INTARESE

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INTARESE

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INTARESE
Work Package 3.6 WASTE

Assessment Protocol

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1 Purpose of the Assessment Protocol

The INTARESE project aims to develop a conceptual framework that forms the bases for integrated assessment of the health impacts of environmental exposures. The purpose of the present assessment protocol is to give a set of procedures that will be followed during the 1st pass assessment (months 18-30) of the specific policy area of waste. Guidelines for the assessment process will be suggested, with the option for further developments and possible update in the future, if necessary, based on partner discussions and agreement and comments / suggestions received from relevant stakeholders.

2 The Assessment Issue

Waste is an environmental, social and economic challenge for developed societies. An average of 3.5 tonnes of waste per person per year is generated in Europe. This is mainly made up of waste coming from households, commercial activities, industry, agriculture, construction and demolition projects, mining and quarrying activities and from the generation of energy.

The “waste management” that is the generation, collection, processing, transport and disposal of waste, is important for both environmental reasons and the health of the public. Overall waste volumes are growing in Europe. Municipal solid waste (MSW) generation has been contributing significantly to this growth (19% increase between 1995-2003) and it is connected to the level of economic activity. With higher levels of economic growth anticipated, overall volume growth is predicted to continue and will concern most wastes. An increase in MSW generation of 42.5% by 2020 compared to 1995 levels has been predicted while a relatively faster MSW growth is predicted in the new EU-10 Member States (European Commission, 2005).

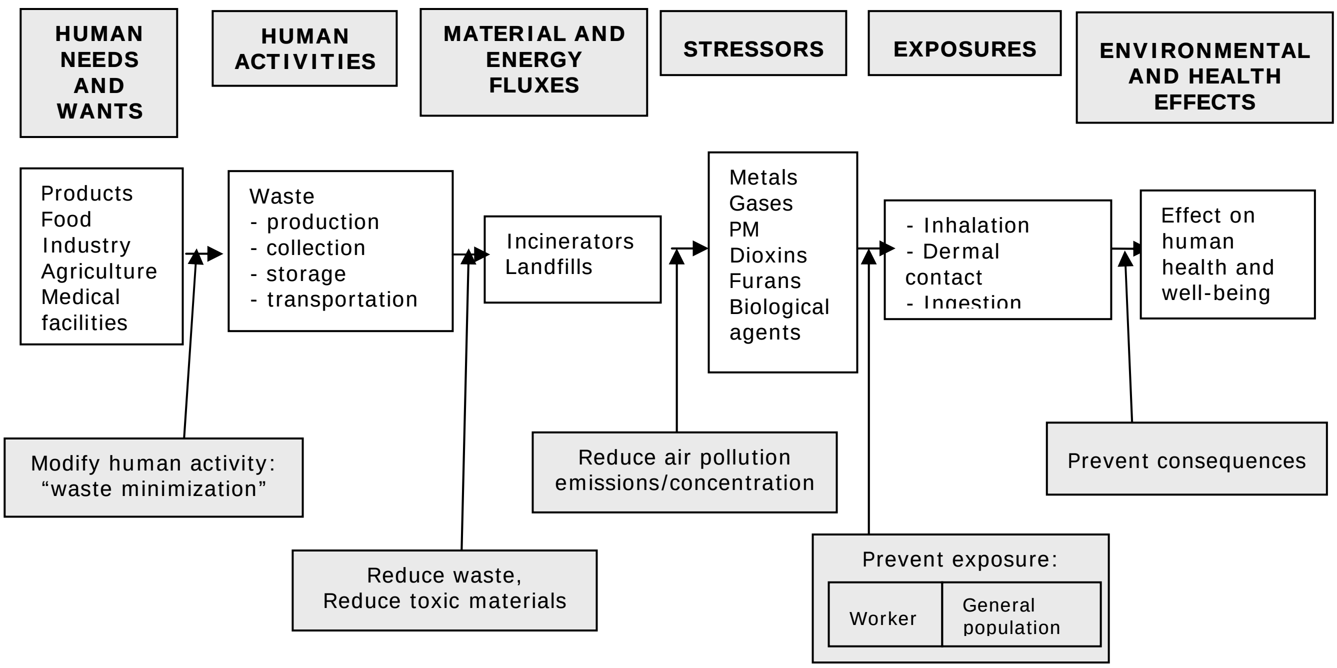
With large quantities of waste being produced, it is important that its management causes as little harm as possible both to human health and to the environment. There are a number of different options available for the treatment and management of waste including prevention, minimisation, recycling, energy recovery and disposal (Strange, 2002; European Topic Centre on Resource and Waste Management http://waste.eionet.europa.eu/etcwmf). An increasing amount of the resources contained in waste is recovered as materials or as energy in incinerators or biogas plants, but approximately half is still permanently lost in landfills.

Efforts are being made to decouple waste production from economic development, through a combination of waste prevention, recycling and re-use; where disposal is necessary, incineration is preferred over landfill. However, the various methods of waste management release a number of substances, most in small quantities and at extremely low levels. Concerns remain about potential health effects associated with the main waste management technologies (incineration, landfilling). Because of the wide range of pollutants that may be released by the various management technologies, the different pathways of exposure, usually long-term low-level character of exposure, and a potential for synergistic and cumulative effects, there are many uncertainties involved in the assessment of health effects in populations exposed to emissions derived from waste management technologies. One important issue in waste management that Europe is facing is the illegal practice of waste dumping or waste burning. These practices are not accounted for in official statistics but it is known that they are present in many European places (e.g. Campania in Southern Italy, see Section 4.3.1) and the environmental and health consequences have not been quantified.

This Assessment protocol is focused on the issue of municipal solid waste (MSW). Municipal solid waste represents approximately 14% of all waste produced and consists mainly of paper and cardboard (35%), organic material (25%), plastic, glass, ferrous material, textiles, aluminium, and other types of waste. At present in the EU, municipal solid waste is disposed of through landfill (49%), incineration (18%), recycling and composting (33%). There are wide discrepancies between Member States, ranging from those that recycle least (90% landfill, 10% recycling and energy recovery) to those which are more environmentally friendly (10% landfill, 25% energy recovery and 65% recycling).

An overview of the complex problem of waste production/disposal, human behaviours on waste, together with actions to be taken in order to prevent adverse effects from waste disposal is showed in Figure 1. The diagram starts with the main driving forces associated with waste production, namely industrial and commercial activities with production of goods to fulfil human needs. As a result, waste is produced with subsequent necessity to collect/store/transport and finally dispose of it. The waste disposal methods currently used represent the source of a wide range of environmental pollutants with, following human exposure, possible deleterious effects on health of the population. At every level of this process, from waste production to public health and environmental health issues as the end consequences, the diagram points out steps where actions could be taken, or human behaviour could be modified, with the final aim to prevent, or at least minimize waste production and decrease negative impact of waste treatment / management on environment and human health.

Figure 1: The waste management flow and possible policy actions



- Durable, long-lasting goods; - Products and packaging as free of toxics as possible; - Products with less raw material in production, have a longer life, or be used again after its original use. - Packing reduced	- Reuse, - Recycling - Buying recycled products - Composting - Separate domestic hazardous waste	- Gas temperature reduction techniques - Air pollution control techniques - Environmental monitoring	- Consider regional scale - Consider multiple media -Individual protection equipment	No options

2.1 Key Stakeholders

A simple list of stakeholders includes industry, central / regional governments, city councils, NGOs, service users, private companies dealing with waste, citizens, scientists, and media. It should be noted that several stakeholders are present in the waste management area especially before waste formation: industry, packing, delivery of goods, and citizens are all involved in the waste formation as well as in the "waste minimization" process. On the other hand, there are several stakeholders at the end of the process where "wastes" represent important economical resources of material (glass, paper, etc) and energy. Since environmental control is also crucial at the end of the process, public institutions play an important role. There are several conflicting interests among the various stakeholders, e.g. national policy versus local policy, industrial interests versus environmental interests, environmental sustainability and employment, waste minimization and energy production. These conflicting interests, together with citizens' concerns of health effects, make choices of waste management a very controversial area.

Identification of important stakeholders and their involvement in the 2nd phase of the assessment will provide an important feedback on policy areas assessed within WP3.6 Waste and will help to communicate issues of uncertainty during the assessment process. *Appendix 1* gives the list of stakeholders identified in three EU countries: UK, Italy, and Slovakia.

2.2 The Policy Context

The main European policy on waste has been defined in the Thematic Strategy on the prevention and recycling of waste proposed on 21 December 2005 (http://eur-lex.europa.eu/LexUriServ/site/en/com/2005/com2005_0666en01.pdf) as a follow up of the 6th Environment Action Programme (6th EAP), adopted by the European Parliament and Council in 2002. A summary of the EU legislation on waste is presented in *Appendix 2*.

The current waste policy aims to prevent waste and promote re-use, recycling and recovery so as to reduce the negative environmental impact. Current EU waste policy is based on a concept known as the "waste hierarchy". This means that, ideally, waste should be prevented and what cannot be prevented should be re-used, recycled and recovered as much as feasible, with landfill being used as little as possible. Landfill is the worst option for the environment as it signifies a loss of resources and could turn into a future environmental liability. The aim of moving towards a recycling and recovery society means moving up the hierarchy, away from landfill and more and more to composting, recycling and recovery.

As already mentioned, under EU policy, landfilling is seen as the last resort and should only be used when all other options have been exhausted, i.e., only material that cannot be prevented, re-used, recycled or otherwise treated should be landfilled. It is to be noted that diversion of waste away from landfill is an important element in EU policy in order to improve the use of resources. In particular, with the aim of fulfilling the targets provided by Directive 1999/31/EC on Landfill of Waste, Member States are obliged to set up national strategies for reducing the amount of biodegradable municipal waste going to landfill. With these measures and with the general provision that only waste which has been subjected to treatment can be landfilled, the Landfill Directive is expected to have a major effect on the waste management system. This includes recovery of waste and possibly also prevention of waste.

On the other hand, although some progress has been made in the area of waste management in Europe (clean up of many old incinerators, implementation of new techniques, etc.) and waste prevention has been the objective of both national and EU waste management policies in recent years, limited progress has been made so far in transforming this objective into practical action.

In sum, the EU policy could be summarized as "less waste to landfill, more compost and energy recovery from waste, more and better recycling". The European policy is expected to have implications for current practices in the Member States and to create new opportunities for waste management options other than landfill with a general move up the waste hierarchy.

3 Scope of the Assessment

3.1 The Assessment Framework

The overall aim is to assess potential exposures and health effects arising from municipal solid wastes throughout their lifecycle, from generation to disposal or treatment. It should be noted that the assessment will be done at the country level. Initially, we shall use Italian data as an example of the assessment (data from region Emilia-Romagna will be used first in a pilot evaluation), followed by the UK and Slovakia assessments. It is expected that the methodology will be used to evaluate policy scenarios at a wider EU scale later on. The assessment protocol will follow the full chain approach illustrated in Figure 2, and the key elements of the assessment are illustrated below.

3.2 Key Elements/Relationships for Waste Assessment

This assessment protocol will evaluate the health impact of different management policies for MSW considering a baseline scenario for the years 2001-2002. The methods implemented for the baseline scenario will be a useful instrument in the 2nd pass of the project to evaluate the changes that are currently occurring and to respond to policy questions arising from future developments (up to the year 2020).

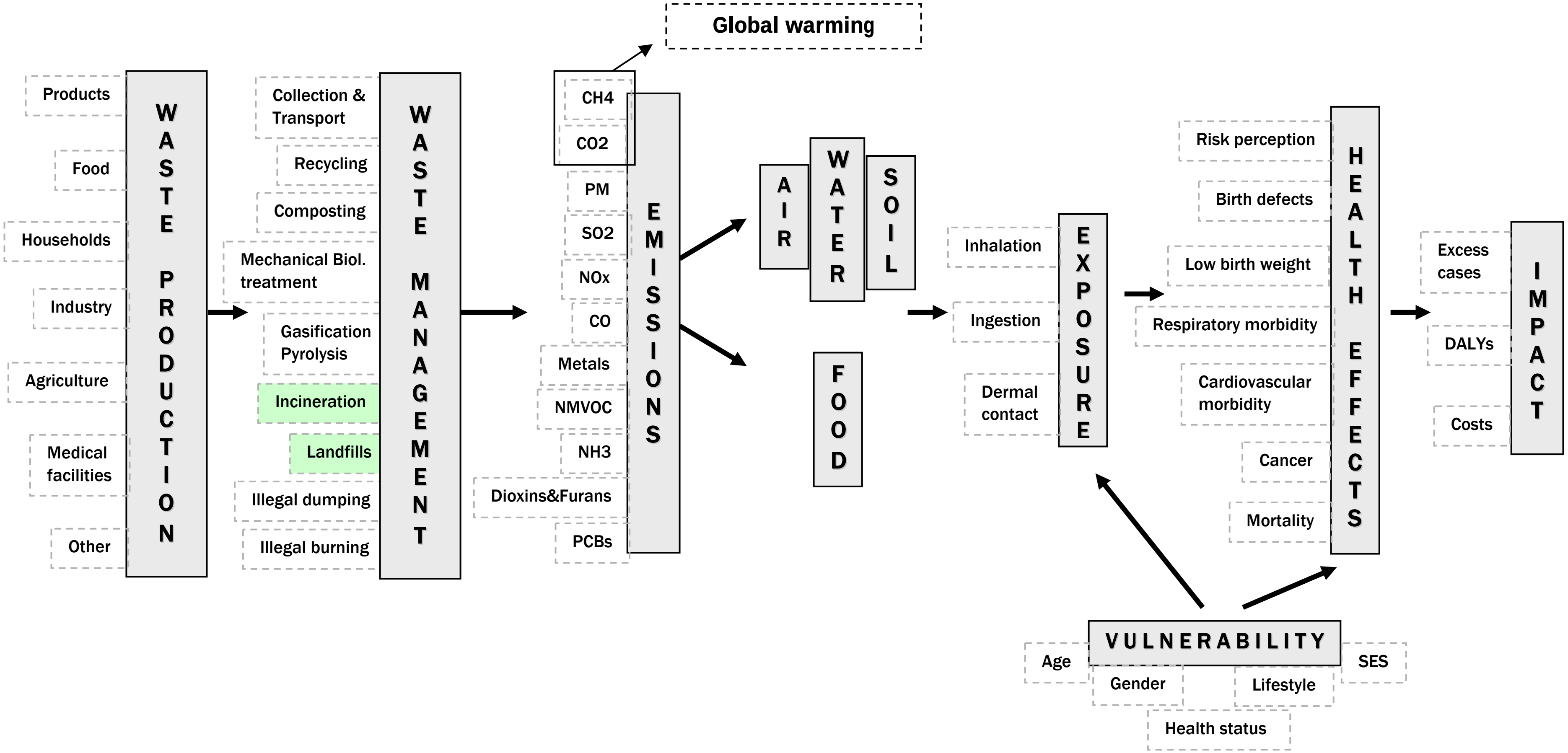
We have divided the process into the following different key elements according to the full chain approach.

1. From generation to management of waste. Describe waste generation and waste management policies for each country.
2. From waste management to emissions of pollutants. Given the baseline scenario, evaluate emission data for the main waste technologies and estimate total emissions of air pollutants at the country level.
3. From emissions to population exposures. Provide an estimate of the size of the population exposed and the level of exposure to pollutants emitted from the main management technologies at the country level.
4. From exposure to health effects. Perform a systematic review of the scientific literature and derive appropriate relative risk estimates and exposure-response functions.
5. Quantification of the health impact. Estimate the integrated health impact attributable to waste management at the country level.
6. Quantification of the external costs. Estimate external economical costs of waste management practices at the country level.

There are some specifications and key choices that are important to consider in this framework.

- There are substantial environmental effects associated with waste transport for both recycling and disposal and we will try to consider transportation in the evaluation of total emissions.
- The quantification of illegal practices of dumping and burning is extremely difficult and only a qualitative assessment will be performed.
- The emission factors that we will consider are based on facilities under normal operational circumstances. There is the possibility of accidental releases that should be considered but are difficult to be quantified.
- Although all major waste management activities will be considered for steps 1 and 2, the focus for the additional steps will be based on incinerators and landfills representing the main ways of waste disposal in the baseline scenario.
- Although pollutants from waste disposal practices are released into all environments, only emissions into ambient air will be taken into consideration in the full assessment, due to the lack of data on emissions into soil and water.
- Cost evaluation is the last point of the evaluation and it is important for present and future scenarios. However, agreed upon methods should be developed within INTARESE and will considered in more detail in the second pass in accordance to the standard approach utilized by all partners.
- Identification of major sources of uncertainty will be briefly considered in the assessment protocol but a continuous review will be performed.

Figure 2: The full chain approach - from waste production to health effects



3.3 The Study Area

The assessment protocol will use information collected for case studies conducted in the three European countries - UK, Italy and Slovakia - which have different waste policy. The national waste management policy will be described, total emissions arising from waste management will be estimated, census data on incinerators and landfill sites in the three countries will be collected, and population exposure will be estimated and used in the assessment.

A short description of waste management in the three countries is reported in *Appendix 3*.

3.4 The Study Population

The study population comprises the general populations of UK, Italy and Slovakia. The local target population will be defined on the basis of their distance from landfills and incinerators. In the case of incinerators, estimates of pollutant concentrations based on local and large scale dispersion modelling will be used to define the target population.

Based on the literature review, increased risk of adverse reproductive outcomes (congenital malformations and low birth weight) and cancer are associated with exposures arising from landfills and incinerators. These findings emphasize the need to consider two subgroups of the population as particularly vulnerable to possible negative health effects of waste management and waste treatment practices – pregnant women, or women of reproductive age in general, and the elderly population.

Socio-economic status plays an important role in the assessment of the health risks from exposure to waste disposal sites, since populations with lower socio-economic status is prone to live closer to waste disposal sites. At the same time, lower socio-economic status is already associated with a higher risk of various negative health outcomes. Therefore, issues related to environmental justice are present here because of the higher probability of exposure for less affluent people and their increased vulnerability.

4 Assessment Methodology

There are several examples in the literature of risk assessment of a single or a limited number of waste management plants (e.g. Mindell & Barrowcliffe, 2005). Results of risk assessment performed at the country level are more limited, although the ExternE methodology (Rabl and Spadaro, 2002; Zoughaib et al, in press) has been applied to estimate external costs of waste management. A complete assessment has been conducted in Singapore (Tan & Khoo, 2006) but with the main focus on environmental impact. Experiences of the health impact assessment in Europe are available from Ireland (Health Research Board Ireland, 2003) and the UK (Enviros, 2004). The latest study provides a wide review focused on environmental and health effects of MSW management. The study has been published by DEFRA (Department for Environment, Food and Rural Affairs of the UK) and performed by Enviros Consulting, Ltd. in cooperation with the University of Birmingham. The methods and the results of this study are relevant for the present health impact assessment.

The following section will explain all the steps that will be taken for the evaluation. In the assessment, the full-chain approach will be implemented (Figure 2); for every key step of this approach, methods/models to be used and the data needed will be described.

In the initial steps, all main processes utilized for waste treatment as the sources of emissions to the environment will be considered and described, but the main emphasize of the quantification of health effects will be based on incineration and landfills, for which models for exposure assessment have been suggested. The assessment of the chain between exposure and health effects will be based on utilising relative risks or exposure-response coefficients derived from the literature and subsequent calculations of health impacts.

4.1 Waste Generation and Management in the UK, Italy and Slovakia

Municipal solid waste (MSW) includes predominantly household waste with sometimes the addition of commercial wastes collected by a municipality within a given area. Of course, industry, agriculture and medical facilities produce large quantities of waste, but their direct contribution to MSW is low. Municipal solid wastes are in either solid or semisolid form and can be classified as biodegradable waste (food & kitchen waste, green waste), recyclable material (paper, glass, bottles, cans, metals, certain plastics, etc), inert waste (construction and demolition waste etc), composite wastes (waste clothing, tetra paks, waste plastics ets), domestic hazardous waste (medication, paints, chemicals, light bulbs, fluorescent tubes, spray cans, fertilizer and pesticide containers, batteries, shoe polish).

The following processes represent the predominant waste management technologies (Enviros, 2004), each being the source of a number of environmental emissions:

1. Materials recycling facilities (MRF)

Materials recycling facility (materials recovery facility) is defined as a central operational plant where source segregated, dry recyclable materials are sorted mechanically or manually for processing into secondary materials. Waste material entering an MRF has normally been subject to some pre-segregation, but further sorting is required which may involve machinery or may involve human contact.

2. Composting

Waste materials that are organic in nature (plant material, food scraps, paper products) are put through a composting and/or digestion system to control the biological process to decompose the organic matter and kill pathogens. The resulting stabilized organic material is then recycled for agricultural or landscaping purposes. There are a large variety of composting and digestion methods and technologies, varying in complexity from simple window composting of shredded plant material, to automated enclosed-vessel digestion of mixed domestic waste. These methods of biological decomposition are differentiated as being aerobic (composting methods) or anaerobic (digestion methods).

3. Mechanical and biological treatment

Mechanical biological treatment (MBT) is a technology for combinations of mechanical sorting and biological treatment of organic municipal waste. The "mechanical" element is usually a bulk handling mechanical sorting stage. This either removes recyclable elements from a mixed waste stream (such as metals, plastics and glass) or processes it in a given way to produce a high calorific fuel called refuse derived fuel (RDF) that can be incinerated or used in cement kilns or power plants. The "biological" element refers to either anaerobic digestion or composting. Anaerobic digestion breaks down the biodegradable component of the waste to produce biogas and soil conditioner. The biogas can be used to generate renewable energy.

4. Pyrolysis/Gasification with energy recovery

Pyrolysis and gasification are two related forms of thermal treatment where waste materials are heated to high temperatures with limited oxygen availability. The process typically occurs in a sealed vessel under high pressure. Converting material to energy this way is more efficient than direct incineration, with more energy able to be recovered and used. Pyrolysis is the thermal degradation of waste in the absence of air to produce gas (often called syngas), liquid (pyrolysis oil) or solid (char, mainly ash and carbon). The solid components may be subsequently fed into a gasification process. Gasification takes place at higher temperatures than pyrolysis with a controlled amount of oxygen. The majority of the carbon content in the waste is converted into a gaseous form (syngas).

5. Incineration (with and without energy recovery)

Incineration is a waste disposal method that involves the combustion of waste at high temperatures ("thermal treatment"). Incineration of waste materials converts the waste into heat, gaseous emissions, and residual solid ash. There are three main approaches that have been adapted for the incineration of municipal waste: mass burning, fluidised bed and refuse derived fuel (RDF) (WHO 1996).

Mass burning refers to the combustion of municipal waste with only rudimentary preparation and separation of the waste. A variety of moving grates have been used to facilitate the movement of the waste through the combustion zone. The grate ensures the passage of the burning refuse through the combustion zone and also allows the provision of adequate supplies of air to guarantee complete combustion of the waste, and ash removal.

In fluidised bed systems, smaller combustion units are used and there is some pre-processing of the waste to facilitate the operation of the fluidised bed. A bed of inert solid particles is fluidised by the flow of combustion air from beneath the bed. Pre-treatment of the waste provides a uniform feed material. In RDF systems, municipal waste is pre-processed using several sorting and shredding stages to produce a stable dry material which can be burned.

6. Landfill

Disposing of waste in a landfill is one of the most traditional methods of waste disposal, and it remains a common practice in most countries. In the past, landfills were often established in unused quarries, mining voids or borrow pits. Older and poorly-managed landfills can create a number of adverse environmental impacts such as wind-blown litter, rodents and other vermin, and the generation of leachate as a result of rain percolating through the waste and reacting with the products of decomposition, chemicals and other materials in the waste polluting groundwater and surface water. Another by-product of landfills is landfill gas (mostly composed of methane and carbon dioxide), which is produced as organic waste breaks down anaerobically. This gas can create odour problems, kill surface vegetation, and is a greenhouse gas.

7. Transportation

Transport of waste, usually using heavy lorries, is a significant part of waste management practices, not only regarding the transport of raw waste to disposal sites, or transfer sites, but transport resulting from separation of the waste into more fractions for advanced treatment (higher distances for recycled materials). Waste transport accounts for 5% of the energy consumed by the transport sector and 15% of freight transport in tonne - kilometers.

It is the aim of this 1st phase assessment to fully describe the current waste management policies in the three countries and subsequently develop future scenarios.

Data on wastes are collected by the National Statistical Institutes and Ministries for the Environment for each year and are reported to Eurostat every second year (*http://epp.eurostat.ec.europa.eu*). Data include municipal waste and waste from industry and trade, both hazardous and non hazardous waste. The European Topic Centre on Resource and Waste Management (*http://waste.eionet.europa.eu/wastebase)* provides another data set *(*Wastebase) and it has detailed information of the policies at the country level. It should be noted that location data of major landfills and incinerators in Europe are available in the EPER database *(http://www.eper.cec.eu.int/eper/default.asp*). Country specific sources of information will be considered in the project, like the Environment Agency in the UK, the Environmental Protection Agency (APAT) in Italy, or the Slovak Environmental Agency.

For each country, we will collect the information detailed in Appendix 4, and we will tabulate the following list of indicators (for the years 2001-2002).

- MSW generated by weight and material type (paper and paperboard, glass, metals, plastic, rubber, wood, textile, other) (Tons, and Tons per inhabitant)
- Recovery for recycling of MSW by material type (Tons and recovery rate)
- Number and population served by curbside recyclable collection programs
- Number of Materials Recycling Facilities
- Number of composting facilities
- Number of mechanical and biological treatment facilities
- Number of incineration facilities
- Number of landfills
- Amount and percentage of MSW recovered for recycling
- Amount and percentage of MSW recovered for composting
- Amount and percentage of MSW treated with mechanical and biological treatment
- Amount and percentage of MSW incinerated
- Amount and percentage of MSW in landfill disposal

Note that not all the waste processed with one technology will end with that technology. Example 1: not all the waste arrived to a recycling facility can actually be recycled. Therefore, an amount will have a different end point, for instance, 80% recycled 20% landfilled. Example 2. Mechanical and biological treatment plants may produce refuse derived fuel (RDF) for later incineration or use in cement or power plants. Example 3. Incinerators produce a considerable proportion of bottom ashes that should be landfilled. Therefore, the amount of solid residue from one technology going to another technology should be noted.

In addition, illegal waste dumping and waste burning are still in practice in many European places. In Slovakia, for instance, there are two kinds of illegal dumping sites: a/ containing communal and construction waste, and b/ mostly stores of obsolete pesticides previously used by agricultural cooperatives of the socialist type. Illegal dumping sites containing plastic materials (e.g. PVC) occasionally start to burn producing polychlorinated dioxins, and dibenzofurans as the result of incomplete combustion. If old pesticide stores are discovered, they are handled by specialized companies observing official safety rules. The other example of illegal dumping and waste burning is in the Campania region of Italy, where Naples is located. Since the 1980s thousands of uncontrolled and illegal sites of urban, toxic and industrial waste disposal have been active in the region. Since 1994 a Commissioner appointed by the national government has held executive authority for waste treatment and disposal policy in the region but the situation has not improved. Landfills are exhausted and, because of repeated episodes of social tension, it is difficult to identify new sites; incineration is not possible because although plants are planned they are not yet completed. In the last few years million of tons of waste ready to be burned in incinerators have been stocked. Toxic waste is illegally buried in quarries, lakes or illegally incinerated on a daily basis. Criminal organizations make money on the illegal disposal of toxic and industrial waste from other Italian regions. Although the systems are complex and difficult to fully understand, an attempt will be made to quantify the phenomenon in each country.

4.2 Quantification of Emissions of Pollutants from Waste Management in the UK, Italy and Slovakia

The next step in the full-chain approach is the assessment of the emissions from waste management into the environment. A description of the main emissions from the main waste technologies is briefly illustrated below on the basis of information available in the UK report (Enviros, 2004). More information has been reported in the WP 3.6 scoping report

4.2.1 Materials Recycling Facilities (MRF)

The greatest hazard is related to biological materials, and particularly bioaerosol. The associated risks are very similar to those occurring in a composting plant (see below), although likely to be of lower magnitude if mainly dry recyclables are handled. Unlike the composting plant, there are also significant chemical and physical hazards to the worker in the MRF, and those chemical hazards including exposure to vapours and suspended particulate matter may extend outside the plant.

The environmental impact of recycling can be summarized as follows:

Air: emission of dust and bioaeresols

Water: wastewater discharge

Soil: landfilling of final residues

4.2.2 Composting

Whenever composting materials are moved, the formation of greenhouse gases and bioaerosol is an inevitable consequence. During optimal management, the composting process generates temperatures sufficient to destroy most pathogenic bacteria. However, these may still survive in any part of the compost that does not reach an adequate temperature and can also be subject to aerosolisation (i.e. becoming suspended in the air). Specific components of the bioaerosol generated during composting are Fungi, Bacteria, Actinomycetes, Endotoxin, Mycotoxins, Glucans.

The environmental impact of composting can be summarized as follows:

Air: emissions of methane (CH4), carbon monoxide (CO) and bioaerosol

4.2.3 Gasification/Pyrolysis with Energy Recovery

The gas produced will contain toxic substances similar to those emitted from incinerators.

The environmental impact of gasification/pyrolysis can be summarized as follows:

Air: emission of particulate matter (PM), SO2, NOx, HCL, HF, NMVOC, CO, CO2, N2O, dioxins, furans, heavy metals (Zn, Pb, Cu, As, Ni, Hg, Cd)

Water: deposition of hazardous substances on surface water

Soil: landfilling of ashes

Ecosystem: contamination and accumulation of toxic substances in the food chain

4.2.4 Incineration (with and without energy recovery)

Concerns over incineration relate mainly to the by-products of the combustion process, most particularly the emissions to atmosphere. Some pollutant emissions from incinerators are formed, in part, by incomplete combustion that may in turn lead to the formation of pollutants such as dioxins and furans. The formation of products of incomplete combustion is governed by the duration of the combustion process, the extent of gas mixing in the combustion chamber, and the temperature of combustion.

Outputs from incinerators include:

1. Furnace bottom ash which contains a large proportion of the non-volatile and non-combustible material such as metals contained in the original waste stream
2. Air pollution control residues (fly ashes)
3. Emissions of gaseous combustion products

The enforcement of a number of European Directive limits over recent years has drastically reduced the concentration of many pollutants in emissions to air from incinerators. The Directive on the Incineration of Waste (European Commission, 2000) imposes even stricter emission limits.

The environmental impact of incineration can be summarized as follows:

Air: emission of particulate matter (PM), SO_2, NOx, HCL, HF, NMVOC, CO, CO2, N_2O, dioxins, furans, heavy metals (Zn, Pb, Cu, As, Ni, Hg, Cd)

Water: deposition of hazardous substances on surface water

Soil: landfilling of ashes

Ecosystem: contamination and accumulation of toxic substances in the food chain

4.2.5 Landfill

The main potential impacts on health arise from landfill gas and exposure to groundwater contaminated by landfill leachate. Both gaseous and aqueous emissions from landfills are highly complex mixtures whose characteristics vary considerably from site to site and with waste composition and age of the landfill.

Emissions of landfill gas and leachate from biodegradable waste materials take place over a period of years following disposal. Landfill gas is the principal component of emissions to air from landfill sites. The composition of the gas varies according to the type of waste and the phase of degradation of the waste but typically it contains a large proportion of methane and carbon dioxide. Small amounts of trace components such as organic gases or vapours are also present. There are a number of ways in which landfill gases and products of combustion are released to the atmosphere.

1. Fugitive gas emissions from passive venting to atmosphere.
2. Collection using a gas extraction system and subsequent burning in flares.
3. Collection using a gas extraction system and utilised to provide heat or power using energy recovery plant that uses the landfill gas as a flammable fuel.

The environmental impact of landfills can be summarized as follows:

Air: emissions of methane (CH4), carbon monoxide (CO), SO_2, HCL, HF, dioxins, furans,

Water: leaching of salts, heavy metals, biodegradable and persistent organics to groundwater

Soil: accumulation of hazardous substances in soil

Ecosystem: contamination and accumulation of toxic substances in the food chain

4.2.6 Transportation

Transportation of waste for both recycling and disposal uses lorries, especially with diesel engines, with the following environmental impact (NSCA 2002):

Air: emission of particulate matter (PM), NOx.

4.2.7 Overview of Emissions to Air from Waste Management Facilities

A detailed investigation on emissions for the described processes has been reported in the UK report (Enviros, 2004, table 2.45 page 115) and Table 2 summarizes the main information on emissions for pyrolysis/gasification, incineration, and landfill derived from that study. The complete original table in the report provides values of estimated emissions in grams per Tonne of processed waste. This report has considered all the available literature and provides a unique source of information for the assessment. The report also used information collected in the documents prepared by the National Society for Clean Air in 2002 (NSCA, 2002).

In addition, a more recent reference document for the best available technique for waste incineration (http://eippcb.jrc.es/pages/FActivities.htm) provides indications on current emissions for incineration plants.

Table 2. Emissions to air from waste management facilities (grams per tonne of MSW)

Substance	Pyrolysis/gasification	Mass burn incineration	Landfill/flaring
Nitrogen Oxides	**780**	**1600**	**75**
Total Particulates	**12**	**38**	**6.1**
Sulphur Dioxide	**52**	**42**	**90**
Hydrogen Chloride	**32**	**58**	**14**
Hydrogen Fluoride	**0.34**	**1**	**2.7**
Volatile Organic Compounds	**11**	**8**	**7.6**
Methane	No data	**19**	**19,000**
Cadmium	**0.0069**	**0.005**	**0.71**
Nickel	**0.04**	**0.05**	**0.0095**
Arsenic	**0.06**	**0.005**	**0.0012**
Mercury	**0.069**	**0.05**	**0.0012**
Dioxins and Furans	**4.8×10^{-8}**	**4.0×10^{-7}**	**5.5×10^{-8}**
Polychlorinated Biphenyis	No data	**0.0001**	No data
Carbon Dioxide	No data	**1000000**	**200000**

(Source: Enviros, 2004, Review of Environmental and Health Effects of Waste Management: Municipal Solid Waste and Similar Wastes, Department of Environment Transport and the Regions, UK).

We will use the information collected in step 4.1 (tonne of waste per treatment technology) and we will apply the emission factors reported in the UK report (Environs, 2004) (grams per Tonne) to estimate the total air emissions of the pollutants indicated below at the country level. A simple spreadsheet will be used and it will allow the calculation of a sensitivity analyses on the basis of real operational data.

The pollutants (mainly emissions into air) of interests are:

- Carbon monoxide
- Carbon dioxide
- Dioxins and furans
- Metals: arsenic, cadmium, mercury, nickel
- Methane
- Nitrogen oxides
- Particulate matter (PM_{10}, $PM_{2.5}$ and ultrafine particles)
- Polychlorinated Biphenyls
- Sulphur Dioxide
- Total Volatile Organic Compounds
- NH_3

4.3 Population Exposure to Pollutants from Incinerators and Landfills

The next step in the health impact assessment is to identify and characterise the population at risk and to derive the population exposure distribution. Therefore, information on all incinerators and landfills at the country level will be collected, the information will be transferred to a GIS system, air pollution dispersion modelling will be applied to the areas where incinerators are present, and the population living within a specific radius from both incinerators and landfills will be estimated. These steps are illustrated below.

4.3.1 Census and GIS Coordinates of UK, Italian and Slovak Landfills and Incinerators

Data for all landfills and incinerators in the three countries will be collected according to the protocol in appendix 4. Geographical coordinates should be available from national sources. In any case, the European Pollutant Emission Register (EPER) contains data about the location of facilities that are obliged to report their emissions to the EPER (municipal waste >3t/h). Data include names, addresses, postcodes and latitude/longitude coordinates. On the database website http://www.eper.cec.eu.int/eper/default.asp location data can be gathered.

The national GIS data sets for the UK, Italy and Slovakia need to be defined. Availability of this data will be checked in their national coordinate systems (e.g. the GIS coordinates of the UK landfill sites are listed in the British National Grid projection).

A European GIS coordinate system will be chosen as part of WP5.1, whose task it is to provide EU-wide data such as boundary data. The projection most likely to be used is the Lambert Azimuthal – Equal Area projection, which is also used in the CORINE2000 land cover dataset.

UK: The UK landfill database was collected as part of a nationwide study of health outcomes in populations living near landfill sites, carried out by the Small Area Health Statistics Unit (SAHSU) at Imperial College, London. Results of this study were already published (Elliott et al., 2001; Jarup et al, 2002); data collected covers the period from 1982 to 1997. The database includes the locations for 19,196 landfill sites plus information on whether they hold hazardous waste and their opening and closure dates. Detailed information on the collection of the landfill database and the GIS methods used to classify populations in Great Britain in terms of their potential exposures can be found in Briggs *et al,* 2002. The number of active landfill sites in England and Wales has gradually decreased, from 3,400 in 1994 to 2,217 in May 2006. In Scotland there were 213 working landfill sites in 2004/2005.

In January 2006 there were 17 municipal waste incinerators active in England and Wales and two in Scotland. Emission data for the 17 incinerators in England and Wales can be downloaded from the Environment Agencies website (http://www.environment-agency.gov.uk/maps/). Similarly, emissions for the 2 Scottish incinerators are reported by the Scottish Pollutant Release Inventory (SPRI) (http://www.sepa.org.uk/spri/index.htm).

Italy: The Italian Environmental Protection Agency (www.apat.gov.it) will provide the database of the landfills in Italy (around 600 at the beginning of 2001). In Italy a detailed census of the 52 incinerators has been made from a national research institute (ENEA, 2007) funded by the national association of stakeholders in waste management (Federambiente). Detailed measurements of emission data will be provided by the regional environmental authority for all eight incinerators located in one region of Northern Italy (Emilia Romagna). In addition, a specific study of one incinerator in Southern Italy (Melfi, Potenza) is available from the National Health Institute (Dr. Giuseppe Viviano).

Slovakia: In Slovakia, the number of incinerators decreased from 69 to 45 (including 18 incinerators for industrial waste) over the last 5 years (2003-2007). Recently, only incinerators meeting the requirements of the Directive 2002/76/ES on waste incineration are active. Information on incinerator census for the baseline year 2001 together with information on the emissions released from incinerators into the environment will be obtained from the National Emission Information System (NEIS) of Slovakia, managed by Slovak Hydro-meteorological Institute (contacts: Dr. E. Sajtakova, elena.sajtakova@shmu.sk; Dr. K. Spisakova, katarina.spisakova@shmu.sk).

At the end of 2001, there were 165 active landfills in Slovakia. The list of landfills, according to region and type of waste (hazardous, inert and other non-hazardous) is available (in Slovak) on the website of the Slovak Ministry of Environment (www.enviro.gov.sk/servlets/files/14374).

4.3.2 Methods for exposure assessment

Appropriate exposure evaluation is vital for health impact assessment. In many point source epidemiological studies, distance used as a proxy measure of exposure may provide quick and inexpensive estimates of exposure. On the other hand, this method has some limitations that may result in exposure misclassification. Atmospheric dispersion modelling represents another approach in exposure assessment that may be more accurate if compared to the distance-based method. If data are available, point source characteristics, meteorological conditions and topographical features can be considered in dispersion modelling.

In this study, to assess population exposure from emissions resulting from incinerators and landfills, both approaches will be applied – air dispersion modelling (both local and large-scalel) and the distance-based approach.

4.3.2.1 Local Air Dispersion Modelling

Local air dispersion modelling will be used for the calculation of increased pollutant concentrations in areas with waste incinerators.

Dispersion modelling for incinerators will be based on the national information on incineration census, actual waste throughput data supplied by the plant operators and meteorological data. In case no data is available, we shall assume that the incinerator is operating at design capacity and data derived from the literature will be used. We will focus on the emissions from the waste gas stack.

This study will use the Atmospheric Dispersion Modelling System (ADMS-Urban) developed by CERC and the UK Meteorological Office (CERC 1999) for modelling dispersion at the local scale. The model uses an up-to-date understanding of the atmospheric boundary. This is described by boundary layer depth and the Monin-Obukhov length, rather than by the Pasquill stability categories. Meteorological data requirements include temperature (°C), wind speed (m/s), wind direction (°), precipitation (mm), cloud cover (oktas), relative humidity (%), boundary layer height (m), and surface sensible heat flux (W/m2).

ADMS-Urban is set up to model the pollutants NOx, NO_2, VOC, SO , CO, Benzene, Butadiene, PM10, and TSP, but may also be used for other pollutants as well, including dioxins and PCBs. Technical parameters necessary for modelling *incinerators* as a point source include stack height (m), stack diameter (m), exit velocity (m/s), emission rate (m3/s), exit temperature (°C) and location of the stack.

ADMS air pollution dispersion model will provide "contours" of additional concentrations for the incinerator. This output file will be transferred into the GIS. A population database at the smallest available unit (e.g. census block) for a given radius (e.g. 20 km) will be added to the GIS as another data layer. Using an overlay function in GIS, the population data will be combined with the air pollution concentration data. In this way, the size of the population exposed to different levels of pollutants will be estimated.

4.3.2.2 Large Scale Air Dispersion Modelling

Large scale air dispersion modelling will be used for the calculation of increased pollutant concentrations in large areas. Modelling will be performed using EcoSenseWeb, an integrated computer system developed for the assessment of environmental impacts and resulting external costs from electricity generation systems and other industrial activities. It is based on the Impact Pathway Approach (IAP) developed in the ExternE-Project (ExternE: www.ExternE.info). More details are presented in Appendix 5.

Various modules of the EcoSenseWeb system refer to a so called "local" and "regional" range analysis. The concept of local and regional range analysis results from the need of performing a European-wide (regional) analysis based on an operational amount of data, but to take into account at the same time the spatial distribution of concentration and receptors at a high resolution within the highly affected area close to the source of emissions. Models and data are provided in a way, that the standard impact assessment includes a local range analysis based on a 10 x 10 km2 EMEP grid (see Appendix 5), covering an area of 10 x 10 grid cells (i.e. 10,000 km2), with the source, e.g. an incinerator located in the centre of the local region.

Local range analysis: The Industrial Source Complex Model (ISC), a Gaussian plume model developed by the US-EPA, will be used. The ISC is used for transport modelling of primary air pollutants (SO2, NOx, particulates) on a local scale (100 km x 100 km around the power plant site). EcoSense provides a short-term version of the model which uses hourly site specific meteorological data. These data are generated within the EcoSenseWeb.

The regional range analysis: The regional range analysis is based on the large EMEP-gridcells (2500 km2) and covers the whole of Europe.

Regional impact assessment is done with regional SR-receptor matrices, i.e. parameterised results of model runs with the EMEP/MSC-West Eulerian dispersion model. These complex model runs are based on certain emission scenarios and meteorological conditions, and a reduction of a pollutant by 15% for each source of emission within a corresponding sub-region. Europe is divided into 66 regions, i.e. some larger countries are subdivided into regions. For a 15% reduction of an airborne pollutant (e.g. NOx) within a country / sub-region of Europe based on meteorological conditions (e.g. in the year 2000) and background emissions of the year 2010 or 2020 a matrix is created. This matrix contains the results in terms of concentrations of a primary (NOx) or secondary (nitrates and ozone, increased sulphates, etc.) air pollutants on the 50 km x 50 km EMEP grid. The chemical reactions are highly complex. For example, a reduction of NOx emissions leaves more background NH3 for reaction with background SO2, etc.

Subsequently, based on the predicted concentration values, the exposure of different receptors is calculated.

4.3.2.2. Distance-Based Approach

The distance-based approach uses the distance from the point source (landfill site and/or incinerator) to estimate the exposed population. Elliott et al (2001), for example, used a 2 km zone around landfill sites as the likely limit of the dispersion of landfill emissions. Since most of the effect estimates derived from the literature are based on 2-3 km, it is likely that the distance of 2 km can be applied to both incinerators and landfills.

4.4. Exposure-Health Effects

The next step in the health impact assessment is to select or develop a suitable set of exposure-response functions that link (individual) pollutants with specific health endpoints. The exposure response function may be a slope of a regression line with the health response as the dependent variable and the stressor as the independent variable. Alternatively, an exposure response function may be reported as a relative risk (RR) of a certain health response for a given change in exposure. We will derive relative risks related to residence near landfills and incinerators from a systematic review of the literature while exposure-response functions related to specific pollutants will be derived from existing reviews of epidemiological and toxicological data. Guidelines provided from WP 1.3 will be used in this context.

4.4.1 Systematic Review of Epidemiological Studies on Health Effects of Exposure to Emissions from Waste Management

A systematic review of epidemiologic literature on health effects associated with collecting, incinerating, landfilling, recycling and composting of MSW has been conducted in order to derive appropriate relative risk estimates associated to various waste management technologies. In this review, we included not only studies on health of the general population, in particular those living near waste sites, but research on occupational exposure was involved as well, because workers may be exposed to the same potential hazards as the community residents, even if the intensity and duration of the exposure and risk may differ.

Relevant papers were found through computerized literature searches on MEDLINE Database from 1/1/1983 through 31/12/2006, using MeSH terms "waste management" and "waste products" and "health effects". We obtained 427 papers with this method. We also conducted a free search with several combinations of relevant key words ("waste incinerator or landfill or composting or recycling" and "cancer or respiratory effects or birth outcome or health effects"), and 224 papers were obtained. In addition, articles were traced through references listed in previous reviews and in publications of the UK Department for Environment, Food and Rural Affairs (Enviros, 2004).

All papers found were checked by three observers to be eligible, and disagreements were resolved by discussion: studies on industrial, toxic or hazardous waste, on sewage treatment or on biological monitoring have not been included and we also excluded articles in languages other than English and not journal articles. A total of 50 papers were reviewed: 35 concerning health effects in communities living in proximity to relevant sites, 15 on employees. The majority of studies evaluate possible adverse health effects in relation to incinerators and landfills, 28 and 10 papers respectively, and investigations of incineration sites refer to old rather than modern incinerators. Instead, there is little on potential problems resulting from environmental or occupational exposures from composting or recycling, and very little on storage/collection of solid waste.

Papers have been grouped according to the following criteria:

- waste management technologies: recycling, composting, incinerating, landfill (the term landfill is used here only for controlled disposal of waste land);
- health outcomes: cancers (stomach, colorectal, liver, larynx and lung cancer, soft tissue sarcoma, kidney and bladder cancer, non Hodgkin's lymphoma, childhood cancer), birth outcomes (congenital malformations, low birth weight, multiple births, abnormal sex ratio of newborns), respiratory, skin and gastrointestinal symptoms or diseases.

For each paper, we have evaluated the study's design (e.g. geographical, cohort, cross-sectional, case-control study, etc.), study population characteristics (subjects, country, age, sex), exposure measures (e.g. occupational exposure to municipal waste incinerator by-products, residence near a MSW landfill, etc.), and results (incl. control for major confounders), predominantly with respect to the quantification of the health effects studied.

Summary tables of the review have been edited and a report is to be prepared.

4.4.2 Use of Epidemiological Data and Toxicological Data to Estimate the Exposure-Response Functions

Quantitative characterization of the human health risk posed by contaminant exposure is usually accomplished through exposure-response assessment quantifying the relationship between contaminant exposure and the resulting response of the human organism. The exposure – response function for individual pollutants will be summarized based on the available literature search using criteria identified in WP 1.3. Final suggestions for the selection of appropriate exposure-response coefficients to be used in our assessment will be prepared on the basis of indications of WP 1.3.

The document produced by WP2.2 (Biomonitoring) on "Biomarkers of exposure, effect and susceptibility: A critical review", and the EPA documents (e.g. EPA, 1995; EPA 2000), toxicological data from animal and occupational exposure studies can be used to estimate dose-response following the exposure to selected pollutants of interest. VOCs, dioxins, furans, PCBs, and metals are all covered in the review document by WP2.2, providing extensive information of a wide variety of issues regarding the availability of human biological monitoring methods and data.

4.5 Quantification of Health Effects

In the 1st phase, quantification of health effects will be performed for baseline national policy scenarios valid for the selected baseline years 2001-2002. The impact of the changes in exposure and subsequently on the health effects resulting from future policy scenarios will be estimated in the 2nd phase of the assessment.

The following activities have been already illustrated:

- The exposed population near landfills and incinerators will be estimated using the GIS approach. Population exposure of the population living close to incinerators will be estimated using air dispersion modelling (section 4.3.2). Population exposure in the large range will be estimated according to section 4.3.3.
- The available literature on health effects of human exposure to emissions from waste disposal sites was checked (section 4.4) and evidence of health effects (Relative Risks) for people living nearby incinerators and landfills will be singled out (section 4.4.2),
- The available exposure-response functions for selected pollutants (PM, SO2, NOx) will be derived from existing reviews and the work performed by WP 1.3.

The next step involves the estimation of the background rates (i.e. prevalence and/or incidence) of the relevant health endpoints in the population at risk and to calculate the burden of disease or death in the population at risk. In more details:

- Baseline health data of interest for the UK, Italy and Slovakia will be obtained in cooperation with WP2.3 and will be based on the routinely collected national morbidity and mortality registries. The table below illustrates the health endpoints (and ICD-9 codes), the age groups, the denominators and the statistics to be considered.

Background health statistics for the quantification

Diagnostic category	ICD-9 codes	Age group	Denominator	Statistics
All non-traumatic deaths	<800	All	Resident pop.	Age-adjusted mortality rates
All respiratory deaths	460-519	All	Resident pop.	Age-adjusted mortality rates
COPD + asthma deaths	490-496	≥65	Resident pop.	Age-adjusted mortality rates
Circulatory admissions	390-459	0-64 ≥65	Resident pop.	Age-adjusted admission rates
Cardiac admissions	390-429	all ages >65	Resident pop.	Age-adjusted admission rates
IHD admissions	410-414	0-64 ≥65	Resident pop.	Age-adjusted admission rates
Respiratory admissions	460-519	All	Resident pop.	Age-adjusted admission rates
COPD + asthma admissions	490-496	≥65	Resident pop.	Age-adjusted admission rates
Lower respiratory infection admissions	466, 480-486	≥65	Resident pop.	Age-adjusted admission rates
Asthma admissions	493	0-14 15-64	Resident pop.	Age-adjusted admission rates
All malignant cancers	140-208	All	Resident pop.	Age-adjusted incidence rates
Laryngeal cancer	161	All	Resident pop.	Age-adjusted incidence rates
Lung cancer	162	All	Resident pop.	Age-adjusted incidence rates
Colon-rectal cancer	154	All	Resident pop.	Age-adjusted incidence rates
Soft tissue sarcoma	171	All	Resident pop.	Age-adjusted incidence rates
N-H lymphoma	200,202	All	Resident pop.	Age-adjusted incidence rates
Low Birth Weight (<2500 grams)		Newborns	Live births	Prevalence data
All congenital anomalies combined	740-759	Newborns	Live births, stillbirths and terminations	Prevalence data
Neural tube defects	740.0-740.2, 741.0-741.9, 742.0	Newborns	Live births, stillbirths and terminations	Prevalence data
Cardiovascular defects	745.0-747.9	Newborns	Live births, stillbirths and terminations	Prevalence data
Abdominal wall defects	756.7	Newborns	Live births, stillbirths and terminations	Prevalence data
Hypospadias and epispadias	752.6	Newborns	Live births, stillbirths and terminations	Prevalence data

- The quantification of the heath burden will be based on two different estimates of population exposure: the distance-based approach using the relative risks estimates from studies on residence near landfills and incinerators and the results of the air dispersion modelling with quantification of pollutants exposure and exposure-response functions. Results of both assessments will be integrated.

A simple algorithm will be used to calculate the number of cases (such as deaths, hospital admissions, etc) associated with a given increase of the air pollutant in the exposed population (or residence in proximity to a landfill or incinerator). For each of the health end-points selected, an estimate of RR will be obtained or calculated from the literature. The RR is the increase in the probability of the occurrence of the adverse effect on health associated with a given change in exposure level.

The number of cases attributable to an air pollution concentration, E, is given by the following equation:
$E = A * B * C * P$,

where
P = the population exposed;
C = the relevant change in concentration of the air pollutant (or exposed/unexposed status);
B = the observed mortality (morbidity) rate of the adverse effect on health obtained from available health statistics.
A = the proportion of effects on health attributable to air pollution, which can be calculated as follows:

$$A = (RR-1)/RR$$

To further characterize the impact of waste management on mortality, the proportion and number of deaths will be complemented by the number of Years of Life Lost due to premature mortality and Disability Adjusted Life Years (DALYs).

Sensitivity analyses will be conducted to evaluate the robustness of the results and also considering the specific issues of population vulnerability due to age and socioeconomic status.

4.6 Evaluation of external costs

A complete evaluation of the external costs from waste management will be performed in the second phase, on the basis of a comprehensive strategy of the INTARESE project. However, given the availability of the Ecosense model already developed within the ExternE project, a methodological evaluation will be prepared.

In order to assess the effects of emissions to the air the “Impact Pathway Approach” (IPA) will be used. The software tool (EcoSenseWeb, see appendix 5) that accounts for each step of the IPA is used for the evaluation of external costs. For green house gases (i.e., CO2 and CH4) the effects of global warming are globally distributed, regardless of where a GHG is emitted it has (more or less) the same effect. The effects are evaluated with certain avoidance or damage costs per kg of emission. These are not modelled by EcoSense but recommended values can be taken from ExternE.

Based on concentration response functions the impacts are calculated (health effects, crop yield loss, impacts on building materials, loss of biodiversity due to land use change and acidification and eutroohication). These impacts are aggregated by monetary evaluation. The sum of external costs and detailed results are reported. All these steps are implemented in the EcoSenseWeb tool.

A detailed protocol will be prepared for the evaluation of external costs due to waste using data collected for the case study in Italy.

5. Anticipated limitations of the assessment

There are relevant limitations to be considered and it should be appreciated that there are important uncertainties we expect to encounter in this risk assessment in both generic and specific terms.

Our risk assessment is characterised by a number of uncertainties that are generic to current approaches to risk assessment. For example, current risk assessment methods are inadequate to assess the cumulative risks of the wide variety of health stressors (e.g. chemical mixtures) that can interact with one another in synergistic or antagonistic ways. In the same vein, we have great difficulty in assessing the long term-effects of prolonged, low-level exposures, or exposures occurring at critical stages of development (e.g. childhood or pre-natal exposure).

In more specific terms, we have listed the sources of uncertainties for each step of our evaluation.

1. <u>Waste generation and management</u>

We expect that there will be inadequacies in data availability and reliability on MSW indicators as they are not uniform and not always available. We expect approximations in the available information on waste composition. Another specific area of uncertainty concerns the amount and treatment of illegally disposed wastes.

2. <u>Emissions of pollutants from waste management facilities</u>

We will estimate total emissions from waste management facilities using the amount of managed waste and tabulated emission factors from the literature. These emission factors have a wide range of uncertainties, some of which have been evaluated and can be quantified (Enviros, 2004). It should be noted, however, that measured air pollution data are sparse, several pollutants are not measured, and data on some processes (composting, gasification) are difficult to find. Finally, the emission factors that we will consider are based on facilities under normal operational activities and there is the possibility of accidental releases that are difficult to quantify.

3. <u>Population exposures</u>

Exact coordinates of the facilities may be difficult to find for some areas of the three countries. We may find difficulties in estimating the exposed population because the location of the plant may be approximate, the size of some landfills is not known, and the unit of the available population data (census block) does not fit our needs. Moreover, we depend on the availability of population data by age and sex at the local level; without these data we have to make estimates on the basis of national statistics thus increasing uncertainties.

The results of the air dispersion models depend on the quality of the data. We will have operational data measured during recent years for most of the incinerators but only estimated emissions based on the plant characteristics for some others.

4. Exposure-response functions

We expect that the exposure response function will be well defined for some pollutants (like PM10). For other pollutants such as Sulphates, Nitrates and NOx, these functions are not so well characterized and a higher level of uncertainty is therefore anticipated. The application of relative risk estimates based on the distance from the plants will also be problematic, as has been illustrated by the difficulty in interpreting epidemiological studies (a summary of these difficulties has been reported in the scoping report).

5. Quantification of the health impact.

Although the quantification is straightforward in terms of calculating excess cases, some difficulties may arise in finding the appropriate health statistics and in taking into account the particular population characteristics near the facilities. However, the most difficult part is the attribution of the effect studied for old plants using old technologies to new facilities. Finally, because a variety of illegal disposal practices exist and because it is difficult to estimate the amounts of waste that are disposed of illegally, determining emissions, exposure levels and health effects will be difficult.

6 Reporting and Communication

The table below indicates the timeline to the next INTARESE annual meeting. It is expected that for a pilot of the full evaluation will be conducted considering Italy (and one region, Emilia Romagna) so that the preliminary results may be presented and discussed. In the meantime, collection of the relevant data for all the countries will be conducted.

An interim report of the results of the first-pass assessment (month 18 – month 30) will be prepared in month 24 (November 2007). This will be distributed to all SP3 work packages and distributed to SP1. At month 30 (June 2008) a final report on the first-pass assessment will be completed and delivered to SP3 partners, INTARESE partners and stakeholders. Both stakeholders and partners will be given the chance to comment on the report and to evaluate potential improvements to the assessment methodology ready for the second pass assessment. There will then follow a period of six months for a full review of the methodology (to be carried out at the same time as the second-pass assessment) leading up to submission of the final report in month 36 (November 2008).

Timetable for WP3.6 Assessment Activity, Tasks, and Deadlines to the next annual meeting

Task	Deadline	Person responsible
Report on waste generation and management in Italy	30st June 2007	Antonio Lazzarino
Report on total emissions from waste technologies in Italy	30st June 2007	Antonio Lazzarino
Census data of incinerators and landfills in Italy	15th July 2007	Andrea Ranzi/ Chiara Baldaloni
Census data of incinerators and landfills in the UK	1st September 2007	Kees De Hoogh
Census data of incinerators and landfills in Slovakia	1st September 2007	Lubica Palkovicova
Results of local dispersion modelling of emissions from incinerators in Italy (pilot)	1st September 2007	Kees De Hoogh
Results of large scale dispersion modelling of emissions from incinerators in Italy (pilot)	30th September 2007	Philipp Preiss
Assessment of population exposure based on dispersion modelling and distance-based approaches in Italy	31st October 2007	Kees De Hoogh
Review of epidemiologic literature and dose response functions	31st October 2007	Simona Milani/Marco Martuzzi
Preliminary assessment of health effects from the exposure to emissions from incinerators and landfills in Italy	19th November 2007	Francesco Forastiere
External costs evaluation protocol	19th November 2007	Philipp Preiss
Annual INTARESE meeting	19th –21st November 2007	--
Meeting of WP3.6 partners (during the Annual INTARESE meeting)	19th –21st November 2007	Francesco Forastiere

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APPENDIX 1

List of stakeholders for the **UK**

Category	Organisation	Website
Public Health Organisations		
	Health Scotland	www.healthscotland.com
	Chartered Institute of Environmental Health (CIEH)	www.cieh.org
	Health Protection Scotland	www.hps.scot.nhs.uk
	Health Protection Agency	www.hpa.org.uk
NGOs		
	Friends of the Earth	www.foe.co.uk
	Waste Watch	www.wastewatch.org.uk
	The Environment Council	www.the-environment-council.org.uk
	Sustainable Communities Initiative	www.sci-scotland.org.uk
	Greenpeace	www.greenpeace.org.uk
	Community Recycling Network	www.crn.org.uk
Government		
	The Waste and Resources Action Programme	www.wrap.org.uk
	Department for Environment, Food and Rural Affairs (DEFRA)	www.defra.gov.uk
	Department of Health	www.dh.gov.uk
	Department of the Environment for Northern Ireland	www.doeni.gov.uk
	Department of the Trade and Industry (DTI)	www.dti.gov.uk
	Environment Agency	www.environment-agency.gov.uk
	Local Authority Recycling Advisory Committee	www.larac.org.uk
	Scottish Environmental Protection Agency	www.sepa.org.uk
	Environment & Heritage Service (Northern Ireland)	www.ehsni.gov.uk
Industry		
	Chartered Institution of Waste Management	www.iwm.co.uk
	SITA	www.biffa.co.uk
	Cleanaway Ltd	www.cleanaway.com
	Cleansing Service Group Ltd	www.csgwasteman.co.uk
	Cory Environmental	www.coryenvironmental.co.uk
	Greater Manchester Waste	www.gmwaste.co.uk
	Grundon Waste Management	www.grundonwastemanagement.com
	Hills Group	www.hills-group.co.uk

	Lafarge Aggregates	www.lafarge-aggregates.co.uk
	Norfolk Environmental Waste Services Ltd	www.norfolk-waste.co.uk
	Onyx Environmental Group plc	www.onyxgroup.co.uk
	Shanks Plc	www.shanks.co.uk
	SITA	www.sita.co.uk
	Viridor Waste Management	www.viridor-waste.co.uk
	Waste Recycling Group	www.wrg.co.uk
	Wyvern Waste Services	www.wyvernwaste.co.uk
European		
	European Commission	www.europa.eu.int
	Environment DG	http://ec.europa.eu/dgs/environment/index_en.htm
International Organisations		
	International Federation of Environmental Health	www.ifeh.org
	US Environmental Protection Agency	www.epa.gov

List of stakeholders for **ITALY**

Category	**Organisation**	**Website**
Public Health Organisations		
	National Institute of Health (ISS)	www.iss.it
	Italian National Agency for New Technologies, Energy and the Environment (ENEA)	www.enea.it
	Regional Public Health Authorities	
NGOs		
	Greenpeace	www.greenpeace.it
	Legambiente	www.legambiente.it
Government National/Local		
	Ministry of Environment	www.minambiente.it
	Ministry of Health	www.ministerosalute.it
	Ministry of Economy	www.tesoro.it
	Environmental Protection Agency (APAT)	www.apat.gov.it
	National Organization of City Councils	http://www.anci.it/anci.cfm
Industry		
	Italian Federation of Public Services, Federambiente	www.federambiente.it
	Aluminium Packaging Consortium (CIAL)	www.cial.it
	Italian Composting Association (CIC)	www.compost.it

	National Packaging Consortium (CONAI)	www.conai.org
	National Consortium for the Collection, Recycling and Reuse of Plastic Packaging (COREPLA)	www.corepla.it
	National Consortium for the Recovery and Recycling of Cellulose-based Packaging (COMIECO)	www.comieco.org
	National Consortium for glass recovery (COREVE)	www.coreve.it
	National Consortium for the Collection, the Recovery and the Recycling of wood packaging (RILEGNO)	www.rilegno.it
	Consorzio Obbligatorio Batterie al piombo esauste e rifiuti piombosi (COBAT)	www.cobat.it
	Consorzio Obbligatorio Oli Usati (COOU)	www.coou.it

List of stakeholders for **SLOVAKIA**

Category	Organisation	Website
Public Health Organisations		
	Public Health Authority of the Slovak Republic	www.szusr.sk
	Regional Public Health Authorities	
NGOs		
	Friends of the Earth	www.priateliazeme.sk
	Greenpeace	www.greenpeace.sk
Government		
	Slovak Ministry of Environment	www.enviro.gov.sk
	Slovak Ministry of Health	www.health.gov.sk
	Slovak Ministry of Economy	www.economy.gov.sk
	Slovak Ministry of Regional Development	www.build.gov.sk
	Slovak Environmental Agency	www.sazp.sk
Industry		
	Odvoz a likvidacia odpadu (Waste Transport and Disposal)	www.olo.sk
	Neokov, Ltd.	www.neokov.sk
	Environ servis ltd.	www.environ.sk
	A.S.A. Slovakia	www.asa.sk/company.htm

APPENDIX 2

EU legislation on waste

http://www.wasteonline.org.uk/resources/InformationSheets/Legislation.htm

The European Union's waste legislation comprises three main elements:

- **horizontal legislation**, establishing the overall framework for the management of wastes, including definitions and principles
- **legislation on treatment operations**, such as landfill or incineration, which may set technical standards for the operation of waste facilities
- **legislation on specific waste streams**, such as waste oil or batteries, which may include for example measures to increase recycling or to reduce hazardousness

Directive	**Publication year**	**Directive number**
Horizontal		
1. Directive on Waste (Waste Framework Directive)	1975	75/442/EEC
2. Directive on Hazardous Waste	1991	91/689/EEC
3. Directive on waste	2006	2006/12/EC
Treatment		
4. Directive on Integrated Pollution Prevention and Control	1996	96/61/EC
5. Directive on the Landfill of Waste	1999	1999/31/EC
6. Directive on the Incineration of Waste	2000	2000/76/EC
Waste stream		
7. Directive on Batteries and Accumulators	1991	91/157/EEC
8. Directive on Packaging and Packaging Waste	1994	94/62/EC
9. Directive on End of Life Vehicles (ELV)	2000	2000/53/EC
10. Directive on Waste Electrical & Electronic Equipment	2002	2002/96/EC

APPENDIX 3

UK:

The main legal framework for the waste strategy in England and Wales is set out in part V of the Environment Act (1995). The Landfill regulations (2002), which came into force in June 2002, implement the Landfill Directive 99/31. The Waste and Emissions Trading Act provides the basis for establishing Landfill Allowance Trading Scheme. A number of stakeholders are involved in developing waste related plans in England and Wales: Central Government and the Welsh Assembly, Regional Planning Bodies in England, Waste Planning Authorities at the local level and The Environment Agency.

The vision for dealing with English waste was described in Waste Strategy 2000 for England and Wales (in Wales replaced by 'Wise about Waste: The National Waste Strategy for Wales, 2002). It sets out targets for the reduction of waste sent to landfills. In 2003, 95% of MSW was landfilled. The waste strategy also includes targets for increasing waste recycling . Within 2004-05, the UK recycling rate was 23% with a further 9% having energy recovered from it. There are further targets to reduce the amount of MSW landfilled. These arise from the landfill directive (the UK has agreed with the European Commission on a four-year derogation to meet the targets). Tradable allowances have been introduced to restrict the amount of biodegradable municipal waste sent to landfills. The government also accepted the recommendations of the 'Waste Not Want Not' report published in 2002; recommendations aim to reduce the growth rate in waste from 3% to 2% per annum; boost recycling by developing the infrastructure; increase choices for managing waste by creating economic incentives, as well as the incentive to reduce damage to the environment; stimulate innovation in waste treatment and waste management organisations.

In Scotland, The National Waste Strategy: Scotland (1999) sets the framework and policies for moving towards sustainable waste management. It was replaced by The National Waste Plan 2003, prepared by the Scottish Executive and the Scottish Environment Protection Agency (SEPA). It provides an integrated summary of the 11 Area Waste Plans that were identified as the Best Practicable Environmental Option (BPEO) for dealing with municipal solid waste.

The Northern Ireland Waste Management Strategy, "Towards Resource Management" (2006-2020), aims to move waste management away from landfills towards more sustainable practices.

Italy:

The National Waste framework law in Italy was issued in 1997 (Legislative Decree 22/97; updated on April 29, 2006 by the legislative decree n. 152 "Environment Act"), transposing three of the main EU directives on waste: European Waste Framework Directive 75/442/EEC (modified by Directive 91/156/EEC); Directive on Hazardous Waste 91/689/EC, and Directive on Packaging and Packaging Waste 94/62/EC. Decree 22/97 implemented the integrated waste management policy set up by the European Waste Strategy; according to the decree the waste management system is based on preventing waste and material generation and energy recovery from waste. It also defined the responsibilities among the main actors of the national waste management system - regions that hold the responsibility for drawing up waste management plans to integrate waste collection, treatment and disposal within optimal management areas (ATO, Ambito Territoriale Ottimale); and local authorities (Autorità di Ambito) have the responsibility to organise municipal waste collection and management.

From January 1st, 2007 decree 152/06 sets targets about the weight of separate collections of municipal waste and by transposing the Directive 2004/12/EC, it improves MSW separate collection and recovery, redesigning the packaging waste management system, on the basis of the "polluter pays" principle and the "shared responsibility" among all involved.

A waste information system has been developed at the national level, based on the National Waste Inventory, established in 1994. Hazardous waste producers and managers are required to report yearly to the National Waste Inventory about managed waste quantities and categories. The Inventory has its headquarters at the

Agenzia Nazionale per la Protezione dell'Ambiente e per i servizi tecnici (APAT) and regional seats at ARPAs (the Regional Environmental Protection Agencies). National Inventory of Waste is considered an implementation tool of the Regulation 2150/2002/EC on waste statistics.

The landfill system in Italy was reorganized by the Legislative Decree 36/03 in 2003. It establishes the classification of the landfills (for hazardous waste, non-hazardous waste and for inert waste), and further specified the type of waste going to landfills and costs involved in the operation of the sites. Additionally, according to art. 5 (1) of the Landfill Directive 1999/31/CE, Italy has developed a national strategy regarding the reduction of biodegradable waste going to landfills.

Directive 2000/76/EC on waste incineration has been transposed into national legislation through Legislative Decree no. 133 of 11 May, 2005. This decree establishes provisions for waste incineration and co-incineration. The decree provides measures and procedures to prevent or reduce, as much as possible, negative effects of waste incineration on the environment, in particular the pollution of air, soil, surface and groundwater, and the resulting risks to human health.

Slovakia:
Waste management in Slovakia is regulated by Act No. 223/2001 on wastes (amended by later regulations; currently Act No. 409/2006 Coll.) and by a set of implementing regulations. The act was put into effect on 1 March 2001 and has been harmonised with all EU Waste Directives, including the Directive 2000/53/EC on end-of life vehicles, the Directives on electrical and electronic equipment waste (WEEE), the Directive on PCB/PCT, the Directive on hazardous waste, the Landfill Directive 1999/31/EC and others. Furthermore, The Waste Act established the non-governmental Recycling Fund that provided more than 40 million EUR for the purposes of building up an infrastructure of waste management and facilities for recovery or recycling wastes.

The Waste Act No. 223/2001 Coll. provides the Ministry of Environment with a mandate to develop a National Waste Management Programme. The Waste Management Plan of the SR for 2006-2010, approved by the Government of SR on 15 February, 2006, is a basic planning document for waste management which covers entire waste management system of the country. Among other things, WMP contains information on total waste management and on management of waste streams (hazardous, municipal, biodegradable wastes, PCBs and packaging wastes), proposed measures to achieve objectives of the WMP for selected waste streams and definitions of recovery and recycling targets. The main strategy is to increase material and energy recovery of wastes and decrease landfilling to 13% according to total produced waste amount in 2010.

Directives on waste incineration (2000/76/EC, 89/369/EEC, 89/429/EEC, 94/67/EC) were transposed to the Act No 478/2002 on air pollution and Order of the MoE 706/2002 on air pollution sources.

In 2004, there were 15.9 millions of tons of waste produced in Slovakia; 27% of this waste has been disposed. Out of this amount, 48% was stored in landfills. MSW represented 1.5 mil tons of waste (294 kg of waste/inhabitant/year); only 14% of MSW was recovered. The majority of MSW (1.3 millions of tons = 87%) was disposed, , 86% in landfills (Report of the Slovak Environmental Agency on the Environment contamination in Slovakia, 2004).

APPENDIX 4

DATA COLLECTION PROTOCOL

Municipal solid waste data by country

A. TOTAL REFERENCE POPULATION *(number of inhabitants)*

B. TOTAL TONS OF WASTE PRODUCED PER YEAR

C. WASTE COMPOSITION *(types of waste fractions)*

Example:
FERROUS
GLASS
MISC NON-COMBUSTIBLES
NAPPIES AND SANITARY
NON-FERROUS METALS
PAPER
PLASTICS
TEXTILES
ORGANIC MATERIAL

Collection and transport data

D. TYPES OF COLLECTION

Example: collection of waste to be recycled, collection of waste to be incinerated, etc.

Per each type of collection:

E. TYPES OF VEHICLES USED

Per each type of vehicles used:

F. FUEL: DIESEL, GASOLINE, ELECTRIC

G. COLLECTION ROUTES

Example: 50% urban mode, 40% rural mode, 10% motorway mode

Treatment data by Country

H. AMOUNT OF WASTE BY TYPE OF TREATMENT

Example: recycling, landfill, incineration, etc.

The following information refers to single facilities in each country. For all the facilities, GIS coordinates should be provided.

For landfills

I. SPECIFICATIONS OF THE FACILITY:
   a. TONNAGE STORED (TONS PER MONTH)
   b. YEAR OPERATION BEGAN
   c. YEAR OF CLOSURE
   d. TREATMENT OF LANDFILL GAS (FLARE OR GENERATOR)

For incinerators

J. SPECIFICATIONS OF THE FACILITY:
   a. TREATED TONNAGE (TONS PER MONTH)
   b. YEAR OPERATION BEGAN
   c. YEAR OF MAJOR CHANGES

d. ELECTRICITY CONSUMPTION (KWH PER MONTH)

e. MATERIAL OUTPUT

BOTTOM ASH (KG PER MONTH)

FLY ASH (TONNS PER MONTH)

f. ENERGY GENERATION

ELECTRICITY (KWH PER MONTH)

Information for air dispersion modelling

stack height (m),

stack diameter (m),

exit velocity (m/s),

emission rate (m3/s),

exit temperature (°C)

APPENDIX 5

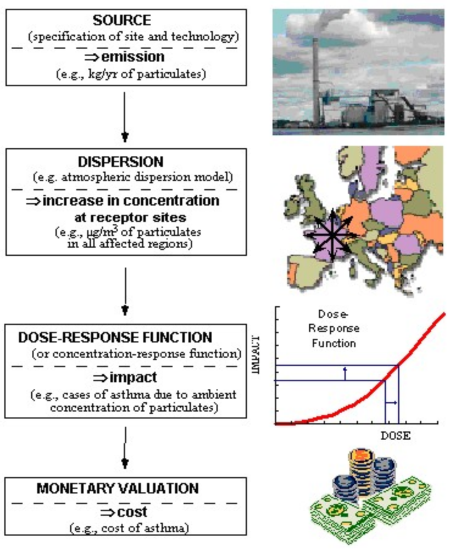
EcoSenseWeb

EcoSenseWeb is an integrated computer system developed for the assessment of environmental impacts and resulting external costs from electricity generation systems and other industrial activities. It is accessible via the internet. Based on the Impact Pathway Approach (IAP) developed in the ExternE-Project (ExternE: www.ExternE.info) on External Costs of Energy funded by the European Commission, EcoSenseWeb provides relevant data and models required for an integrated impact assessment related to pollutants.

Modules for assessment of emissions to air, soil and water are also included. Comprising so called classical airborne pollutants, heavy metals, green house gases and radio nuclides. Different impact categories are considered including human health, crops yield loss, damage to building materials, loss of biodiversity and climate change.

One of the major objectives of the EcoSenseWeb development was to produce a user friendly system that is capable of performing a highly standardised impact assessment procedure with a minimum of data required as input from the user. Only the technical data of the facility to be analysed has to be added by the user. All other data are provided by the system, thus the user looses no time by the tedious compilation of data. However, it is obvious that the approach of providing all important data and models to the user limits the flexibility of the system. Although the various modules of the system have a potential for high flexibility, the current EcoSenseWeb version is limited to a set of standard applications that can very easily be carried out. A basic decision during the design phase of the system with respect to an easy handling of the system was the selection of a single co-ordinate system. The European wide grid used by the "Co-operative Programme for Monitoring and Evaluation of the Long-Range Transmission of Air pollutants in Europe" (EMEP) with the spatial resolution of 50 x 50 km2 (EMEP50 grid) was applied. The EcoSenseWeb system provides an interface supporting the transfer of geographical data according to the EUROSTAT "Nomenclature of Territorial Units for Statistics" (NUTS) to the EMEP50 grid system.

The EcoSenseWeb and the calculation of external costs follow the so called Impact-Pathway Approach (IPA). The IPA, a bottom-up approach, is depicted in the figure below.



Impact-Pathway-Approach

EcoSenseWeb uses results of three air transport models completely integrated into the system:

- o The Industrial Source Complex Model (ISC) is a Gaussian plume model developed by the US-EPA. The ISC is used for transport modelling of primary air pollutants (SO2, NOx, particulates) on a local scale (100 km x 100 km around the power plant site, with a resolution of 10 x 10 km2 grid). EcoSenseWeb provides a short-term version of the model which uses hourly site specific meteorological data.
- o SR-matrices for regional modelling based on EMEP/MSC-West Eulerian dispersion model

- SR-matrices for intercontinental transport modelling in the Northern Hemisphere
- SR-matrices for modelling of North-African countries based on same model as used for SR-matrices for the Northern Hemisphere. Therefore, the results are based on 2001 meteorological year and emission scenario for 2000. Currently, there is no distinction into different heights of release possible.