directives – to replace their old aircraft with modern, low-noise models. In SAS, such aircraft make up 81% of the fleet, and by the year 2000 the remaining 19% will have been replaced. In the new generation of jet aircraft, the noise level has been reduced by 8–10 dB, which corresponds to a halving of perceived noise, and the noise from SAS's new MD-90s is as much as another 4-6 dB below this level.

Facts checked by: Ass. Prof. Staffan Hygge, head of the Laboratory for Applied Psychology at the Royal Institute of Technology in Gävle, which carries out specialist studies of human reactions to noise, light and heat.

MCDONNELL DOUGLAS MD-90-30
Passengers: 141 (SAS version)
Engines: 2 International Aero Engines turbofan V2500-D5
Cruising speed: 815 km/h
Range: 2,800 km
Fuel consumption: 4.1 l/100 ASK
Number in SAS fleet: 8 (from 1997)

SAS's new short-haul and medium-haul aircraft, put into service on November 11, 1996. is by far the least noisy of present-day large commercial aircraft. The noise level for the MD-90 is, at best, around 11 dB below current certification limits, the "Chapter III regulations", and thus well short of the new limits under discussion, which may mean lowering the Chapter III regulations by a further approx. 3 dB.

In economic terms, this means that the aircraft complies with all airport restrictions concerning noise and may therefore be utilized with unlimited flexibility in SAS's route systems, and also that the costs of noise charges are minimized.

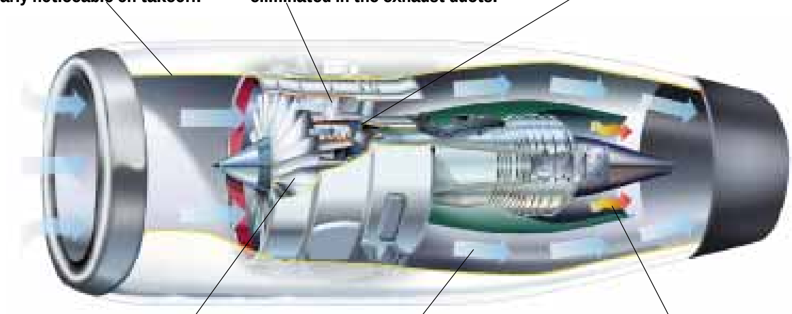
The MD-90 is noise-optimized in the cabin as well. Compared with its predecessor, the MD-80, cabin noise from the engines is 5 dB lower.

NOISE ATTENUATION
Noise is attenuated:
- **From the engine on the far side by the body of the aircraft itself.**
- **In a forward direction during the takeoff and approach by the wings.**
- **Downward as a result of turbulence behind the wings spreading as a noise-reflecting layer of air.**

ACOUSTIC ABSORPTION
An extended engine cowling increases the area for acoustic absorption in both the air intake and the exhaust outlet and reduces backward-emitted noise, which is particularly noticeable on takeoff.

PARTICULAR FREQUENCIES
Careful choice of the number of blades and vanes of the air intake, and also of the distances between them, confines the noise to particular frequencies that are largely absorbed and eliminated in the exhaust ducts.

BLEED VALVE SILENCERS
Silencers with special bleed valves reduce noise during the aircraft approach by releasing part of the exhaust into the bypass duct.



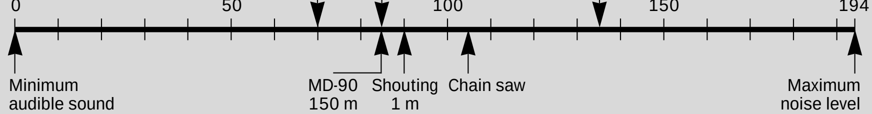
SPECIALLY DESIGNED FAN
A broad-bladed fan with fewer blades, designed specially to give a high output but nevertheless reduce noise.

LOW FLOW VELOCITY
Compared with older jet engines, larger quantities of air flow through the engine at a lower velocity, which reduces both the level and the frequencies of the sound.

LOW EXHAUST VELOCITY
Exhaust velocity and therefore noise are reduced by mixing of the exhaust that is expelled at a high velocity with the bypass air that flows out at a low velocity.

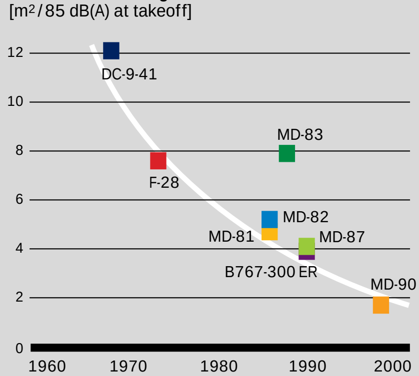
How is noise measured?

[dB(A)]

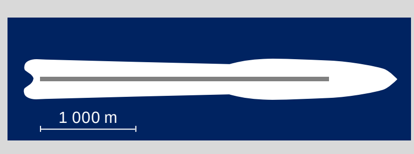


Noise is measured in decibels (dB), a "logarithmic" measure, with 3 dB corresponding to a halving or doubling of noise level. For perceived noise the equivalent figure is 10 dB. The figures are often weighted to take into account people's psychological experience of noise, eg as dB(A). For variable noise, EPN (Equivalent Perceived Noise) is used. Flight noise level, for example, is a weighted measure of sound intensity, frequency composition and distribution over 24 hours.

This is how much flight noise has diminished
[m^2/85 dB(A) at takeoff]



MD-90 the quietest
[85 dB(A) at takeoff]



One way of describing the environmental impact of noise is to state the size of the area where it exceeds a particular level, which in the aviation context is often 85 dB(A). For the least noisy aircraft, this "noise footprint" has shrunk by 90% over the past 20 years. SAS's new MD-90 has a noise footprint for 85 dB(A) at takeoff 1.7 km^2 (less than the enclosed area at major Scandinavian airports).

mental profile of roads, has shown that electricity used in highway and street lighting accounts for a startlingly large proportion of total environmental impact. A simultaneous Finnish study yielded the same result.

Obviously, LCA is used not only in industry. The Swedish Environmental-Protection Agency used findings from LCA studies to examine whether different objectives for material recycling are environmentally justifiable, and several original objectives were revised as a result. Various environmental labeling programs more or less formally use LCA to define the criteria for labeling of a product type. Regarding washing machines, for example, LCA studies have shown that the biggest environmental impact is exerted by electricity consumption during use. Thus, this is the aspect selected for emphasis in environmental labeling.

In an ongoing Ph.D. study at the Chalmers Institute of Technology in Gothenburg, Henrikke Baumann is studying how listed Nordic corporations use LCA. In the International Journal of Life-Cycle Assessment, 3/96, she reports some results and conclusions. She has found that businesses are, admittedly, beginning to integrate LCA findings into their activities, but that LCA work is still very much a learning process: rather than actually using LCA, companies are currently studying how to use the tool in their operations. Perhaps the primary effect of businesses' LCA work to date has therefore been to increase and systematize knowledge of their in-house product systems.

But LCA is spreading rapidly. In 1993 between 20% and 40% of listed corporations in the various Nordic countries were using LCA. Today, the proportion is probably closer to 50% in each country. In other words, Scandinavian trade and industry have really only begun to use LCA, and a sharp increase in its use in the future – in product development, for example – may be expected.

Contd. p. 41


ADILS VIKING
KATE VIKING

An Integral Part of SAS's Quality Work

Since 1995, SAS has used Total Quality Management (TQM) as a method of continuous quality development. This includes environmental issues as an independent area, but also as an integral part of other areas of operations.

SAS's TQM work (*Fig. 2*) is based on the system developed by the European Foundation of Quality Management (EFQM). Within the framework of this system, the goal is to attain the highest European quality rating during 1998.

The TQM method is based on descriptions of the present situation and SAS's goals in nine central areas, such as Leadership, Customer Satisfaction and Social Influence & Environmental Awareness (Fig. 3). Each area of operations in SAS has broken down these descriptions of goals at local level, where they have been compared with the present situation. Priority has been given to the differences between present situation and goals then identified, and action programs have then been adopted in the nine TQM areas.

Environmental impact and measures occur in two dimensions: As an independent area, but also as part of all the other areas. Our view is that, to be effective, environmental work should be integrated as a natural part of all operations.

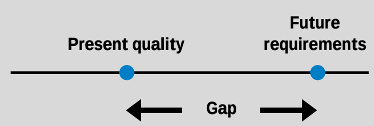
The TQM model presupposes systematic follow-up of the work. SAS has decided to use "gap analysis"(*Fig. 1*) to carry out continuous evaluation of how we are performing in relation to current objectives and future requirements. By comparing the present situation, area by area, with our objectives we can identify the points at which measures need to be applied if our goals are to be achieved. Accordingly, we can ensure the right resource utilization and correct priorities.

Similarly, gap analysis gives us documentation for the important decision on future affiliation to an international standard for environmental management and auditing. At present, SAS is evaluating an option based on EMAS approval, with ISO 14000 as the control system (both these environmental management systems are explained on page 48), and analyzing our progress in relation to the requirements imposed for affiliation to these systems.

EXISTING SYSTEMS

Through national initiatives, in some cases precipitated by official requirements, SAS has already introduced parts of the following environmental management and environmental auditing systems in the three Scandinavian countries.

Fig. 1: **GAP ANALYSIS**



As the name suggests, gap analysis identifies areas where there is a gap between the company's status at the outset and expected requirements, so that measures can be applied to attain the objectives adopted.

NOT UNIVERSALLY APPLICABLE

So far, we have focused solely on the strength of life-cycle assessment. But there are also, of course, several weaknesses. It is imperative to point these out, since if too much is read into the results of LCA its intrinsic shortcomings are not understood there is, obviously, an aggravated risk of its inadvertent misuse.

Certain shortcomings are built into the method itself and will always exist. Others are associated with the fact that LCA is not yet fully developed, and it is hoped that these will be eliminated as use of the method increases.

Let us first consider some weaknesses inherent in the method itself. In brief, most of these may be said to stem from the fact that LCA is a simplified – sometimes highly simplified – model of reality. Not every aspect can be included: a truly comprehensive study would be completely unfathomable and unreasonably time-consuming.

- *One limitation of the method relates to "system limits". Since not every part of the product system can be included, the parts deemed relatively unimportant for some reason are excluded. Such judgments are, of course, more or less uncertain.*
- *Some parts of the system are virtually always excluded. Admittedly, LCAs sometimes include the environmental impact that arises in manufacture of equipment used in the production process studied; but this impact is not included in full. Thus dam construction, turbine manufacture, etc are included in a hydropower LCA, but production of the trucks used is not. Since the trucks were not made solely to move materials in dam construction, their manufacture is not deemed assignable to the dams.*
- *No account is taken of the timing of different emissions in the life cycle. This causes problems where the life cycle extends over several decades. There is, for example, no evidence that current recycling technology is representative of the technology that will be used in 25 years' time, but usually this is the assumption indirectly made. Thus past data are being used to describe future technology.*

Contd. p. 43

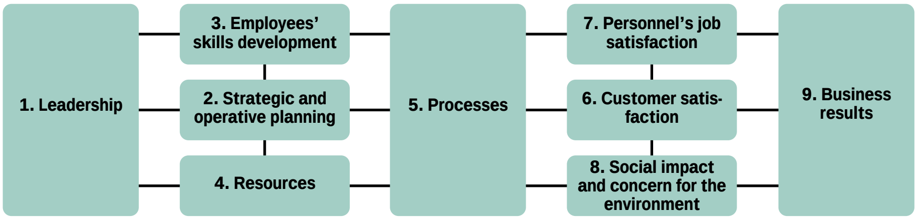
■ In Denmark since 1992, SAS has voluntarily applied a system of environmental accounts that link important parameters of environmental management ("green key statistics") to the corresponding financial effects. With effect from 1996, this is prescribed by law for some 4,000 major businesses with an environmental impact in Denmark, and from 1999 for SAS. Until then, we shall continue to apply the system on a voluntary basis. In addition, SAS Denmark has also introduced environmental management systems for purchasing, energy and construction projects.

■ Since 1992, the Norwegian authorities have applied a law on internal control entailing a system of documentation and auditing of various health, environmental and safety parameters. In SAS, a system of internal control has been established for annual audits and reports to Norwegian authorities regarding, for example, emissions for which concessions are required. This practice has been extended to include full environmental audits within the framework of the internal control system.

■ In Sweden, the environmental authorities apply a concession system to create regional framework conditions for individual companies. Under this system, businesses subject to supervision are obliged to draw up environmental reports annually. SAS in Sweden has concessions for certain emissions and systems of chemical-waste disposal, and these are monitored and inspected locally.

The latter part of 1996 saw the inception of a Scandinavian development project aimed at drawing up joint standards and tools for the implementation of Denmark's workplace valuation system and Norway's and Sweden's internal control systems. These standards and tools are aimed at both the work environment and the external environment, and are to be established as part of TQM. This is helping to pave the way for the establishment of a certification system of environmental management comprising both the strategic and the operative level of business.

***FIG. 2:* SAS'S TQM WORK – AN OVERVIEW**



Within each strategic area, objectives have been adopted for each year up to and including 1998. Besides the fact that environment is an area in its own right, environmental goals are included among the various goals in each area.

***FIG. 3:* SAS'S TQM WORK – THE ENVIRONMENTAL AREA**

8. (Social impact and) concern for the environment[1]

		Attained
Starting point, 1995	• SAS's public environmental image is worse than our environmental data show.	
Present situation, 1996	• The first Environmental Report is issued.	✓
	• A smoothly functioning environmental organization exists.	✓
	• The environmental policy/strategy is communicated (partially integrated) in the functional organization.	✓
	• Concern for the environment is integrated into the work of business and resource planning and the purchasing policy.	✓
	• Environmental training has been commenced in some parts of SAS.	[2]
	• There is increased commitment concerning internal and external environmental information, including the environmental policy.	[3]
	• The proportion of Chapter II aircraft is reduced, and the first MD-90 aircraft is in operation.	✓
	• Concern for the environment has been integrated into inflight service.	✓
	• A more systematic working approach regarding environmental issues is being applied in ground operations.	✓
	• Proactive work on environmental framework conditions relating to environmental charges and restrictions is under way.	✓
Goals for 1997	• The Environmental Report covers development in important environmental areas, and environmental auditing is be carried out.	
	• SAS's environmental policy is known throughout the company.	
	• Guidelines concerning environmental profiling and sponsoring exist.	
	• Environmental aspects are part of the company's market profile.	
	• Environmental training and information are conducted systematically.	
	• The proportion of Chapter II aircraft has diminished further.	
	• Opinion polling on SAS's environmental image is to be carried out.	
Goals for 1998	• Systematic work and reporting on the environment and resources.	
	• The first Boeing 737-600 is taken into service.	
	• SAS is perceived as a company that is concerned about resources and the environment, and one of the leaders in the airline industry.	
	• SAS is perceived as a company that purposefully and continuously works for a better environment and for optimal resource utilization.	
	• Measurement of resource and environmental impact is carried out, in units that are relevant for benchmarking in the Environmental Report and can be valued by an external environmental auditor.	
	• Continuous opinion polling of public views regarding SAS's concern for the environment is carried out.	

[1] For reasons of space, the half of the strategic area relating to social impact is excluded from this Report.
[2] For reasons of cost, environmental training has not yet been implemented other than in management groups and as parts of other training.
[3] Although important information campaigns have been carried out, a comprehensive strategy for environmental information is still lacking.

During 1996, the progress aimed for was achieved for all aspects of environmental work except environmental training and the environmental information strategy (see notes 2 and 3 above).

Environmental Work in Practice

Since SAS adopted an environmental strategy in 1995, thereby systematizing our environmental efforts, initiatives for hundreds of improvements in the company have been taken. To implement these as efficiently as possible and also lay sound foundations for further initiatives, SAS has continued to develop its environmental management system.

SAS's functional type of organization requires linking of environmental responsibility and work to the line management and the departments' other duties. SAS's environmental management philosophy expresses this as follows: "*Every manager entitled to make decisions and responsible for the budget has a duty to include an environmental evaluation as part of the documentation for decision-making.*"

Part of the SAS Management Team's job is to define goals, strategies and guidelines for the company's environmental work. These are then broken down into specific objectives in each area in SAS. This results e.g. in a number of projects that are monitored annually with respect to fulfillment of aims and repercussion on SAS's financial results (on pages 14, 16, and 23, the major environmental projects in 1996 are reported).

Formulating strategy and goals is an annual process. SAS's statement of strategies for 1997 includes a description of international developments since the preceding year. In the new description, we make the following points, among others:

■ Growing public environmental awareness will increasingly govern the customers' choice of transportation mode and provider.
■ Environmental charges for air traffic will, to a growing extent, be used in the EU until the turn of the century.
■ EU airports will increasingly relate landing fees to environmental considerations and/or introduce operative restrictions on the types of aircraft with the heaviest environmental impact.

For SAS's development this means:
■ The environment must be regarded as one of several quality parameters in TQM work, which necessitates a well-developed system of environmental management.
■ In flight operations, above all, we must at all times use the best available environmental technology that is financially defensible (as when, in 1996, we became the first European airline to put into service McDonnell Douglas's low-noise MD-90, and in 1998 we shall be the first in Europe to fly Boeing's 737-600 with the DAC engine).
■ In both cabin and ground operations, we must integrate environmental considerations and conduct systematic environmental efforts (as when, in 1996, we initiated a major environmental project in our cabin operations and also undertook a complete inventory of all real estate).
■ SAS's purchasing policy must stipulate environmentally sound products and services.
■ We must carry on a continuous dialog with decision-makers in areas relating to the environmental framework of aviation.

■ An emission can vary widely in impact, depending on where in the world it occurs – a fact that is disregarded in the methods of describing environmental impact used in LCA.
■ One cannot take into account every significant environmental aspect. Instead, as a rule, a selection must be made. Aspects like the work environment, odor, noise and the impact of land use are usually entirely disregarded.

Weaknesses in LCA due to the fact that it is not yet a fully developed instrument include, for example, the meager supply of quality-assured data to date. Analysts have had to use data that happened to be available, with considerable variation in data quality as a result. This was one main reason why early studies arrived at different results despite having the same subject of analysis. The method used was often to compare the client's own, up-to-date data with data several years old on competing products, which distorted results in the client's favor.

Major efforts are now under way to surmount these problems of data supply, especially in industry. Public databases on raw materials and unit processes, for example, are being compiled and agreements reached on the type of information to be stored. More users are thereby gaining access to the same data and this, combined with harmonization of LCA methods, will enhance comparability and facilitate the work.

LCA IN AVIATION

In the airline industry, LCA has better prospects of being useful to the airlines than to the aircraft manufacturers. The environmental impact of an aircraft may, on good grounds, be assumed to consist very largely in fuel consumption and noise, and no LCA is needed to verify this. The aircraft producers are striving to select environmentally sound materials, but the rigorous quality requirements of aviation leave them little freedom of choice. Meaningful analysis of an aircraft's entire life cycle is, moreover, difficult. Service life often exceeds 25 years, and future methods of material recovery can hardly be predicted

Contd. p. 45

■ We must conduct single-minded environmental profiling work.

VISION, GOALS AND STRATEGY

SAS's environmental vision, goals and strategy form a system that, within the framework of overall quality efforts, is effective in promoting specific environmental efforts (*Fig. 1*).

The vision links operational and financial goals with environmental considerations and social awareness. These are intimately connected: well-run operations and continuous investments in quality, as well as in safety and the environment, are essential preconditions for a sound financial position.

The environmental goals state SAS's ambitions for the environmental program and the quality of environmental performance we seek to achieve. We aim to be among the leaders in the airline industry. The environmental goals also state that the environmental aspects of all decisions must be integrated with our other operations, on a par with SAS's traditional quality goals in the areas of safety, punctuality and service.

The environmental strategy indicates key areas for action. One cornerstone is that SAS should always seek production methods and techniques characterized by low energy use and resource consumption, minimal emissions, small waste volumes and scope for recycling. Such assessments must, wherever feasible, be based on a life-cycle perspective (see p. 27).

Another central area of concern is, by means of information and training at all levels in the organization, to familiarize SAS's employees with our environmental approach. This will ensure that consideration for the environment is genuinely incorporated into day-to-day work. This philosophy of environmental management also applies e.g. to SAS's purchasing policy, in which concern for the environment is an established element on a par with others. This means that all subcontractors must fulfill SAS's environmental requirements, both when new contracts are negotiated and when old ones are renegotiated (see e.g. the account of environmental projects in cabin operations in 1996, p. 16).

The fundamental goal of the environmental strategy is to ensure a good trend of profitability by seeking environmentally correct and cost-effective solutions. We believe that sound environmental solutions go hand in hand with sound finances, and the key term in the balance between environmental and financial considerations is "cost-effectiveness". SAS chooses the solutions that yield the best possible environment for every krona invested.

Coordinating work on the external and work environments – with many natural links, especially in ongoing work in the line organization – is also vital.

ENVIRONMENTAL ORGANIZATION

SAS's environmental efforts are controlled by the SAS Management Team and SAS Environmental Forum (*Fig. 2*).

Overall environmental responsibility rests on the SAS Management Team, and the Senior Vice President, Public Relations & Government Affairs has environmental issues as an area of responsibility. The team's commitment is crucially important for SAS's scope for implementing a successful environmental program.

The chief task of SAS's Environmental Manager is to direct and coordinate environmental work in the company. He must ensure that the environmental strategy is drawn up and implemented and that information and training activities concerning the environment are carried out. In ad-

***FIG. 1*: VISION, GOALS, STRATEGY**

SAS's Environmental Vision

• SAS must develop profitably in free competition, with optimal utilization of resources and minimal environmental impact, in order to contribute to the sustainable development of society.

By "sustainable development" we mean resource consumption and environmental impact which do not exceed nature's ability to replace the resources and repair any possible environmental damage caused by human activities.

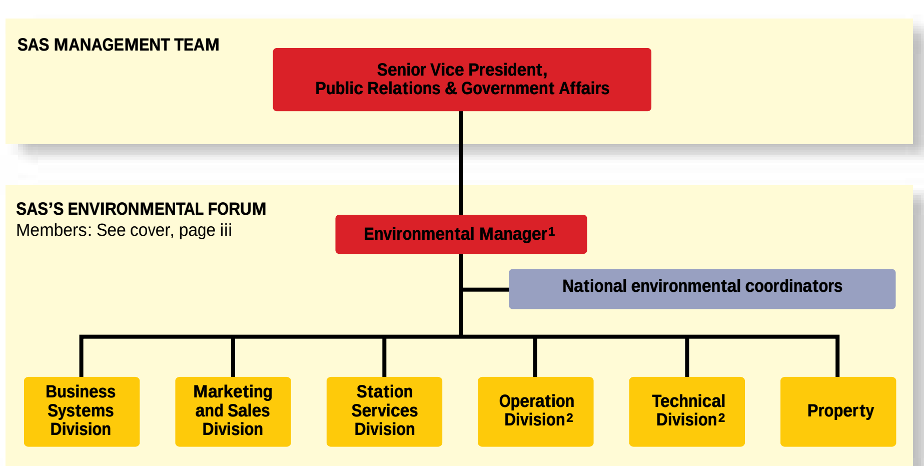
SAS's Environmental Goals

• To develop one of the airline industry's most ambitious environmental programs.
• To maintain environmental standards on a par with SAS's foremost competitors in the industry.
• To coordinate and harmonize environmental goals and action with other objectives for production, quality and economy.

SAS's Environmental Strategy

• Within the framework of SAS's financial and qualitative goals, all operations must be conducted so as to cause the least possible environmental impact.
• SAS must develop into one of the airline industry's leading companies in the environmental sphere.
• Environmental work must be conducted at all levels and within all units of SAS, thus creating increased environmental awareness throughout the organization.
• Environmental aspects must be included in all documentation for decision-making.
• SAS must utilize and introduce the methods that minimize the environmental impact of production, characterized by low energy use, maximal recycling potential and minimal emissions.
• SAS must issue an account of its environmental work in a separate annual report.
• SAS must promote understanding among external associates of the role and environmental impact of air transportation.

***FIG. 2:* SAS'S ENVIRONMENTAL ORGANIZATION**



[1] *Also coordinates SAS's representation in international environmental forums.*
[2] *During 1996, the Operation and Technical Division were combined under what was then the Production Division.*

dition the Environmental Manager is responsible for producing and publishing SAS's environmental report.

The Environment Manager also directs the work of SAS's Environmental Forum – a cross-divisional group that advises on, directs and instigates work on environmental issues. The day-to-day work of the participants in their respective divisions creates two-way communication on environmental issues throughout the organization. Since 1996, the Forum has also included representatives of the Sales and Marketing Division. This ensures that the company's skills in market communication are utilized for environmental information, and that environmental issues are integrated as a natural part of SAS's overall profile and marketing.

Special environmental coordinators in the three Scandinavian countries have the task of coordinating environmental work at national level and assisting their respective national organizations by providing advice in the environmental sphere. They also ensure that the requirements of the national environmental agencies are complied with and reported. The coordinators are organizationally linked with the company health service. This ensures a connection between the external environment and the work environment, and also comprehensive solutions for the entire sphere of health and the environment. (See p. 7 for a summary of SAS's work on health and the work environment, and p. 70 in SAS's 1996 annual report for a complete account.)

In the jointly owned companies where SAS has board representation (e.g. SAS International Hotels), the board members are responsible for ensuring that environmental efforts comply with SAS's environmental approach and strategy.

In the aviation sector, there are detailed plans for emergency rescue services and crisis management in the event of crashes and other accidents. Prevention and clean-up of contaminating discharges form an important part of these plans, especially in Europe. At our hub airports, especially in Scandinavia, SAS plays an integral part in incident planning and drills.

SAS's environmental organization is aimed at comprehensive solutions for both the external and the work environment.

TRAINING AND INFORMATION

In SAS's overall priorities, the company has not yet been able to allocate the large-scale resources required for general environmental training of all its employees. However, the environmental department's cooperation with central management groups has partly taken the form of briefings on environmental strategy and action plans, and this may be regarded as an explanation for the efficiency achieved in management of our environmental work. SAS has not yet decided whether more broadly oriented instruction is to be given, and if so when.

SAS's Environmental Report also serves as one of the most important sources of

with much certainty.

However, this situation is not confined to aircraft manufacture. LCA is not used elsewhere in the transportation sector either, on any substantial scale, for product development. There is, for example, no automotive corporation that makes full use of LCA in its product development, although many have taken the initial steps. For most players, making the product environmentally sound is still synonymous with ensuring low fuel consumption and making material-recycling feasible – measures that need no LCA to be identified.

Among aircraft manufacturers, LCA can be more useful in areas other than actual product development, e.g. in evaluating the logistics of the large-scale transportation services to which decentralized production gives rise.

For an airline, LCA is more obviously more needed. Environmental requirements are crucial criteria in the selection of new aircraft – but, as we have seen, these criteria can presumably be applied without the aid of formal life-cycle assessments. However, the airline industry also includes extensive service and maintenance operations. Besides large fleets of aircraft there are, for example, surface-treatment and paint shops, and LCA is as useful in these activities as it is in any other industry.

Air freight is another substantial line of business. Here, airline customers will increasingly demand LCA data for their own logistic analyses. Moreover, an airline's "product" includes numerous service activities, e.g. ground and inflight catering. The choice between disposable and reusable materials in cabin work is a good example of an area in which the answer to the question "What is the best choice for the environment?" is far from self-evident.

With its capacity for summing up the overall picture, LCA is the only instrument capable of clarifying this question – if not yet, perhaps, providing an unequivocal answer. ■

information for SAS's own employees. Internal environmental information is otherwise disseminated through the staff magazine Inside and the internal video Focus. Environmental items are integral to the Management Team's agenda, and all environmental project work is reported to the Environmental Forum.

Environmental initiatives are channeled through the national units for company health care/health, the environment and safety, TQM processes, the labor unions and SAS's regular suggestions channels.

COOPERATION

Goals adopted for 1996 emphasized strengthening of proactive cooperation within the industry and with government agencies aimed at generating a better framework for competitively neutral environmental control of the aviation industry.

SAS's ongoing efforts in international forums (ICAO, IATA, AEA and N-ALM), dialog with national authorities and industrywide cooperation (Partner's Forum and dialog with subcontractors) are described in more detail on p. 32. SAS has also undertaken to develop its environmental work in accordance with ICC's 16 principles for environmentally sound leadership, and is represented in ICC's Swedish section.

Other environmental forums attended by SAS in 1996 include a reference group appointed by the Center for Business and Policy Studies (SNS) for two publications on transportation and the environment.

SAS also collaborates with the Association of Norwegian Airlines in issuing "Aviation and the Environment".

Other forms of cooperation include dialog with representatives of the financial sector on businesses' environmental information. Each SAS station is also engaged in a continuous dialog with the operators of the airports concerned and local authorities.

During the year, SAS engaged in discussions in Denmark concerning ecotourism with the Danish Association for International Cooperation, the WWF, the Conservative Learning Association and other non-profit organizations. In Norway, SAS attended meetings with the Bellona Environmental Foundation and the Norwegian

SAS's "Best Environmental Report" award in Norway and Sweden, its own communication activities and coproduction of environmental publications helped to give SAS a high environmental profile in 1996.

Society for the Conservation of Nature.

SAS also cooperates in the work of the following national industrywide bodies:

■ The Association of Norwegian Airlines SAS is represented in governing bodies and various environmental working groups.

■ The Swedish Aviation Association SAS is represented in the various bodies.

■ The Confederation of Danish Industries SAS is included the aviation section of the Confederation.

PROFILING AND SPONSORING

One driving force behind SAS's environmental information is the goal of aligning the corporate environmental image with the environmental data we actually have to show, thereby creating an understanding of the environmental improvements attained in aviation over the past few years. A strategy for environmental profiling has therefore been drawn up in the management group of the Senior Vice President, Public Relations & Government Affairs. It is aimed at customers and the public on the one hand and the mass media, government agencies and other interest groups on the other.

In accordance with this strategy, SAS attended environmental trade fairs, seminars and debates in 1996, and also engaged in an active dialog with the mass media on environmental issues. SAS also advertised on the environmental theme in the Scandinavian and international press.

SAS Swedish Domestic produced the brochure "SAS and the Environment in Sweden", which was distributed in aircraft seats during March. The inflight magazine Scanorama specifies fuel consumption per ASK for SAS's various aircraft, and during the year two leading articles had the environment as their theme.

The 1995 Environmental Report, also distributed in the aircraft seats on board, was also ordered in class sets by several colleges and universities in Scandinavia, Europe and the U.S.

SAS is one of the main sponsors of the "Clean up Sweden" campaign, and supports the work of the WWF as a corporate friend.

From 1997, it will be possible to monitor the effects of these activities on SAS's environmental profile by continuous polling.

Terms and Abbreviations

Acidification A chemical reaction involving a fall in pH in lakes, groundwater and soil due to the effects of nitric acid, which is formed from nitrogen oxides (see definition), and sulfuric acid, which is formed from sulfur dioxide (see definition).

Soil acidification has an indirect impact on vegetation, while acid precipitation on the surface of foliage affects plant life directly. Biodiversity in lakes and waterways decreases. Acidification steps up leaching of nutrients into the ground, while solubility of heavy metals and aluminum in the soil also increases. This may inhibit root growth and, accordingly, reduce nutrient absorption. Microorganism activity is also affected, since their capacity to break down organic material is impaired.

Acid rain also attacks iron structures and objects made of limestone and marble, such as statues and facades.

AEA *Association of European Airlines.* (See also p. 33.)

APKs *Available Passenger Kilometers,* available capacity for passengers expressed as the number of seats multiplied by the number of kilometers flown (see also *ASKs, ATKs, RPKs, RTKs*).

ASKs *Available Seat Kilometers,* the available number of passenger seats multiplied by the distance flown (see also *APKs, ATKs, RPKs, RTKs*).

ATKs *Available Tonne Kilometers,* available capacity for passengers and cargo expressed in tonnes (metric tons), multiplied by the distance flown (see also *APKs, ASKs, RPKs, RTKs*).

Atmosphere The gaseous envelope surrounding the earth (see also *Stratosphere, Troposphere*).

Bactericide Added to the sanitizing liquid in lavatories on board to reduce infection risks. SAS uses an quadrivalent ammonia compound.

BARLA The Swedish Civil Aviation Administration's working group for charges relating to noise and emissions. (See also p. 33.)

Biofuel Solid or liquid fuel produced from living organisms, primarily plants.

BS 7750 The British Standards Institution's standard for environmental management and audits (see also *Environmental Management Systems*).

CAEP *Civil Aviation Environmental Protection,* technical committee in ICAO (see definition) charged with developing and establishing rules and recommending measures to reduce the environmental impact of aviation. (See also p. 32.)

Cabin factor Percentage of available passenger capacity that is utilized during a flight.

Carbon dioxide (CO_2) Formed in the combustion of all fossil fuels. Carbon dioxide is also a key component in the circle of life: it is released in the air exhaled by animals and absorbed in plants' photosynthesis.

Carbon dioxide forms a sheath around the earth that lets in the sun's shortwave UV radiation but blocks the longwave heat radiated from the earth's crust. An increase in atmospheric CO_2 content therefore retains more heat on earth, while the average temperature in lower layers of air rises — the "greenhouse effect" (see definition). Cultivation and combustion of biofuels do not contribute to the greenhouse effect since the burning plant parts release the same volume of carbon dioxide as they absorbed from the air and bound during their relatively short life. It is when large quantities of carbon dioxide previously stored in the earth's crust for millions of years are released into the atmosphere in the course of a few decades, owing to fossil-fuel combustion, that the balance is disrupted.

Carbon dioxide is very difficult to extract from exhaust fumes. The only means of reducing carbon dioxide emissions is to burn less fossil fuels – something airlines are anxious to do for financial reasons too, since lower fuel consumption automatically entails lower costs. Since the 1970s, fuel efficiency has increased by approximately 50%, and the new SAS aircraft to be phased in from 1998 will consume 15-30% less fuel than those they are replacing.

Carbon monoxide (CO) Toxic and combustible gas formed by incomplete burning of substances containing carbon, e.g. fossil fuels.

Certification ICAO's (see definition) requirements regarding noise and emissions of carbon monoxide, nitrogen oxides and hydrocarbons (see definitions and *Chapter II, III*).

CFCs *Chlorofluorocarbons,* certain halogenated hydrocarbons, sometimes referred to by the trademark Freon (see also *Depletion of the Ozone Layer*).

Chapter II, III ICAO's (see definition) noise certification requirements.

CO Carbon monoxide (see definition).

CO_2 Carbon dioxide (see definition).

Concession Official permit to conduct certain business operations, often designed to ensure compliance with environmental protection requirements and appropriate utilization of natural resources.

dB *Decibel,* logarithmic unit of sound measurement. Figures are often weighted to take into account the human psychological perception of sound, e.g. as db(A). See also p. 38.

Depletion of the ozone layer High-altitude ozone, in the stratosphere, absorbs shortwave (ultraviolet) solar radiation, thereby protecting life on earth. The ozone layer is very thin: were all the ozone found in the stratosphere to be collected at sea level, it would be only some 3-4 mm thick.

In recent years, human use of gases like Freon and Halons have caused rapid depletion of the ozone layer, particularly over the Antarctic. These halogenated hydrocarbons cannot be broken down or extracted from lower layers of air; instead, they are borne up into the stratosphere. There they are broken down by shortwave sunlight, releasing chlorine atoms that break down ozone far more rapidly than it is formed.

Without the protective ozone layer, proteins and other vital organic molecules could not exist (except underwater, since water also absorbs UV light). A depleted ozone layer also exacerbates the risk of skin cancer, cataracts and impairment of the immune system.

Like other industries, airlines are endeavoring to replace ozone-depleting chemicals with less harmful alternatives. This mainly applies to Freon, used in air-conditioning equipment, and Halons, used for fire suppression. SAS has replaced a more dangerous type of Freon with one that has considerably less effect on ozone, invested in a Halon-recycling plant in Copenhagen and entirely phased out Halons in Stockholm.

Ecoefficiency The capacity to deliver reasonably priced products and services that satisfy human needs and enhance quality of life while progressively reducing ecological impacts and resource consumption, throughout the life cycle, to a level at least in line with the earth's estimated carrying capacity.

EMAS *Eco-Management and Audit Scheme (see BS 7750, Environmental Management System).*

Emission Discharge of a substance into air, soil and water.

ENTAF *Environmental Task Force,* working group in IATA that deals particularly with environmental issues. See also p. 33.

EPNdB *Equivalent Perceived Noise level,* a unit commonly used in the aviation context that expresses average perceived noise level.

Eutrophication Nitrogen availability is a growth-limiting factor in most natural ecosystems, and vegetation responds rapidly to increased nitrogen availability by eutrophication. Today, the nitrogen load on lakes, groundwater and soil in certain parts of South Sweden already exceeds the limit of what plants can absorb. Originally a local phenomenon, with eutrophication resulting from agriculture in limited land areas, the problem has now reached regional proportions, with increasingly large areas affected by atmospheric deposition of nitrogen.

Increased nitrogen availability and rapid growth mean that foliage ages faster and is shed, and trees become more vulnerable to frost and less resistant to parasites. Algae and other microorganisms start to appear on e.g. tree foliage and trunks, and in time nitrogen-loving plants proliferate, eliminating others from ecosystems and causing a fundamental change in species composition. Nitrogen oxide in water forms nitrate, and when this leaches into groundwater it impairs the quality of drinking water.

Nitrogen inputs also cause imbalance in waterways. They boost the production of biological material, which uses abundant oxygen in the course of decomposition. The deoxygenation that may then result kills bottom-living fish and crustaceans. Plants that thrive on nitrogen spread at the expense of others, and a phenomenon much noted in recent years has been the proliferation of certain marine algae ("algal blooms").

Fossil fuels Fuels comprising organic carbon and hydrogen compounds in sediment or underground deposits – especially coal, oil and natural gas.

Freon See *CFCs.*

GCD *Great Circle Distance,* definition of the shortest distance between two points, taking the curve of the earth's surface into account.

Glycol A "relative" of alcohol that is sprayed on aircraft in cold weather to prevent ice formation. Nowadays propylene glycol, which is nontoxic, is used. Approximately 80% of the glycol runs off the aircraft when it is applied, and seeps into the ground unless collected. A further 15% is emitted into the air and thus spreads in the vicinity of the airport. Heavy emissions may cause deoxygenation in groundwater and small waterways, since oxygen is required to break down the glycol.

Airports use vacuum trucks and flushing sites to collect run-off glycol for reuse. SAS is also attempting to minimize consumption through more effective application techniques.

Greenhouse effect Certain gases in the atmosphere, such as carbon dioxide, nitrous oxide (laughing gas), methane and ozone, absorb much global heat radiation and redirect it to the earth's surface. At present, there are no entirely reliable estimates of how much the earth's temperature will change owing to the influence of emissions on this "greenhouse effect". However, there is believed to be a risk of a larger temperature change over the next 100 years than the aggregate change since the last Ice Age 10,000 years ago.

Raised temperatures cause increased evaporation and precipitation – but not uniformly worldwide. Dry areas become drier, while low-lying countries may incur flooding problems.

There is also a risk of polar ice thaw, with a consequently rising sea level. However, the mean annual temperature in Antarctica – which has the largest mass of ice – is several tens of degrees below freezing point, so there is a margin of safety.

A more serious problem would be the expansion in the seawater volume that would ensue from a temperature rise. With a rise of 1.5–4.5°C, this expansion is assumed capable of raising sea level by 20–140 cm.

Today, there is marked scientific uncertainty concerning the scope and timescale of these presumed effects, which are the target of major research efforts.

Halons A general designation for halogenated hydrocarbons and, specifically, a brand name for fire-extinguishing agents (see also *Depletion of the Ozone Layer*).

HCs Hydrocarbons (see VOCs).

Heavy metals Certain high-density metals, e.g. cadmium and mercury, that once they have entered the food chain are persistent in the long term and can thus wreak severe damage.

ENVIRONMENTAL MANAGEMENT SYSTEMS

EMAS The EU's *Eco-Management and Audit Scheme* originally focused on the industrial sector, where experience of applying environmental management and auditing was longest. However, pilot projects are under way in preparation for the anticipated revision of EMAS in 1998, with extension of the system to include such activities as transportation, services and public administration as well. (With the Swedish Civil Aviation Administration, SAS participates in this work through the register authority for EMAS in Sweden, the Environmental Control Council.)

Under the EMAS Ordinance, companies can voluntarily register their facilities in the system. The company is then required e.g. to adopt an environmental policy for the whole of its operations and also, for the facility in question:

• Carry out an environmental survey and define environmental targets.
• Introduce an environmental program and environmental management system in order to fulfill environmental policy and targets.
• Implement environmental audits.
• Draw up an environmental report.
• Engage an accredited environmental inspector to examine and approve the environmental policy, program, management system, survey or audit procedure and environmental report.
• As appropriate, to disseminate the approved environmental report among the public.

ISO 14000 Summary designation of international standards in the environmental sector that are administered by the International Standardization Organization.

The general management principles on which ISO 14000 is based are the same as in the ISO 9000 quality standard. Draft environmental standards exist in several areas, and in 1996 the first of these – ISO 14001 and 14004, which form the basis of an internationally accepted system of environmental management – was adopted. An approved system of this kind is a condition of EMAS registration of facilities.

Differences between EMAS and ISO 14001 In many respects, the EMAS Ordinance resembles the ISO 14001 standards, but since they were developed at different times and in different forums there are some important distinctions:

• The EMAS Ordinance is currently adapted for industrial facilities in the EEA, while the ISO standards are intended for use by all types of organization throughout the world (which means that the activities EMAS is adapted for are also covered by ISO 14001).
• EMAS registration relates to a facility, including its environmental policy, program, management system, survey or audit procedure and environmental report, while ISO 14001 certification covers only the environmental management system.
• EMAS refers primarily to environmental auditing of facilities and their environmental aspects, while ISO 14001 refers to auditing of environmental management systems. However, through an extension in procedure the ISO standards can be applied in such a way as to cover the environmental-audit requirements in EMAS as well.
• Both EMAS and ISO 14001 stipulate the drawing-up and maintenance of an environmental policy that enjoins continuous improvements. Unlike the ISO standard, EMAS also requires the environmental policy to be based on the premise that environmental impact may not exceed that exerted with economically realistic utilization of the best available technology.
• EMAS, but not ISO 14001, requires environmental reports for specific facilities to be drawn up and issued to public bodies and the public.
• According to EMAS, a company must ensure that suppliers to the facility to be registered apply environmental standards corresponding to the company's own. These requirements are less clearly expressed in ISO 14001.

Hydrocarbons See *VOCs.*

IATA *International Air Transport Association,* international cooperative body for 254 of the world's airlines (see also p. 32).

ICAO *International Civil Aviation Organization,* the UN's specialist agency for international civil aviation. One of its functions is to develop binding norms for commercial aviation. (See also p. 32.)

ICC International Chamber of Commerce.

ISO 14000 The International Standardization Organization's standard for environmental management and audits (see also *BS 7750, Environmental Management Systems*).

Life-cycle assessment (LCA) Systematic method used to describe and evaluate a product's total environmental impact throughout its entire life cycle (see also p. 27).

Low-level ozone (O_3) Ninety percent of atmospheric ozone is found at an altitude higher than 10 km. At lower altitudes (in the troposphere, see definition), ozone is formed by sunlight acting on hydrocarbons, nitrogen oxides, carbon monoxide, etc (see *Nitrogen oxides*). Low-level ozone is formed at the lowest level of the troposphere, i.e. up to 100–200 meters.

Combined with sulfur dioxide and nitrogen oxides, ozone damages plant life. It also occurs over large areas in such concentrations as to be a cause of plant damage in its own right.

M Million (as in MSEK) or mega- (as in Mtonne, i.e. one megatonne = 1,000,000 tonnes).

N-ALM The *Nordic Working Group for Environmental Issues in Aviation,* composed of civil aviation, environment and communications authorities, and airlines (see also p. 33).

NO_X Nitrogen oxides (see definition).

Nitrogen oxides (NO_X) A collective name for various compounds of oxygen and nitrogen. These are formed in all combustion in aircraft engines since the high temperature and pressure cause the atmospheric nitrogen and oxygen to react with each other, mainly during the takeoff and ascent when the engine temperature is at a maximum.

At low altitudes nitrogen oxides are converted into nitric acid (HNO_3), which is deposited in the natural environment. In moderate quantities, nitrogen has a positive effect on growth, but when the limit to what the vegetation can absorb is exceeded nitrogen contributes to acidification (see definition) of soil. Throughout the troposphere (see definition), nitrogen oxides react with VOCs (see definition) and sunlight, forming "oxidants", especially ozone (O_3, see definition), which at altitudes up to 100–200 meters is known as low-level ozone. In the rest of the troposphere, i.e. above 100–200 meters, ozone works as a highly effective greenhouse gas (see *Greenhouse effect*). At altitudes above 8–10 km (the lower stratosphere, see definition), where aircraft sometimes cruise during long flights, nitrogen oxides remain in the air for years before finally reacting with and breaking down ozone molecules (see *Depletion of the Ozone Layer*). However, the contribution of air traffic to the "hole" in the ozone layer is assumed to be negligible.

With effect from 1996, ICAO has tightened up its controls on nitrogen oxide emissions and in about 2000 these controls are expected to be made even more stringent. New engines with double annular combusters (DACs), for example, reduce emissions by up to 40% compared with the previous generation of engines. SAS has decided to equip a large part of its fleet with DAC engines from 1998.

O_3 Ozone (see definition)

Oxidants Group of powerful oxidizing agents, including ozone (see also *Low-level ozone*).

Ozone, ozone layer See *Low-level ozone* and *Depletion of the ozone layer.*

Photochemical Of or relating to a process, reaction, etc caused by absorption of solar radiation.

Photosynthesis The process by which all plants convert light into chemical energy, mainly by fixing carbon in the form of carbon dioxide.

RPKs Revenue Passenger Kilometers, utilized (sold) capacity for passengers expressed as the number of seats multiplied by the distance flown (see also *APKs, ASKs, ATKs, RTKs*).

RTKs Revenue Tonne Kilometers, utilized (sold) passenger and cargo capacity expressed in tonnes (metric tons), multiplied by the distance flown (see also *APKs, ASKs, ATKs, RPKs*).

SETAC *Society of Environmental Toxicology and Chemistry,* an interdisciplinary Euro-American organization that has e.g. made a major contribution to the development of life-cycle assessment (see definition) methodology.

SNS The Swedish Industrial Council for Social and Economic Studies, a nonprofit association engaged in applied social research.

SO_2 Sulfur dioxide (see definition).

Stratosphere Part of the earth's atmosphere (see definition) between 10 and 50 km above the earth's surface.

Sulfur dioxide (SO_2) Formed in fossil-fuel combustion, through the sulfur in the fuel being oxidized by atmospheric oxygen. In the atmosphere it is slowly condensed by "photochemical oxidation", forming sulfuric acid (H_2SO_4). A small proportion of sulfur dioxide is further oxidized to form sulfur trioxide (SO_3) which, on emission, immediately absorbs water, in turn forming sulfuric acid.

Sulfuric acid in precipitation contributes to acidification (see definition). Locally, sulfur dioxide may also be present in such high concentrations as to cause direct damage to the stomata of plants, modifying plant respiration and impairing gas penetration. It also disturbs photosynthesis, thus inhibiting growth. Sulfuric acid is also highly corrosive and attacks iron, limestone and marble, with visibly damaging effects on statues and facades in cities with polluted air.

Aviation fuel contains a minute proportion of sulfur and, accordingly, causes only minor emissions of this substance. The same applies to the "green" diesel now used in ground vehicles. In the airline industry, as in many others, sulfur dioxide emissions come largely from oil-fired heating. In the past few years, SAS has cut its sulfur emissions by 80%, both by switching to oils with a lower sulfur content in its oil-fired heating plants and by replacing oil-fired with LPG-fired heating, district heating or electricity where it is cost-effective to do so.

Sustainable development Keeping the aggregate environmental impact of activities in the various sectors of society within the limits of what humankind, society and nature can tolerate in the long term.

TQM *Total Quality Management,* see p. 41.

Troposphere Lowest part of the earth's atmosphere (see definition) extending to an altitude of between 10 and 20 km above the earth's surface.

VOCs *Volatile Organic Compounds,* collective name for a number of different compounds, including most hydrocarbons (HCs). They are emitted during incomplete combustion of fossil fuels — in aviation mainly when the engine is at low speed and the temperature in the combustion chamber is low. This category also includes all types of solvents that evaporate from e.g. detergents and paints.

With nitrogen oxides and sunlight, VOCs form low-level ozone (see definition). Solvents containing chlorine also contribute to the depletion of the ozone layer (see definition). Many constituents of solvents also cause direct damage, such as leaf loss in plants and poisoning of fish and mammals.

From April 1, 2002 only aircraft with low VOC emissions will be permitted in the EU. The modern aircraft that SAS is now phasing in will have hydrocarbon emissions more than 90% lower than their predecessors. As in other industries, a switch to non-solvent chemicals is taking place in aircraft maintenance. Where this is not feasible, SAS is first phasing out all chlorinated substances.

Sources: "Air Pollution Control" (Grennfelt et al), Dept. of Environmental Conservation at the University of Gothenburg, 1989; "Strategy for Sustainable Development", the Swedish Environmental Protection Agency's 1993 action program; the Swedish National Encyclopedia; etc.

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Is there anything you think we do really well?

Is there anything you think we don't do well enough?

Do you have any suggestions as to how we can improve our environmental work?

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