A Costly Process?

Finding the cost components in the waste-to-value chain

Ceres Logistics recently undertook a project for Defra examining the costs of waste management from households, through supply chains, to disposal or market.

This project responded to the Defra call for research under the Waste and Resources Research and Development Programme. Specifically, it addressed the economic theme on "understanding the true costs of waste management". The overall aim was to identify the cost components of the nodes and links within various material "waste-to-value" supply chains. Further objectives included an assessment of carbon emissions and transport distances through these chains.

As anyone involved with managing waste will readily recognise, mapping material flows is not a trivial task. The possible flow combinations faced in undertaking the analysis are quite surprising, as some arithmetic quickly demonstrates (taking the most complex choice at each step and working back up the "chain"):

- materials on the market may have originated from up to five sources (composting facility, reprocessor, consolidator/merchant, transfer station, energy from waste facilities)
- items at a reprocessor have six possible sources
- waste at merchants will have originated from up to five sources
- the materials recovery facility could have up to four sources.

Thus, there are up to 600 possible routes (5 x 6 x 5 x 4) and there were 16 classifications of waste considered. In other words there are a possible 9 600 (600 x 16) interlinked "supply chains". In addition, there are at least four different types of vehicle of six different weight classifications, ie 24 shipping options. This would imply that there are at least 230 040 (9 600 x 24) totally interdependent and inseparable "supply channel" options, with each material experiencing variability on a moment-by-moment basis in processing costs and throughput time.

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Approximately 13 500 tonnes require processing per hour of a five day working week. Our model handles this in 100 tonne entities, so for every "real time" hour, the "model" processes 31m "movements" (230 040 x 135). As each process (movement) has a minimum of three steps (input, process and output) this is a mind boggling 93m actions; even this excludes any cost calculations or sortation, updating of variables and/or route selection decision logic.

Because of the need to deal with this complexity, the decision was made to move away from the ubiquitous Microsoft Excel spreadsheet approach. Having built complex supply chain models for other clients, including the MoD and DVLA, we understood that the best way to approach this problem was by using specialist simulation software to construct a comprehensive model of the routes that waste materials followed through the various installations to either disposal or the market (domestic or export). Once constructed this model could then be calibrated with the data available and used to simulate the cost behaviour over any selected period of time.

Since the aim was to understand national waste management economics the model was built from the top down, ie at UK national level. As Figure 1 shows it is a pretty complicated "wiring" diagram. This is to be expected since materials can "flow" through the system in a wide combination and variety of routes, as described earlier. What is shown is the base model. Each of the boxes depicted on the diagram is of itself another complex flowchart. These sub-flowcharts are models in their own right and can be run alone or activated by the main base model, as it requires the materials to flow through these processes.

As each element of the model is interlinked with its surrounding processes and activities, the spider's web nature of the waste sector is easily demonstrated and the error of a simplistic linear supply chain approach becomes very quickly evident. Furthermore, the freedom to place specific or aggregate counters at any point in the system makes a vast array of measurements easily possible: cost, carbon, energy, asset use and volume through facilities, for example.

Based on the model calibrated with 2003/04 waste data (currently updating with 2005/06 data), our analysis of the simulated outputs enabled various outputs and comments to be reported, among them were:

- the overall cost for the management of household waste in England was approximately £1.9bn
- costs in 2003/04 are dominated by residual waste management (£1.5bn), with an average of £74 per tonne, although recycling supply channels have a higher average cost per tonne (£105) and a total of £379m
- waste and reprocessing facility costs account for £1.17bn, while transport was estimated to cost £730m
- a comparative analysis of different recycling systems for a number of materials indicates that "bring" and civic amenity (CA) sites frequently offer a cheaper supply chain option

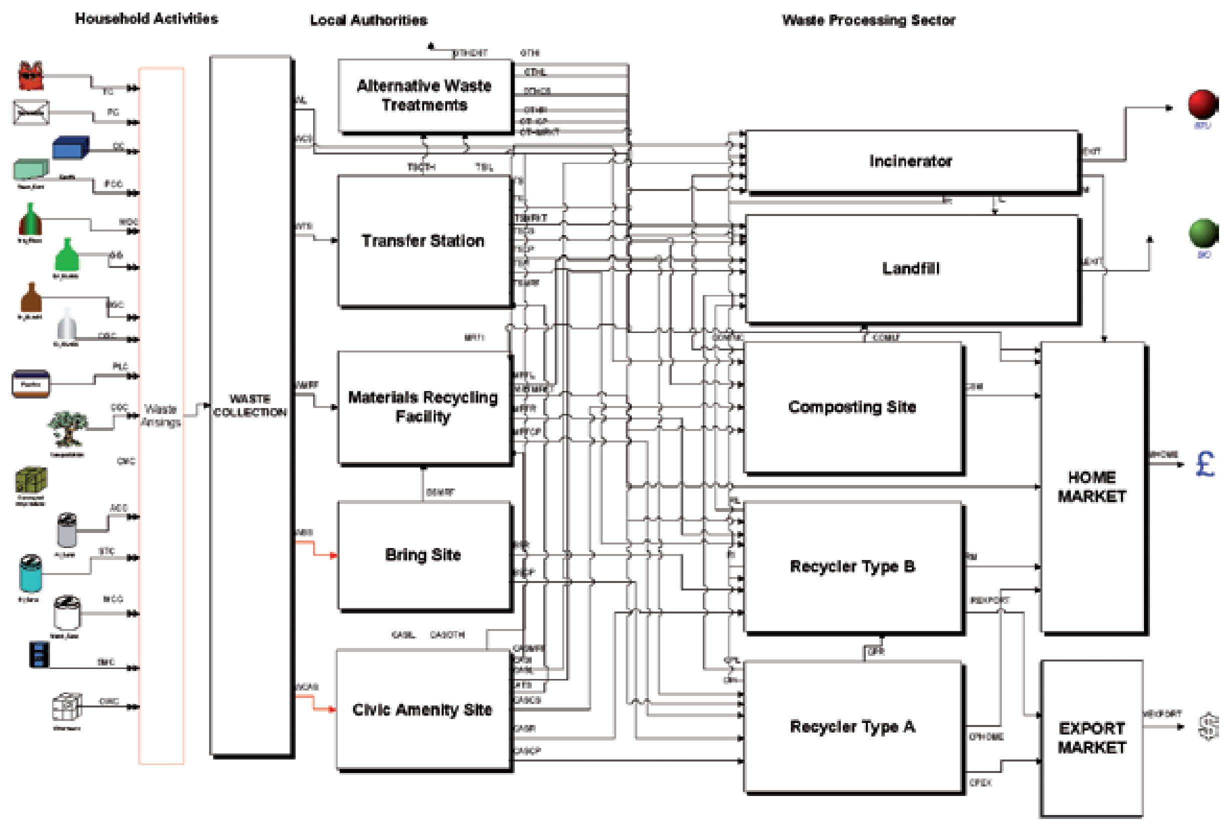

Figure 1: showing the wide combination of routes in which materials can flow through the system

compared with household collection, although CA sites result in higher emissions of CO_2
- commingled dry recyclable household collections incur lower costs than sorted recyclable collections. However, when the cost of sorting commingled materials at a MRF is considered, the total supply chain cost is not always cheaper
- based on our data assumptions the analysis estimates that a total of 248m km or 3.8bn tonnes km are undertaken in the transport of household waste (excluding car trips to "bring" and CA sites). This represents 38 percent of overall costs and results in 13 percent of total system carbon emissions. Household collection transport is responsible for 47 percent of this mileage.

It was also discovered that, in most instances, the average cost of managing household waste exceeds any average revenues generated in the market. The greater part (71 percent) of overall costs is disposal to landfill, 48 percent of which is landfill tax. For recyclables, 64 percent of costs were incurred prior to reprocessing, ie from local authority budgets.

For some local authorities increasing targets and the resultant cost of waste management may require a trade-off between waste and other service provision, particularly as the marginal cost of extracting more material from a decreasing waste fraction increases.

The supply of waste material for recycling from both commercial and municipal sources significantly exceeds domestic demand. Such a reliance on export demand continuing has systemic risk, should export quantity decrease, particularly at a time when recycling targets are increasing and the supply of material – domestic recycling capacity – is decreasing. For example, many paper mills have been forced to close as a result of increasing energy costs and UK incineration capacity is limited.

The model of the waste "supply chain" developed by this project shows there are a number of "supply chain" players: collection and disposal authorities, Defra, other Central Government departments, waste management companies, waste merchants and reprocessors each with their own aims, objectives and agendas. For example, local authorities are concerned with achieving tonnage targets, whereas reprocessors are more concerned with the quality of the input material.

The layout of the flows and variety of paths for waste materials shows that, based upon best logistical and supply chain management principles, the UK lacks a structure that can be cost-effective and efficient. Viewed against good management practices the current system is fragmented by a governing political complexity that is driving dysfunctional actions and uncertain environmental and economic outcomes. In addition to unnecessary complexity, this confused structure and logistics architecture limits any real potential to be derived from economies of scale and the critical mass of material to make rail, or other alternative transport modes, feasible.

Overall, by identifying the variety of routes and the cost components, this research and the results of the simulation demonstrate the complexity of the "waste-to-value" structure and the difficulties that this poses for its management, policy options and decision-making.

In order to meet the requirement of the project to identify the cost components, the holistic treatment of the "supply chain" processes was essential. As a direct consequence of this approach in the scoping of the model, the analysis is able to indicate how there are significant and additional benefits to be gained from good logistics and supply chain principles, for example:
- balancing the target-driven supply push and domestic demand pull, in terms of quantity and quality
- analysing the sensitivity to and recognising the risk from changes to export levels
- exploration of the economies of scale and the critical mass of material that would be possible to make rail, inland waterways and offshore shipping more valid options, and, possibly, the use of alternative fuels
- investigation of strategically locating facilities to provide a service to the most people, irrespective of political boundaries
- synchronising and balancing flows and activities throughout the supply chain.

Not only did we set out to answer the main question of identifying the cost components, we also set out to develop an approach that could be economically and efficiently updated with new data, or be applied at the operational level for local authorities and waste companies. Clearly these approaches will never produce the precise answer at a national level but it does allow numerous "what if" questions to be assessed for their impact over many years, against the effect of variations in taxes, seasonality, cost changes and many other factors. CIWM

For further information on the project email info@cereslogistics.co.uk