GENERAL INFORMATION

PETUS description of tool in use	
Name of the case	Assessment of organic waste treatment in Denmark.
Name of the tool	"Socio-economic Assessment of Environmental Products" (economic analysis) and "ORWARE" (LCA-analysis for organic waste)
Country	Denmark
City / region Total area (km2) Population Density (people/km2)	Country of Denmark 43.560,76 5.397.640 123,91
Tool user's profile a. Organisation name (municipality, NGO, national or regional department, company, etc.) b. Field of activity c. Detailed contact/feedback (project website, e-mail, address, tel., fax)	a. Danish Environmental Protection Agency (EPA) (In Danish: Miljøstyrelsen) b. Environmental regulation in Denmark c. Miljøstyrelsen • Strandgade 29 • 1401 København K • Tlf.: 32 66 01 00 • Fax: 32 66 04 79 • mst@mst.dk. http://www.mst.dk/
Reviewer, date	Jesper Ole Jensen, BYG-DTU, 07.02.2005

Short description of the case

The case concerns applying a cost-benefit analysis in combination with an LCA-based tool (ORWARE) on organic household waste treatment, to find the most sustainable solution. The aim of the analysis was to find the most economic and environmentally friendly way of managing organic household waste: 1. recycle waste by anaerobic digestion (and use the energy produced), 2. Recycle waste by central composting, 3. Waste incineration and energy recovery. The analysis is made on a national level, based on experiences (costs) of different waste treatment methods from a number of municipalities. This is a break with the commonly accepted waste strategy, based on a priority of 1. Reducing waste, 2. Re-use, 3. Recycle (or incinerate), 4. Deposit. This prioritisation has however been criticized for being unscientific, as it does not systematically take all environmental and economic consequences into account. The analysis also breaks with traditional ways of choosing between different waste strategies, which typically would consist of a comparative analysis of operation cost, supplied with analysis of environmental consequences (interview with EPA-representative).

The Cost Benefit-analysis shows that when all phases of waste treatment are included it is more expensive for society to recycle organic household waste by anaerobic digestion or central composting than by incineration. Incineration is the cheapest solution for society, while central composting is the most expensive. The environmental Life Cycle Analysis have shown that there are only small environmental benefits connected with anaerobic digestion of organic household waste compared with the incineration of the waste. The conclusions will form the guidelines for the Danish Environmental Protection Agency's (EPA) recommendations on the municipalities' waste policy, and therefore might have a large influence on the waste policy in general.

The case illustrates how applying an economic and environmental assessment on different waste strategies can change the view on which strategies are regarded as the more sustainable.
The case study is related to the PETUS key problems 8.1. (Management of waste disposal) and 8.3. (Waste transportation).

Sector	Waste	Energy	Water	Transport	Green/blue	Building & Land Use
	X					

Scale of project	Component	Building	Neighbourhood	City	Region
					X (country)
Status of project	Starting up	Ongoing	Finished	Start date	End date (exp.)
			X	2003	2003

Key words

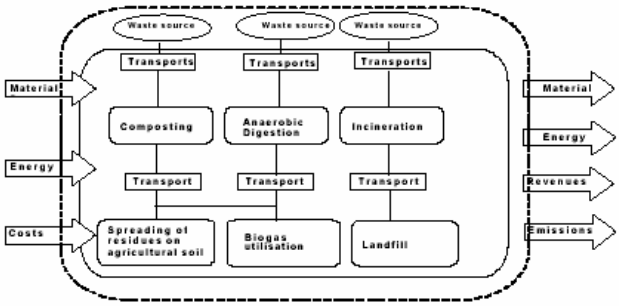
waste, Life Cycle Assessment, ORWARE, cost-benefit analysis, recycling, incineration, anaerobic digestion, compost, waste reduction.

Project a. Object (building, city park, wind farm, etc.) b. Type of activity (regeneration, renovation, new development, etc.) c. Type of product (plan, scheme, design project, etc.)	a. The project involves the management of organic waste from households (local sorting, collection, disposal). b. The case concerns an assessment process of a sector policy on national level. c . Production of guidelines for municipalities.
Tool a. Character (according to WP3final0704.doc)	a. The tools used were calculation tools: LCA and socio-economic analysis.

b. Benchmarks (qualitative or quantitative) c. Availability (paid/ free)	b. The outcome of the analysis is a number of quantitative calculations, making it possible to compare the different solutions. c. Normally the Swedish developers are being paid to make an ORWARE analysis
Decision-making process a. Stage of the tool implementation (preliminary, midterm, etc.) b. Level (political, technical, etc.) c. Public participation	a. The tool is implemented at the design/preliminary stage. b. Decisions on the project were made at the political level. c. There was no public participation.

DETAILED INFORMATION

A. Detailed description of project and tool	
1. Description of context (existing strategies, laws, policy, action plans, etc.): EU, national, regional, municipal	The background for the analysis is the EU consideration of increasing the re-use of organic waste. Also in the national waste plan, Waste 21, the general intention is to increase the recycling of waste. However, these views, based on the rationales of the waste hierarchy, are increasingly being challenged by environmental LCA-analysis and economic analysis, based on different rationales.
2. Description of project a. Background (What caused the initiation of the project?; What was the problem? Who initiated the project?); b. Objectives/aims (sustainability statement – what issues of sustainability were attacked); c. Time interval and stages of project realization; d. Financing – amount, sources, institutions involved, partnerships, levels. e. Other sectors involved in the particular project/problem (conflicts and/or links)	a. In 2003 the Danish Environmental Protection Agency (EPA) carried out an economic and environmental analysis of the consequences of increasing recycling of organic household waste. The analysis concerned waste management in municipalities, but was made on a national level (for the municipalities in general), to support the decision on which strategy the EPA should recommend to the municipalities. The analysis was based on a number of partial analysis and full-scale tests on different waste management solutions, completed 1999-2001. b. The analysis compared the economic and environmental benefits of three treatment methods on organic waste: 1. recycle waste by anaerobic digestion (and use the energy produced), 2. recycle waste by central composting, 3. waste incineration and energy recovery. c. The analysis was carried out in 2003, but is based on data from tests and analysis carried out 1999-2001. These tests were primary full-scale experiments on different types of two-part collection of household waste. These tests were carried out by teams of experts in three Danish cities, and analysed in relation to environmental benefits and economy. The results from these tests are used as basis for the cost-benefit analysis. d. The assessment was completed by the Danish EPA, as a part of the regulation of the sector. The analysis carried out were all financed by the EPA e. The assessment involves energy, transport, and soil quality.
3. Description of tool	The tools used in the analysis are: • "Socio-economic Assessment of Environmental Products" (economic analysis). This method has been widely used by the Ministry of Traffic (and more generally in the transport sector). The principles from this method have been applied on the waste sector. • ORWARE (environmental analysis). ORWARE is an acronym for ORganic WAste REsearch. The development of ORWARE was financed by the Swedish Waste Research Council between 1993-1997 and between 1998-1999 by the Swedish Energy Authority. In the beginning ORWARE was focused on environmental aspects of treatment of organic (biodegradable) wastes, hence the chosen name of the model. Today it includes all kinds of municipal solid waste, as well as submodels for calculation of economic aspects. The current ORWARE model handles several treatment methods such as anaerobic digestion, composting, landfilling, incineration, thermal gasification, sewage water treatment and transports. This LCA-tool has been used in several Swedish studies on waste strategies (see figure below). More information can be found at: http://www.ima.kth.se/im/orware/

	 Figure 1. Conceptual model describing the waste management system in the ORWARE model as adapted to Denmark. a. ORWARE and Cost Benefit Analysis are calculations tools.
a. Character (according to WP3final0704.doc) - calculation tools, process tools, assessment methods, generic tools, simulation tools, guidelines, framework tools, schemes, indicators and monitoring, checklists, case-specific tools; b. Availability of the tool (web-based / paper, paid / free, etc.) c. Based on existing tool or newly elaborated; d. Adaptation of the tool to the local context (are there local experts involved in tool's development?) e. Other tools implemented to support the project development	b. Both tools are paper-based. c. The tools are based on existing tools. d. The LCA-analysis using ORWARE was carried out by Swedish university departments, who have participated in developing ORWARE: JTI, Swedish institute of agricultural and environmental engineering and KTH, Royal institute of technology e. No other tools were implemented
B. Tool implementation	
1. Argumentation for choosing the tool a. What were the reasons for the implementation of the tool? (voluntary or requested by what local, national, etc regulation) b. Who took the initiative for choosing /elaboration the tool? c. What were the criteria for choosing the tool? d. Was there knowledge of other tools and were they considered?	a. ORWARE had been used in a number of cases in Sweden on waste assessment. In Denmark there was no similar tool, being able to make a LCA-based analysis. There is a tool under development (at DTU), but this was not ready to be used at that time. b. The selection of tools was made by the Danish EPA c. ORWARE has been used for analysis in a number of cases (mainly in Sweden), which is the main reason for choosing this tool. . d. There are similar tools to ORWARE available. EASEWASTE is an LCA-model under development at DTU. "Integrated Solid Waste" is a Norwegian LCA-based approach, but it has not been turned into a calculation tool, or used in any studies to date. The developer of EASEWASTE would not suspect any major differences in the results if the analysis had been carried out using this model. With EASEWASTE, composting would also not look attractive, as this method of recycling does not produce energy (source: interview with J. Kirkeby). There are also other tools, based on different rationalities, for instance the "ecological rucksack". According to the EPA, the "ecological rucksack" is not seen as a different approach, but an approach that could provide information for a more detailed LCA-analysis of waste (waste imported and materials imported from outside the EU).
2. Barriers for the tool implementation What were the main problems in the tool implementation? (Regulation, information available, public awareness, lack of clear SD definitions and	There was no problem or barrier using ORWARE for the analysis. However, the usability of the analysis can be discussed. This is especially due to the local conditions in the municipalities which might be different that the general assumptions in ORWARE, which

benchmarks, communication etc.)	deals with general in Danish municipalities.
C. Influence of the tool on the decision-making process	
1. Description of the decision-making process/ procedures a. Stages b. Levels (political, technical, etc.) c. Sources of information used during the dmp; d. Who are the decision-makers? e. Who made the final decision for the project implementation? Was it political or technical decision?	a. The analysis of the different ways of managing organic waste was made at the stage of defining a waste policy. The analysis formed the basis for the EPA's recommendations to municipalities on local waste strategies. It is, however, up to the municipalities on how to formulate the strategy locally. b. The decision to carry out the analysis on organic waste management was made at the political level. According to the EPA, using this analysis have made the consequences clearer, and has emphasized that clearer arguments are needed to explain the formulation of a certain waste strategy. The analysis was expected to show clearer differences between the different treatment methods, which would have enabled more direct recommendations to be identified to which strategies the municipalities should use. As the differences however are limited, the EPA accepts that municipalities use strategies other than incineration, ~~as~~ since local conditions might support this. c. The results of the analysis was communicated in a report from the Danish EPA. d. The decision to apply the assessment on organic waste treatment was carried out by the government. Politicians in the municipalities decide whether they want to follow the guidelines from the assessment
2. Tool in decision-making process a. At what stage was the tool implemented? By whom? (experts, politicians, etc.) b. How did the tool output influence the process (added or skipped levels/stages in the existing decision-making process, etc.)?	a. The tool was implemented in the analysis of different strategies for management of organic waste. This was decided by the Danish EPA b. The conclusions from the report have been received rather differently in Danish municipalities, as they use different collection and treatment methods. Examples of how the report has been received by some local authorities follow: (Source: Miljømagasinet (The radio programme "The environmental Magazine"), P1 d. 23. May 2003). In **Grindsted** the municipality is surprised about the conclusions. The municipalities own calculations and experiences show that it is cheaper to sort and collect the household waste in two fractions. Moreover they criticise that the benefits of reversal of nutrients to the soil by composting is not included in the analysis, and that the conclusions from the report might reduce the citizens incentives to sort their waste. **Herning** municipality has, as a result of the report, abandoned their anaerobic digestion (biogas) waste treatment, based on sorting and collection in two sections. They made the decision as they were facing the need to invest in new containers for residues, and were aware that the new analysis was on the way. Many citizens have complained to the municipality about this, as they feel that they finally had a system that worked and did something good for the environment. However, the municipality insists that real environmental effect must be the primary motivation for choosing waste treatment method and the change is in response to the findings of national findings. Moreover, the citizens do not sort the waste 100% correctly (95% were sorting ok, but 5% did not). This causes problems with the biogas technology, which has not been sufficiently developed. Although this might be improved, the municipality do not expect a return to the recycling strategy. **Fredericia** municipality has, since 1992, used a low-tech compost plant which functions very well; citizens come to the plant with their household and garden waste, producing usable compost. The

	sorting is very good, and it is likely that citizens are willing to expand the sorting and recycling strategy. The municipality's experience is that it would cost app. 250 DKr. more per household per year to take the waste to incineration (due to environmental tax on incineration). Moreover, CO_2 emissions are reduced, and it creates a product (compost) which is used by the citizens. In **Copenhagen**, the guidelines from the EPA on organic waste will largely be followed. Although the waste-hierarchy will still be respected, focus on re-use is declining; instead more efforts will be made on collecting hazardous household waste. However, in some areas, for instance urban regeneration and renewal, projects on waste sorting and reuse will be started (interview, Copenhagen Waste Office). The EPA recognizes that there are a number of positive environmental effects connected with recycling, which it has not been possible to include in the analysis. This could for instance be improved soil quality and less use of pesticides, as a consequence if the soil from composting process was used in private gardens. It is however assessed that the inclusion of these effects would not affect the results of the analysis. The EPA accepts that local conditions might mean that in some places there are more benefits of sorting, collecting and re-using waste in separate sections, instead of incineration (for instance, the distances for collecting the waste locally, as this is a main factor in the environmental account). It is however important that the citizens accept and support this solution (by sorting their waste correct), as the result is highly dependent on the degree of sorting by the users. If this is the case, they don't expect the EPA's report to influence the local preferences of waste treatment. The EPA refers to the EASEWASTE model under development at DTU, suggesting it be used by the municipalities to assess which is the most efficient waste management method locally. The socio-economic analysis does not always give the same result as local cost-benefit assessments, as for instance the tax on incineration affects the municipal cost-benefit analysis, but not the national. Also, Fredericia does not have its own incineration facilities, and therefore has to pay "rent" for incinerating the waste in other places, which makes it more expensive for the municipality (and for the society in general).
c. Quantitative goals or benchmarks defined? (If YES, which – and what were they compared to?)	c. *Extracts from the report:* "In the cost benefit analysis both economic consequences for the affected parties and welfare-economic consequences for the society as a whole have been investigated. In the welfare-economic analysis the value of the environmental effects has been included. The analysis was carried out by the Danish EPA, but was followed and discussed by a number of other actors from the waste sector. The LCA-analysis using ORWARE was carried out by JTI, Swedish Institute of Agricultural and Environmental Engineering and KTH, Royal Institute of Technology. The analysis shows that it is more expensive (in a holistic way) for society to recycle organic household waste by anaerobic digestion or central composting than by incineration. Incineration is the cheapest solution for society, while central composting is the most expensive. The primary reason for recycling being more expensive than incineration is the necessary, but cost-intensive, dual collection of the household waste. Treatment itself is cheaper for recycling compared to incinerating. In the analysis the extra cost of the dual collection is calculated on the basis of full-scale experiments/tests in several municipalities.

d. Was the tool used to support argumentations?	The total welfare-economic additional cost, compared to present treatment, of recycling about half of the organic household waste, equal to 300,000 tonnes, by anaerobic digestion is DKK 230 mill. per year . The additional cost of recycling 300,000 tons by central composting is DKK 270 mill. per year. Anaerobic digestion of 100,000 tonnes will imply additional costs in the order of DKK 70 mill. per year, whereas central composting of 100,000 tonnes will lead to an additional cost of close to DKK 80 mill. per year. Furthermore, technical studies have shown that there are only small environmental benefits connected with anaerobic digestion of organic household waste compared with the incineration of the waste". (*end of extracts)*. The analysis and calculations are based on assumptions on prices and costs, for instance on collection of waste, and different taxes on waste treatment. It has been analysed how sensitive the conclusions are to changes in these assumptions, and it appears that the ranking of the three alternatives – incineration, anaerobic digestion and composting – are rather stable to changes in the basic assumptions. "Break-even"-prices have also been calculated, i.e. calculations how much the basic assumptions should change before the ranking of alternatives would change. As an example: Experiences have shown that the extra costs for collecting two-parts households waste (waste sorted in an organic and non-organic fraction) from individual houses is 150 Dkr. per household per year, compared to traditionally non-sorted waste. This makes sorting and composting a more expensive alternative. To make this solution as economically favourable as the traditional solution, the extra-cost prices for collecting two-part waste should be reduced to 50 Dkr. per household per year. d. The analysis was expected to show clearer differences between the different treatment methods, which would have enabled more direct recommendations on which strategies the municipalities should use. As the differences however are limited, the EPA accepts that municipalities use other strategies rather than incineration, as local conditions might support this. If, for instance, the municipality has as well established recycling programme the EPA will accept that the municipality continues to base the treatment of the organic waste on sorting and composting.
3. Transparency of decision-making process a. How was the information of the dmp disseminated? - directly (decision makers – public) or indirectly (decision makers - NGO, PR company, etc. - public); sources of dissemination used (mass media, internet, brochure, etc.) b. How was the public involved? c. Was there a public discussion over the project and at what stage of the project development?	a. The results of the assessment have been disseminated to local decision makers (municipalities) in a report and in guidelines for future management of organic household waste. b. There was no aim to involve the public in the assessment, but different actors in the waste sector have followed and commented on the assessment. c. There was no public discussion over the project although the local implementation of the assessment might involve public discussion.
D. Expert assessment/analysis/comment of the tool effectiveness	
1. Assessment by tool users a. Were there measurable improvements as a result of the tool implementation? If YES, what? If no: why not? b. Were there any spin-off's or unintended consequences? c. General view on the tool? Lessons learned?	a. It is difficult to predict what the consequences of the analysis will be. It is clear, that the analysis will be received differently according to the local context. However, some municipalities have already changed their waste policies from recycling (anaerobic digestion) to incineration as a result of the investigation. b. There were no spin-offs or unintended consequences as a result of the tools use. c. ORWARE is rather complicated to use (even for PhD students), therefore municipalities will probably not use it in their waste policy. If EASEWASTE is easier to use, it might be used in local waste planning, although it is not developed directly for this purpose. It seems more likely that the tools will be used for general analysis

d. Potentials for further use of the tool? e. Will the actors recommend it or use it in other cases - why / why not?	(for instance on a national level or as a part of research projects) and the results will be provided to municipalities who can then act accordingly. There are a number of environmental effects connected with recycling that have not been included in the analysis, but the EPA has estimated that these effects would not affect the results of the analysis. Lessons learned: • The results from using new tools breaks with the current understanding of what is the most sustainable solution. • National analysis (cost-benefit and LCA) does not necessarily correspond with local experiences due to contextual situations. d. The EPA expects that this analysis method will also be used in the future, for assessment of other alternatives on environmental policies. e. see d.
2. Reviewer's assessment of the tool (usefulness, sustainability relevance, who are the actors excluded? etc.) Suggestions and needs for further development of the tool	The analysis is very useful, but has to be seen in relation to the local context (waste treatment management, equipment, political attitudes etc.). Ideally, the analysis should be carried out locally, but this requires much data and resources. The development of EASEWASTE (or other similar tools) might, over time, provide the municipalities with the necessary decision support.
E. Additional information on the case study available	
Websites	
References *concerning the case but also the key words or problem* (papers, articles, reports, laws, etc.)	Danish EPA (2003) *Skal husholdningernes madaffald brændes eller genanvendes? Samfundsøkonomisk analyse af øget genanvendelse af organisk dagrenovation*. Environmental Project No 814. København: Miljøstyrelsen Baky, A. and Erikson, O. (2003). *System analysis of organic household waste in Denmark (ORWARE)*. Environmental Project No. 822, 2003.
Other sources (Interviews, conferences, discussions, etc.)	Interview with Janus Kirkeby, assistant professor at Environment and Resources, DTU, d. 05.08.03. Interview with mrs. Camilla Damgaard, Danish EPA (Miljøstyrelsen), d. 19.05.2003 Interview with mrs. Merete Christoffersen, Copenhagen Waste Office (Københavns kommunes affaldskontor), d. 6.6.03 Miljømagasinet P1 d. 23. May 2003 (Radio programme)
Contact details for further information	Mrs. Camilla Damgaard, Danish EPA. Tlf.: 32 66 01 00