LCIA Methods and Links:

Eco-indicator 99: http://www.pre.nl/eco-indicator99/
EDIP 97: http://ipt.dtu.dk/~mic/EDIP97
EDIP 2003: http://ipt.dtu.dk/~mic/EDIP2003
EPS 2000d: http://eps.esa.chalmers.se/
(Dutch) Handbook on LCA: http://www.leidenuniv.nl/cml/ssp/projects/lca2/lca2.html
Impact (2002)+: http://www.epfl.ch/impact
JEPIX: www.jepix.org
LIME: http://www.jemai.or.jp/lcaforum/index.cfm
Swiss Ecoscarcity: http://www.e2mc.com/BUWAL297%20english.pdf
TRACI: http://epa.gov/ORD/NRMRL/std/sab/iam_traci.htm

Short description of LCIA methods

Eco-Indicator 99

Eco-indicator 99 was developed in a top down fashion. The weighting problem was the key problem that was to be solved. Weighting was simplified by:

- Using just three endpoints; this minimizes the mental stress among panelist to take into account too many issues
- Defining these three issues as endpoints that are reasonably easy to understand

The weighting problem has not been solved, but weighting and interpretation of results without weighting has been made easier. Other new ideas in the methods are the consistent management of subjective choices using the concept of cultural perspectives. This has lead to a good documentation of the choices and to the publication of three versions, each with a different set of choices. Other issues are, the introduction of the DALY approach, the introduction of the PAF and PDF approach, as well as the surplus energy approach

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Link: Eco-indicator 99: http://www.pre.nl/eco-indicator99/

Literature:

Dreicer M., V. Tort, P. Manen, 1995. *ExternE, Externalities of Energy*, *Vol. 5. Nuclear*, Centre d'étude sur l'Evaluation de la Protection dans le domaine Nucléaire (CEPN), edited by the European Commission DGXII, Science, Research and Development JOULE, Luxembourg

Frischknecht R., Braunschweig A., Hofstetter P., Suter P. (1999), Modelling human health effects of radioactive releases in Life Cycle Impact Assessment, Draft from 20 February 1999, accepted for publication in Environmental impact Assessment Review.

Hofstetter, P. (1998): Perspectives in Life Cycle Impact Assessment; A Structured Approach to Combine Models of the Technosphere, Ecosphere and Valuesphere. , Kluwers Academic Publishers, 1998, Info: www.wkap.nl/book.htm/07923-8377-X.

Köllner, T.; Species-pool Effect Potentials (SPEP) as a yardstick to evaluate land-use impacts on biodiversity. Submitted to and accepted by the Journal of Cleaner Production. August 1999

Meent, D. van de; Klepper, O (1997): Mapping the Potential Affected Fraction (PAF) of Species as an Indicator of Generic Toxic Stress. RIVM report 607504001, June 1997; RIVM. Bilthoven

Müller-Wenk, R. (1998-1): Depletion of Abiotic Resources Weighted on the Base of "Virtual" Impacts of Lower Grade Deposits in Future. IWÖ Diskussionsbeitrag Nr. 57, Universität St. Gallen, March 1998, ISBN 3-906502-57-0

Murray, C.J.L., Lopez, A.D. , Quantifying disability: data methods and results, Bulletin of the World Health Organisation, 72 (3), 1994, p 481-494.

EDIP97 & EDIP2003

EDIP97 is a thoroughly documented midpoint approach covering most of the emission-related impacts, resource use and working environment impacts (Wenzel et al., 1997, Hauschild and Wenzel, 1998) with normalization based on person equivalents and weighting based on political reduction targets for environmental impacts and working environment impacts, and supply horizon for resources. Ecotoxicity and human toxicity are modeled using a simple key-property approach where the most important fate characteristics are included in a simple modular framework requiring relatively few substance data for calculation of characterization factors. Comparison of the use of EDIP97, CML 2001 and Eco-indicator 99 in Dreyer et al., 2003.

Update through EDIP2003 methodology (Hauschild and Potting, 2003, Potting and Hauschild, 2003) supporting spatially differentiated characterization modeling which covers a larger part of the environmental mechanism than EDIP97 and lies closer to a damage-oriented approach. This part of the general method development and consensus programme covers investigations of the possibilities for inclusion of exposure in the life cycle impact assessment of non-global impact categories (photochemical ozone formation, acidification, nutrient enrichment, ecotoxicity, human toxicity, noise).

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Link:

EDIP 97: http://ipt.dtu.dk/~mic/EDIP97
EDIP 2003: http://ipt.dtu.dk/~mic/EDIP2003

References:

Dreyer, L.C., Niemann, A.L., and Hauschild, M.Z.: Comparison of three different LCIA methods:EDIP97, CML2001 and Eco-indicator 99. Does it matter which one you choose? Int.J.LCA, 8(4), 191-200, 2003

Hauschild, M.Z. and Wenzel, H.: Environmental assessment of products. Vol. 2 - Scientific background, 565 pp. Chapman & Hall, United Kingdom, 1998, Kluwer Academic Publishers, Hingham, MA. USA. ISBN 0412 80810 2

Hauschild, M. and Potting, J.: Spatial differentiation in life cycle impact assessment – the EDIP2003 methodology. Guidelines from the Danish Environmental Protection Agency, Copenhagen, 2004 (in press).

Potting, J. and Hauschild, M.: Background for spatial differentiation in life cycle impact assessment – the EDIP2003 methodology. Environmental project no. ¤¤, Danish Environmental Protection Agency, Copenhagen, 2004 (in press).

Wenzel, H., Hauschild M.Z. and Alting, L.: Environmental assessment of products. Vol. 1 - Methodology, tools, techniques and case studies, 544 pp. Chapman & Hall, United

Kingdom, 1997, Kluwer Academic Publishers, Hingham, MA. USA. ISBN 0 412 80800 5.

EPS 2000d

The EPS 2000d impact assessment method is the default impact assessment method in the EPS system. It is developed to be used for supporting choice between two product concepts. Category indicators are chosen for this purpose, i.e., they are suitable for assigning values to impact categories. Category indicators are chosen to represent actual environmental impacts on any or several of five safeguard subjects: human health, ecosystem production capacity, biodiversity, abiotic resources and recreational and cultural values. The characterization factor is the sum of a number of pathway-specific characterization factors describing the average change in category indicator units per unit of an emission, e.g. kg decrease of fish growth per kg emitted SO_2. An estimate is made of the standard deviation in the characterization factors due to real variations depending on emission location etc. and model uncertainty. This means that characterization factors are only available, where there are known and likely effects. Characterization factors are given for emissions defined by their, location, size and temporal occurrence. Most factors are for global conditions 1990 and represents average emission rates. This means that many toxic substances, which mostly are present in trace amounts, have a low average impact. Weighting factors for the category indicators are determined according to people's willingness to pay to avoid one category indicator unit of change in the safe guard subjects.

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Link: EPS 2000d: http://eps.esa.chalmers.se/

References

Bengt Steen, A Systematic Approach to Environmental Priority Strategies in Product Development (EPS). Version 2000 – General System Characteristics. Chalmers University of Technology, Centre for Environmental Assessment of Products and material Systems (CPM) Report 1999:4, Gothenburg 1999.

Bengt Steen, A Systematic Approach to Environmental Priority Strategies in Product Development (EPS). Version 2000 – Models and Data. Chalmers University of Technology, Centre for Environmental Assessment of Products and material Systems (CPM) Report 1999:5, Gothenburg 1999.

(Dutch) Handbook on LCA

The (Dutch) Handbook on LCA provides a stepwise `cookbook' with operational guidelines for conducting an LCA study step-by-step, justified by a scientific background document, based on the ISO Standards for LCA. The different ISO elements and requirements are made operational to be `best available practice' for each step. The life cycle impact assessment methodology recommended is based on a midpoint approach covering all emission- and resource-related impacts, for which practical and acceptable characterization methods are available (Guinée et al., 2002). Best available characterization methods have been selected based on an extensive review of existing methodologies world-wide. For most impact categories a baseline and a number of alternative characterization methods is recommended and for these methods comprehensive lists of characterization and also normalization factors are supplied. Ecotoxicity and human toxicity are modeled adopting the multi-media USES-LCA model developed by Huijbregts (Huijbregts et al., 2000 and 2001). The Handbook provides characterization factors for more than 1500 different LCI-results, which can be downloaded at *http://www.leidenuniv.nl/cml/ssp/projects/lca2/index.html*.

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Link: (Dutch) Handbook on LCA:
http://www.leidenuniv.nl/cml/ssp/projects/lca2/lca2.html

References:

Guinée J.B., Heijungs R., Huppes G., 2004: Economic Allocation: Examples and Derived Decision Tree. Int. J. LCA 9 (1), 23-33 (OnlineFirst; Doi: http://dx.doi.org/10.1065/lca2003.10.136) <http://dx.doi.org/10.1065/lca2003.10.136>)

Suter, G., 2003: Handbook on life-cycle assessment; operational guide to the ISO Standards. SETAC Globe, May-June, 2003, pp. 39-40.

Klöpffer, W., 2002. Handbook on Life Cycle Assessment - Operational Guide to the ISO Standards (Book Review: The Second Dutch LCA-Guide, published as book). Int. J. LCA 7 (5), 311-313.

Guinée, J.B. (Ed.), M. Gorrée, R. Heijungs, G. Huppes, R. Kleijn, A. de Koning, L. van Oers, A. Wegener Sleeswijk, S.Suh, H.A. Udo de Haes, J.A. de Bruijn, R. van Duin and M.A.J. Huijbregts, 2002. Handbook on Life Cycle Assessment: Operational Guide to the ISO Standards. Kluwer Academic Publishers. Dordrecht (Hardbound, ISBN 1-4020-0228-9; Paperback, ISBN 1-4020-0557-1; see also http://www.kap.nl/prod/b/1-4020-0228-9)

Guinée, J.B. (eindredacteur), M. Gorrée, R. Heijungs, G. Huppes, R. Kleijn, A. de Koning, L. van Oers, A. Wegener Sleeswijk, S. Suh, H.A. Udo de Haes, J.A. de Bruijn, R. van Duin and M.A.J. Huijbregts, 2002. Levenscyclusanalyse: De ISO-normen uitgewerkt in een praktijkgerichte Handleiding. VROM.

Guinée, J.B., 2001. Handbook on life cycle assessment - operational Guide to the ISO Standards. Int. J. LCA 6 (5), 255.

Guinée, J.B., G. Huppes & R. Heijungs, 2001. Developing an LCA guide for decision support. Environmental Management and Health, Vol. 12, No. 3, pp 301-311.

Huijbregts, M.A.J., J.B. Guinée and L. Reijnders, 2001: Priority assessment of toxic substances in life cycle assessment. Part III: Export of potential impact over time and space. Chemosphere 44, pp. 59-65.

Huijbregts, M.A.J., U. Thissen, J.B. Guinée, T. Jager, D. Kalf, D. van de Meent, A.M.J. Ragas, A. Wegener Sleeswijk and L. Reijnders, 2000: Priority assessment of toxic substances in life cycle assessment. Part I: Calculation of toxicity potentials for 181 substances with nested multi-media fate, exposure and effects model USES-LCA. Chemosphere 41, pp. 541-573.

IMPACT 2002+

The IMPACT 2002+ life cycle impact assessment methodology proposes a feasible implementation of a combined midpoint/damage approach, linking all types of life cycle inventory results (elementary flows and other interventions) via 14 midpoint categories to four damage categories. For IMPACT 2002+ new concepts and methods have been developed, especially for the comparative assessment of human toxicity and eco-toxicity. Human Damage Factors are calculated for carcinogens and non-carcinogens, employing intake fractions, best estimates of dose-response slope factors, as well as severities. The transfer of contaminants into the human food is no more based on consumption surveys, but accounts for agricultural and livestock production levels. Indoor and outdoor air emissions can be compared and the intermittent character of rainfall is considered. Both human toxicity and ecotoxicity effect factors are based on mean responses rather than on conservative assumptions. Other midpoint categories are adapted from existing characterizing methods (Eco-indicator 99 and CML 2002). All midpoint scores are expressed in units of a reference substance and related to the four damage categories human health, ecosystem quality, climate change, and resources. Normalization can be performed either at midpoint or at damage level. The IMPACT 2002+ method presently provides characterization factors for almost 1500 different LCI-results, which can be downloaded at http://www.epfl.ch/impact

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Link: Impact (2002)+: http://www.epfl.ch/impact

References:

Jolliet, O., Margni, M., Charles, R., Humbert, S., Payet, J., Rebitzer, G. and Rosenbaum, R.,2003. IMPACT 2002+: A New Life Cycle Impact Assessment Methodology. . Int J. of LCA 8 (6) 324-330.

Crettaz, P., Rhomberg, L., Brand, K., Pennington, D.W. and Jolliet, O., 2002. Assessing Human Health Response in Life Cycle Assessment using ED10s and DALYs: Carcinogenic Effects; Int. Journal of Risk Analysis, 22 (5) 929-944.

Pennington, D.W, Crettaz, P., Tauxe, A. and Jolliet, O., 2002. Assessing Human Health Response in Life Cycle Assessment using ED10s and DALYs: Non-Carcinogenic Effects; Int. Journal of Risk Analysis, 22 (5) 945-961.

JEPIX - Japan Environmental Policy Priorities Index

This method is developed and applied by the JEPIX Forum, a voluntary initiative of several organizations and private persons from Environmental Accounting, Environmental Management, Eco-Rating and Life Cycle Impact Assessment in Japan.
Inspired by the Swiss EcoScarcity method, JEPIX is based on the distance-to-target principle, but in many respects takes different approaches to derive Ecofactors for the weighting of interventions. The method puts more emphasis on a transparent, simple and understandable, but trend-consistent description of the political situations rather than on the preciseness of natural science based modelling. It is designed to indicate, where political pressure is high and therefore new legal requirements are likely to occur and hence to rise environmental costs for industry. Therefore it is considered as complementary to existing LCIA methods, that indicate damage to environment and/or society.
A first version of JEPIX was published in 2003 as a draft focusing on emissions and addressing 11 focal subjects of Japanese environmental legislation. It provides weighting factors for some 1050 interventions. For substance bound legislation, the weighting is based on annual flows (actual and target), whereas for effect oriented legislation midpoint models such as GWP, ODP, Human Toxicity or POCP are used to derive national flows. As the environmental situation varies substantially across Japan, the weighting factors for some 150 substances are scaled to reflect the situation in each of the 47 prefectures as well as for some 100 rivers, 15 lakes and 3 inland sea areas/bays.
The draft version was published in 2003 with support of the Japan Environmental Ministry (MoE), the Ministry for Economy Trade and Industry (METI) and the Ministry for Education and Technology (MEXT).
Since 2003 some 40 leading Japanese Companies (including Komatsu, Canon, TEPCO, Suntory, Fuji Film, All Nippon Airways, J-Power, etc.) are applying this method to evaluate and communicate their environmental performance data and to conduct LCA of products and services. Under the Centre of Excellence Program of the Japanese government, the method will be enhanced based on their experience. The final version of JEPIX is expected for publication in 2006. An integration of resources as well as the adoption of newly available data on chemicals is already under development.

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Link: JEPIX: www.jepix.org

References:

Miyazaki, N., Siegenthaler, C., Kumagai, S., Shinozuka, E., Nagayama, A.(2003): JEPIX – Japan Environmental Policy Priorities Index, Japan Science and Technology Inc/Sustainable Management Forum Japan, Tokyo, in Japanese.

Miyazaki, N., Siegenthaler, C., Schoenbaum, T., Azuma, K. (2003): Japan Environmental Policy Priorities Index 2003 (JEPIX), 21st Century COE Monograph Series 7, Social Science Research Institute of International Christian University, Tokyo, 2004, in English.

JEPIX FORUM (2004): JEPIX FORUM Annual Report 2003, Centre of Excellence Program, International Christian University/Yamatake, Tokyo, in Japanese.

LIME

LCA National Project of Japan has conducted a study aimed at the development of a Japanese version of the damage oriented impact assessment method called LIME (Life-cycle Impact assessment Method based on Endpoint modeling). In LIME, the potential damage on socio economic impact caused by the utilization of abiotic resources, increase of extinction risk and loss of primary production caused by mining of resources are measured as main damages of resource consumption. Modeling socio-economic impact was based on the concept of user-cost, which accounts for the equity of future generations. The procedure to measure damages on ecosystem is based on studies estimating the risk of extinction of specific species in the field of conservation biology. Lists of damage factors of mineral resources, fossil fuels and biotic resources like wood material have already prepared and released to the public. The development of these factors enables us to compare and integrate with the damages derived from the other impact categories like global warming and acidification without value judgment of ordinary people.

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Link: LIME: http://www.jemai.or.jp/lcaforum/index.cfm

Reference:

Itsubo, N.; Sakagami, M.; Washida, T.; Kokubu, K.; Inaba, A. Weighting Across Safeguard Subjects for LCIA through the Application of Conjoint Analysis, *International Journal of LCA*, 2004, 9 (3) pp. 196-205.

Swiss Ecoscarcity Method (Ecopoints)
The method of environmental scarcity – sometimes called Swiss Ecopoints method – allows a comparative weighting and aggregation of various environmental interventions by use of so-called eco-factors. The method supplies these weighting factors for different emissions into air, water and top-soil/groundwater as well as for the use of energy resources. The eco-factors are based on the annual actual flows (current flows) and on the annual flow considered as critical (critical flows) in a defined area (country or region). The eco-factors were originally developed for the area of Switzerland (see references below). There, current flows are taken from the newest available statistical data, while critical flows are deduced from the scientifically supported goals of the Swiss environmental policy, each as of publication date. Later, sets of eco-factors were also made available for other countries, such as Belgium and Japan.

The method has been developed top-down and is built on the assumption that a well established environmental policy framework (incl. the international treaties) may be used as reference framework for the optimization and improvement of individual products and processes. The various damages to human health and ecosystem quality are considered in the target setting process of the general environmental policy; this general environmental policy in turn is then the basis for the 'critical flows'. An implicit weighting takes place in accepting the various goals of the environmental policy. The ecopoints method contains common characterization/classification approaches (for climate change, ozone depletion, acidification). Other interventions are assessed individually (e.g. various heavy metals) or as a group (e.g. NM-VOC, or pesticides).

The method is meant for standard environmental assessments, e.g., with specific products or processes. In addition, it is often used as an element of environmental management systems (EMS) of companies, where the assessment of the company's environmental aspects (ISO 14001) is supported by such a weighting method.
The method was first published in Switzerland in 1990. A first amendment and update was made for 1997, which is the current version. A next version, based on 2004 data, will be available in 2005.

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Link: Swiss Ecoscarcity: http://www.e2mc.com/BUWAL297%20english.pdf

References:

Brand, G., Braunschweig, A., Scheidegger, A., Schwank, O.: Weighting in Ecobalances with the Ecoscarcity Method – Ecofactors 1997. BUWAL (SAFEL) Environment Series No. 297, Bern 1998.

Müller-Wenk, R.: The Ecoscarcity Method as a Valuation Instrument within the SETAC-Framework, in: Udo de Haes/Jensen/Klöpffer/Lindfors (Ed.): Integrating Impact Assessment into LCA, SETAC-Europe, Brussels 1994, p. 115-120.

Ahbe, S., Braunschweig, A., Müller-Wenk, R.: Methodology for Ecobalances Based on Ecological Optimization, BUWAL (SAFEL) Environment Series No. 133, Bern 1990.

For company applications, see the annual company, sustainability or environmental reports of e.g.

- Canon Switzerland (www.canon.ch/d/about/dyn/eco_rep.cfm?theme=2),
- La Poste (http://www.post.ch/SiteOnLine/FR/Accueil/1,1727,15316-172,00.html)
- McDonald's Switzerland (www.mcdonalds.ch/downloads/umweltbericht_de.pdf)
- various financial institutions such as Bâloise Insurance, Credit Suisse or the Zürich Cantonal Bank
- or the environmental report of the Swiss federal administration (http://www.rumba.admin.ch/download/Organisation/Umweltbericht_BV_03_d.pdf)

The Tool for the Reduction and Assessment of Chemical and Other Environmental Impacts (TRACI)

TRACI is an impact assessment methodology developed by the U.S. Environmental Protection Agency that facilitates the characterization of environmental stressors that have potential effects, including ozone depletion, global warming, acidification, eutrophication, tropospheric ozone (smog) formation, ecotoxicity, human health criteria–related effects, human health cancer effects, human health noncancer effects, and fossil fuel depletion. TRACI was originally designed for use with life-cycle assessment (LCA), but it is expected to find wider application to pollution prevention and sustainability metrics.

To develop TRACI, impact categories were selected, available methodologies were reviewed, and categories were prioritized for further research. Impact categories were characterized at the midpoint level for various reasons, including a higher level of societal consensus concerning the certainties of modeling at this point in the cause-effect chain. Research in the impact categories of acidification, smog formation, eutrophication, human health cancer, human health noncancer, human health criteria pollutants was conducted to construct methodologies for representing potential effects in the United States. Probabilistic analyses allowed the determination of an appropriate level of sophistication and spatial resolution necessary for impact modeling for each category, yet the tool was designed to accommodate current variation in practice (e.g., site-specific information is often not available). The methodologies underlying TRACI reflect state-of-the-art developments and best-available practice for life-cycle impact assessment (LCIA) in the United States.

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Link: TRACI: http://epa.gov/ORD/NRMRL/std/sab/iam_traci.htm

References

Bare, J.C., G.A. Norris, D.W. Pennington, and T. McKone (2003) TRACI: The Tool for the Reduction and Assessment of Chemical and Other Environmental Impacts. Journal of Industrial Ecology **6**(3), pp. 49-78.