

## Product-related Environmental Information Systems in Austrian Companies

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### Abstract

*The project 'Product-related Environmental Information Systems (PEIS) in Austrian Companies' aims at integrating life cycle thinking in Austrian enterprises. A survey carried out in Austrian companies reveals details of PEIS applications (degree of dissemination, intended purpose, motivations), requirements of business with regard to PEIS and recommendations to other companies and their representative bodies as well as scientists, consultants and policy makers. In Austria application of PEIS is mainly done because of activities in the context of the environmental management system. Companies are familiar with some of the PEIS but rarely use them to integrate life cycle aspects. With a few exceptions, PEIS are not applied on a routinely basis.*

*More than 20 different PEIS are characterised by parameters related to 'range', 'process,' 'result', 'adaptation*

*to the specific case', and 'operating expense'. The characteristics rely on the results of a questionnaire answered by consultants. Furthermore, results of an expert assessment are taken into account. Requirements of strategic planning, capital investment, design & development, communication & marketing and operational management are described by the same criteria set as used for the characterisation of PEIS. A comparison of the profiles of decision types on the one hand and the characteristics of PEIS on the other hand leads to the identification of PEIS suitable for a given decision type. Since the profiles presented are based on the assessments of only a few persons, the results must be understood as a first starting point, which shall be refined in succeeding activities.*

### Introduction

The outcome of the project 'Product-related Environmental Information Systems (PEIS) in Austrian Companies' (funded by the 'Factory of Tomorrow' – an initiative of the Austrian Federal Ministry of Transport, Innovation, and Technology (BMVIT)) aims at integrating life cycle thinking in Austrian enterprises. A closer look on the environmental impacts associated with the 'produced' products might complement site-specific measures such as environmental managements systems (EMS). Certain optimisation tasks can be treated meaningfully only by taking into account the entire life cycle of a product. An important pre-condition for considering the life cycle ('from cradle to grave') is information about existing product-related environmental information systems (PEIS), their possibilities and limits. Success stories of existing PEIS applications shall motivate Austrian enterprises to integrate life cycle methods into their business practices.

The results of the project are a contribution to providing a knowledge base on PEIS and to promoting the use of PEIS in Austrian enterprises, as

- information about users (enterprises, consultants and scientific experts in Austria) as well as methods is collected
- more than 20 different frequently used PEIS are characterised
- requirements of decision types in enterprises are analysed
- the PEIS profiles are compared with the requirements of decision types in order to identify PEIS suitable for the respective application purpose
- recommendations for representative bodies, policy makers and method developers were summarised
- a manual 'PEIS in theory and practice' will be published separately in the Internet ([www.fabrikderzukunft.at/puis](http://www.fabrikderzukunft.at/puis)).

## PEIS in Austrian enterprises – empirical investigations

Empirical investigations have been performed in Austrian enterprises by questionnaire and interviews. They offer a view on the details of PEIS applications (diffusion rate, fields of application, motivation), requirements of enterprises with respect to PEIS as well as their recommendations at other enterprises, science and policy. The practice of PEIS applications in Austrian enterprises has been investigated via questionnaire. The following target groups were contacted with the questionnaire:

- Companies having an environmental management system (EMS) (ISO 14.001 or EMAS certificate)
- enterprises with eco-labelled products

- 'Oekoprofit' enterprises
- Enterprises of the Styrian car cluster (AC Styria)
- Building industry
- Chemical industry
- Electronic industry
- Metal industry

The questionnaire has been sent to 956 enterprises and 127 questionnaires have been returned, this corresponds to a return ratio of 13.3%. Enterprises, which already have an EMS, participate in Oekoprofit programs or manufacture eco-labelled products, answered approximately twice as often as the other enterprises.

## Results of the survey by questionnaire

For the list of PEIS presented in the following chapter it was asked, whether this PEIS is in use within the company, whether it has been used but by now is not applied any more, whether it is known (by name) or not.

112 enterprises (88.2%) indicate, that they have used or use at least one PEIS of the list. Only 2 enterprises say that all of the mentioned PEIS are unknown to them. For 103 enterprises (81.1%) one or several PEIS are unknown. At the same time 107 enterprises (84.3%) know at least one of the PEIS, even if they do not use it. Altogether 479 PEIS are applied in 112 enterprises. Details of PEIS application and knowledge on PEIS are summarised in table 1.

Table 1: Diffusion rates of PEIS in Austrian companies ( in %)

PEIS	Applied	Applied, but application stopped	Known, but not applied	Not known	No answer
Ecological product assessment methods					
Environmental Priority Strategies (EPS)	0.8	2.4	16.5	70.9	9.4
Sustainable Process Index (SPI); Ecological Footprint (EFP)	1.6	0.8	20.5	67.7	9.4
Critical Volumes	1.6	0.8	22.8	65.4	9.4
Eco-Indicator	2.4	0.8	17.3	70.1	9.4
Life Cycle Assessment (LCA)	3.1	3.9	46.5	37.8	8.7
Environmental Impact Points (EIP)	7.1	2.4	37.0	44.9	8.7
Materialinput pro Serviceeinheit (MIPS, Material Input per Service Unit)	11.8	2.4	34.6	41.7	9.4
Cumulative Energy Requirement Analysis (CERA)	15.0	0.8	35.4	39.4	9.4
Economic methods					
Flow cost accounting	6.3	1.6	44.1	38.6	9.4
Life Cycle Costing (LCC), Full Cost Accounting (FCA)	7.1	1.6	45.7	33.9	11.8
Total Cost Accounting (TCA)	9.4	3.1	38.6	37.8	11.0
Environmental Cost Accounting	15.7	6.3	48.8	19.7	9.4
General decision instruments					
Benefit analysis	9.4	3.9	43.3	29.1	14.2
ABC-Analysis	41.7	4.7	27.6	17.3	8.7
Environmental decision and information instruments					
Material flow accounting (MFA)	25.2	7.9	46.5	13.4	7.1
Environmental risk assessment (ERA)	27.6	2.4	39.4	22.8	7.9
Material exclusion lists	31.5	3.1	22.8	31.5	11.0
Check lists	40.6	6.3	32.3	12.6	7.9
Input/Output-Analysis	58.3	8.7	16.5	12.6	3.9
Environmental performance figures, Benchmarks	60.6	3.1	18.9	11	6.3

The methods used most frequently are Environmental performance figures (60.6%) and input/output analysis (58.3%). Both PEIS belong to the group of the environmental decision

and information instruments, which have thus (with 310 denominations) the highest diffusion rate. For the general decision instruments (ABC- and benefit analysis) 65 applications were stated.

Economic methods are used by only 49 enterprises, the column 'known, but not used' has been ticked as often as for the environmental decision and information instruments, however. Among the 'original' methods of ecological product assessment (55 applications) the most frequent methods are CERA (Cumulative Energy Requirement Analysis) with 19 denominations and MIPS (material input per service unit) with 15 entries.

If enterprises use environmental decision and information instruments, then it is more probable that these also use 'original methods' of ecological product assessment. Among the different industries represented in the sample as well as between ISO 14001, EMAS and oeko-profit certified enterprises and the ones, which have no EMS, there slight differences are determined in kind and frequency of PEIS applications.

The most important reasons to introduce PEIS into a company are:

- finding weak points in the resources and energy demand of enterprises (45 resp. 77.6% of the 58 enterprises answering here)
- cost savings (41 resp. 70.7%)
- being in line with environmental laws (27 resp. 46.6%)
- improving the corporate image (25 resp. 43.1%)
- information for consumers and public (24 resp. 41.4%)
- employee information (22 resp. 37.9%)
- minimising product-related ecological effects (22 resp. 37.9%).

Most often, PEIS are applied on already existing products or services (49 enterprises of 52 answering this question, i.e. 94.2%). In 17 cases (32.7%) PEIS are used in the product development process. In only a few cases a PEIS is used for the comparison of products (either products of the company or of the competitor). More

than 80% of the PEIS using enterprises estimate that time requirements of PEIS applications are very high. Personnel expenditures are indicated as high by almost 60% of the enterprises. Economic expenses, however, are estimated to be not relevant – only approx. 30% of the enterprises think they are high.

## Interviews in Austrian enterprises

Interviews in 13 enterprises complement the survey via questionnaire. The visited companies are members of the chemical industry (4 companies), metal industry (5), electrical and electronic industry (2) and building industry (2). At first, the environmental managers were asked details of their experiences with PEIS. The second part of the interviews dealt with requirements on PEIS considered to be important for companies. Recommendations to other enterprises, scientists, consultants as well as policy makers were given. The results of the interviews supplement and/or modify the picture received by the questionnaire evaluation: According to the questionnaire survey 26 empirical reports on 8 different 'original' PEIS and 2 economic PEIS could be expected in the 13 visited companies. But in the interviews it turned out that this figure has to be reduced to only 8 actual experiences: 4 reports on EIP application, LCA (1), EcoIndicator (1) and SPI (1) as well as for 'economic analysis' (1) could be identified. CERA and MIPS are the PEIS applications represented in the sample most often (6 denominations for each). In the interviews it turned out that the methods 'CERA' and 'MIPS' have been ticked as 'applied', if there exists some kind of 'energy management' and/or a 'materials accounting' in the enterprise. The names of these two methods apparently lead to misinterpretations because they are easily understandable in German and thus suggest to be methods commonly used in companies. Similar difficulties might arise for 'environmental cost accounting'.

All asked companies stated accordingly that there have not been any hurdles during the introduction phase of PEIS. Support by the business management is judged as particularly important. If PEIS are in use for a longer period repeatedly problems are reported due to lacking motivation. The importance to inform and involve all employees has been stressed.

In the asked enterprises applications of the PEIS 'EIP', 'LCA' as well as an 'economic material flow analysis' are performed to the companies site. LCA, EcoIndicator and SPI have been used for product evaluations. Only in a single enterprise (of the electrical and electronic industry) the PEIS 'EcoIndicator' is used by routine in the product development process. An enterprise of the metal industry uses the PEIS 'Environmental Impact Points (EIP)' on a regular basis (annually) related to EMS activities. All other PEIS applications so far accomplished in the interviewed enterprises usually have been unique projects only. Most often the project has been initiated by research institutions which thereby also determined the kind of PEIS to be used as well. In 3 cases the (non-Austrian) mother company prescribed method selection and application. Information on expenses as well as the cost/benefit relationship usually is not analysed – and thus reports on costs (financial, personnel and time) are solely based on estimations. External support is judged as important, or even essential, because smaller companies usually do not have PEIS expertise. The 'external' view and authority of external consultants are further benefits. A look at the time scale reveals that most of the asked enterprises have begun to participate in environmental programs (EMS, PEIS application) only 3 to max 7 years ago. This may indicate that many Austrian enterprises, particularly the smaller ones, are still at the beginning of a development from site-specific environmental measures towards life cycle thinking. A comparison with the results of

a study performed by the IÖW in Germany (Konrad et al, 2002) highlights many common features but also slight differences to the situation in Germany.

## PEIS – overview and characterisation

On overview is given on more than 20 different product-related environmental information systems (PEIS). They are characterised by a criteria system consisting of the categories 'range', 'process', 'result', 'adaptation to the specific case' and 'operating expense'. The characterisation of PEIS is, on the one hand, based on a survey by questionnaire among consultants with knowledge on PEIS; on the other hand, the results of an expert assessment (GrAT et al. 2003) have been taken into account.

The PEIS under investigation divide into 'environmental decision and information instruments', 'general decision instruments', 'economic methods' and 'ecological product assessment methods'.

## Environmental decision and information instruments

The term 'environmental decision and information instruments' is chosen for methods, which are in use for environmental inventories and which can be adapted for product-related questions. These include:

- **Environmental performance figures, benchmarks.** Environmental performance figures are absolute or relative numbers, which inform about environmental parameters. They describe either a partial aspect of the system or are representative for the total system. For system comparisons (benchmarking) relative numbers with a suitable reference are necessary.
- **Check lists.** Check lists are catalogues of criteria, questions etc., which can be used to evaluate environmental impacts of products

and processes. Frequently results are visualised by strategic wheels.

- **Material exclusion lists.** Listings of materials and compounds, which are to be excluded in the procurement, or shall not be used in product design or production.
- **Input/output analysis (I/O analysis).** I/O analysis looks at (physical and/or monetary) inputs and outputs within defined system borders. It is used for the analysis of conditions and their change in production systems.
- **Material flow accounting (MFA).** Balance of materials (chemical elements and their compounds, natural and produced material mixtures) related to product groups, enterprises and/or sites, needs (e.g. living, mobility), regions or nation.
- **Environmental risk assessment (ERA).** Analysis of the possible effects of activities, particularly by the release of substances on humans and ecological systems. Identification of probability and possible effects of risks. Helps in decision making in order to accept or reduce a risk.

## General decision instruments

General decision instruments are not specific ecological instruments, but can be used for environmental and product-related questions. They include:

- **ABC analysis.** Is an instrument for the in-plant weak point analysis and can be adapted to environmental relevant questions: the environmental criteria are divided in three categories (A, B or C) according to the urgency of need of action.
- **Benefit analysis.** Analyses complex alternatives, and arranges the individual alternatives according to the preferences of decision makers. The total benefit consists of the weighted partial benefits, multiplied by their respective degree of performance.
- **Multi-Criteria Analysis (MCA).** Is an instrument of the economic science. Deals with problems for which a part of the bene-

fit and/or the costs is evaluated in non-monetary units.

- **Cost benefit analysis (CBA).** Extends costs consideration in companies on all internal costs and evaluates hidden and liability costs. It is used for evaluating the profitability of investments.
- **Sustainability compass.** The sustainability compass (Eco compass) represents the change within a set of indicators (specified before) in form of a strategic wheel. The number as well as the kind of the indicators is variable.

## Economic methods

Economic methods are characterised by the fact that not only direct costs are taken into account but also life cycle aspects are considered. Usually the results are expressed in monetary units.

- **Environmental Cost Accounting.** Monetary evaluation of internal and external environmental costs.
- **Life Cycle Costing (LCC), Full Cost Accounting (FCA).** Cost factors of a product are determined along the entire life cycle (including costs for research & development, production, use and/or maintenance, repair and disposal). FCA includes external costs (paid by the public) as well.
- **Total Cost Accounting (TCA).** Extends costs considerations in companies on all internal costs and evaluates hidden and liability costs to estimate the profitability of investments into clean production.

## Ecological product assessment methods

Ecological product assessment methods are methods particularly developed to evaluate the environmental impacts associated with the life cycle of a product.

- **Life Cycle Assessment (LCA).** Compiles the material and energy flows caused by a product along its entire life cycle and consists of the steps 1) Goal and Scope Definition, 2) Life Cycle Inventory (LCI), 3) Life

Cycle Impact Assessment (LCIA) with different aggregation methods and 4) Interpretation. Standardised procedures rely to ISO 14040 et sequ. (e.g. CML method), 'stream-lined' versions are also available.

- **Environmental scarcity method, Environmental Impact Points (EIPs).** The model has been developed in Switzerland and relates the present environmental impacts (current flows) to loads judged as dangerous (critical flows). The emissions of different substances in air, water and soil as well as those associated with the consumption of energy resources are thereby combined into Environmental Impact Points (EIPs).
- **Critical Volumes.** Emissions of pollutants are weighted and aggregated with reference to the immission limit values for water, soil and air. A full aggregation is possible.
- **Environmental Priority Strategies (EPS).** The EPS model developed in Sweden for the product development process considers effects on 'human health', 'bio diversity', 'production capacity of the ecological system', 'abiotic resources' and 'aesthetic values'. The results are presented as money values of market prices, of the 'willingness to pay' (e.g. for the preservation of species or natural areas), as well as the costs of a sustainable use of energy and resources.
- **Eco indicator 95/99.** Developed in the Netherlands for designer and product manager. Emissions of pollutants are assigned impact categories (according to ISO 14040 et sequ.) and divided by the average European impact. The environmental impacts are further assigned to so-called damage categories (effects on the human health, quality of the ecological system, fossil and mineral resources).
- **Cumulative Energy Requirement Analysis (CERA).** All primary energetic expenses along the entire life cycle of a product or a service (see also VDI 4600) are summed up.
- **Material Input per Service unit (MIPS).** The intensity of the environmental impact of a service or a functional unit is shown by

the input of material (quantity of nature in kg or t) per service unit (MIPS) along the entire life cycle.

- **Sustainable Process Index (SPI), Ecological Footprint (EFP).** Is a simple and descriptive measure, which sums up the ecological impacts by taking into account the land consumption associated with human activities.

## Criteria system

The characterisation of the PEIS mentioned above is on the one hand based on a questionnaire survey among consultants, and on the other hand on the results of an expert assessment (GrAT 2003). In order to consider the experiences of users with different product-related environmental information systems (PEIS), a questionnaire was dispatched (via email) at 51 experts/consultants. 10 different experts sent back by 18 questionnaires including results for 8 different PEIS. Most information was given for LCA (6 answers), SPI (3) and MIPS (3). The project 'suitability and applicability of evaluation methods for sustainability management' (GrAT 2003) analysed a broad range of PEIS via expert assessment. The results of both analyses have been combined in a concerted criteria system. The following categories of criteria are used to characterise properties of PEIS.

## Range

Each PEIS aims at representing and evaluating reality. Since the reality itself cannot be measured, the examined range will be limited to parts of it with defined system borders. The range of a PEIS is subdivided in 'length', 'width' and 'depth' and covers: the phases in the life cycle of the product considered ('length'), the dimensions of sustainability included ('width') as well as the steps of the 'emissions (cause) – impact – effect' chain ('depth') taken into account.

## Process

A fixed procedure or an algorithm aims at providing a result. The process represents thus the way towards the result. A distinction has to be made whether the emphasis of the method is on the procedure, i.e. whether the participation of all parties involved is regarded as essential, or the result itself is most important.

## Result

In general, the result is the core of the PEIS application. The appropriate kind of result is the most important criterion for testing the suitability of methods for the respective application. It is differentiated between decision-oriented and information-orientated results.

## Adaptation to the specific case

Either, the adaptation to given tasks may be substantial for the choice of a PEIS appropriate for a specific application case. Or, the availability of a standardised procedure is essential.

## Operating expense

Fitness of PEIS in practice largely depends on the operating expense and relates to personnel, economic and time requirements as well as technical pre-requisites.

## Environmental decision types and suitable PEIS

The classification and description of decision types in enterprises follows the structure and text used in the handbook (Wrisberg & Udo de Haes, 2002) which has been developed in the course of the EU-project CHAINET.

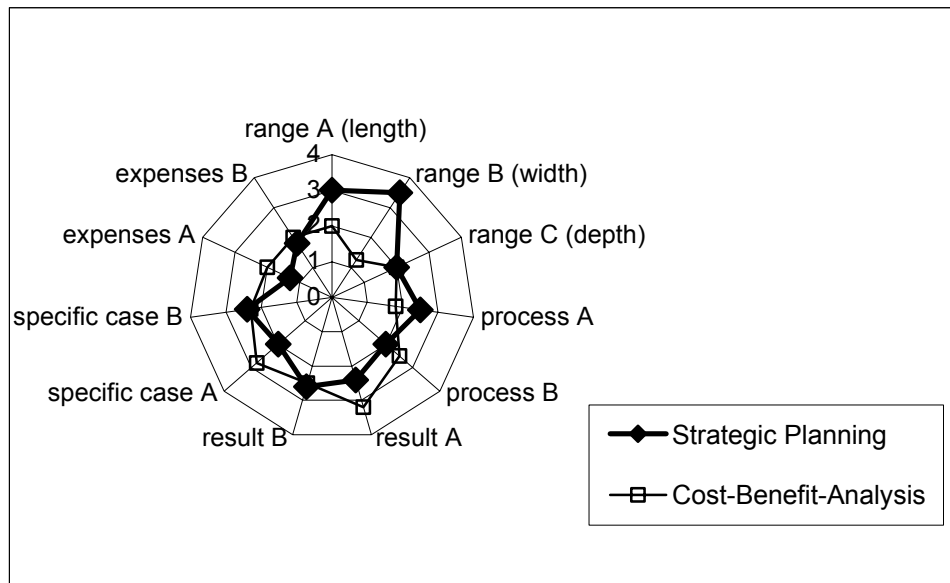
‘Strategic planning’ aims at formulating the managerial policy. Improvement of product responsibility, maintenance of the site, holding up market position and economic success are in

the centre of interest. ‘Capital investment’ covers decisions on the strategic level as well, but is more specific than strategic planning. Costs connected with decisions of long-term importance are to be evaluated.

The corporate activity ‘Design and Development’ on the tactical level deals with design, optimisation and comparison of products, services or processes. ‘Communication and marketing’ is positioned on the operational level and covers different activities as e.g. ecolabelling, marketing activities or environmental reporting. ‘Operational management’ aims at reducing the ecological impacts related to business activities by enforcing appropriate measures. New locations, optimisation and comparison (benchmarking) of existing locations as well as ‘green’ procurement are the main fields of activity.

## Suitable PEIS

The different requirements of strategic planning, capital investment, design & development, communication & marketing as well as environmental management can be defined with the help of the same criteria system (presented in a preceding chapter) that is used to obtain the characteristic profiles of PEIS. Comparing the requirement profiles of decision types and characteristic profiles of PEIS shall help to identify PEIS suited best for the respective application. However, the profiles are based on the estimates of some few experts – thus the results may serve only as a first starting point, and follow-up activities shall lead to a broader basis. Figure 1 illustrates the approach for the example strategic planning and cost benefit analysis. The PEIS cost-benefit analysis does neither fulfil the requirements of ‘length’, ‘width’, and ‘depth’ nor of the ‘A’ criterion of process. For all other criteria the requirements of strategic planning are met by cost-benefit analysis.



*Figure 1: Comparison of requirements of strategic planning and characteristics of cost-benefit analysis within the criteria system.*

## Strategic Planning

A look at the deviations of requirements of strategic planning and the characteristics of PEIS reveals that the PEIS deficits are mainly within the criterion 'range', since none of the PEIS does consider all dimensions of sustainability. The analysis performed by the project teams inter alia results in the recommendation of life-cycle-based PEIS, i.e. ecological product assessment methods. Full 'width' (inclusion of economics, ecology and social issues) and 'depth' (steps considered in the cause-effect chain) are however most often missing. The strong focus on ecological aspects alone is seen negative for strategic planning. PEIS based on cost and/or benefit have similar deficits regarding ecological and social issues. The advancement of life-cycle-based methods towards several dimensions (including i.e. risk) thus seems to be necessary.

## Capital Investment

The methods best suitable for capital investments have to provide cost-based information and have to include one or more life cycle aspects. The comparison of requirement profile of

capital investment and PEIS characteristics shows that extending TCA by benefit aspects might be a suitable combination to systematically evaluate investments.

## Design and Development

Ecological product assessment methods have been designed for the assessment of existing products as well as for the design and development of new products and services. Therefore all PEIS of this sub-group can be applied during the design process. In early phases of the design process check lists and other simple tools will be sufficient. While for the product design there is a set of instruments available, there exist far less tools for the design of processes.

## Communication and Marketing

One has to differentiate between the rather information-orientated needs of inter-company communication and the decision-oriented adjustment of consumer information.

In the future, application of PEIS in communication and marketing will be enforced by the IPP initiative of the European Union.

## Operational Management

As for communication & marketing, PEIS applications in operational management will be expanded in the next time, since many enterprises strive to secure the economic future of their sites by taking into account all dimensions of sustainability and including risk aspects and cause-effect aspects of environmental impacts. The use phase of products often cannot be influenced by manufacturers; ecological procurement, however, offers many possibilities for the upstream integration of life cycle aspects. Easy integration of data, quick decisions and the possibility of continuous improvement will be crucial success factors for the implementation of PEIS in environmental management (to be used for intern comparisons or benchmarking with industry leaders and other comparable enterprises).

## Conclusions/Outlook

As part of the project 'Product-related Environmental Information Systems (PEIS) in Austrian Companies' a so-called strategy paper has been drafted for the target groups companies, representative bodies, scientists, consultants and policy makers. Recommendations are based on the opinions of Austrian enterprises, scientific publications (Konrad, W. et al 2002; Wrisberg, N.; Udo de Haes, H., 2002) and summarise possible measures and strategies to introduce and systematise PEIS applications in Austrian companies. The suggested measures comprise:

- success factors of an operational PEIS introduction
- possible procedures for small and medium-sized enterprises
- extensive and reliable database as important condition for diffusion strategies, platforms for information exchange, success stories
- Eco-Design activities, propagation of eco-labelling, environmental reporting and environmental management systems

- standardisation of simpler ('streamlined') PEIS
- enhancing product responsibility by screening of supplier and 'green' procurement guidelines

A 'factory of tomorrow' will produce with a minimum of resources and environmental impacts at a maximum of benefit. In order to justify a selection between possible alternatives, profound information about ecological, economic, and social effects is indispensable. The project 'PEIS in Austrian companies' is a contribution to reach this goal, as (product-related) environmental information systems are characterised, and the requirements of different decision types are defined via the same criteria system. The manual 'PEIS in theory and practice' will be published in the Internet ([www.fabrikderzukunft.at/puis](http://www.fabrikderzukunft.at/puis)) and will help to select methods suitable best for applications planned.

The use of PEIS for strategic planning and in early phases of the design process can strengthen the provision of services instead of products. With the assistance of PEIS the eco-efficiency of renewable resources can be evaluated. If PEIS identify improvement options at the other end of the product life cycle (the disposal) recycling and/or using cascades will become promising options.

Those enterprises, which do not only have in mind short success, but want to secure sites as well as employees occupation at the long term, have to reconcile economic, ecological and social goals. A systematic integration of life cycle aspects of products or services offered may take place by the appropriate application of PEIS. In order to make PEIS application not only a coincidental and singular project, but to integrate suitable and/or adapted PEIS into all fields of activity of the enterprise, the commitment of the managing directors is indispensable.

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