Survey on Danish environmental indicators in the building sector

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Contents

Introduction

This survey on Danish environmental indicators in the construction sector is primarily based on:

- Current extracts from reports on strategies, action plans and indicators
- Schematic descriptions of a number of Danish indicators sets meant to be used within the building sector, primarily with focus on environmental sustainability

Some indicators have been in use for a number of years, others are still under testing and further development.

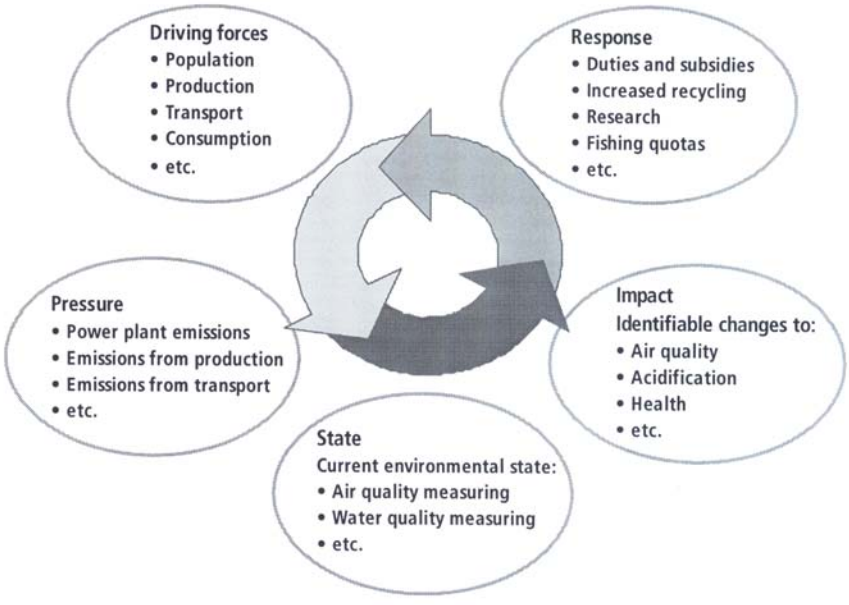
National level

Extracts are presented from:

- Statistical Yearbook 2001 Environment and energy
  - which includes environmental data for households, manufacturing, energy and water supply, constriction and other sectors of interest for the building sector
- "Discussion paper: Set of indicators for Denmark's Strategy for Sustainable Development" Danish Government 2001
  - which includes proposals for sustainability indicators related to Denmark's national strategy for sustainable development, which now are being revised by the new government

Statistical Yearbook 2001 Environment and energy 1

The DPSIR model
The environmental has been based on a so-called DPSIR model, which is a theoretical and internationally recognised model. This model comprises five elements: Driving forces, Pressure, State, Impact, and Response.



Driving forces
This mode is based on the fact that the vast array of human activity in our society -the driving forces -may occasion environmental problems. For example, these driving forces may be the amount of energy produced. Driving forces are economic activities on which we a depend, but they do not provide any information on the state of the environment in themselves.

Pressure
Production in Denmark causes pressure on the environment in the form of emissions and discharges of large amounts of waste associated with this production. For example, electricity generation at a power station may involve the burning of coal at power stations, occasioning the release of carbon dioxide and other substances such as sulphur and nitrogen, and the task then is to identify and calculate such emissions. Carbon dioxide is a so-called greenhouse gas which is not dangerous in itself. However, as carbon dioxide quantities increase, this gas contributes to a gradual process of global heating, which may cause me ting of the polar ice caps and changes in rainfall patterns.

State
Thus, human pressure on its surroundings and environment causes this environment to slowly change its nature. As is the case with other types of status supervision, regular measurement of the state of the environment is carried out. In the example quoted above, carbon-dioxide emissions contribute to a status report which shows greater carbon-dioxide concentrations in the atmosphere.

Impact
A given state will typically have an impact on the environment. In the power-station example, the impact of increased concentrations of carbon-dioxide gas in the atmosphere is an increase in global heating. Also, atmospheric concentrations of sulphur may cause greater acidification of lakes due to sulphur oxides. Such environmental impacts may not necessarily be immediately identifiable, but will be observed over a period of years in the form of changes to the state of the environment.

Response
If the state of the environment is not acceptable, this constitutes an environmental problem. Such a problem will typically entail a response from the authorities. Responses may either be political (examples include bans on environmentally harmful substances or the introduction of "green taxes and duties")or behavioural. It is a so possible to promote desirable behaviour by providing subsidies in support of alternative production methods and processes which are less harmful to the environment.

A response might a so take the form of international agreements. As far as carbon-di-oxide emissions are concerned, the Danish response has entailed the introduction of duties and international agreements. Also, the population may react by changing their behaviour as regards particular issues. Such behavioural changes may manifest themselves as deliberate product choices based on a positive or negative view of the relevant production methods or product contents. The phrase used to describe individuals who display such behaviour is "political consumers".

The five elements which comprise the DPSIR model are very different. Some of the elements are calculated as physical quantities, and some in monetary values – i.e. quantitative measures. Other elements within the model concern the agreements entered into -qualitative measures. As it is not possible

to measure the five elements of the mode by the same yardstick, the ways in which these five elements are addressed in the model will a so differ.

"Discussion paper: Set of indicators for Denmark's Strategy for Sustainable Development" Danish Government 2001

A set of Indicators for Denmark's National Strategy for Sustainable Development has been presented for open

This discussion paper presents a proposal for a set of indicators related to Denmark's Strategy for Sustainable Development.

The paper explains what indicators are, and where and how they are applied - also in an international context. The discussion paper further presents a proposal for a set of indicators intended to highlight the development and results vis-à-vis objectives and initiatives in the proposal for Denmark's Sustainable Development Strategy, published by the Danish government on 16 March 2001.

The aim is to establish a set of sustainable development indicators, anchored in public debate, which Denmark will utilise in the future as a tool for reporting on the implementation of objectives and activities in the strategy. The proposal paves the way for a debate on which indicators will be relevant in demonstrating progress towards sustainable development in the years ahead.

Why set up indicators for sustainable development?

Selected indicators can be a tool to follow the implementation and outcome of the national Strategy for Sustainable Development. For this reason, Denmark should have a set of indicators to monitor whether activities and objectives in the national strategy are reached.

Definition:
An indicator can be defined as a parameter reflecting the development in the state and condition or an interrelation pertinent to realising key objectives or initiatives.

Indicators do not in themselves bring about changes, but represent a valuable tool for highlighting the development, identifying challenges and following the implementation and results of activities. Not all phenomena are suitable for presentation as indicators, but in many fields indicators can provide a straightforward picture that readers can relate to.

Indicators contain information that is often less detailed and more aggregated than data and statistics. The gross national product or unemployment rates are familiar examples of indicators reflecting a country's economy and unemployment. Application frequency represents an environmental indicator showing the environmental load of pesticides. The content of indicators for sustainable development goes farther than conventional environmental indicators by also focusing on factors such as consumption, resource aspects, real savings and links between economic growth and environmental load.

With a view to illustrating the development towards the objectives and visions of the strategy, Denmark needs to put together a set of indicators, giving a representative and comprehensive picture of the various activity areas in the strategy.

Indicator activities in international and regional/local fora

Several international forums are conducting activities targeted at developing environmental, sectoral and sustainability indicators. Some of the key international players are: the OECD, the UN Commission on Sustainable Development (CSD) and the EU Commission with its relevant institutions: the statistics office (Eurostat) and the European Environment Agency. The World Bank, the World Resource Institute, World Watch, Baltic 21, the Nordic Council of Ministers and a range of NGOs are also developing sustainability indicators.

In recent years, many of the countries to which Denmark is normally compared have initiated work to develop sustainable development indicators. Eight European countries helped testing the UN set of indicators for sustainable development. Several countries have also starting developing national sets of sustainable development indicators.

A Danish set of indicators may find valuable inspiration in other countries' set of indicators, where it proves relevant to compare Denmark's objectives and development with the development in other countries. Thus, it would be natural for Denmark to adopt generally recognised international sets of indicators, where relevant. However, a Danish set of indicators for sustainable development cannot be based solely on existing, international sets of indicators. First of all, data accessibility, relevance and precision may prove difficult to manage in such comparisons. Second, the international sets of indicators are still under development, and, finally, a range of international problems has no relevance for Denmark. Denmark would have to adjust indicators and supplement them with indicators that better cover objectives and activities in the Danish national Strategy for sustainable Development.

Several regional and local authorities in Denmark are working to establish sustainable development indicators as an element of local Agenda 21 activities. A national set of indicators could be used to inspire these regional and local activities, while also opening up greater opportunities for comparing the local and the national indicators.

Whom do indicators address?

A Danish set of indicators for sustainable development has a wide target group. This is why the indicators should be meaningful and comprehensible to politicians, people from professional associations, environment associations and trade associations, researchers and interested citizens.

How do indicators relate to the strategy?

It is important to select indicators that show the development in relation to key objectives or activities in the Sustainable Development Strategy. The proposal also considers where Denmark can presently set up indicators. Improvements to indicators and follow-up on objectives form a natural part of the government's ongoing work. The government expects the set of indicators to improve in step with the attainment of a better data basis for illustrating objectives and initiatives, or in step with the emergence of new objectives and initiatives essential for achieving sustainable development.

The proposal for Denmark's national Strategy for Sustainable Development contains overall objectives related to sustainable development, supplemented by concrete areas of activity where objectives and activities have been set up to reflect the objective of sustainable development.

Denmark is contemplating laying down two sets of indicators for sustainable development. These consist of:

- *A detailed, specific set of indicators, able to describe development and results for each area of activity compared to objectives and initiatives of the strategy. As a point of departure, Denmark is considering to select a range of indicators for each area of activity. But the number of indicators to be selected will depend on the character of the activity area and on the set objectives and initiatives. The set of indicators will be updated every year and will be available electronically on a special website for sustainable development.*
- *A set of key indicators able to describe development and results in the overall objectives for sustainable development in the strategy. This set contains about 20 indicators, which will also be updated every year and reported on the website. The indicators will also be presented in an easily comprehensible pamphlet, to ensure that decision-makers and the interested public obtain an overall and explicit description of the endeavours to achieve sustainable development.*

Key set of indicators

The Danish vision of sustainable development is founded on eight objectives and principles:

1.) We must maintain a high level of welfare and employment – while breaking the link between economic growth and the impact on the environment and natural resources
2.) We must secure high biological diversity and protect the ecosystems
3.) We must create a safe and healthy environment for everyone and maintain a high level of protection
4.) We must use resources more efficiently
5.) We must ensure that Denmark takes action at the international level
6.) We must ensure that environmental considerations are included in all sectors
7.) We must ensure that the market structure supports sustainable development
8.) We must ensure that sustainable development is our common responsibility

Key indicators	
We must maintain a high level of welfare and employment – while breaking the link between economic growth and the impact on the environment and natural resources	K1. GNP per capita K2. Environmental load of four factors (greenhouse gasses, nutrients (N and P) into the ocean, release of acidifying substances) compared to GNP K3. Real savings K4. Employment distributed on age groups
We must secure high biological diversity and protect the ecosystems	K5. Natural areas
We must create a safe and healthy environment for everyone and maintain a high level of protection	K6. Average life expectancy (distributed on men and women) K7. Greenhouse gas emission distributed on sectors K8. Consumption of hazardous chemicals

We must use resources more efficiently	K9. Resource consumption for three factors (energy, drinking water, waste
We must ensure that Denmark takes action at the international level	K10.Development aid
We must ensure that environmental considerations are included in all sectors	K11 and K12. Each year, two sectors are chosen and their environment profile illustrated by means of an index for three selected environmental loads compared to the sectoral development
We must ensure that the market structure supports sustainable development	K13. Volume of green taxes
We must ensure that sustainable development is our joint responsibility	K14. Number of eco-labelled products K15. Number of state institutions having reported their green procurer K16. Number of environmentally certified companies

Urban and housing development

The government's overall objective is to promote sustainable development of towns, housing and construction. Residents and users in urban and housing areas should participate actively in this development, for instance by embracing a lifestyle where respect for the environment and lowered resource consumption are a natural part of everyday life. When it comes to social life, buildings and infrastructure, towns must be organised and managed with a view to achieving significant reductions in resource consumption and environmental loads. Towns should be vibrant and diverse, and town centres should be strengthened as centres of business and culture. The individual parts of a town should contain dwellings, service businesses and public institutions so that the town becomes more alive.

The growth of town areas should be limited, and old industrial and port areas should be put to better use. The transport-generating functions of a town should be located so that the optimum number of people can benefit from public transport. And the negative impacts of growing car traffic in towns should be curtailed along with their other environmental loads. Towns should offer a varied supply of dwellings, and intensify activities targeted at depressed urban quarters. Urban renewal creates a balance between old and new and emphasises quality, excellent architecture and urban ecology. Preservation-worthy cultural environments also have to be safeguarded. By the same token, the quality of urban recreative options should be improved, and allotment gardens preserved.

Perspectives:

The proposed strategy aims at ensuring vibrant and diverse urban and housing areas of high quality with a varied offer of dwellings. Thus, Denmark may need to explore the possibility of developing indicators for this area. Work has been launched to develop actual town statistics. In this connection, work is being conducted to establish indicators for urban quality in the broad sense of the word. The government's committee on urban development (Byudvalg) has decided to develop indicators for urban social development that can show development trends in depressed urban and housing areas. To follow up on the work performed by the industrial and urban policy com-

mittee (Erhvervs- og Bypolitisk Udvalg), indicators will be developed for urban development and industrial conditions.

Urban and housing development	
Objectives and activities	Indicators
Land growth of towns should be limited.	1. Land used for urban zone
New urban structures should reduce transport demands	2. The share of new office buildings in Greater Copenhagen located within 500 metres from a train station
The quality of urban recreative possibilities should be improved	3. Sq. m. green area accessible within a walking distance of 15 min. per inhabitant in Odense, Aalborg and Copenhagen.
Additional requirements posed to energy and ressource consumption	4. Energy consumed for room heating in towns in total (energy per sq. metre) 5. Index for trends in power consumption, water consumption and waste volumes in dwellings/ households (calculated per inhabitant).

Municipal level

A number of Danish municipalities have prepared a local Agenda 21, and a number of municipalities have prepared local environmental demands and guidelines regarding new buildings and renovation of buildings. But these demands are only to a limited degree expressed as quantitative indicators.

Building sector level

Extracts are presented from:

"Action Plan for Sustainable Development in the Danish Building and Construction Industries"
The Danish Product Panel for Building and Construction
On the initiative of the Danish Environmental Council for Cleaner Products, the Danish Product Panel for Building and Construction was established in the autumn of 2000 as one of several product panels. In this context, “products” are defined as buildings and structures seen in a life-cycle perspective. An independent body, the panel consists of a number of persons representing the main players of the Danish building and construction industries, lays down its own business procedures and work process and has sole responsibility for the outcome of its work.

The main task of the panel is to draw up a plan to ensure environmentally sustainable development in the Danish building and construction industries and to suggest initiatives to start a process of development aimed at achieving this overall objective. The panel considers this task to be completed by the current action plan published March 2001.

Sustainability
The overall environmental objectives are based on initiatives aimed at ensuring sustainable development on a local, regional and global scale.

The Brundtland Commission defined sustainability as development that meets the needs of the present without compromising the ability of future generations to meet their own needs. Sustainable development means preserving social welfare and economic prosperity within a given environmental framework.
The short-term aim is to make social and economic growth environmentally neutral. The long-term goal (over a period of 30-50 years) is to improve the total environmental efficiency of the building and construction industries by a factor of 10.
From a life-cycle perspective, the building and construction industries account for as much as 50% of total energy consumption in Denmark. Moreover, these industries also consume large volumes of materials as well as hazardous and environmentally harmful substances, whose properties and effects are largely not known.
Although public initiatives in many other areas will also reduce the environmental impacts from the building and construction industries, the challenges facing these industries are nevertheless huge when it comes to development.

Prioritised environmental impacts
As great importance is attached to the simultaneous development of environmental and health objectives within the building and construction industries, it is crucial that action is taken against the following environmental impacts during the life cycles of buildings and structures:

- Energy consumption and environmental effects
  The aim is to cut total energy consumption and reduce the share of non-renewable energy. This will reduce a number of environmental effects such as acidification from SO2 and NOX emissions, environmental pressure from nutrient salts and greenhouse effect changes from CO2 emissions.
- Consumption of materials and waste prevention.
  The principal aim is to reduce and optimise the consumption of scarce, non-renewable material resources, prevent excessive consumption of renewable material resources and reduce volumes of generated waste and promote recycling of such waste.
- Consumption of hazardous and environmentally harmful substances.
  The overall aim is to reduce adverse health impacts and toxic environmental effects, one purpose of which is to improve physical indoor conditions as well as health and safety at work.
- Other environmental impacts.
  This category includes any impacts concerning the use of and the effects on urban public space and landscape, water consumption, emissions into soil and water, noise and vibrations as well as indoor environmental conditions and conditions relating to health and safety at work that are not improved by the reduction of the above-mentioned, generally prioritised environmental impacts. These environmental impacts can be reduced in specific building and construction projects.

Tentative environmental targets
A number of concrete proposals for tentative environmental targets for the three above-mentioned, generally prioritised environmental impacts.

The targets specified are deliberately set at an ambitious level to stimulate development. Technologically, it is believed that the targets can be met, but more information about economic consequences as well as organisational and political barriers will be needed. As a result, the action plan suggests that target achievement is routinely checked on the basis of a number of en-

vironmental indicators and that the tentative targets are adjusted in line with developments in society and technology.

The following tentative, concrete environmental targets are given for the prioritised environmental impacts and effects in order to facilitate the achievement of the long-term, general objectives.

The targets specified are deliberately set at an ambitious level to stimulate the necessary development. Technologically, it is believed that the targets can be met over time, but more information about economic consequences as well as organisational and political barriers will be needed. It will therefore be important for the fulfilment of this action plan that methods and tools are developed for the purpose of measuring and adjusting environmental targets – partly at an industrial level on a national scale, partly in the individual building and construction projects in which targets must be easy to use and easy to understand.

Targets for reducing energy consumption and emissions into air

National targets

The general targets are set in relation to the Danish Government's energy action plan, Energy 21, the aim of which is to stabilise Denmark's total energy consumption and to meet the following CO2 targets:

- CO2 emissions must be reduced by 20% in relation to 1988 levels by 2005.
- The transport industry only needs to stabilise its emissions in relation to 1988 levels by 2005, so the other industries must reduce their emissions by more than 20%.
- CO2 emissions should be reduced by 50% in relation to 1990 levels by 2030.

These targets cannot be applied directly to the building and construction industries due to their complexity – not least because of the long-term lives of buildings, structures and elements and, consequently, the very large significance of existing buildings and structures.

Targets set by the Danish Product Panel for Building and Construction

The panel proposes the following tentative environmental targets for the building and construction industries:

- Existing buildings and structures (energy consumption in terms of operations)
  Total energy consumption for the existing stock of buildings and structures must be reduced by 10% in relation to 1999 levels by 2005 and by 50% in relation to 1999 levels by 2020. The share of renewable energy must be increased at the same time.
- Newly erected buildings and structures (total energy consumption)
  Total energy consumption for all newly erected buildings and structures as seen throughout their life cycles must be reduced by 50% in relation to 1999 levels by 2005 and by 75% in relation to 1999 levels by 2010. The share of renewable energy must be increased at the same time.

Targets for reducing material consumption and generated waste volumes

National targets

Danish environmental policy sets no direct targets for reducing the consumption of materials. For waste prevention, the Government's national waste plan, Waste 21, sets the following national targets:

- Total waste volumes must be stabilised by 2004, and volumes should be reduced in the long term.
- For total volumes of generated waste, the targets for handling waste in 2004 are as follows:
  - 64% must be recycled;
  - 24% must be incinerated; and
  - 12% must be deposited.
- The 2004 targets set specifically for the building and constructions industries are as follows:
  - 90% of total waste volumes from the building and construction industries must be recycled; and
  - Hazardous and environmentally harmful waste fractions must be separated.

Targets set by the Danish Product Panel for Building and Construction
The panel proposes the following tentative environmental targets for the building and construction industries:

- The consumption of scarce or strongly hazardous and environmentally harmful substances must be reduced by 50% in relation to 2000 levels by 2005.
- By 2005, the use of renewable material resources must be based only on materials originating from sustainable production that takes fauna and animal life into account to the widest possible extent.
- Waste prevention schemes must be introduced to reduce waste volumes by 25% in relation to 2000 levels by 2015.

Targets for reducing the consumption of hazardous and environmentally harmful substances
The Danish Product Panel for Building and Construction proposes the following deadlines for the building and construction industries to meet the national targets for reducing hazardous and environmentally harmful substances:

- The use of particularly prioritised, undesirable hazardous and environmentally harmful substances (26 substances/groups of substances, see the List of Undesirable Substances, Environmental Review no. 9, 2000, from the Danish Environmental Protection Agency) should be phased out by 2005.
- The use of other undesirable hazardous and environmentally harmful substances (about 50 substances/groups of substances in addition to the 26 substances/groups of substances mentioned above, see the List of Undesirable Substances, Environmental Review no. 9, 2000, from the Danish Environmental Protection Agency) should be reduced by 50% by 2010.
- The use of other hazardous and environmentally harmful substances (about 1,400 substances/groups of substances, see the List of Effects, Environmental Review no. 6, 2000, from the Danish Environmental Protection Agency) should be documented and reduced by 25% by 2015.
- The use of hazardous and environmentally harmful substances must be mapped out by 2005 to allow for the identification and separation of these substances through renovation or demolition.

Environmental indicators

The Danish Product Panel for Building and Construction has described a project for the development of a set of environmental indicators to be used for evaluation/ benchmarking of environmental efforts regarding new buildings and renovated buildings. The project shall include methods, tools and reference data, which facilitates the practical use of the indicators.

Furthermore these indicators shall serve as the basis for a superior set of indicators, designed to monitor and regulate the environmental policy in the construction sector at the national level. The suggested indicators are also intended to be used in the context of a joined benchmarking system. This system is thought to be accompanied by the establishment of the institutions and procedures necessary for the reporting, verification of key-figures, and the use and implementation of the indicators at clients, planners and administrative bodies.
The environmental indicators shall to the highest degree possible

1 be user friendly
2 indicate all relevant environmental impacts
3 include the relevant impacts during the buildings' entire life cycle
4 be concise and comprehensible
5 be generally accepted
6 relate to the economical consequences, that is environmental lifecycle costs and cost-benefit evaluation of different CO2 reduction measures
7 take the uncertainties of the data to be used into consideration.

To meet all these demands it may be necessary for certain areas to develop both simple and easy to use indicators and indicators, whose use require more data, tools and resources.

The project is strongly related to the sets of indicators presented for:

- Environmental assessment and classification of buildings
- Green accounting

The project is not yet decided, but it will be included in a discussions of the implementation of the action plan in 2002.

Building level

Four sets of indicators are presented:

- Environmental assessment and classification of buildings
  - first of all meant for clients and the design of new buildings
- BEAT (Building Environmental Assessment Tool)
  - first of all meant for consultants and the design of new buildings and retrofitting
- Energy labelling of houses and owner occupied flats
  - first of all meant for building owners and selling of houses and flats
- Green accounting
  - first of all meant for use during use and operation of residential buildings (a number of other methods/tools for green accounting is in practical use)

Beside it should be noted that the two first tools are related to a Danish manual on environmental management in project design.

Product level

One set of indicators are presented:

- Environmental product declarations for building products
  - first of all meant for use during design and construction of buildings

Environmental assessment and classification of buildings

General characteristics

Name: Miljødeklarering og –klassificering af bygninger ['Environmental assessment and classification of buildings', in Danish]

Origin (country, developers, year): Denmark, Danish Building and Urban Research Institute, consultancy enterprise 'RAMBØLL', architectural office 'arne hansen miljø og arkitektur', 2001

Contact: Jørn Dinesen, jod@by-og-byg.dk / www.by-og-byg.dk

Web site:

Sources: (*Dinesen, Jørn; Hansen, Arne et al., 01*)

Form of presentation:	Book	IT-tool	Other
		X	

Status		**State of development**	
Legal obligation		Implemented / in use	
Voluntary	**X**	Test-implemented	
Certificate		Draft	**X**
Scientific descriptive			
Other			

Evaluation

Strengths:

1.) scope

Broad scope.

2.) use

- Well balanced between the environmental scientific demand of broad coverage and precise display of the relevant environmental aspects and the user demand of simplicity.
- Smart aggregation system (through expression in points)
- Takes the residents' / users' interests in indoor climate into account by addressing it rather thoroughly.
- the building's environmental profile can be displayed in a very comprehensible radar chart
- the high level of aggregation facilitates the system's common use as a labelling / declaration system

Weaknesses:

1.) scope

Does not take the placement of the building into account.

2.) use

Lacks experiences from test-implementation.

Scope

(The quantification on all the environmental aspects in scope is based on BEAT, except for indoor climate)

In comparison with a 'normal' reference building and along with a visualisation of their environmental impacts are buildings placed in class C, B, or A.

'The purpose of the method is to motivate buildings owners to choose alternative solutions with low environmental impacts by pointing out relevant environmental objectives and provide a documentation of their fulfilment. Furthermore, the method could be used as a basis for a voluntary arrangement of environmental declaration in co-operation with the buildings sector." (Dinesen, Jørn; Hansen, Arne et al., 01)

User groups:		**Decision making situations:**	
International. Organisations		Legislation	
Government		District plan	
Municipality		Architectural & engineering design activities	**X**
Main contractors	**X**	Construction	
Construction enterprises		Production of construction materials	
Suppliers		Operation	
Buyers of property	**X**	Renovation	**X**
Facility managers			
Residents and users			
The public			
Consultants	**X**		
Scientists			
Others:			

Scale:	**Life cycle phases:**			
	Localisation	Production / Construction	Use / operation	Demolition / waste management
Building elements / construction materials		**X**	**X**[1]	
Buildings		**X**	**X**[2]	**X**
Groups of buildings				
Infrastructure	x[3]			

[1] In the same way as BEAT the 'Environmental assessment and classification of buildings' considers the durability of the building, building elements and construction products in its LCA-based assessment.

[2] It also considers the consumptions that can be attributed to the buildings technical standards (installations, insulation, …). It does not measure the actual consumptions as caused by the individual users / inhabitants.

[3] The building's distance to public transport facilities is considered as well as different sources of energy supply (e.g. renewable / non-renewable energy – compare BEAT 2002, which the 'Environmental assessment and classification of buildings' is based upon).

Environmental aspects		sphere of quantification				
		Driving forces & Societal response	Application of principles / specific measures	Resource – consumption / measurement / pressures on the Environment	Environmental effects· Environmental damages	Others:
Energy + related emissions	**X**			**X**		
Water + wastewater	**X**			**X**		
Material consumption + waste	**X**			**X**		
Indoor environment	**X**		**X**			
Toxicity & hazard. substances	**X**		**X**			
Working environment						
Local environment	**X**		**X**			
Others: 'Own choice'[4]	**X**					

[4] *'Finally there has been included an indicator "own choice", which is open for new indicators, that are considered important." (Dinesen, Jørn; Hansen, Arne et al., 01)*

Indicators

<table>
<tr><td>Underlying indicator principle
(LCA, DPSIR, input-output, checklist, other)</td><td colspan="2">LCA, checklist</td></tr>
<tr><td colspan="3">The indicators used</td></tr>
<tr><td colspan="3">Four levels of aggregation, each with its indicators:</td></tr>
<tr><td colspan="3">4. level.(the highest)
Unit:
points (the fewer the better)</td></tr>
<tr><td colspan="3">Three classes, all referring to a reference building, which is defined by corresponding precisely to the demands of the current building regulations:
– Class A (most environmentally friendly, cutting edge technology)
– Class B (quite good)
– Class C (just slightly above standard)</td></tr>
<tr><td>3.level
Unit:
Based on calculations with the IT-tools BEAT 2001 and Bv98[5]:
– PE/(m^2 x year) (Person Equivalents per square metre per year) and
– a corresponding number of POINTS</td><td>2. level</td><td rowspan="5">1. level
Unit:
for not quantifiable indicators (especially the indoor-climate related ones):
points given for the application of certain measures (e.g. water saving installations)or the reaching of certain benchmarks (e.g. maximum indoor temperatures)</td></tr>
<tr><td>Energy consumption</td><td></td></tr>
<tr><td>Material consumption</td><td></td></tr>
<tr><td>Waste</td><td>Volume waste
Slag and ashes
Hazardous waste</td></tr>
<tr><td>Contribution to global climate change</td><td>Global warming
Ozone depletion</td></tr>
<tr><td>Contribution to air pollution</td><td>Acidification
Photochemical ozone formation</td><td></td></tr>
<tr><td rowspan="4">Indoor climate</td><td>Air quality</td><td>Offgasing
Dust
Ventilation
Moisture resistance</td></tr>
<tr><td>Thermal climate</td><td>Low temperature
High temperature
Draught
Heat radiation to cold surfaces
Individual climate control</td></tr>
<tr><td>Daylight, view, artificial light</td><td>Daylight conditions
View
Solar shading
Artificial lighting</td></tr>
<tr><td>Noise and acoustics</td><td>Transmitted noise from outside
Transmitted noise from other rooms
Noise from installations
Reverberation time</td></tr>
</table>

[5] An IT-tool for the calculation of a building's thermal requirement and energy frame (*Aggerholm, Søren; Grau, Karl, 98*).

Other indicators	Hazardous substances Water consumption Operation of the building Localisation of the building (transport) Own choice	

Additional explanation

In order to reach a high level of aggregation (7 Indicators and finally only *one* of the characters A, B or C) this assessment system is composed of indicators, some of which are composed of sub-indicators so that the system in some respects operates with indicators on four different levels. From level to level information is aggregated by using a point-system, that expresses the buildings environmental performance in certain respects in 'points', which then are summed up to reach the next level of aggregation. Example: gas emission, dust, ventilation and moisture protection (level 4) together form the indicator 'air quality' (level 3), which, together with energy consumption, material consumption, impact on the climate, air quality and "other indicators" forms the level 2. The last level aggregates these to one of the classes A, B or C.

BEAT ('Building Environment Assessment Tool')

General characteristics

Name: BEAT ('Building Environmental Assessment Tool') **Origin (country, developers, year):** Denmark, Ebbe Holleris Petersen, Danish Building and Urban Research (DBUR), 2001 (second edition) **Contact:** Ebbe Holleris Petersen, eep@by-og-byg.dk / www.by-og-byg.dk **Web site:** http://www.by-og-byg.dk/udgivelser/pc-programmer/beat2001/generelt.htm **Sources:** (*Holleris Petersen, Ebbe, 97*), (*Holleris Petersen, Ebbe; Dinesen, Jørn et al., 01*)			
Form of presentation:	Book	IT-tool	Other
		X	

Status		**State of development**	
Legal obligation		Implemented / in use	x
Voluntary	**X**	Test-implemented	**X**
Certificate		Draft	
Scientific descriptive	**X**		
Other			
Evaluation			
Strengths: precise, voluminous database, database can be accomplished if necessary, good visualisations in bar-charts			
Weaknesses: **1.) scope** Water consumption is not addressed in general, since water is not considered a scarce resource. However, water could easily be integrated as scarce resource into the database. **2.) use** Quite labour intensive. Specific data not yet in the database are sometimes difficult to provide.			

Scope

BEAT is an LCA-based IT-inventory tool and database for the environmental assessment of building products, building elements and buildings. The database currently contains data for most conventional primary building products used in the Danish building industry (cement, concrete, gypsum-boards etc.), as well as a large number of commonly used building elements. In addition to these it also contains a number of energy sources and means of transport. It calculates the environmental impacts caused by the construction materials, considering the materials' entire lifecycle in an LCA-approach, and the expected energy consumption in the building's operation phase.			
User groups[6]**:**		**Decision making situations**[7]**:**	
internat. Organisations		Legislation	
Government		District plan and municipality demands	
Municipality		Architectural & engineering. design activities	**X**
The public		Production of building materials & -elements	x
Scientists	x	Construction	**X**
Suppliers[8]	x	Buying and selling	
Construction enterprises	**X**	Renovation	**X**
Consultants	**X**	Operation[9] and maintenance	
Building owners		Use (residents' + user activities)	
Facility managers		Others:	
Residents and users			
Others:			

Scale:	**Life cycle phases:**			
	Localisation	Production / Construction	Use / operation[10]	Demolition / waste management
Building elements / construction materials		**X**	**X**	**X**
Buildings		**X**	**X**	**X**
Groups of buildings		x	x	x
Infrastructure	x[11]			

[6] '**X**' in bold indicates the focus points of the indictor-system, normal 'x' indicates peripheral points.

[7] *'Decision* making situations' means those situations, in which environmentally relevant *decisions are taken*, NOT the situations, when the consequences of the decisions taken in earlier phases of the building's life cycle occur.

[8] Meaning suppliers of construction materials and –elements in the construction- and renovation phase as well as suppliers of electricity, water, and heating in the use / operation phase.

[9] This means all what is independent of the users' and residents' individual activities.

[10] The consumption of energy for ventilation and heating is calculated separately, painting and building elements that need to be replaced are fully considered, energy consumption due to individual applications (lamps, electric machines,..) are ignored.

[11] BEAT considers different ways of energy supply (e.g. renewable energy, coal power plants,…)

Environmental aspects		sphere of quantification				
		Driving forces[12] & Societal response[13]	Application of principles[14] / specific measures[15]	Resource – consumption[16] / measurement / pressures on the Environment[17]	Environmental effects[18, 19]; Environmental damages[20]	Others:
Energy + related emissions	**X**			x	**X**	
Water + wastewater						
Material consumption + waste	**X**			x	**X**	
Toxicity & hazard. substances	**X**			x	**X**	
Indoor environment						
Working environment						
Local environment[21]						
Others:						

[12] E.g. growth of the human population.

[13] E.g. implementation of an eco-taxation, environmental management,…

[14] E.g. thermal ventilation

[15] E.g. the existence of energy saving bulbs, shared washing facilities, water saving installations,… .

[16] These can either be measured (like the electricity and water consumption in the operation phase) or calculated, like the amount of raw oil consumed for transport in the production of a certain product or material.

[17] E.g. amount of emitted CO_2

[18] E.g. acid rain. acidification, nutrient enrichment, ecotoxicity, human toxicity, persistent toxicity, stratospheric ozone depletion, photochemical ozone depletion, global warming, hazardous waste, slag and ashes & bulk waste.

[19] BEAT calculates acidification, nutrient enrichment, ecotoxicity, human toxicity, persistent toxicity, stratospheric ozone depletion, photochemical ozone depletion, global warming, hazardous waste, slag and ashes & bulk waste.

[20] E.g. diminution or extinction of certain species.

[21] E.g. land use, destruction of habitats, air quality, noise,…

Indicators

Underlying indicator principle (LCA, DPSIR, input-output, checklist, other)	LCA
BEAT can present the results of its calculations both as amounts of raw materials/emissions, as effects (e.g. CO2-equivalents for global warming and SO2-equivalents for acidification – here the emissions of various substances contributing to the environmental effect (e.g. to global warming) are converted by multiplication with an equivalency factor to e.g. CO2-equivalents and thus made comparable with one another) and as normalized and weighted environmental profiles (using the Danish EDIP-method – 'Environmental Design of Industrial Products', (*Wentzel, Henrik; Hauschild, Michael et al., 97*))	
The indicators used	
Highest level of aggregation	next level of aggregation
Unit: After normalisation and weighting: Person Equivalents per reference year(1995) and reference area (Denmark / World) (mPE_{WDK95}) Before normalisation and weighting: - see in the respective cells -	Unit: usually in tons, gas in Nm3
contribution to global warming Unit: CO2-equivalents	Emissions to air: carbon dioxide (CO2) carbon monoxide (CO), N2O metane (CH4), …
acidification Unit: SO2-equivalents	Emissions to air: Sulphur dioxide (SO2) Ammonia (NH3) Hydrogen chloride (HCl, Nitrogen oxides (NOx), …
nutrient enrichment	Emissions to air[22]: Nitrogen oxides (NOx) N2O Ammonia (NH3),…
photochemical ozone formation	Emissions to air (mostly transport related): Carbon monoxide (CO) Volatile organic compounds ('VOC'), power plant VOC, car (diesel) Metane (CH4) Formaldehyde,…
human toxicity	Emissions to air: Nickel (Ni) Lead (Pb) N2O Quicksilver (Hg) Nitrogen oxides (N0x),…
persistent toxicity	mostly emissions to air: Arsenic (As) Lead (Pb) Cadmium (Cd) Zinc (Zn) Quicksilver (Hg), …
consumption of fuel-resources	Crude oil, natural gas, coal, brown coal, …
consumption of metal-resources	Aluminium, iron, copper, manganese, nickel, zinc,…
hazardous waste	Unspecified hazardous waste, unspecified hazardous waste containing heavy metals, unspecified chemical waste,…
slag & ash	slag & fly-ash (mainly from the power plant)
bulk waste	bricks, mortar, unspecified, hazardous waste (glasswool), ….

[22] Emissions to water can principally also contribute to nutrient enrichment but according to the author of BEAT occur very rarely in the construction sector.

Energy labelling of houses and owner occupied flats

General characteristics

Name: Energimærkning af huse og ejerlejligheder ['Energy labelling of houses and owner occupied flats', in Danish] **Origin (country, developers, year):** Denmark, Ministry for Environment, The Danish Energy Agency, , 1997 **Contact:** Ole Michael Jensen, omj@by-og-byg.dk / www.by-og-byg.dk **Web site:** http://www.emsekretariat.dk/, http://www.ens.dk/uk/index.asp **Sources:** (*Danish Energy Agency, Ministry for Environment, 99*),			
Form of presentation:	Book	IT-tool	Other
	X	**X**	**X** through professional energy consultants

Status		**State of development**	
Legal obligation	**X**	Implemented / in use	**X**
Voluntary		Test-implemented	
Certificate		Draft	
Scientific descriptive			
Other			

Evaluation

Strengths:

1.) scope

2.) use

Based on easily accessible data, very user friendly, comprehensible and action oriented due to:

- quantification in units per property
- quantification in money
- combination with proposals for measures for improvement and a cost benefit analysis
- extreme simplification (the A to M-ranking)

linkage with the selling of the property, a situation, where the new residents consider in which improvements to invest

Weaknesses:

1.) scope

2.) use

Scope

Rating system that describes a property's characteristics related to energy- and water consumption, independent of the residents actual consumption. Along with the certification concrete improvement measures are proposed and a cost-benefit-calculation is carried out.
Legally prescribed (for small properties when they are sold, for large buildings once a year).
Scope: consumption of electricity, heating, water.

Two different systems:

- for small properties: calculations scheme,
- for large buildings: measurement

User groups:		**Decision making situations:**	
internat. Organisations		Legislation	
Government		District plan	
Municipality		Architectural & engineering. design activities	**X**
The public		Production of building materials & -elements	
Scientists		Construction	
Suppliers		Buying and selling	**X**
Construction enterprises		Renovation	**X**
Consultants	**X**	Operation and maintenance	**X**
Building owners	**X**	Use (residents' + user activities)	
Facility managers	**X**	Others:	
Residents and users	**X**		
Others:			

Scale:	**Life cycle phases:**			
	Localisation	Production / Construction	Use / operation	Demolition / waste management
Building elements / construction materials				
Buildings			**X**	
Groups of buildings				
Infrastructure				

Environmental aspects		**sphere of quantification**				
		Driving forces & Societal response	Application of principles / specific measures	Resource – consumption / measurement / pressures on the Environment	Environmental effects, Environmental damages	Others: Cost-benefit calculation
Energy + related emissions	**X**			**X**		
Water + wastewater	**X**			**X**		
Material consumption + waste						
Indoor environment						
Toxicity & hazard. substances						
Working environment						
Local environment[23]						
Others:						**X**

[23] E.g. land use, destruction of habitats, interference with infrastructure systems,…

Indicators

Underlying indicator principle (LCA, DPSIR, input-output, other)		input-output
The used indicators		**unit of quantification**
Two different systems:		
For small properties	For large properties	
highest level of aggregation: a letter: A: low environm. impact B: medium C: high + Emission of CO_2/year	highest level of aggregation: a letter between A and M, with A being the best (= low consumption	Tons CO_2 per year / property
next level: Annual consumption of Oil / gas for heating Water Electricity		Heating: litres of fuel / (property x year), calculated expenses: Danish Crowns Water: m^3 / (property x year), calculated expenses: Danish Crowns Electricity : kWh / (property x year), calculated expenses: Danish Crowns

Green accounting

General characteristics

Name: Green Accounting for Residential Areas **Origin (country, developers, year):** Denmark, Ole Michael Jensen, Danish Building and Urban Research Institute ('By og Byg'), 1998 **Contact:** Ole Michael Jensen, omj@by-og-byg.dk / www.by-og-byg.dk **Web site:** http://www.by-og-byg.dk/udgivelser/pc-programmer/groent_regnskab/index.htm **Sources:** (*Jensen, Ole Michael, 98*), (*Jensen, Ole Michael, 99*)			
Form of presentation:	Book	IT-tool	Other
		X	

Status		**State of development**	
Legal obligation		Implemented / in use	**X**
Voluntary	**X**	Test-implemented	
Certificate		Draft	
Scientific descriptive	**X**		
Other			

Evaluation

Strengths:

Based on easily accessible data, widely in use, comparatively simple comprehensible method, comparison of the green accounts from different years clearly reveal, if improvements have been achieved and can serve as an incentive for action.

Weaknesses:

1.) scope

Restricted to resident behaviour related consumption, does not take transport into account

2.) use

Scope

Focuses on the resource- and energy consumption in the operation phase. Monitoring of behaviour related consumption.			
User groups:		**Decision making situations[24]:**	
International. Organisations		Legislation	
Government		District plan	
Municipality	**X**	Architectural & engineering. design activities	**X**
Main contractors		Construction	
Construction enterprises		Production of construction materials	
Suppliers		Operation	**X**
Buyers of property		Renovation	**X**
Facility managers	**X**		
Residents and users	**X**		
The public	**X**		
Consultants	**X**		
Scientists	**X**		
Others:			

Scale:	**Life cycle phases:**			
	Localisation	Production / Construction	Use / operation[25]	Demolition / waste management
Building elements / construction materials				
Buildings			X	
Groups of buildings			X	
Infrastructure			x[26]	

[24] *'Decision* making situations' means those situations, in which environmentally relevant *decisions are taken*, NOT the situations, when the consequences of the decisions taken in earlier phases of the building's life cycle occur.

[25] The consumption of energy for ventilation and heating is calculated separately, painting and building elements that need to be replaced are fully considered, energy consumption due to individual applications (lamps, electric machines,..) are ignored.

[26] Green Accounting considers different sources of energy (e.g. renewable energy, coal power plants,…)

Environmental aspects		sphere of quantification				
		Driving forces & Societal response	Application of principles / specific measures	Resource – consumption / measurement / pressures on the Environment	Environmental effects· Environmental damages	Others:
Energy + related emissions	**X**			**X**		
Water + wastewater	**X**			**X**		
Material consumption + waste	**X**			**X**		
Indoor environment						
Toxicity & hazard. substances						
Working environment						
Local environment						
Others:						

Indicators

Underlying indicator principle (LCA, DPSIR, input-output, other)	input-output
The used indicators	**unit of quantification**
CO_2-emission (for both Heating and Electricity)	t CO_2-emission / (person x year)
Heat consumption	MWh/(100m^2 x year) or MWh/(person x year)
Electricity consumption	kWh/(person x year)
Water consumption	m^3 / (person x year)
Waste	kg / (person x year)

Environmental Product Declarations for building products

General characteristics

Name: Environmental Product Declarations for building products (EPDB) **Origin (country, developers, year):** Denmark, Danish Building and Urban Research (DBUR), Danish Technological Institute, 2002 (under development) **Contact:** Klaus Hansen, klh@by-og-byg.dk , www.by-og-byg.dk **Web site:** **Sources:** (*Hansen, Klaus, 02*)			
Form of presentation:	Book	IT-tool	Other
	X		

Status		**State of development**	
Legal obligation		Implemented / in use	
Voluntary	**X**	Test-implemented	
Certificate	**X**	Draft	**X**
Scientific descriptive			
Other			

Evaluation

Strengths:

Good visualisation of the environmental impacts in bar charts
Environmental impacts are clearly allocated to the phases 'material', 'production', 'use' and 'disposal', which makes it easy to identify improvement potentials.
Concept contains a lot of thoughts on the implementation.

Weaknesses:

1.) scope

2.) use
Some producers complain about the difficulty to collect the necessary data on their products.

Comments / implications for my project:

Scope

EPDB can be characterised as a concise LCA for each specific building product accompanied by an environmental 'user guideline'.

It shall fulfil ISO type III requirements and therefore includes an assessment based on the LCA methodology (read 'BEAT') and a third party control.

The declaration for each specific product is a document of two pages, containing

- the product's contents
- an environmental profile (in the form of bar charts)
- a short description of processes, which contribute considerably to the environmental impact
- a 'user guideline', pointing out processes for which the environmental impact to a high degree depends on the context in which the product is used.

User groups:		**Decision making situations:**	
internat. Organisations		Legislation	
Government		District plan and municipality demands	
Municipality		Architectural & engineering. design activities	**X**
The public		Production of building materials & -elements	**X**
Scientists		Construction	**X**
Suppliers	**X**	Buying and selling	**X**
Construction enterprises	**X**	Renovation	**X**
Consultants	**X**	Operation and maintenance	
Building owners	**X**	Use (residents' + user activities)	
Facility managers		Others:	
Residents and users			
Others:			

Scale:	**Life cycle phases:**			
	Localisation	Production / Construction	Use / operation	Demolition / waste man-agement
Building elements / construction materials	x[27]	**X**	**X**	**X**
Buildings				
Groups of buildings				
Infrastructure				

Environmental aspects		**sphere of quantification**				
		Driving forces & Societal response	Application of principles / specific measures	Resource – consumption / measurement / pressures on the Environment	Environmental effects· Environmental damages	Others:
Energy + related emissions						
Water + wastewater						
Material consumption + waste						
Toxicity & hazard. substances	**X**					
Indoor environment						
Working environment						

[27] The LCAs consider transport and different forms of energy supply (renewable, fossil-fuel based,…)

Local environment						
Others:						

Indicators

Underlying indicator principle (LCA, DPSIR, input-output, checklist, other)	LCA (based on BEAT)
The indicators used	
(the same as in BEAT[28] + calorific value) Contribution to Global warming Acidification Energy consumption Calorific value Material consumption Nutrient enrichment Photochemical ozone formation Toxicity Volume waste Hazardous waste	Unit: After normalisation and weighting: Person Equivalents per reference year(1995) and reference area (Denmark / World) (mPE_{WDK95})
In the bar chart the different overall values of the bars indicating the values of the different indicators are subdivided, indicating the shares of the different phases 'material', 'manufacturing', 'use' and 'disposal'.	

[28] For a more detailed description see the 'indicator' paragraph of the BEAT presentation.

Literature

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Environmental Indicators. 1.6.3 Sensitivity The indicator should be sensitive to changes in the state of the environment that it is meant to indicate. We will also require that the indicator should be sensitive to changes in the composition of the basic structures e.g., by focusing on the marginal areas. Unfortunately, indicators that are sensitive to the changes we want to measure, may also be sensitive to other changes.Â Important examples are increased corrosion of buildings and other capital equipment, and decreasing productivity of the labour force due to increasing health problems. We do not, however, believe that this is the most important reason for most people's concerns for the environment. Today, Danish firms are world leaders in the pharmaceutical, maritime shipping and renewable energy sectors. In 2019, Denmarkâ€™s GDP is expected to increase 1.8%. Denmark exports large amounts of food, oil and gas. However, its manufacturing sector heavily relies on the importation of raw materials. In general, the country is quite prosperous and Danish society is supported by robust social welfare programs. Environmental Issues of Denmark. According to a recent report from the European Environment Agency, Denmark has continued to make great strides in improving the health of its various ecosys The environment-related indicators illuminate phenomena such as urbanization and the loss of biological diversity; agricultural output and declining forest area; freshwater withdrawals and freshwater growing scarcity; electricity production and greenhouse gas emissions. The indicators also reveal the progress that countries have made on many of the environment targets set by the 2030 Agenda for Sustainable Development.Â Every year relevant new environment indicators are added to the WDI.Â Agriculture remains an important economic sector in many economies, and agricultural activities are a source of food and revenue for large segments of the population in many countries.