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GOOD PRACTICE IN PLANNING OF WASTE MANAGEMENT SYSTEMS

Krzysztof PIKOŃ*

* Dr.; Faculty of Environmental Engineering and Energy, The Silesian University of Technology, Konarskiego 18A, 44-100 Gliwice, Poland
E-mail address: *Krzysztof.Pikon@polsl.pl*

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Abstract
Waste management systems are usually very complex. Because of the nature of the problem there is no single "best" method of waste treatment. Each type of waste can be treated in different installation using different technology. List of choices is very long. The problem is even more complex when we take into consideration that the stream of waste in fact consists of several different types of waste. The decision making process should be done on the basis of modern environmental LCA thinking as well as economic and social analysis. In the paper some remarks about proper practice in optimizing waste management systems are given.

Streszczenie
Systemy gospodarki odpadami są z reguły bardzo złożone. Ze względu na cechy odpadów nie istnieje jedna „najlepsza" metoda ich zagospodarowania. Każdy rodzaj odpadów wymaga zastosowania innej technologii do ich unieszkodliwienia. Lista potencjalnych opcji jest bardzo długa. Sytuacja jest tym bardziej złożona, że jednocześnie w strumieniu odpadów mogą się znaleźć zmieszane frakcje o skrajnie różnych właściwościach. Proces decyzyjny musi się opierać na nowoczesnym podejściu środowiskowym uwzględniającym cały cykl życia oraz na analizie społecznej i ekonomicznej. W artykule zostały przedstawione zagadnienia związane z optymalizacją systemów gospodarki odpadami i narzędziami wsparcia procesu decyzyjnego opartego na właściwym planowaniu.

Keywords: **Waste management systems; LCA analysis; Optimization; Modelling.**

1. INTRODUCTION

The waste hierarchy refers to the 3Rs of reduce, reuse and recycle, which classify waste management strategies according to their desirability. The 3Rs are meant to be a hierarchy, in order of importance.

The waste hierarchy has taken many forms over the past decade, but the basic concept has remained the cornerstone of most waste minimisation strategies. The aim of the waste hierarchy is to extract the maximum practical benefits from products and to generate the minimum amount of waste.

Some waste management experts have recently incorporated a "fourth R": "Re-think", with the implied meaning that the present system may have fundamental flaws, and that a thoroughly effective system of waste management may need an entirely new way of looking at waste. Some "re-think" solutions may be counter-intuitive, such as cutting fabric patterns with slightly more "waste material" left – the now larger scraps are then used for cutting small parts of the pattern, resulting in a decrease in the net waste. This type of solution is by no means limited to the clothing industry. Source reduction involves efforts to reduce hazardous waste and other materials by modifying industrial production. Source reduction methods involve changes in manufacturing technology, raw material inputs, and product formulation. At times, the term "pollution prevention" may refer to source reduction.

Waste Hierarchy was introduced by the Council Directive 75/442/EEC: waste framework directive. Waste Hierarchy is the principal of all modern waste management systems in EU. The newest Directives on waste management (2008/98/EC and 2006/12/EEC) indicate that minimization of waste production is the most important principle to be introduced.

The directive establishes a framework for the management of waste across the Community and a waste management hierarchy (prevention or reduction of waste production and its harmfulness; recovery of waste, including recycling, reuse or reclamation, or the use of waste as a source of energy). The basis for this directive is the Community's waste strategy.

Member States are required to establish an integrated and adequate network of disposal installations, taking account of the best available technology not involving excessive costs, in accordance with specific objectives such as the principle of proximity and self-sufficiency in waste disposal.

Member States shall draw up management plans governing, in particular, the types, quantities and origins of the wastes to be upgraded or disposed of, the general technical requirements, all of the special arrangements concerning specific wastes, and the appropriate locations and installations for the disposal.

Companies or establishments treating, storing or dumping waste for another party must obtain an authorisation from the competent authority which concerns, in particular, the types and quantities of waste to be treated, the general technical requirements and the precautions to be taken.

The "polluter pays" principle is to apply to the disposal of waste, to ensure that the cost of disposing waste is generated by the waste producer or by the waste holder who passes it on for collection or disposal.

Many authors [1, 2, 3] express opinion that waste hierarchy is not modern solution nowadays. In 2007 European Commission wanted to overrule the realm of waste hierarchy and introduce LCA analysis as a basis for waste management systems. It didn't happen but since that time if we want to do something against waste hierarchy and we have the proof – gained using LCA – that planned solution is better for the environment – we can do it.

2. CHANGES IN EUROPEAN MUNICIPAL SOLID WASTE MANAGEMENT SYSTEM

The practice of municipal waste management varies in different European countries. According to Eurostat data, old member states (EU15) use a wider variety of waste treatment methods including recycling, incineration and, for a small part of the total amount of waste, landfilling – unlike in new member states where landfilling is still the prevalent form of waste treatment. New member states generally need to change their waste management policy to fulfil the requirements set forth in EU directives (Framework Directives on Waste and on Hazardous Waste, Community Strategy for Waste Management, Directives on Packaging and Packaging Waste, Landfill and Incineration directive etc.). An overwhelming majority of municipalities in new member states have to define their future systems of municipal waste management to make it economically viable and environmentally friendly. Unfortunately, economic criteria together with legal requirements are treated as the most important. Environmental evaluation is treated as less important and sometimes even omitted[4].

Before 1990, around 90% of the municipal waste was disposed of in landfills. However, in the late 1980s and beginning of the 1990s, several countries began introducing policies to reduce the use of landfills as outlet for municipal waste. In 1994 and 1999, two directives aiming to increase the recycling and recovery of packaging waste (Packaging and Packaging Waste Directive) and to divert biodegradable municipal waste away from landfill (Landfill Directive) were introduced.

Both directives have reinforced the diversion of waste from landfill. It is expected that the diversion will continue, but a slight increase in landfilled waste has been seen since 2007. The model uses relative shares of landfill, incineration and recycling, and due to the considerable increase in waste generation, the landfill share will have to be very low if the landfill of waste is to remain at a constant level or even decrease. In 2020, 34% of the generated waste is assumed to be landfilled. This share may be too high, especially in the light of the latest Structural Indicators published by Eurostat that show a landfill rate in the EU-15 of 34% in 2006 and 41% for the EU-27 (Eurostat). Incineration of waste with energy recovery is assumed to reach 23% in 2020.

Most municipal waste was also landfilled in the

EU-15 until 1990. From the mid-1990s Member States started to expand their recycling activities noticeably. This trend is expected to continue. Incineration with energy recovery is also expected to increase to some extent [5].

Waste Management System (WMS) must comply with the general requirements of European waste policy. For waste management planning at the municipal level the most relevant directives are:

- Directive 75/439/EEC: disposal of waste oils
- Directive 86/278/EEC: usage of sewage sludge in agriculture
- Directive 91/157/EEC: batteries and accumulators containing dangerous substances
- Directive 94/62/EEC: packaging and packaging waste
- Directive 99/31/EEC: landfill of waste
- Directive 96/59/EEC: disposal of polychlorinated biphenyls and polychlorinated terphenyls (PCBS/PCTS)
- Directive 2000/53/EEC: endof-life vehicles
- Directive 2006/66/EC.
- Directive 2008/98/EC.

Application of two of them the most important and the most valuable changes for the environment will force: Landfill Directive and Packaging Waste Directive.

3. PRINCIPLES OF WASTE MANAGEMENT DECISION MAKING

We can indicate 3 basic principals which should be applied when planning waste management system:

1. We have to make proper environmental evaluation of the system.
2. We have to make proper social evaluation of the system.
3. We have to make proper economic evaluation of the system.

The tools – based on LCA – of assessement of the sustainability of waste management systems must consider environmental, economical, and social indicators. However, there are many other important aspects, which cannot be measured or are difficult to measure by any indicator.

Although the basic principles of waste management remain unchanged, from day to day new technologies are developed for the implementation of these principles. These developed technologies become more complicated and they should be used in accordance with changed legislations, financial, economical and social aspects. This needs a capability of management to afford making right decisions at the right time. The proper cost assessment as well as profitability of different waste treatment methods is crucial issue which was examined by many authors [6].

The implementation of LCA is absolutely essential from the environmental point of view (this is obvious for the economic analysis).

The complex LCA analysis of different scenarios should be made. Each scenario, apart from general user inputs, consists of three basic waste management sub-systems:

- Temporary Storage
- Collection and Transport
- Treatment, Disposal & Recycling

For all scenarios the environmental, economic and social impacts can be determined, providing a sustainability assessment of the various alternatives.

If LCA is applied the waste hierarchy should be treated rather as list of choices – not as imperative [7].

The problem is that more expensive systems are often more environmental friendly. In other words results of ecomonic and enviromnetal evaluation lead to opposite conclusions.

For a successful operation of the waste management system, the waste quantities and compositions should be analysed and forecasts should be made at an early stage. Furthermore, the processes of waste treatment and disposal should be monitored and the emissions should be measured continuously. All these tasks require a monitoring and controlling system in addition to the constructed facilities and purchased equipment while the waste quantities could be determined due to weighing all waste deliveries to the treatment facilities.

Planned measures for a better waste management are mostly linked with additional financial burden for the waste generators. To achieve the accep¬tance of the new waste management system, the following conditions should be fulfilled [8]:

- an efficient and reliable waste collection and disposal, which fulfils the wishes of different groups of the public,
- an optimised payment structure: just distribution of costs according to polluter pays principle and higher taxes for wealthy population groups according to

solidarity principle, realizing the planned long-term macroeconomic benefits.

4. OPTIMIZATION

The optimization process should lead to defining the optimal waste management solution for given area.

The optimal is defined as the best solution from the environmental and social point of view but under economically and technically viable conditions, taking into consideration the costs and advantages. The Definition is similar to definition of BAT [9].

"Economically viable" is a key condition in the definition of waste management optimization. This term is difficult to grasp. There are no guidance to define it . Economic textbook do not provide direct access to the subject, either. Economic viability (EV) evidently does not belong to those technical terms for which a clear-cut definition exists. In dictionaries of current English, the explanation one finds under the entry viable is: able to exist or capable of surviving. If we take this definition of viable as starting point, we are led to the following question: What would be a suitable indicator and what would be the threshold value for this indicator to distinguish economically viable solutions from non-viable ones in a specific case?

We have to determine:

1. Method that can be used to determine economic viable state.
2. System boundaries (at what economic-performance level should viability be examined; should only internal advantages be taken into account, or also external ones?).

Helpful clues and guidance to approach these questions can be obtained by looking at the relevant economic and environmental-policy context. Business decision-making processes, in particular methods over acceptance and/or refusal of projects give the economic context.

To find the economically viable projects entrepreneurs use various investment analysis methods. The most common methods used in practice are:

- Net Present Value: The cash in- and outflows are discounted to the present. Criterion:NPV is greater than 0.
- Internal Rate of Return: This method determines the discount rate for which the present value of cash inflows equals the cash outflows of a project (also used as static approach). Criterion: IRR is greater than the chosen discount rate of the next best alternative.
- Payback Method: Emphasizes the time needed until the cumulative net cash flows equal the investment (amortisation).

In order to introduce the environmental objective "high level of protection" into the model serves the "environmental threshold". This threshold is policy-based as it is determined to balance economic and environmental interests. It divides measures into ones which are considered necessary by environmental policy and thus become viable ultimately by being regulated and into ones that are not viable.

If, in a purely economic evaluation projects are ranked according to their EV, then cost neutrality would divide projects which are profitable from ones which can be realised only at a loss. However, it is the economic threshold, which divides measures into economically viable ones – of which the market-place takes care – and ones which can be established on the market only through regulatory or promotional environmental-policy measures.

Cost-benefit analysis (CBA) is the most sophisticated method to balance economic and environmental aspects.

The tasks of operational management are the organisation of the collections routes, time schedules and maintenance and repair of the equipment. In addition to household wastes, the collection of clinical, hazardous and other specific wastes should also be ensured. The concept for the collec¬tion of recyclables could be further developed according to local and temporary circumstances.

To determine reference values for these indicators would mean the creation of viability benchmarks which are relative easy to calculate and apply, respectively of definite cut-off points for unreasonable measures. The decision regarding such cut-off points / benchmarks is a political one, as it sets the ambition level for protecting the environment, taking into account the envisaged high level of environmental protection and the resilience of a sector.

Guidance for the elaboration of benchmarks for cost relations could be obtained from empirical examples of advanced environmental technologies applied under market conditions [10].

5. PROPER MODELLING OF THE SYSTEM

A waste management system is defined as a set of elements (objects, processes) linked by relationships. The list of the elementary processes of one of the subsystems is vast.

The modelling of waste management systems is connected with simulation of the real elementary processes of which waste management is composed. Because of the complexity of the subject, dedicated software packages are in use nowadays featuring decision support systems for solving many complex problems in the area of design, analysis and optimization of single processes.

Modelling an integrated waste management system involves the following problems [11, 12, 13, 14]:

– planning of the management systems variants for wastes of all groups,
– management of processes, systems, subsystems,
– analysis of the constituent processes of systems,
– optimization of the elementary processes of the waste management system (process control, scheduling of tasks),
– investigation of correlations among the particular system elements and processes,
– identification of data structures identifying the system elements or processes,
– predictive (forecasting changes of the shape of processes, predicting changes of the parameters of processes, forecasting changes in waste generation),
– analysis of migration of pollutants from the technological processes of waste processing and disposal,
– analysis, identification and classification of environmental hazards,
– modelling of processes, elementary objects,
– modelling of the geo-environmental data.

The general systems modelling problem encompasses the following stages:

1. Development of the conceptual model
2. Development of the continuous mathematical model,
3. Development of the discrete mathematical model, deterministic (with known functional relationships by discretization of the ordinary/partial differential equations defined in the continuous model) [15]
4. Development of the numerical model (basic one), structural
5. Development of the reactive, adaptive object-oriented model
6. Verification of the model
7. Calibration of the model parameters (estimation of parameters) [16].
8. Validation of the model (evaluation of conformity of the model with the real system/process)
9. Testing of the object model
10. Analysis of the model stability and sensitivity.

Simulation of real waste management systems, encompassing all constituent processes consists in representation of the occurring physical phenomena as mathematical relationships describing roughly the nature of the particular processes [17].

6. CONCLUSIONS

– When planning a waste management system, it is extremely important to be aware that the choice of waste treatment method affects the environment and some processes outside the waste management system, like the generation of heat and electricity, as well as production of plastics, paper etc.
– Scenario analysis should be made when planning waste management system.
– The optimization – as a part of decision making process should be based on environmental, social and economic analysis. The economic viability is the crucial issue in decision making process and evaluation.
– Environmental analysis should be made on the basis of multi-criteria model (like CML2001) based on LCA.
– The system should be modelled and developed as a set of objects communicating with each other, implemented in software by special object types whose definition includes both data and methods allowing many complex operations to be carried out (based on given algorithms).

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