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Parallel session 1d - Environmental Impact Assessment

Integrated I/O-LCA and multi-criteria analysis applied to the case of Danish consumption

by

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The work presentation is based on work done by an interdiciplinary group of Danish scientist lead by Prof. Mette Wier, Danish Institute of Local Government, Studies,
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Product environmental impact assessment

Background

Evaluating sustainable consumption must be based on assessment of all the environmental impact of the total consumption measured on product level in order to compare one product group by the other. Furthermore the environmental impact at all stages in a product's life-cycle must be included.

Objective

In this presentation we describe an integrated environmental assessment system that can measure sustainable development and use the system to calculate the environmental impact of the Danish consumption and evaluate the relative importance of consumer goods on a scale of good or bad environmental performance

The integrated environmental assessment system

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Integrated environmental and economic accounting system (NAMEA) - I/O-LCA with environmental accounts

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Environmental profiles of consumption goods based on effect index

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Environmental performance index by DEA

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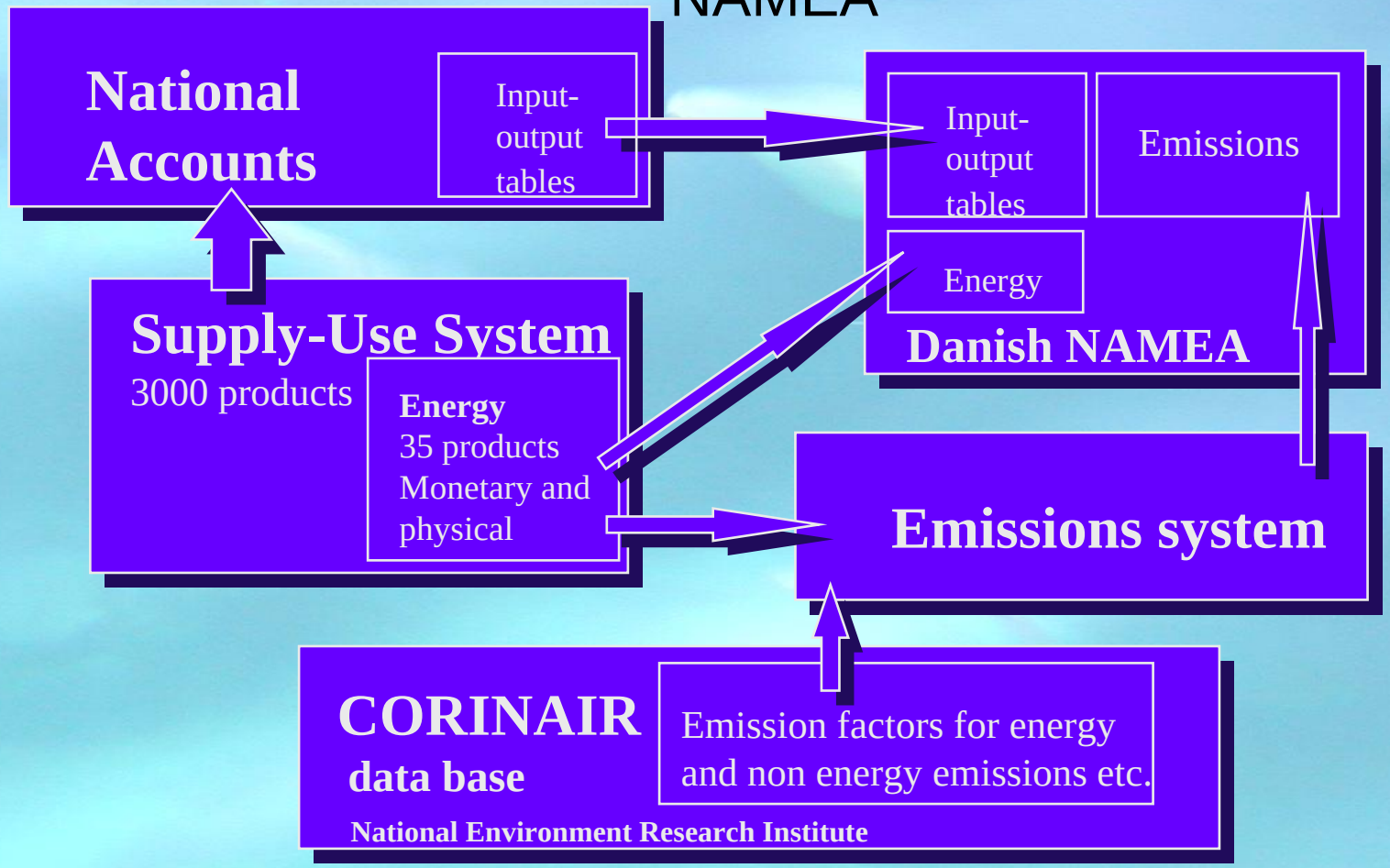
Ranking consumption goods according to environmental performance

The integrated environmental assessment system

Integrated environmental and economic accounting system - NAMEA



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The integrated environmental assessment system

Environmental profiles of consumption goods based on effect index

Each consumer good are characterised by an environmental profile that can be aggregated into environmental effect indices.

Environmental themes:

- **Global warming potential index**
- **Acidification index**
- **Ozone depletion index**

Resource consumption:

- **Water use**
- **Total material requirement**

The integrated environmental assessment system

Environmental effect index – example of GWP

- Greenhouse gases includes CO_2, CH_4, N_2O and industrial greenhouse gases such as HFCs

$$GWP = \sum F_i \times GWP_i$$

- Weighting emissions in CO_2 equivalence
- GWP factors from IPCC – *Intergovernmental Panel on Climate Change*

The integrated environmental assessment system

Environmental performance index

Weighting several environmental themes into one performance index for each consumption group may be done by several approaches:

- Economic welfare approach, fx damage cost, public opinion poll
- Science approach, fx ecological threshold values or limits set for human health quality
- Policy approach, fx distance to policy targets

The integrated environmental assessment system

Environmental performance index by DEA

- Data Envelopment Analysis – DEA do not require pre-choice of weights
- DEA is developed to analyse productivity in cases where there is no prices attached to the production material. DEA can be used in environmental analysis and emissions are treated as non-priced “material”. Hence another type of productivity or efficiency can be measured
- DEA chose those the optimal “weights” for the most efficient production conditions for each consumer goods allowing one consumer good to be compared by the other.

The integrated environmental assessment system

How to interpret the results?

- Evaluate – on a relative scale – how well the different consumer goods perform
- Relative eco-efficiency score, i.e. a measure of how well the goods perform per fx 1000 EURO. Can be used to evaluate the efficiency of fx the production technology
- To evaluate sustainable development DEA scores based on the total emissions of an economy must be calculated

Case study – Danish household consumption

Consumption data

- Danish input-output tables comprise 130 industries and 35 categories of final demand, e.g. private consumption, public consumption, gross fixed capital formation, export etc. Private consumption is sub-divided into 72 consumption groups, 5 of which are direct energy consumption by households.
- For simplicity the consumption groups are aggregated into 11 groups in this case study
- The unit of measure used is consumption per 1000 DKK

Energy flow data

- The accounts show balances for supply and use of 40 types of energy. The usage is allocated across 130 industries and households

Case study – Danish household consumption

Environmental and resource consumption accounts

- Accounts for air emissions shows the emission for each type of substance by 130 industries and house holds, i.e.
  - GWP-index: Greenhouse gases, i.e. CO_2, CH_4, N_2O and HFCs, PFCs, SF_6
  - PAE-index: Acidifying substances, i.e. SO_2, NO_x and NH_3
  - ODP-index: Ozone depleting substances, i.e. CFCs and halons
  - POCP-index: Photochemical oxidation substances, ie. CH_4, NMVOC and CO
  - Metals, i.e. Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn and PAHs, i.e. pyrene and fluoranthene
- Accounts for water show use of ground water and surface water by 130 industries and house holds.
- Accounts for total material requirement (TMR) – is a measure of the global resource extraction necessary to provide the material input to the Danish economy and is allocated across 130 industries and households.

Case study – Danish household consumption

Environmental profiles from I/O-LCA analysis

Table 1. Environmental performance across Danish product types, 1997

	Potential acidification index (mol/1000 DKK)	Global warming potential index (kg/1000 DKK)	Ozone depletion potential index (mg/1000 DKK)	Air pollution by hazardous substances (g/year × m^3/ng/1000 DKK)	Water Consumption (m^3/1000 DKK)	Total Material Requirement (kg/1000 DKK)	Photo-chemical Oxidation Index (g/1000 DKK)	Eco-efficiency score (%)	*(Ranking)*
Foods	37	126	154	0.5	2.2	630	37	24	(10)
Beverage and tobacco	12	53	91	0.1	0.9	218	16	58	(5)
Clothing	6	45	105	0.1	0.5	238	18	50	(6)
Household app. incl. operation	2	23	93	0.1	2.3	166	13	76	(3)
Electricity	63	733	12	0.2	0.3	2172	71	37	(7)
Heating	40	608	26	8.6	0.2	555	502	21	(11)
Health	4	33	87	0.1	0.2	131	13	70	(4)
Transportation	18	131	141	0.7	0.1	286	420	26	(9)
Services	2	19	34	0.0	0.1	88	9	171	(1)
Media and electronics	4	36	106	0.1	0.1	163	15	98	(2)
Recreation and entertainment	10	62	96	0.3	0.7	309	27	34	(8)

Reference: Wier, M., Christoffersen, L.B., Jensen, T.S., Pedersen, O.G., Keiding, H., Munksgaard, J (2005). Evaluating sustainability of household consumption – using DEA to assess environmental performance. *Economic Systems Research, 17(4), 425-447.*

Case study – Danish household consumption

Environmental performance index – consumption goods performing less environmentally friendly

- Large variations in environmental effect measured as product intensity can be observed across index types, as well as across product types
- Effects types such as *global warming, acidification* and *photochemical oxidation* are primarily related to energy and agriculture thus consumption goods such as electricity, heating, transportation and food products perform least environmentally friendly
- *The ozone depletion* index shows impact mainly on food products and transportation. **I**n DK the use is reduced significantly (Montreal protocol) and tied only to a few industrial activities
- *Air pollution by metals and PAHs* shows impact mainly on heating, i.e. from combustion processes
- *Water consumption* is mainly related to household operation and food production
- *Total material requirement* is mainly related to the production of electricity, i.e. through the use of fossil fuel. However, also food consumption, i.e. through the use of biomass and energy requirement for food production and household building maintenance, i.e. due to consumption of concrete, wood, metal etc. contributes to high TMR

Case study – Danish household consumption

Environmental performance index

	Relative eco-effiency score by DEA in %	Ranking by DEA
Foods	24	10
Beverage and tobacco	56	5
Clothing	50	6
Household app. incl. operation	76	3
Electricity	37	7
Heating	21	11
Health	70	4
Transportation	26	9
Services	171	1
Media and electronics	98	2
Recreation and entertainment	34	8

Case study – Danish household consumption

Conclusion

- Danish household:
  - Best environmental performance – services including insurance, education, kindergardens etc.
  - Worse environmental performance – heating and food
- Linking I/O-LCA with environmental indexing and ranking provides a good evaluation tool for identifying products with high environmental impact
- Environmental performance scores would be valuable to decision-makers as well as to citizens as they provide a simple way of revealing the success or failure of policies
- The environmental performance index may be a good indicator for evaluation of sustainable consumption
- The integrated model system is based on national accounts and environmental statistics and therefore can easily be updated.

Case study – Danish household consumption

Further applications – scenarios of environmental impact from consumption

- Based on economic projections and resulting change in consumption, fx from national economic models, it is possible to calculate change in environmental impact from consumption i.e. to compare different scenarios

- Based on change in family structures/lifestyles, calculated change in environmental impact from consumption.

References:

Wier, M., Christoffersen, L.B., Jensen, T.S., Pedersen, O.G., Keiding, H., Munksgaard, J (2005). Evaluating sustainability of household consumption – using DEA to assess environmental performance. *Economic Systems Research, 17(4), 425-447.*

Wier, M., Munksgaard, J., Christoffersen, L.B., Jensen, T.S., Pedersen, O.G., Keiding, H. & Lenzen, M. (2003). Environmental performance indices, family types and consumption patterns. In: Tiezzi, E. & Uso, J.-L.: Ecosystems and Sustainable Development IV. WIT Press. - Advances in Ecological Sciences 18: 657-668.

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- Thank you for your attention!