Danish Experience in Developing Integrated Approach to Separate Collection and Central Sorting of Valuable Recyclables from the MSW

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Abstract

The paper presents experience from several larger Danish municipalities/regions where a rethink of the current system of separate collection and subsequent marketing of recyclable materials parallel to biological and thermal treatment of the bio-fraction/residual fraction has resulted in a planned new approach to combined separate collection of the MSW followed by central sorting of recyclables thereby focusing on resource efficiency, affordability, citizens service and meeting sustainability targets using life cycle assessment and economic tools for optimising and informing the choice of integrated and multi-stringed recycling and waste management systems for MSW.

The paper presents the economic comparison of the two principle options of i) full source separation and separate collection or ii) co-mingled collection of recyclables, based on various applications of e.g. multi-compartment receptacles, multi compartment collection vehicles, underground containers, separate receptacles for source separated single waste streams, centralised after-sorting facilities etc. It further presents the outcome of Climate Assessment of the options and an assessment of the public service level.

1. Introduction

1.1. Waste management in Denmark

The management of waste in Denmark is determined by the EU legislation and the Danish Waste Management Strategy as well as several pieces of Danish legislation that regulate several aspects of waste management, energy systems, agricultural by-products, acceptance criteria, design and permitting criteria for facilities etc. The key aspects of Danish waste management include:

- Municipalities are responsible for providing sufficient treatment and disposal capacity for waste and can direct all waste, except source separated industrial/commercial waste for recycling
- The 98 municipalities have formed approximately 45 inter-municipal waste management companies, often one municipality may be a member of 1-2 inter-municipal companies (i.e. separate companies for waste incineration, hazardous waste reception and disposal capacity or one that provides all of these services)
- There is a regulated preferences for sale of heat and power to the local district heating system and the national grid, which provides a very significant revenue stream for waste incineration plants
- Differentiated waste taxes disfavours landfilling, favours recycling and tolerates incineration with high energy recovery
- Taxes on virgin aggregates, by-laws for demolition of old buildings and standards for aggregates and concrete produced from recycled building rubble favours recycling of construction and demolition waste

Table 1: Danish waste data for the year 2009

Source	Total	Recycling		Incineration		Landfilling	
	2009	2009	Target 2012	2009	Target 2012	2009	Target 2012
	1,000 tonnes	%	%	%	%	%	%
Households	3,437	42	33	52	60	4	7
• Domestic waste	1,659	12	20	88	80	1	0
• Bulky waste	601	26	25	47	50	15	25
• Garden waste	616	99	95	0	5	0	0
• Other (metals, demolition)	559	–	–	–	–	–	–
Commerce/service	2,026	46	50	46	45	6	5
Industry	1,457	58	65	18	20	23	15
Construction/infrastructure	4,970	96	90	1	0	3	0
Waste water treatment	799	54	50	43	45	3	5
Coal fired power plants	1,164	97	90	0	0	3	10
Other	19	–	–	–	–	–	–
Total	**13,872**	**69**	**65**	**24**	**29**	**6**	**6**

Source: Danish Environmental Protection Agency 2011

- Landfills are not allowed to receive any waste that is not inert or that could have been recycled or used for energy recovery
- Waste water sludge requirements allow the bulk of Danish waste water treatment sludge to be disposed to agricultural land. However, in the greater Copenhagen area most sludge is incinerated

Due to the above policies and regulations, Denmark is among the countries in the world that dispose the least amount of waste to land. Because of the landfill rules MBT residues cannot be landfilled and therefore there are no MBT facilities. However, there are two minor facilities producing RDF/SRF based on pre-sorted waste. Because of the high energy revenue for conventional waste-to-energy facilities there is currently limited business scope for production and combustion of RDF as well as for anaerobic digestion either in connection with MBT facilities or as stand-alone AD facilities based on source separated organic feedstock.

Table 1 shows the most recently published Danish waste data (Danish Environmental Protection Agency 2011).

1.2. The current drivers for change in the waste collection system

The EU has set a target of 50 % recycling of certain waste fractions in the municipal waste stream by 2020. Several countries, regions and cities have in addition to the overall EU targets determined their own and often more ambitious targets.

The national waste management plan for Denmark is currently under revision. It is yet unknown whether more ambitious recycling targets will be set for the new planning period 2013-2019. In 2009 around 69 % of all waste generated in Denmark was recycled which was above the national target at 65 %. Currently the target for the selected waste streams from MSW is equal to the EU target of 50 % of waste materials such as paper, metal, plastic and glass from households (Directive 2008/98/EC).

Whilst the overall recycling rates are high in Denmark, the recycling rates from household waste are relative low, primarily due to large scale application of waste-to-energy. Denmark is by far the country in the world with the highest installed waste incineration capacity per capita (AvfallSverige 2009), which is quite a bit higher than other countries such as Sweden, Netherlands, Switzerland that also have a large installed incineration capacity.

Denmark is among the countries in the world that utilises the highest amount of energy per tonne of waste also (Figure 2), which is due to the favourable conditions for sale of both base load district heating to the district heating networks throughout Denmark as well as sale of electricity to the grid. Servicing the significant investments made in the energy efficient ways to recover maximum heat and powers as well as the equally significant revenue streams from sale of energy play an important role when considering investments in additional material resource recovery systems balanced against the potential revenue from sale of recyclables.

It could be argued that whilst the EU and Danish resource policies strongly support increasing the recovery of scarce and valuable resources from the waste streams, the existing waste-to-energy as well as energy supply safety policies strongly prioritises the use of waste as a *renewable* and *non-fossil* fuel source, which in turn raises the bar for when material recovery becomes economically viable and necessitates that recovery of material resources from household waste is cost efficient and effective compared to the status quo.

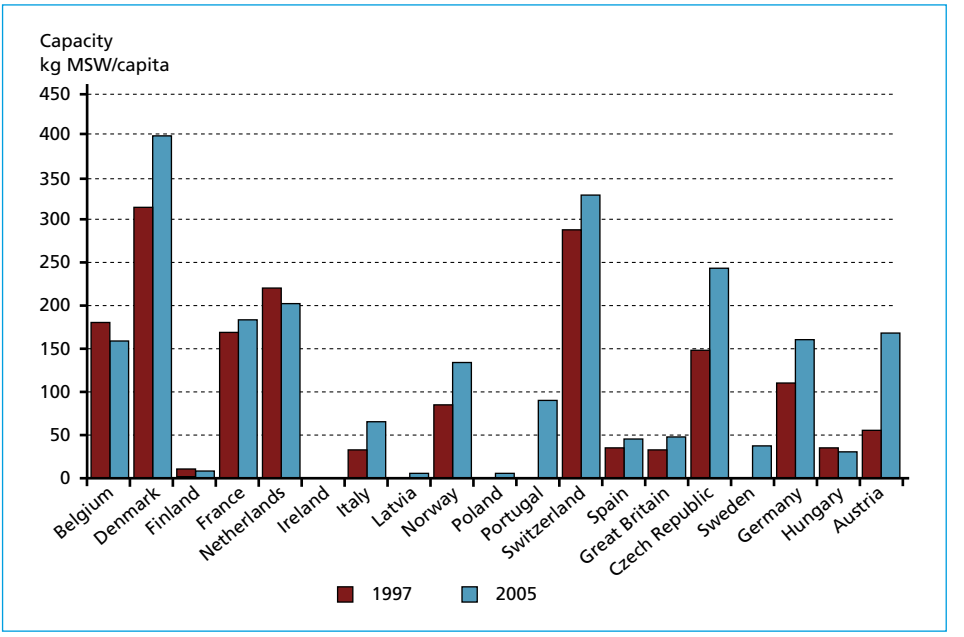

Figure 1: Installed Waste incineration capacity per capita in selected European countries 2005 and 1997

Source: AvfallSverige 2009

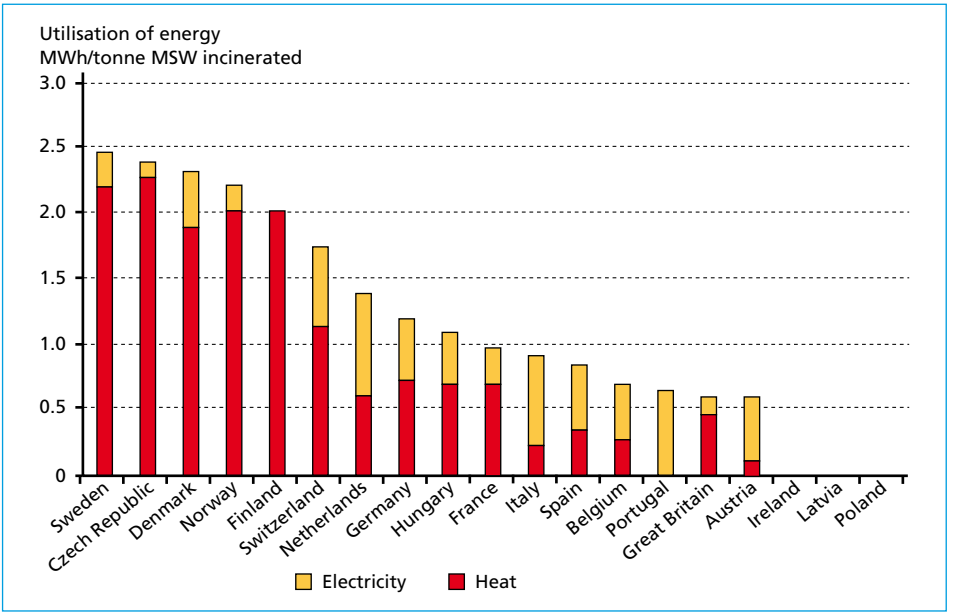

Figure 2: Utilisation of energy in waste incineration plants in selected European countries 2005

Source: AvfallSverige 2009

However, it is important to emphasise that *Waste-to-Energy and material recovery is not mutually exclusive*, and all available statistical evidence show that those countries that incinerate the most waste are also the countries that recycle the most waste. This is because it is a matter of being actually well-organised and regulated rather than having the right intentions or even policies in place.

Therefore, Denmark is currently not fully meeting the 2020 EU recycling target of 50 % of certain materials in the household waste stream, and new initiatives are required to achieve a higher recycling rate for household waste. It is doubtful whether the 50 % target can be reached without expanding the current limited separate collection of bio waste. However, currently the emphasis in the Danish municipalities is on expanding the separate waste collection services through a combination of:

- Increased public service level via close-by neighbourhood glass and paper containers (bring system)
- Increased kerb-side collection of recyclables (and separate collection of more types of materials)
- Introduction of multi-compartment receptacles (i.e. 4 room and 2 room containers) for single family houses
- Investigating the economics and logistics of co-mingled collection of a number of dry recyclables for subsequent final sorting at central facilities
- Investigating the economics and logistics of collection of dry residual waste for subsequent sorting at central facilities

COWI has conducted a number of studies and financial, environmental and logistical assessments for the Danish inter-municipal waste management companies, municipalities and the Danish Environmental Protection Agency. This paper is based on the results and experience from these assignments and studies.

There are several tricky issues when measuring the recycling rates, including:

- Uncertainty concerning the actual recycling potentials
- Uncertainty concerning the baseline against which the percentages shall be calculated
- Uncertainty about the extent of actual recycling, as in the EU it is generally assumed that 100 % of a waste stream that is sent to a *recycling facility* is actually recycled. This, however, is normally not the case. i.e. much reject is sent for thermal treatment or landfill disposal. For this reason some countries can report 0 % landfilling whilst still landfilling significant amounts of reject from sorting or from bio-stabilisation activities.

Some of the tricky examples in Europe include: i) How are beverage container recycling rates to be calculated in countries with widespread return systems compared to countries with one-way containers collected for recycling?, or: ii) How are bio waste recycling rates calculated in countries with wide spread use of kitchen waste disposal system that send shredded organic matter for biogas production in the waste water treatment system, compared to those who collect bio waste in separate containers for sorting, composting or biogas production?, or: iii) How is recycling of metals from incinerator bottom ash and recycling of bottom ash as road base included in recycling rate

2. Scenarios for Optimising the waste collection system

Table 2 below shows some of the principal scenarios that have been considered by the Danish EPA (Danish EPA 2011) for increased recovery of resources from the household

Table 2: Calculated cost index and recovery rates for selected scenarios for a typical Danish 550,000 inhabitant region

Scenario	Description		% recovery rate							
		Calculated costs index	Paper	Cardboard	Plastic	Glas	Metal	Bio waste	Residual	Total
0	**Typical current situation**: Paper and glass via **iglos**, Cardboard, plastic and metal via civic aminity sites. Residual waste incl. biowaste converted to heat and power via WtE and collected from households in a single container/sack.	117	47	1	1	68	75	–	–	17
1	**Source separation – Few fractions**: Paper collected at households. Iglos for glass. Household collection of organic waste for composting/AD and residual waste for incineration.	103	70	1	1	68	75	64	–	48
2	**Maximum source separation in containers:** Many fractions collected in separate compartments at households (paper, cardboard, plastic and metal in a 4-compartment container). Iglos for glass and separate household collection of bio waste for composting/AD and residual waste for incineration.	122	70	47	30	68	86	64	–	51
3	**Maximum source separation in bags**: Paper/cardboard, plastic, metal, bio waste and residual waste collected in 6 different bags for central optical sorting of bags. Iglos for glass. Biowaste for AD and residual waste for incineration.	108	66	45	29	85	68	60	–	49
4	**Source separation and central sorting including residual waste**: Paper and co-mingled cardboard/plastic/metal in two-compartment container. Iglos for glass. Separate collection of biowaste and residual waste for AD/Composting and incineration in two-compartment container.	100	75	68	55	78	96	64	–	55
	Total amount of waste (tonnes/annum)		44,643	6,534	8,989	8,946	4,458	62,975	32,478	169,023

Source: Danish Environmental Protection Agency 2011

waste. The study focused on selected waste collection and recovery scenarios based on typical Danish waste catchment areas of 550,000 inhabitants generating a typical amount and composition of waste as per the Danish Waste Data System records. Based on such generic but typical Danish conditions as well as typical transport distances, collection and treatment costs as well as costs/revenue from off-taking of recovered resources (typically to central Europe/Germany) and energy (electricity and heat) the total system costs as well as recycling rates were estimated.

2.1. Assumptions

The study of the Danish EPA 2011 was based on the following key assumptions:

- Waste generated by a *standard* waste generation region with 550,000 inhabitants, living in 150,000 single family houses and 100,000 apartments
- Only household waste is considered including recyclable materials collected via both bring and kerbside collections services
- Amount and composition of household waste in accordance with the Danish EPA 2003 study (REF). Separately collected fractions have been estimated additionally.
- The source separation in the households is ambitions but realistic based on effective awareness and communication efforts
- Incineration of waste takes place at a 200,000 tonne/annum WtE facility
- Other treatment (sorting and biogasification) occurs at a facility having large scale operation (capacity for much larger catchment area).
- Long-distance transportation is included also

2.2. Recovery rates and costs of the Danish EPA Study – Costs are indexed having the cheapest at index 100 –

All costs connected to collection (purchase and emptying of containers), transport to facilities, central treatment/sorting and sale of recyclable materials and energy are included in the calculations. Index 100 corresponds to approx. 140 Euro per ton collected waste. Costs of collection amounts to approx. 70 – 95 % of the total costs in the scenarios. Scenarios having the largest recycling rate (materials and energy) have very low net costs related to treatment and sale of recyclables/energy.

2.3. CO_2 profile of scenarios

The specific study did not calculate the CO_2 impact of the scenarios. From another study in Denmark the CO_2 profile of similar scenarios has been estimated. The CO_2 profile is shown below:

The following features can be derived from the figure:

- The waste sector contributes to savings in CO_2 when applying recycling of materials and recovery of energy leaving zero household waste for landfilling
- Collection and transport generate a very low emission of CO_2, much lower than the savings achieved via recycling and energy recovery
- Highest CO_2 savings are achieved via recycling of paper and metals from the household waste stream

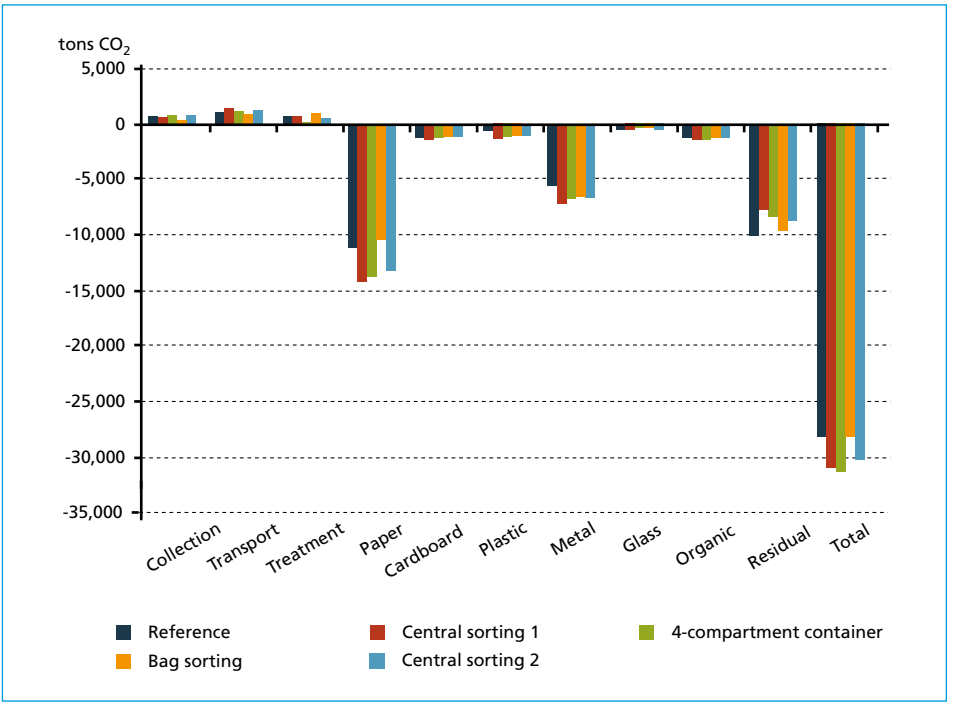

Figure 3: CO_2 profile of scenarios

2.4. Service Level

A study on the same scenarios has included an assessment of the service level provided to the households in terms of e.g. ease of service, quality of receptacles etc. The assessment is qualitative only and indicated in the table below.

Table 3: Assessment of the service level provided to the households

	Scenario 0	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Bring/Kerbside service	2	1	2	2	2
Need for waste bags	1	3	1	2	2
Environmental consciousness at citizen	2	1	3	3	3
Number and aesthetics at receptacles	3	2	3	1	1
Complexity of sorting guides	2	3	1	1	2
Emptying frequency	2	2	3	1	1
Total Score	**18**	**16**	**19**	**16**	**17**

From the assessment made it can be derived that the service level for the citizens not necessarily will change significantly when changing from present situation to services providing much greater opportunity to recycle the household waste. The actual assessment will be very dependant on the actual parameters scored as well as introducing weightings of each of the parameters.

3. Conclusions

The result of resent studies and assessments carried out in Denmark by among others the Danish Environmental Protection Agency and several municipalities and inter-municipal waste management companies show that it is possible to increase the recycling rates considerably for household waste by refining the waste collection system with the introduction of additional collection and bring services for source separated waste. At the same time the costs of doing so will not result in significant increases. Creating new optimised collection concepts combined with centralised and large scale advanced sorting and treatment solutions will merely result in costs of the same level as to day.

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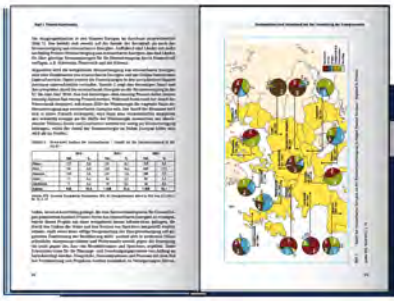

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