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PROVISION OF A TECHNO-ECONOMIC STUDY ON DIFFERENT OPTIONS OF HOSPITAL WASTE MANAGEMENT IN THE *SZENT IMRE* HOSPITAL, BUDAPEST, HUNGARY

Techno-Economic Options — Technical Report No. 3

Prepared For Government of Hungary
by the United Nations Industrial Development Organization

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ABSTRACT

PROVISION OF A TECHNO-ECONOMIC STUDY ON DIFFERENT OPTIONS OF HOSPITAL WASTE MANAGEMENT IN THE *SZENT IMRE* HOSPITAL, BUDAPEST, HUNGARY

Objective

Details are outlined for two techno-economic options with alternatives available to the Szent Imre hospital in particular, and in general for Hungarian healthcare facilities.

These two options and other material outline the benefits that can be derived from an economic approach and discusses some of the legal requirements which can be difficult to attain and regulate effectively.

Aims

- To segregate clinical/ infectious waste and to treat each effectively in a cost-effective manner.
- To use the effectiveness of governance within the healthcare industry to increase the awareness to handle all wastes safely and at minimum cost.
- To consider the attributes of microwave disinfection.
- To develop economic management techniques, especially unit cost control budgets.
- To facilitate recycling of glass, metal, paper and plastic. Well-managed, licensed and regulated waste disposal, recycling and treatment industries can be lucrative businesses.
- Mercury spillage from broken thermometers is a matter of great concern, and should be addressed with utmost urgency.

Options include

The consideration of the benefits of region (off-site) incineration with combined heat and power as the most effective means of treatment of clinical waste together with attendant economic advantages and management's considerations.

The second option concerning hazardous (non-clinical) considers pragmatic simple risk assessments (PEC/PNEC ratios) so that water miscible solvents and formaldehyde can be discharged to drain. It also outlines how silver recovery from x-ray film development is a high priory in order to make a medium term contribution to reduce waste management charges.

Sources of Finance

One of the alternatives outlined is for the formation of autonomous, self regulated financially self-sufficient hospital trusts.

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ABBREVIATIONS

ADR	European Agreement Concerning the International Carriage of Dangerous Goods by Road
BOD	Biological oxygen demand
BPEO	Best practical environmental option
BSO	Backstopping Officer (For this project — Dr. Zoltán Czisér, UNIDO, Vienna)
CEC	Commission of the European Communities
CD-ROM	Compact disc — read-only-memory
CEE	Central and Eastern European (Region)
CHP	Combined heat and power
CMO	Chief Medical Officer
COD	Chemical oxygen demand
COSHH	Control of Substances Hazardous to Health
CPL	Classification packaging and labeling
DC	Development cooperation
DFID	Department for International Development
DOSE	Dictionary of Substances and their Effects
DSA	Daily Subsistence Allowance
EBRD	European Bank of Reconstruction and Development
EC	European Commission; or European Community
EMAS	Environmental management and audit scheme
EMS	Environmental management system
EINECS	European Inventory of Existing Chemical Substances
EU	European Union
FIFO	First-in-first-out
GBq	*Giga Becquerel*
GLP	Good laboratory practice
GMP	Good manufacturing practice
GOST	State Standard of USSR (Gosudarstvennyi Standard USSR), Izdatelstvo Standartov Novopresnenski Per.3 D-557, Moscow
HMSO	Her Majesty's Stationery Office
IAEA	International Atomic Energy Agency, Vienna
IBC	International Business Communities Limited
IDSP	Industrial Development Support Programme
IFCS	International Forum on Chemical Safety
ILO	International Labour Office
IMS	Integrated management system
IOMC	Inter-organizational Programme for the Sound Management of Chemicals
IPC	Integrated pollution control
IPCS	International Programme on Chemical Safety

IPPC	Integrated pollution prevention and control
IRPTC	International Register of Potentially Toxic Chemicals
ISG-3	Internet Forum on Chemical Safety
ISO	International Standards Organization
JIT	Just in time
MAK	Maximale arbeitsplatz konzentration
MEL	Maximum exposure limit
MBI	Market based instruments
MSDS	Material safety data sheet
NGO	Non-government organization
OECD	Organization for Economic Cooperation and Development
PCB	Polychlorinated biphenyl
PCCDs	Polychlorinated dibenzo dioxins
PCDFs	Polychlorinated dibenzo furans
PEC	Predicted environmental concentration
PET	Polyethylene terephthalate
PHARE	Polish-Hungarian Assistance for Reconstruction and Economy
PNEC	Predicted no effect concentration
POP	Persistent organic pollutant
PRTR	Pollutant Release and Transfer Register
PVC	Polyvinyl chloride
SI	Statutory Instrument
STW	Sewage treatment works
TC	Technical cooperation
TCDDs	Tetrachlorodibenzodioxins
TQM	Total quality management
UK	United Kingdom of Great Britain and Northern Ireland
UN	United Nations
UNCED	United Nations Conference on Environment and Development
UNEP	United Nations Environment Programme
UNIDO	United Nations Industrial Development Organization
UNITAR	United Nations Institute for Training and Research
WHO	World Health Organization

I. RECOMMENDATIONS

A. Incineration

The overall **Recommendation** for the safe disposal of clinical/infectious waste is the provision of large-scale regional incinerators incorporating combined heat and power. Their cost-effectiveness could be increased by burning of general garbage and waste vegetable oils available in Hungary.

B. Microwave Disinfection

This is an attractive alternative to clinical incineration and additionally could be considered in the form of a mobile unit.

It is **Recommended** that this is considered for use at the Szent Imre hospital, who should 'import' clinical waste from other hospitals in the region to ensure the most economic operation, i.e. 250 kg/hr on a 168 hr week basis.

C. Pyrolysis

The unit under consideration has a number of attributes. However its final recommendation needs to await fabrication facilities in the United Kingdom.

D. Waste Segregation/Recycling

It is vital that hospitals adopt sound procedures for segregation of non-clinical waste from clinical waste and thus obviate excessive costs.

Non-clinical waste should be separated into putrifiables to landfill or to municipal incineration (see also A. above); glass, metals, paper, and plastics should be recycled. New (and potentially lucrative) industries for recycling may need to be developed through Ministries of Trade and Industries/Economies.

E. Chemicals in Pathology Departments

Waste acetone and ethanol after suitable dilution can be discharged to drain, or alternatively used for laboratory spirit lamps within the department or the neighboring bacteriological laboratory.

Formaldehyde as the PEC/PNEC ratio is ≈ 0.05; there is no reason why this should not be discharged to drain.

Ministerial agreement will be required, and it is proposed that this be discussed at the International Workshop scheduled for later in the program.

F. Silver

It is **very strongly recommended** that silver recovery units are purchased for the five major x-ray film processing units. The sale of the recovered silver should recoup a substantial percentage of the hospital's waste management expenditure.

G. Mercury

It is **vital** that the Szent Imre hospital management give the most urgent attention to removing the problem of the breakage of mercury/glass thermometers. Inhalation of mercury vapor has the potential to cause occupational health adverse effects, and discharges to drain adverse effects to the aquatic environment. **Recommendations** for very urgent action are detailed in this Report.

H. Waste Handling

This has to be planned, organized and operated as a complete system. Ideally, in the future and after improvements in waste management techniques, accreditation to the ISO 14000 series should be sought.

I. Economic Management Forum

It is **recommended** that a forum should be developed within the Region to provide an interface between Ministries of Environment and other Ministries, such as Health, Economy, and certainly Finance, with collaboration from the local Municipalities, the Occupational Pension Fund and other interested parties. The principle objective should be risk reduction.

J. Economics / Risk

It is emphasized that improvements in economic performance and stability are achievable only by appreciating fully the costs, benefits and risks involved. The two options with their various alternatives illustrate how such risks can be minimized. Unit cost control budgets procedures **should be instituted** at the earliest possible opportunity.

K. Training

It is **recommended** that the government(s)should publicize the need for waste control, recycling, re-use and reduction via the media and also by introduction of these topics into the curricula of primary and secondary education. It is reiterated that waste recovery and reprocessing can be lucrative commercial opportunities. Registration and continuing professional development for professionals should be instituted.

L. Water Management

i. Mains Water Supplies

Whilst there is a need for continuous vigilance to prevent leakage, there is little opportunity at the Szent Imre hospital for further saving. A further detailed set of analytical chemical data is advised

ii. Waste Water to Drain

Currently, as there is no charge for sewage strength, the use of garbage grinders for selected wastes could be considered and discussed with the relevant authorities. However, this is <u>not</u> recommended by the consultants.

II. EXPLANATORY NOTE

This Techno-economic Options report will provide a number of concepts and outline proposals which can be discussed at an International Workshop later in the program.

Other parts of this Technical Report Series are:

No. 1 Waste Management Master Plan
No. 2 Szent Imre Hospital —Waste Audit
No. 4 Training In-house Hospital Management, Szent Imre Hospital 7—11 September 1998
No. 5 International Workshop — Handout
No. 6 Appendices
No. 7 Inspections of Other Hungarian Hospitals and Incinerators
No. 8 Final report

It should be noted that:

- The word *dispose* has been used throughout, whereas the preferred word within the European Commission is now *discard*; and

- The word ***Region*** means Central and Eastern Europe; whereas *region* means an area around a town, e.g. 50 km around Budapest.

III. GENERAL INTRODUCTION — UNIDO'S ROLE

There is an urgent requirement to raise the effectiveness of governance systems within the healthcare industry in the practice of reducing the disposal of clinical, hazardous and non-clinical waste. Such improvement in management will lead to efficient, accountable and transparent sustainable environmental development. It will involve the design, mediation and implementation of incentive regimes and consensus building systems to enable the creation of sustainable development and, for example, the creation of purer and more wholesome potable water supplies.

In order to achieve sustainable industrial development in a county such as Hungary, with her economy in transition, there is a need to promote competitive industry within both the waste management sector and the healthcare industry itself by the introduction of autonomous financially self-sufficient hospital management systems. This will create productive employment with increased health and safety for both the generators of clinical, hazardous and non-clinical healthcare waste and for those involved in its treatment. Such techniques, which are lucrative businesses in Western Europe, ensure that the environment is protected and in such a manner as not to exceed the functional limit of ecosystems and simultaneously conserve renewable resources and efficiently utilize non-renewable resources.

Most developing countries, and especially those with economies in transition, have enacted environmental legislation and regulations in order to reduce industrial pollution. However, whilst the regulations are in place, the means to undertake monitoring and above all enforcement of such regulations is not always available — suitable training will obviate these deficiencies.

Furthermore, for other reasons, the regulatory requirements are not always met, including:

- The regulations are hard to meet — and hence they may need to be adopted in a step-wise manner;
- There can be inadequate institutional capacities for an effective environmental regulatory program;
- The regulations may not eliminate discrepancies for compliance.

UNIDO has the capability to advise and supply information relating to policy issues, capacity building, provision of environmental monitoring and control methodologies, advice on operational set-up of regulatory agencies and networking between governments, institutions, universities, professional associations, NGOs, and other stakeholders in environmental issues. These can be achieved by taking into account the interaction between the environmental and socio-economic conditions of a country, bearing in mind the cultural situation, and assistance to regulatory agencies to assess accurately the actual magnitude of emissions to all environmental media.

One area in which UNIDO is able to offer specific and advantageous advice is in cleaner production, which applies especially to waste management. As indicated later, manufacturers of clinical products should be encouraged to consider their ultimate fate — one solution is miniaturization.

Cleaner production can result in savings in material and energy (which should be recovered in incineration plants) costs, and simultaneously increase occupational health and safety, because of the diminution of pollutants escaping into the workplace and to the natural environment.

There is a need to transfer environmentally sound techniques to enable enterprises large and small to undertake:

- An internal diagnosis;
- A cleaner production assessment — this can apply equally to hospital and waste treatment operators;
- Production management assessment;
- Identification and selection of environmentally sound technology and techniques which would allow enterprises to comply with environmental standards;
- In turn, via a business plan, there can be a social commitment and a negotiated environmental covenant.

The transfer of environmentally sound technology, and in particular techniques, will entail the use of environmental accounting, environmental impact assessments and benchmarks.

Regrettably, all pollutants and waste (in particular hazardous clinical wastes) cannot be reduced sufficiently through cleaner production ideologies and hence, in order to meet environmental standards, other techniques have to be utilized to make such wastes safe in terms of health, safety and the environment and in a cost-effective and pragmatic manner.

In turn, this requires capacity building in:

- Assessment and selection of the best practical environmental option, the best appropriate means of pollution monitoring (e.g. use of field/hand held generic monitors for toxicants) or waste treatment technologies and techniques;
- Training in specific pollution control or waste treatment techniques;
- The development of commercially viable pollution control and waste treatment service industries (in Western Europe some of these are very lucrative);
- Upgrading of municipal waste facilities.

UNIDO (and their other IOMC partners) can assist on the reduction of contamination of drinking water, improve wastewater quality, whatever the sources, and remembering that control/ reduction at source is always preferable to 'end-of-pipe'.

UNIDO can assist in capacity building in:

- Development and management of integrated waste programs (the example of the discharge of formaldehyde to drain, with the use of PEC/PNEC ratios, rather than incineration, supports this concept);
- Technology selection and transfer;
- Provision of advice to municipalities and enterprises by local advisory services;
- Enhancement of job creation through the markets of recyclable and transformed products — this activity has to relate to non-clinical waste.

It is vital that there is very sound environmental management of chemicals, including hazardous clinical waste and promotion of health, safety and environmental protection of all environmental media.

Environmentally sound management of chemical and biological waste has been a high priority of environmental policies in developed countries, e.g. the European Union, the USA and Japan. This is not as extensive in developing countries and especially those with economies in transition and wishing to become members of the European Union in the near future where derogation for the strict EU regulations are unlikely to be granted.

In particular, assistance is required to control and restrict the use of persistent organic pollutants (POPs), some pesticides, including those useable in healthcare, and other environmentally hazardous substances, whose use has been banned or severely restricted in developed countries.

The use of Pollutant Release and Transfer Registers (PRTRs) is a very useful tool for measuring and monitoring the environmental compatibility of industrial development.

However, a commitment to undertaking a PRTR is major for many governments, especially in ascertaining the true composition of many imported formulations and articles and more so if xenobiotic transformations are taken into account.

The import/export of waste needs to be very strictly controlled via the Basel Convention. (See Technical Report No. 6 — Appendix C.)

In undertaking the foregoing, stress needs to be placed on voluntary codes of practice such as *Duty of Care*, *responsible care* and the *accreditation* via ISO 14000 and the Eco-management and Audit Schemes (EMAS) which are widely operated within the EU. (See Technical Report No. 6 — Appendix H.)

In all cases, networking throughout the Region is to be advocated. The International Workshop to be held in the Region at a later phase of this program, should nurture the initiation of a networking scheme for healthcare and hospital waste throughout the Region.

IV. FUNCTIONING HOSPITAL WASTE INCINERATION AND SIMILAR FACILITIES IN HUNGARY

There are a number of hospital incinerator facilities and these are listed below in Section A and B. In addition, there is a medical waste sterilization unit at the Szent Laszlo hospital in Budapest. (These and other data in Section D were kindly supplied by Dr. Amanda Horvath, National Public Health Institute).

Additionally, as shown in Section C, there are a number of other incinerators in the country (data supplied by the British Embassy, Budapest).

Details of hospital waste production are shown in Section E, which includes ten tables of relevant data.

A. Incinerators Located at Hospitals and Operating Within Compliance with Regulations

County	Incinerator Site	Incinerator Type	kg/h
Budapest	Korányi TBC	Purator	400
Budapest	SOTE	Pyromed 240	240
Bács-Kiskun	Kecskemét	ÖSKO	100
Fejér	Székesfehérvár	Mester VH 150	60
Heves	Eger	Mester VH 150	60
Heves	Gyöngyös	Mester VH 150	60
Jász-Nagykun-Szolnok	Karcag	Pirotherm	100
Pest	Kerepestarcsa	Agrokontakt	100
Somogy	Kaposvár	Pirotherm	100
Szabolcs-Szatmár-Bereg	Nyíregyháza	Ciroldi	150

All the above incinerators are fixed hearth with secondary chamber and flue gas cleaning systems.

There are a further 35 hospital incinerators which do not comply.

B. *Incinerators Not On Hospital Sites and Which Burn Medical Waste in Compliance with Regulations*

Sajóbábony (B-A-Z county)
Györ Grabo (Györ county)
Debrecen Hajdúkomm (Hajdú county)
Dorog regional hazardous waste incinerator (Komárom county)
Szombathely (Vas county)
Füzfö (Veszprém county)

C. *Other Incinerators*

i. Medical Waste Incinerator

Septox Company Limited
Evezö u.4
H-1036 Budapest, Hungary
Telephone/fax 00 361 68 6291

ii. Industrial Waste Incinerator

. Nitrokémia plc
Balatonfüzfö
Füzfögyártelep
H-8184 Budapest, Hungary
Telephone 00 361 88 35 2011 Fax 00 361 88 35 1705
Contact: Mr. Jòzsef Baracskai, Technical Director

MOL Rt Dunai Finomitò
(MOL plc Danube Refinery)
Százhalombatta
POB 1
H-2443 Budapest, Hungary
Telephone 00 361 23 35 2010 Fax 00 361 23 35 4586
Contact Mrs. Péter Erdös (Dr), Head of Department (Environmental)

MOL Rt Tiszai Finomitò
(MOL plc Danube Refinery)
Tiszaúváros
Mezöcsáti ut
H-2443 Budapest, Hungary
Telephone 00 361 49 31 1587 Fax 00 361 49 31 1152 Telex 62430
Contact Mr. Jòzsef Máté, Director of Energy Department

D. Municipal Landfill Sites and Waste Dumps

Registered by public health authorities	2016 sites (1996)
Controlled by public health inspectors	1281 sites (1996)

From these properly operated landfill sites — ~100

Infectious hazardous waste and other hazardous wastes are prohibited for disposal on municipal landfill sites.

Three hospitals have declared that sterilized waste can be disposed of to landfill sites, but this is microbiological culture waste only and in small quantities.

E. Hospital Waste Production

As part of work undertaken for the PHARE TDQM program H 9305-04.02/1671, the following details of hospital waste have been recorded in Tables 1–10.

It can be seen that there is considerable variation in waste handling facilities throughout Hungary.

A total of 175 hospitals throughout 19 counties plus Budapest generates a total of ~6,500 tonnes of hazardous waste per year. This means that on an average basis 93,574 beds produce ~70 kg/bed/year of which ~65 kg is infectious waste.

Details of transport of hazardous waste are detailed in Table 5 where it can be seen that a number of licensed transfers ranges from 37.5% to 100%, depending on location — the low figures are a matter of considerable concern and need to be improved to comply with both ADR and Hungarian transport regulations. Similarly, Table 8 shows clearly that the percentage of hazardous waste documents from 0% to 54.5% is inadequate, which in turn means that the hospitals, the transport companies, and the receivers of the hazardous (infectious) waste are failing in their *duty of care* (see Technical Report No. 6 — Appendix N). In the United Kingdom, this is a serious offense and there have been a number of successful prosecutions. It is **recommended** that the regulators in Hungary need to ensure that *duty of care* is undertaken at all times.

This deficiency is further shown in Table 10, where the percentage of hospitals using the yellow code varies from 0% to 100%, average 76.0%. Those hospitals not in compliance with the International Good Code of Practice in the use of 'yellow' containers need to rectify this position with all speed.

Table 1. Common data and characteristic indices of hospital waste production in 1995

	County (capital)	No. of Hospitals	No. of Beds	Total Amount of Hazardous Waste (kg/year)	Amount of Hazardous Waste per Bed (kg/bed/year)
1	Békes	6	3,067	291,907	95.18
2	Györ-Sopron-Moson	17	4,581	385.774	84.21
3	Jász-Nagykun-Szolnok	4	2,913	325,820	111.85
4	Borsod-Abaúj-Zemplén	11	6,003	328,614	54.74
5	Bács-Kiskun	5	3,897	645,116	165.54
6	Veszprém	10	3,749	75,489	20.14
7	Komárom-Esztergom	8	2,568	144,881	56.42
8	Budapest	41	27,757	1,890,574	68.11
9	Hajdú-Bihar	6	4,395	366,755	83.45
10	Heves	6	3,224	148,600	46.09
11	Somogy	5	2,912	116,164	39.89
12	Nógrád	4	1,896	255,680	134.85
13	Pest	9	4,598	247,997	53.94
14	Tolna	4	2,014	79,809	39.63
15	Zala	5	2,384	94,096	39.47
16	Szabolcs-Szatmár-Bereg	6	4,194	259,368	61.84
17	Vas	8	2,649	132,648	50.07
18	Csongrád	7	4,167	311,671	74.80
19	Baranya	9	3,833	236,082	61.59
20	Fejér	4	2,773	209,719	75.63
	Total	175	93,574	6,546,764	69.96

Table 2. Infectious waste production in 1995

	County (capital)	No. of Hospitals	No. of Beds	Total Amount of Infectious Waste (B) (kg/year)	% of B to the Total Amount of Hazardous Waste	Amount of Hazardous Waste per Bed (kg/bed/year)
1	Békes	6	3,067	277,050	95	90.33
2	Györ-Sopron-Moson	17	4,581	383,861	99	83.79
3	Jász-Nagykun-Szolnok	4	2,913	226,028	69	77.59
4	Borsod-Abaúj-Zemplén	11	6,003	283,227	86	47.18
5	Bács-Kiskun	5	3,897	632,070	98	162.19
6	Veszprém	10	3,749	74,568	99	19.89
7	Komárom-Esztergom	8	2,568	94,148	65	36.66
8	Budapest	41	27,757	1,816,267	96	65.43
9	Hajdú-Bihar	6	4,395	353,454	96	80.42
10	Heves	6	3,224	138,028	93	42.81
11	Somogy	5	2,912	96,031	83	32.98
12	Nógrád	4	1,896	247,264	97	130.41
13	Pest	9	4,598	242,978	98	52.84
14	Tolna	4	2,014	71,834	90	35.67
15	Zala	5	2,384	92,364	98	38.74
16	Szabolcs-Szatmár-Bereg	6	4,194	231,261	89	55.14
17	Vas	8	2,649	127,914	96	48.29
18	Csongrád	7	4,167	292,282	94	70.14
19	Baranya	9	3,833	232,132	98	60.56
20	Fejér	4	2,773	199,711	95	72.02
	Total	175	93,574	6,112,472	93	65.32

Table 3. Amount of other hazardous waste (C) in 1995

	County (capital)	No. of Hospitals		No. of Beds	Other Hazardous Waste (kg/year)	% of C to the Total Amount of Hazardous Waste	Other hazardous waste per bed (kg/bed/year)
		A	B		C		
1	Békes	6	4	2,307	14,857	5	6.44
2	Györ-Sopron-Moson	17	5	2,563	1,913	1	0.75
3	Jász-Nagykun-Szolnok	4	4	2,913	99,792	31	34.26
4	Borsod-Abaúj-Zemplén	11	9	5,031	45,387	14	9.02
5	Bács-Kiskun	5	4	3,162	13,046	2	4.13
6	Veszprém	10	3	1,421	921	1	0.65
7	Komárom-Esztergom	8	7	2,470	50,733	35	20.54
8	Budapest	41	26	21,014	74,307	4	3.54
9	Hajdú-Bihar	6	5	4,365	13,301	4	3.05
10	Heves	6	5	3,059	10,572	7	3.46
11	Somogy	5	2	1,547	20,133	17	13.01
12	Nógrád	4	4	1,896	8,416	3	4.44
13	Pest	9	5	3,080	5,019	2	1.63
14	Tolna	4	4	2,014	7,975	10	3.96
15	Zala	5	4	1,784	1,732	2	0.97
16	Szabolcs-Szatmár-Bereg	6	5	3,664	28,107	11	7.67
17	Vas	8	6	2,404	4,734	4	1.97
18	Csongrád	7	7	4,167	19,389	6	4.65
19	Baranya	9	3	1,742	3,950	2	2.27
20	Fejér	4	3	1,532	10,008	5	6.53
	Total	175	115	72,135	434,292	7	6.02

A = Number of hospitals; B = all examined; C = given in ... cases

Table 4. Transportation of hazardous waste

	County (capital)	No. of Hospitals	Septox		Cz+Cz		Zöld Zóna		Progress		Others		Own Transport	
			A	B (%)	A	B (%)	A	B (%)	A	B (%)	A	B (%)	A	B (%)
1	Békes	6	2	33.3	0	0.0	0	0.0	0	0.0	5	83.3	1	16.7
2	Györ-Sopron-Moson	17	8	47.1	0	0.0	3	17.6	0	0.0	4	23.5	0	0.0
3	Jász-Nagykun-Szolnok	4	0	0.0	0	0.0	1	25.0	0	0.0	1	25.0	2	50.0
4	Borsod-Abaúj-Zemplén	11	3	27.3	0	0.0	0	0.0	0	0.0	5	45.5	3	27.3
5	Bács-Kiskun	5	4	80.0	0	0.0	0	0.0	0	0.0	2	40.0	4	80.0
6	Veszprém	10	5	50.0	0	0.0	2	20.0	0	0.0	5	50.0	1	10.0
7	Komárom-Esztergom	8	0	0.0	0	0.0	6	75.0	0	0.0	0	0.0	0	0.0
8	Budapest	41	29	70.7	2	4.9	7	17.1	2	4.9	6	14.6	2	4.9
9	Hajdú-Bihar	6	3	50.0	0	0.0	1	16.7	0	0.0	2	33.3	0	0.0
10	Heves	6	0	0.0	0	0.0	0	0.0	0	0.0	3	50.0	1	16.7
11	Somogy	5	1	20.0	0	0.0	1	20.0	0	0.0	2	40.0	0	0.0
12	Nógrád	4	2	50.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
13	Pest	9	3	33.3	0	0.0	4	44.4	1	11.1	3	33.3	1	11.1
14	Tolna	4	2	50.0	0	0.0	0	0.0	0	0.0	2	50.0	0	0.0
15	Zala	5	0	0.0	0	0.0	1	20.0	0	0.0	3	60.0	0	0.0
16	Szabolcs-Szatmár-Bereg	6	3	50.0	0	0.0	0	0.0	0	0.0	4	66.7	0	0.0
17	Vas	8	0	0.0	0	0.0	0	0.0	0	0.0	7	87.5	7	87.5
18	Csongrád	7	1	14.3	0	0.0	1	14.3	0	0.0	5	71.4	4	57.1
19	Baranya	9	9	100.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
20	Fejér	4	2	50.0	0	0.0	0	0.0	0	0.0	2	50.0	0	0.0
	Total	175												

A = Number of deliveries / collections in the county
B = Participation of company / transporter in the county (%)

Table 5. Number of transporters with licenses to transport hazardous waste

	County (capital)	No. of Hospitals	Other transfers		Own transfers		Total transfers		
			A	B	A	B	A	B	%
1	Békes	6	7	6	1	0	8	6	75
2	Györ-Sopron-Moson	17	15	15	0	0	15	15	100
3	Jász-Nagykun-Szolnok	4	2	2	2	0	4	2	50
4	Borsod-Abaúj-Zemplén	11	8	6	3	1	11	7	63.6
5	Bács-Kiskun	5	6	5	4	3	10	8	80
6	Veszprém	10	12	12	1	1	13	13	100
7	Komárom-Esztergom	8	6	6	0	0	6	6	100
8	Budapest	41	46	45	2	1	48	46	95.8
9	Hajdú-Bihar	6	6	6	0	0	6	6	100
10	Heves	6	3	2	1	1	4	3	75
11	Somogy	5	4	4	0	0	4	4	100
12	Nógrád	4	2	2	0	0	2	2	100
13	Pest	9	11	9	1	0	12	9	75
14	Tolna	4	4	2	0	0	4	2	50
15	Zala	5	4	3	0	0	4	3	75
16	Szabolcs-Szatmár-Bereg	6	7	6	0	0	7	6	85.7
17	Vas	8	1	1	7	2	8	3	37.5
18	Csongrád	7	7	4	4	1	11	5	45.4
19	Baranya	9	9	8	0	0	9	8	88.8
20	Fejér	4	4	3	0	0	4	3	75
	Total	175							

A = Number of transfers; B = Licensed transfers

Table 6. Frequency of transfer of hospital waste

	County (capital)	No. of Hospitals	Hospitals with own incinerator	Total amount of infectious waste (kg/year)	Other hazardous waste (kg/year)	% infectious waste	Frequency of transfer				
							A	B	C	D	E
1	Békes	6	4	277,050	11,786	95.9	0	0	1	1	4
2	Györ-Sopron-Moson	17	2	383,861	1,913	99.5	6	1	6	13	5
3	Jász-Nagykun-Szolnok	4	3	204,909	99,792	67.2	0	0	0	0	3
4	Borsod-Abaúj-Zemplén	11	6	155,271	83,343	65.1	0	0	1	1	8
5	Bács-Kiskun	5	3	632,070	13,046	98.0	1	0	2	3	3
6	Veszprém	10	2	74,269	921	98.8	0	0	3	3	8
7	Komárom-Esztergom	8	3	94,148	50,733	65.0	0	0	6	6	0
8	Budapest	41	4	1,607,720	108,308	93.7	3	24	11	38	7
9	Hajdú-Bihar	6	1	353,454	48,732	87.9	0	1	0	1	3
10	Heves	6	5	138,028	10,572	92.9	0	0	0	0	6
11	Somogy	5	1	96,031	20,133	82.7	1	0	4	5	0
12	Nógrád	4	3	247,264	8,416	96.7	0	0	1	1	1
13	Pest	9	0	158,130	89,867	63.8	1	2	2	5	1
14	Tolna	4	1	71,834	7,975	90.0	0	0	1	1	1
15	Zala	5	0	92,364	21,712	81.0	0	0	2	2	2
16	Szabolcs-Szatmár-Bereg	6	2	217,511	41,857	83.9	0	1	3	4	3
17	Vas	8	1	128,414	4,734	96.4	0	2	1	3	4
18	Csongrád	7	4	293,282	19,389	93.8	0	3	1	4	3
19	Baranya	9	0	226,932	9,150	96.1	0	1	2	3	2
20	Fejér	4	4	199,711	10,008	95.2	0	0	0	0	4
	Total	175									

A = Every day; B = Several times a week; C = Weekly; D = More than weekly; E = Rarely.

Table 7. Methods of measuring hospital infectious waste

	County (capital)	No. of Hospitals	Weighing	Volume calculation	Bales	Other	Hospital scales	Average weight calculation	Weighing at the site of deactivating
1	Békes	6	3	1	4	0	1	2	3
2	Győr-Sopron-Moson	17	5	2	11	0	2	9	8
3	Jász-Nagykun-Szolnok	4	4	0	1	0	2	1	2
4	Borsod-Abaúj-Zemplén	11	7	1	4	0	6	3	6
5	Bács-Kiskun	5	1	2	3	0	2	3	0
6	Veszprém	10	5	1	3	1	0	2	7
7	Komárom-Esztergom	8	2	0	4	0	0	0	6
8	Budapest	41	18	8	21	0	10	15	16
9	Hajdú-Bihar	6	5	0	0	1	3	2	1
10	Heves	6	4	3	2	0	3	1	2
11	Somogy	5	4	0	1	0	0	1	3
12	Nógrád	4	1	0	1	0	0	2	0
13	Pest	9	5	1	4	1	1	3	4
14	Tolna	4	2	0	1	0	1	1	1
15	Zala	5	2	0	1	0	1	1	1
16	Szabolcs-Szatmár-Bereg	6	5	1	4	0	4	4	2
17	Vas	8	2	0	3	0	0	2	4
18	Csongrád	7	4	4	7	0	3	4	5
19	Baranya	9	1	4	6	1	1	4	1
20	Fejér	4	1	0	3	0	0	4	2
	Total	175							

Table 8. Types of transport documents

	County (capital)	No. of Hospitals	Number of transfers	Transport documents	% of documents of transport to total number of certificates	Invoices	% of invoices	Hazardous waste invoices	% of hazardous waste invoices
1	Békes	6	8	3	27.3	2	18.2	6	54.5
2	Györ-Sopron-Moson	17	15	8	50.0	4	25.0	4	25.0
3	Jász-Nagykun-Szolnok	4	4	3	42.9	2	28.6	2	28.6
4	Borsod-Abaúj-Zemplén	11	11	9	50.0	4	22.2	5	27.8
5	Bács-Kiskun	5	10	5	62.5	0	0.0	3	37.5
6	Veszprém	10	13	9	47.4	7	36.8	3	15.8
7	Komárom-Esztergom	8	6	5	41.7	3	25.0	4	33.3
8	Budapest	41	48	33	47.1	15	21.4	22	31.4
9	Hajdú-Bihar	6	6	3	60.0	0	0.0	2	40.0
10	Heves	6	4	5	50.0	3	30.0	2	20.0
11	Somogy	5	4	4	50.0	2	25.0	2	25.0
12	Nógrád	4	2	1	50.0	0	0.0	1	50.0
13	Pest	9	12	8	44.4	5	27.8	5	27.8
14	Tolna	4	4	2	50.0	1	25.0	1	25.0
15	Zala	5	4	5	50.0	4	40.0	1	10.0
16	Szabolcs-Szatmár-Bereg	6	7	6	54.5	3	27.3	2	18.2
17	Vas	8	8	5	71.4	0	0.0	2	28.6
18	Csongrád	7	11	6	40.0	5	33.3	4	26.7
19	Baranya	9	9	4	30.8	2	15.4	7	53.8
20	Fejér	4	4	4	80.0	1	20.0	0	0.0
	Total	175							

Table 9. Methods of deactivating

	County (capital)	No. of Hospitals	No. of beds	Infectious waste (kg/year)	Other hazardous waste (kg/year)	Autoclave	Storage after deactivating	Incineration	No. of companies with licenses
1	Békes	6	3,044	277,050	11,786	0	0	6	6
2	Győr-Sopron-Moson	17	4,171	383,861	1,913	1	0	17	17
3	Jász-Nagykun-Szolnok	4	2,809	204,909	99,792	0	0	4	4
4	Borsod-Abaúj-Zemplén	11	5,852	155,271	83,343	0	0	10	10
5	Bács-Kiskun	5	3,897	632,070	13,046	0	1	4	5
6	Veszprém	10	3,617	74,269	921	0	0	10	10
7	Komárom-Esztergom	8	2,355	94,148	50,733	0	0	8	7
8	Budapest	41	26,708	1,607,720	108,308	3	0	39	41
9	Hajdú-Bihar	6	4,278	353,454	48,732	0	0	5	4
10	Heves	6	2,861	138,028	10,572	1	0	6	5
11	Somogy	5	2,912	96,031	20,133	0	0	5	2
12	Nógrád	4	1,672	247,264	8,416	0	0	2	2
13	Pest	9	4,515	158,130	89,867	0	0	9	9
14	Tolna	4	1,725	71,834	7,975	0	0	3	3
15	Zala	5	2,384	92,364	21,712	1	0	5	5
16	Szabolcs-Szatmár-Bereg	6	4,176	217,511	41,857	0	0	3	6
17	Vas	8	2,366	128,414	4,734	1	0	8	7
18	Csongrád	7	4,047	293,282	19,389	1	1	7	8
19	Baranya	9	3,716	226,932	9,150	0	1	8	8
20	Fejér	4	2,847	199,711	10,008	0	0	4	2
	Total	175							

Table 10. Percentage of selective hazardous waste collection ORKI licenses for bins and use of yellow color code

	County (capital)	No. of Beds	% Selective collection	% with ORKI license	% with yellow color code
1	Békes	3,067	100	43.5	31.5
2	Györ-Sopron-Moson	4,581	100	64.3	64.3
3	Jász-Nagykun-Szolnok	2,913	100	92.6	92.6
4	Borsod-Abaúj-Zemplén	6,003	100	65.3	78.6
5	Bács-Kiskun	3,897	100	41.9	71.8
6	Veszprém	3,749	58.8	31.2	31.2
7	Komárom-Esztergom	2,568	96.2	95.4	95.4
8	Budapest	27,757	93.8	84.0	92.2
9	Hajdú-Bihar	4,395	99.5	83.7	83.7
10	Heves	3,224	100	0	41.5
11	Somogy	2,912	100	64.5	64.5
12	Nógrád	1,896	64.4	64.4	56.0
13	Pest	4,598	100	100	81.1
14	Tolna	2014	100	4.4	70.1
15	Zala	2384	100	100	87.3
16	Szabolcs-Szatmár-Bereg	4,194	100	81.8	94.4
17	Vas	2,649	95.1	86.8	77.6
18	Csongrád	4,167	100	25.2	66.6
19	Baranya	2,833	100	100	100
20	Fejér	2,773	100	0	0
	Total (average)	93,574	95.5	68.3	76.0

V. BACKGROUND AND RELATED PRELIMINARY INFORMATION

This topic outlines general economics in section A, indicating how strict waste management can result in reduction, reuse, and the ability to recycle waste. Section B describes some of the constraints which apply in developing countries, and section C examines the relationship between economics, waste management and the environment. Other important and related topics are described in Sections D–L.

A. Economics

The volume of waste generated is fueled by economic development. There is a direct link between the improvement of the standard of living of the people and the amount of domestic, industrial, commercial and medical waste, generated by any modern society.

The traditional method of eliminating waste was, and remains, disposal to landfill. The increase in waste volumes, coupled with the generation of hazardous waste, reached such proportions, that the valuation of landfills became a medium term threat. The problem became compounded by contamination of the atmosphere and groundwater.

Efforts were undertaken to remedy the negative influence of landfills on the ecosystem, but this proved inadequate and ineffective.

Incineration technology was developed in the 1950s and was considered to offer an attractive alternative method to reduce the waste volume to be landfilled. Conventional combustion technology was the starting point for the development of waste incinerators. A strong emphasis was placed on the thermal energy recuperation aspects, whereas emissions and residual ash quality remained a secondary preoccupation.

During the 1980s, society became more sensitive to environmental protection and to respect the ecological balance. As a result, all highly industrialized countries have issued stricter regulations concerning pollution control. Conventional incinerators now require extremely sophisticated flue gas and residue control systems, to meet strict emission limits.

The public sensitization resulted in stricter waste management, now called the four 'R' principle:

Reduce

Reuse

Recycle

Recovery

- **Reduction** of volume of waste is the best way of avoiding the problems of waste treatment;
- **Re-using** principally packaging materials.
- **Recycling** parts of the waste stream, including energy, contributes to lowering waste volume and postponing the exhaustion of raw material sources.
- **Recovery**. Ascertaining that a waste may be recovered and used for the same or a similar purpose.

B. Working Within Existing Constraints In Developing Countries

Circumstances in developing/industrializing countries sometimes present obstacles to the strengthening of national systems for the sound management of chemicals. For such management to be pragmatic and realistic and thus have a reasonable chance of success, these management activities need to be tailored to existing constraints such as the availability of resources, economics and the level of infrastructure.

i. Challenges and Constraints in Developing Countries

The challenges are numerous and vary considerably between countries. Some are:

- General constraints, such as a lack of sufficient telecommunications and information and infrastructures such as libraries;
- A general lack of trained human resources in government, aggravated by the tendency for qualified personnel to move into the private sector;
- Rapid turnover of government staff resulting in loss of 'institutional memory';
- A lack of experience within institutions dealing with environmental problems; and
- Corruption, especially from affluent foreign entrepreneurs in relationship to inadequately remunerated government administrators.
- The last of these challenges is of particular concern as many of such institutions may have only recently been established in response to an increasing global and national focus on environmental issues. These factors are especially applicable to the pharmaceutical industry, in view of the high level of regulation necessary for both the quality of the final products, and likewise for waste disposal.

Other constraints relate specifically to waste management, including:

- Lack of clear hospital management policies and political commitment, related to general lack of attention and emphasis placed on waste management issues in many countries.
- Lack of mechanisms for communication and cooperation among ministries and between industrial sectors and government regulators.

- Lack of access to information/data necessary for chemical management decision, including inadequate local data/statistics — some of these problems are associated with inadequate library and/or telecommunication problems.

- Lack of access to information on existing international, regional, and national healthcare management activities. Again, due to inadequacy of libraries/telecommunications.

- Lack of trained personnel to collect, interpret and use data necessary for waste management decisions.

- Language barriers related to the translation of international information (e.g. Material Data Sheets (MSDSs), etc.)

- General lack of awareness and preparedness within the population about hospital and other healthcare management problems and safety practices.

ii. Addressing Constraints in a Practical Manner

Whilst some of these constraints can be addressed successfully, others need to be accepted as they are, as it would be economically impractical in the short term to obviate the problem. For the latter cases, countries need to seek innovative solutions and use priority-based strategies in order to achieve their waste management objectives and to overcome resource limitations and similar constraints. When comprehensive solutions are lacking, countries should seek to identify pragmatic intermediate solutions which can achieve immediate and considerable reduction in risk. This principle needs to be applied to the healthcare industry in particular. Some examples and indicators are given in Section C below.

The overall strategic approach used in strengthening or establishing national waste management can, to a large degree, determine how successful efforts are to overcome obstacles and address national needs. For example, creation of multi-sectorial networks which foster collaboration and information exchange can be a very effective and economic means for overcoming frequent turnover of government staff and/or lack of formal coordinating mechanisms. A multi-stakeholder approach can also assist to overcome resource constraints, as it mobilizes the expertise and capacities of the various parties within and outside government in addressing chemical management objectives. Stakeholders include those who are taking financial risks such as bankers, insurers, shareholders, etc.

One specific problem which many countries face is the lack of access to information. Overcoming information-related constraints requires both:

- Improved technical infrastructure (e.g. Internet access, software, CD-ROMs, etc., hardware); and

- The creation of ready sources of information among national institutions and people, together with the enhancement of their capabilities to access, interpret, and effectively use data for hospital waste management purposes.

The establishment of pilot programs for Internet access, with the cooperation of industry, international and/or regional organizations, is one possible specific activity towards this goal. Industry's potential contributions in addressing information gaps (e.g. provision of MSDSs, classification, packaging and labeling (CPL) information, Internet access, etc.) can be crucial in countries with very limited resources.

iii. Pragmatic Opportunities To Achieve Risk Reduction

Whilst Chapter 19 of Agenda 21 encourages the development of comprehensive national systems for the sound management of chemicals, globally; reality in many countries suggest that a stepwise approach which takes care of immediate concern, and tackles the most severe problems as a matter of priority, is more feasible in the short term, particularly for countries facing severe resource constraints. For example, whilst the development of an inventory of chemicals in use appears to be a logical first step in a national management scheme, collection of the required information consumes significant resources and does not *per se* achieve any reduction in chemical or biological risks. In comparison, tackling requirements for hazardous chemicals, especially those in common usage within the healthcare industry, together with mandatory provisions of MSDSs would lead to significant risk reduction without incurring extensive administrative infrastructure.

Guiding Principles

These can assist within countries in pursuing a pragmatic approach to national waste management decision-making. A *problem-based approach* in which the search for solutions to specific problems becomes the driving force for decision-making, assists in directing resources and effort towards priority aspects of concern. An emphasis on *preventive measures*, such as worker education, pollution prevention techniques, including 'good housekeeping' and substitutions of safer alternatives, can assist in the avoidance of new problems, whilst addressing existing sources of risk, invariably in a cost-effective manner. A r*esults orientated* approach ensures that only those activities that achieve reduction in risk or other desired objectives will continue to be implemented. In this respect, establishing accountability measures and monitoring the effectiveness of specific strategies are important, and flexibility is needed to ensure that the course of action can be amended if it proves not to be effective. Finally, a *collaborative and participating approach* in which the strengths and potential contribution of all concerned parties are mobilized, can assist in bringing about positive change. In addition, to actors in government and the private sector, the involvement of dedicated groups and individuals who are active in social and scientific issues (such as academies of arts and science, professional societies, etc.), can form an important role to improve chemical management and safety, especially through increased public awareness, thus leading to preparedness and improvements in hospital and healthcare safety.

Practical Strategies and Action

A pragmatic approach can lead to concrete and immediate results in addressing specific areas of waste management at the country level, e.g. increasing awareness and preparedness of risks and safe use practices and fostering increased attention to hospital management problems can be a practical way in which to achieve risk reduction. This might entail focusing on education and training at all levels, including raising the awareness of decision-makers; establishing legal requirements to ensure that dangerous chemicals which are used in the country within the healthcare industry, are always accompanied by MSDSs and appropriate CPL information, and that this information is disseminated to all users, transporters, etc., emphasizing that real-life risks and potential consequences of chemical and clinical waste misuse by documenting specific case studies and scenarios; and strengthening risk communication efforts and safe use training.

In the area of policy-making and development of regulatory and enforcement schemes, the focus should be on the problems of greatest priority, e.g. efforts should be targeted towards those industrial sectors which do not have sound waste management practices and which contribute significantly to chemical and associated biological-related problems and risks. Information management policies should be designed to meet specific risk reduction objectives, with the intended use of information clearly defined before resources are spent on its collection. Given that many countries rely on pharmaceutical chemicals which are imported, strengthening borders and custom control, including training border agents to recognize potentially hazardous and/or illegal biological/infectious waste or chemical shipments, can be a practical measure to gain, control of chemicals used and biological waste transported throughout the country.

To foster waste management within the health(care) industry, a collaborative approach can be used, such as working with industry and other commercial bodies, including small and medium enterprises, to trade associations, chambers of commerce and industry, professional societies and academia, to develop practical solutions to address the most severe problems and risks. Providing incentives and taking steps to raise awareness and preparedness within industry regarding possible economic gains associated with sound waste management practices, and raising the issue of chemical management as a competitive issue (e.g. to emphasize that export sectors of countries whose industries do not adopt sound chemical management policies may suffer economically), and other possible strategies. Promoting voluntary agreements and industry-driven concepts, such as **Responsible Care** and product stewardship programs, can also spur action towards improved management and increased corporate responsibility. This is of particular relevance when multinational entrepreneurs invest in new (or old) hospitals in developing/industrializing or least developed countries.

C. Economics, Waste Management and The Environment

i. Environmental Toxicology Assessments

Until very recently, adverse effects to both the natural environment (air, soil and water) and occupational exposure, viz. environmental toxicology assessments, had been low priority issues in developing countries, especially in regard to disposal of clinical wastes.

Increasingly, awareness of 'environmentally friendly' products and processes now being significantly adopted in developed countries; developing countries have become aware of the requirement to initiate similar procedures if they are to trade in international markets.

ii. Free Market Economies

Many countries are moving at different rates towards a free market economy as compared to the 'protectionism' of former regimes.

Bankers, insurers, stockbrokers and, perhaps most importantly shareholders, are becoming more aware of the need for a company to show that it demonstrates 'Responsible Care' and 'Due Diligence', and 'Duty of Care' — these are of particular importance in the case of the disposal of clinical and other hazardous wastes, downstream effects, and more recently on the concept of the need to develop clean products and processes.

iii. Monitoring

As many national laboratories are poorly equipped and staff inadequately trained in ecotoxicology/environmental toxicology assessment techniques, considerable importance needs to be given to:

- Equipping laboratories;
- Ensure that these laboratories are accredited, ideally to GLP; and
- That staff are adequately trained in
  - Sampling,
  - Laboratory procedures, and
  - Assessment of data obtained, e.g. in hazard data sources, risk assessment, management and reduction, to ensure safety in aspects of clinical and hazardous waste disposal.

The equipping of laboratories is a matter to be considered most carefully.

- Working to a well-defined program to ensure the maximum use of resources.

D. Environmental Regulations

Many of the countries in Central and Eastern Europe's former environmental legislation is wholly (e.g. Armenia), or partially (e.g. the Czech Republic) based on the former Soviet Union GOST standards. Many of these are neither pragmatic nor enforceable/controllable at least without entailing excessive costs to industry and for this reason were often not enforced.

Most countries in Central and Eastern Europe are either wishing to receive assistance in promulgating new environmental legislation, or such legislation is being debated in their parliaments. It was obvious that in order not to impose unrealistic financial burdens on industries which were being redeveloped that new legislation had to be a step-wise process (e.g. the British procedures for Integrated Pollution Control. (See also Technical Report No. 6 — Appendix J.)

Great attention is necessary in the development of new industries that prior to permission being granted to reconstruct, environmental impact assessments are undertaken, this is of particular importance in the case of incinerators used for the incineration of clinical and other hazardous waste.

E. *Environmental Protection Agencies*

Governments in developing countries will need to decide if the Ministry of Environment is to be the enacting/controlling authority, or whether to devote the working/controlling authority to an Environmental Protection Agency

Whatever the outcome, governments, industry and the public, need to appreciate fully the benefits, costs and risks regarding segregation, storage, possible reuse, transport and especially disposal of waste.

As far as the aquatic environment is concerned, great attention must be given to Predicted Environmental Concentration (PEC) and Predicted No Effect Concentrations (PNEC), and the PEC/PNEC ratios; see also Technical Report No. 1 — Waste Management Master Plan, Section V, and Technical Report No. 6 —Appendix F.

F. *Pollution Control and its Economic Consequences*

Failure to adopt adequate environmental protection measures can lead to serious and multifaceted consequences.

This can result in contaminated rivers subsequently abstracted for drinking water resources. It was noted (see Technical Report No. 1 — Waste Management Master Plan, sections I and V) that the drinking water at the Szent Imre hospital is contaminated with both haloforms (total >10 μg/l) and formaldehyde (11 μg/l) which undoubtedly results from the inadequate quality of the raw water sources (the Danube river either direct or via the 'so-called' bank side treatment). This poor water quality might result in major investments in advanced potable water treatment.

It is hence vital that all due consideration is given to the best possible means for the treatment of clinical and other hazardous wastes, e.g. flue gas washing from incinerators or from storage areas at incinerator complexes must never be allowed to contaminate the ground water.

As aptly stated in the Black Sea Environment Programme poster *The Ecosystem of the Black Sea is Dying*, massive pollution has resulted in massive fish mortalities. One consequential effect is that fish meal is scarce, resulting in inadequate feed for poultry, leading to a reduction in poultry products including eggs. Hence, failure to manage and control sewage effluent means secondary losses in human food requirements and is adversely affecting both fisherman, poultry farmers and cereal, fruit and vegetable farmers, resulting in an increase in healthcare requirements.[1]

Consideration should be given to trans-boundary pollution effects. This is to protect both the environment and to avoid costly litigation.

G. *Economic Failures*

Due to health hazards, swimming in the Danube river near to Budapest is now not allowed.

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[1] Richardson, M.L. (Ed.). 'Epilog', in: *Environmental Xenobiotics*, 1996a, Taylor & Francis, London, pp. 457—468.

Any healthcare industry which does not attain to the principles of **'Responsible Care'**, **'Duty of Care'** (see also Technical Report No. 6 — Appendix N) and **'Due Diligence'**, will suffer financial burdens by the unnecessary wastage of costly raw materials, inadequate recycling, poor energy management, and above all poor waste management, which can very easily become an expensive liability, both for itself and the community at large.

Economic and legal instruments have to be improved (or developed) and regulated to optimize the benefits to local communities. (See also Technical Report No. 6 — Appendices B and E–J)

H. Transboundary Consequences

Inadequate environmental control and pollution has far reaching transboundary consequences; national boundaries are not recognized by clouds of poisonous gas clouds nor pollutants in rivers or seas. Pollutants from coal fired power stations in Great Britain are reputed to have caused acid rain adverse effects in Scandinavia. Chemical emissions in the former East Germany have resulted in deforestation in Central Europe. Deforestation, unless quickly remedied can result in barren hill sides which can take millenniums to recover (c.f. the Velebrit mountains in Croatia).[2]

Similarly, the economic consequences of environmental damage by warfare, e.g. in Bosnia and Croatia, and especially their transboundary adverse effects, appear to be neglected by the media, mediators and politicians.

I. Environmental Instruments to Improve the Environment

Environmental improvements can be achieved by:

- National reviews of experience to date with economic instruments in selected countries initially, and to include issues concerning the transferability of design and implementation of essential facilities and the means to interpret environmental toxicology data.
- The nature and technical merits of different types of economic instruments related to water pollution, including effluent taxes, water treatment fees, low interest loans, deposit refund schemes, and innovative mechanisms such as tradable effluent permits. Most people need education in the true cost of water and the disposal of waste.
- Lessons learned and their incorporation into the design and improved implementation of economic instruments.
- Methods for sharing of experience and information, e.g. through exchange of experts, study tours, etc.

[2] Richardson, M.L. (Ed.). *The Effects of War on the Environment: Croatia*, 1995, E & FN Spon, London, pp. 221.

J. *Environmental Economics*

The pollution of many areas in Central and Eastern Europe has imposed severe economic losses. There is a requirement to facilitate the design of policies and programs aimed at reducing the extent of degradation in a cost effective manner.

Costs and benefits identified and measured using environmental economic methods are relevant, both to micro- or project-level decision-making, as well as to overall policy-making. Also, there is a need to consider how economic instruments may be employed as policy tools for improving environmental quality in the most cost-effective manner possible.

There is a relationship between economy-wide policies (including micro- and macro-economic as well as sectorial policies), in the evaluation of environmental policies. In the Region, there is a need to estimate the likely impacts of economic reform on the levels of environmental degradation, impacting on all ecosystems. This would involve attempts to estimate the probable environmental impact of current dramatic changes, for example in the healthcare, agricultural and industrial sectors and in foreign trade.

There will be a requirement for a combination of support for targeted research, or case studies and capacity building to assist decision-makers in the Region to incorporate environmental costs and benefits into their decision-making. Work programs in the areas of economic instruments, and the implications of broader economy-wide policies on the environment will need development; of particular importance will be the transfer and dissemination of results and methodologies.

Initially, valuation studies will include a combined contingent valuation/cost survey of potential in the region, a survey of the economics of the depletion of the general environment, fisheries, potable water resources and a review of costs and benefits associated with wastewater treatment.

K. *Environmental Economics and Investments*

An environmental economic approach can facilitate the design of policies and programs aimed at reducing the extent of environmental degradation and resource depletion, and specifically the 'external' costs imposed upon society, in a cost effective manner. Emphasis should be given to the costs of inaction, developing and assisting to implement pilot economic instruments and, demonstrating the positive value of investment in environmental protection and remediation. Such objectives can be accomplished through a combination of support for targeted research or case studies, and the development of policy options and capacity building to assist decision-makers incorporate environmental costs and benefits into their decision-making.

Within the Region, the use of economic instruments rely on a combination of command-and-control and market-based instruments in their environmental policies.

The role of economic instruments is expected to increase over time because:

- The transition to a market economy in the former socialist countries, and a general trend towards less government intervention.

- The demonstrated cost-efficient response of enterprises and households to economic instruments.
- The collapse of the state revenue systems, restrictive budgets and the need to create new revenue-raising mechanisms for environmental protection within the economies in transition.

L. Environmental Economics and Sustainability

Developing countries need to display a commitment to sustainable development which raises the economic standard of living of their population, without further degrading and, preferably, improving the quality of their environment. Such a commitment needs an incentive based approach to policy on the grounds that the integration of economic and environmental policies leads to the most cost-efficient route to sustainable development.

In order to achieve sustainable development, countries must make wise use of limited resources in meeting aims of reducing unemployment, increasing competitiveness and protecting the environment; but this does not mean they should apply resources automatically to those actions which secure the largest rate of return per unit of resource spent. Major emphasis should be to elicit and apply the criteria of cost-effectiveness in the overall field of environmental policy. It is recognized that:

- Pressures on the environment are bound to increase in the next two decades.
- Planned policy measures will reduce potential environmental damage substantially but at an economic cost.
- Even the implementation of planned measures may result in the environment being temporarily in a more degraded state than currently.

As a result, there is now a requirement for a concerted global effort to devise and adopt policy measures which are based on market forces and have the potential to de-couple economic growth from further degradation of the environment, especially so from the disposal of waste from healthcare, with its benefits to mankind.

The following might be considered:

- The identification of benefits that might accrue from positive environmental policy.
- The selection of indicators of benefit which are credible and measured for a significant number of developing countries. The resulting indicators of impact and effectiveness must be measurable in the sense of at least permitting a ranking of priorities for action.
- Data deficiencies, especially in environmental toxicology and ecotoxicology monitoring, will be identified.

In respect of potential policy interventions, advice will be needed on:

- The degree of threat: should a country direct action first to those areas where the threat is greatest and/or most immediate; or

- The likelihood of success: how should the probability of success be factored into the analysis.

The pollution of water resources imposes severe economic losses. There is a requirement to facilitate the design of policies and programs aimed at reducing the extent of degradation in a cost effective manner.

This process should firstly attempt evaluating or quantifying the economic damage, or costs, imposed by degradation and the benefits which accompany environmental protection and restoration. Costs and benefits identified and measured using environmental economic methods are relevant, both to micro- or project-level decision-making, as well as to overall policy-making. Also, there is a need to consider how economic instruments may be employed as policy tools for improving environmental quality in the most cost-effective manner possible.

The relationship between economy-wide policies, including micro- and macro-economic as well as sectorial policies, and the evaluation of environmental policies. In the region, there is a need to estimate the likely impacts of economic reform on the levels of environmental degradation, impacting on the ecosystems. This would involve attempts to estimate the probable environmental impact of current dramatic changes, for example in the healthcare, agricultural waste disposal and industrial sectors and in foreign trade.

A program for enhancing the use of economic instruments will commence with a review of the current use of instruments such as fees, green taxes, etc., at the national level. Such knowledge is currently lacking and would form an essential knowledge base for future programs of policy formulation in the area.

One new concept to be developed is the Regional and transboundary aspects of pollution, including complete river basin (i.e. the whole Danube river) and the possible need for transnational economic instruments, such as pollution permits, tradable at the international level.

It is **Recommended** that a forum will be developed for providing an interface between ministries of environment and sectorial, economy and possibly financial ministries. The incorporation of environmental economic elements into the broader work of economic management will be but one objective, and that has to be *Risk Reduction*.[3]

VI. AVAILABLE PRACTICES TO DISINFECT/INCINERATE AND DISPOSE OF HAZARDOUS HOSPITAL WASTES

There is no simple procedure for the disposal for hazardous hospital wastes.

A. *Categories of Hazardous Healthcare Waste*

There are a number of categories of hazardous healthcare waste and these are indicated in Table 11. Their means of safe disposal will incur different procedures.

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[3] Richardson, M.L. (Ed.). *Risk Reduction: Chemicals and Energy into the 21st Century*, 1996b, Taylor & Francis, London, pp. 612

Table 11. Categories of hazardous healthcare waste

Waste category	Description and examples
Infectious waste	Waste suspected to contain pathogens, e.g. laboratory cultures, waste from isolation wards, tissues, materials or equipment having been in contact with infected patients, excreta
Pathological waste	Human tissues or fluids, e.g. body parts, blood and other body fluids, human fetuses
Sharps	Sharp waste, e.g. needles, infusion sets, scalpels, knives, blades, broken glass
Pharmaceutical waste	Waste containing pharmaceuticals, e.g. pharmaceuticals which are expired or no longer needed, items contaminated or containing pharmaceuticals (bottles, boxes)
Genotoxic waste	Waste containing substances with genotoxic properties, e.g. waste containing cytotoxic drugs (often used in cancer therapy), genotoxic chemicals
Chemical waste	Waste containing discarded chemical substances, e.g. laboratory reagents, film developer, disinfectants which are expired or no longer needed, solvents
Wastes with high content of heavy metals	e.g. batteries, broken thermometers, blood pressure gauges
Pressurized containers	Gas cylinders, cartridges and aerosol cans
Radioactive waste	Waste containing radioactive substances, e.g. unused liquids from radio diagnostic or laboratory research, contaminated glassware, packages or absorbent paper, urine and excreta from patients treated or tested with unsealed radionuclides, sealed sources
Plastics waste	In healthcare establishments, plastics waste can be a major waste management requirement. Plastics contaminated with human (animal) body fluids/tissues should be incinerated or microwave disinfected; non-infected waste should be recycled/recovered for re-use. Halogen containing plastics (e.g. PVC) should be avoided as these can lead to dioxin formation during incineration.

B. Outline of Disposal Procedures

An overview of disposal and treatment methods suitable for healthcare waste categories are shown in Table 12 (courtesy of the World Health Organization, Geneva).

Table 12. **Overview of disposal and treatment methods suitable for healthcare waste categories**

Technology or method	Infectious waste	Anatomic waste	Sharps	Pharmaceutical waste	Cytotoxic waste	Chemical waste	Radioactive waste
Rotary kiln	yes	yes	yes	yes	yes	yes	low-level infectious waste
Pyrolytic incinerator	yes	yes	yes	small quantities	no	small quantities	low-level infection waste
Single chamber incinerator	yes	yes	yes	no	no	no	low-level infectious waste
Drum or brick incinerator	yes	yes	yes	no	no	no	no
Chemical disinfection	yes	no	yes	no	no	no	no
Wet thermal treatment	yes	no	yes	no	no	no	no
Microwave irradiation	yes	no	yes	no	no	no	no
Encapsulation	no	no	yes	yes	small quantities	small quantities	no
Safe burying inside premises	yes	yes	yes	small quantities	no	small quantities	no
Sanitary landfill	yes	no	no	small quantities	no	no	no
Discharge to the sewer	no	no	no	small quantities	no	no	low-level liquid waste
Inertization	no	no	no	yes	yes	no	no
Other methods				return expired drugs to supplier	return expired drugs to supplier	return unused chemicals to supplier	decay by storage

In this report and the Options detailed in Section VII, detailed consideration has been given to incineration/pyrolysis units, microwave disinfection and the limitations/precautions of discharging selected hazardous substances to sewer.

The sources of healthcare waste include, among others, hospitals, clinics, laboratories, research centers, animal research, blood banks, nursing homes, mortuaries and autopsy facilities. Within the community there are in addition a number of minor sources of healthcare waste including physicians' offices, dental clinics, home healthcare, small nursing homes, acupuncturists, psychiatric clinics, cosmetic piercing and tattooing, funeral services, paramedic services, institutions for disabled persons.

C. *Treatment and Disposal Methodologies*

In addition to the details provided in Section VII (hospital waste management (cost estimation)) below, the basic facilities include:

i. Aims of Treatment and Disposal

— to limit public health and environmental impacts by:

- Transforming the waste into non-hazardous residues by treatment;
- Containing the waste/residues to avoid human exposure;
- Containing the waste/residues to avoid dispersion into the environment.

As discussed later in this report, numerous factors need to be taken into account when choosing a treatment and/or disposal route. Prior to purchasing technology, long-term operation and maintenance aspects should be investigated. It is vital to consider the final disposal routes for the residues.

ii. Criteria for Environmental Options

- Prevailing regulations;
- Forthcoming regulatory requirements, such as those prescribed by the membership of the European Union;
- Available facilities in the region;
- Quantities of generated waste categories;
- Availability of qualified (registered) personnel;
- Technologies available on market;
- Available facilities for final disposal (landfill);
- All environmental aspects;
- Available space at hospital premises;
- Related costs/financing, see Sections IX and X below.

In view of the complexity of the above, it is not possible to recommend one 'best option', as it may not be applicable locally.

iii. Treatment and Dispersal Methods

— an overview is shown in Table 12.

iv. Incineration

Incineration remain the optimal choice, especially when used with combined heat and power as discussed later in this report. Briefly, incineration involves:

- Reduction of combustible waste to inorganic incombustible waste (ashes) and exhaust gases;
- Reduces significantly waste volume and weight;
- Residues (ashes) then need to be transferred to a final disposal site (landfill) or preferably used in the construction industry;
- Treatment efficiency is a function of incineration temperature and incinerator type;
- Not all wastes can be incinerated;
- Investment and operation costs vary greatly according to type of incinerator — but it is emphasized that a high proportion of such costs can be recovered by use of combined heat and power production (usually only feasible for large incinerators);
- Produces combustion gases which require very strict monitoring and control.

Wastes that should not be incinerated include:

- Pressurized gas containers;
- Large amounts of chemical waste;
- Radioactive waste;
- Silver salts or radiographic waste (the silver should be recovered for sale as waste silver);
- Halogenated plastics (e.g. PVC);
- Volatile metals, e.g. mercury and cadmium;
- Mercury and cadmium;
- (Ampoules of) heavy metals.

Types of incinerators. Briefly these include:

- Rotary kiln — 1200 – 1600 °C;
- Double chamber pyrolytic incinerators — Pyrolysis temperature 800 – 900 °C and burning temperature of ~1200 °C;
- Single chamber furnaces with static grate 300 – 400 °C (not recommended);
- Simple field incinerators < 300 °C only to be considered in adverse or difficult circumstances, e.g. following natural disasters or war zones.

Incineration of healthcare waste

Advantages

- Good disinfection efficiency;
- Drastic reduction of weight and volume.

Disadvantages

- Efficiency of chemical and pharmaceutical waste treatment is good for rotary kiln, ~95% for pyrolytic incineration, very limited for lower temperatures;
- Toxic emissions to atmosphere — require sophisticated monitoring and controls;
- Maintaining temperature levels (and efficiency) in field incinerators is difficult (in reality impossible);
- Usually high costs for high temperature incineration which can be reduced by use of combined heat and power;
- High maintenance costs.

Whilst incineration has been the preferred method for many years, and is still the most widely used treatment method for healthcare waste, numerous alternative processes (see Table 12) have been developed and could be considered.

v. Simple Chemical Disinfection

Treatment by contact to commonly used product for surface disinfection include:

- Requires shredding of waste;
- May introduce corrosive chemicals into the environment;
- Efficiency depends on operational conditions;
- Only the surface is disinfected;
- Human tissue should usually not be disinfected;
- Special disposal (and further treatment) required to avoid pollution of the environment.

Chemical disinfection is used routinely in healthcare to clean certain instruments and equipment, floor and walls. It has more recently been extended to healthcare waste. Waste is disinfected by the addition of chemicals that kill or inactivate the pathogens contained in the waste. However, the final disposal can result in costly pre-treatment prior to disposal to any environmental medium and hence is not considered in this report as a viable alternative to heat treatment.

Perhaps its greater suitability is to treat liquid waste such as blood, urine, stools, or hospital sewage. It should be noted that chemical treatment of human excreta is widely practiced in aircraft.

Table 13 summarizes the principle advantages and drawbacks of such disposal methods.

vi. Commercial Chemical Disinfection Systems

There are a number of self-contained, fully automatic systems available commercially, containing procedures such as:

- Shredding of the waste;
- Chemical treatment;
- Encapsulation.

The possible advantages include:

- Landfilling of residues;
- Easy to operate.

Possible disadvantages include:

- Require specialized operators for maintenance;
- Expensive;
- Consumes valuable landfill space.

Table 13. Summary of main advantages and drawbacks of treatment and disposal methods

Treatment/Disposal method	Advantages	Drawbacks
Rotary kiln	Adequate for all infectious waste, chemical and pharmaceutical waste.	High investment and operating costs.
Pyrolytic incineration	Very high disinfection efficiency; Adequate for all infectious waste, and most pharmaceutical and chemical waste.	Destruction of cytotoxics not complete; Relatively high costs of investment and operation.
Single chamber incineration	Good disinfection efficiency; Drastic reduction of weight and volume of waste; The residues may be landfilled; No need for highly qualified operators; Relatively low investment and operation costs.	Generation of significant emissions of atmospheric pollutants; Need for periodic slag and soot removal; Inefficiency in destruction of thermally resistant chemicals and drugs such as cytotoxics.
Drum or brick incinerator	Drastic reduction of weight and volume of the waste; Very low investment and operating costs.	Only 99% destruction of microorganisms; No destruction of many chemicals and pharmaceuticals; Massive emission of black smoke, flying ashes, toxic flue gas and odors.
Chemical disinfection	Highly efficient disinfection good operating conditions; Some chemical disinfectants are relatively inexpensive; Drastic reduction in waste volume.	Requirement of highly qualified technicians for operation of the process; Use of hazardous substances which require comprehensive safety measures; Inadequate for pharmaceutical, chemical and some types of infectious waste.
Wet thermal treatment	Environmentally friendly; Drastic reduction in waste volume; Relatively low investment and operation costs.	Shredding are subjected to many breakdowns and bad functioning; Operation requires qualified technicians; Inadequate for anatomic waste; Pharmaceutical and chemical waste or waste which are not easily penetrable by steam.
Microwave irradiation	Good disinfection efficiency under appropriate operational conditions; Drastic reduction in waste volume; Environmentally friendly.	Relatively high investment and operation costs;
Encapsulation	Simple and safe; Low costs; May also be applied to pharmaceuticals.	Not recommended for non-sharp infectious waste.
Safe burying	Low costs; Relatively safe if access restricted and where natural infiltration is limited.	Only safe if access to site is limited and some precautions taken.
Inertization	Relatively inexpensive.	Not applicable to infectious waste.

vii. Wet Thermal Treatment Systems

These are procedures which expose the waste to steam under pressure, e.g. autoclaving (can be essential with certain infectious waste which cannot be heat treated rapidly), larger site facilities or off-site facilities.

Characteristics —

- Low investment and operating costs for simple operations;
- Environmentally friendly;
- Not appropriate for tissue or carcasses;
- Trained operatives required.

These were not further considered in this Report, as the consultants considered incineration or microwave disinfection to be the only pragmatic choices for use in Central and Eastern European Regions.

The biggest advantage of this method in comparison to incineration is the absence of emission of combustion gases.

viii. Microwave Incineration

This valuable technique is outlined further in Section VII, Option 1, Incinerators, disinfection and associated units.

In principle, the following stages are involved:

- Waste is shredded;
- Waste is humidified for homogeneous heating;
- Microwaves rapidly heats the waste;
- Microbiological inactivation by heat conduction and radiation;
- Routine microbiological testing required;
- Waste is compacted for landfill, or ideally used as a fuel in power generation.

ix. Disposal to Land

Not recommended for untreated hazardous waste

Minimum requirements for land disposal include:

- No deposit on open dumps;
- A high degree of management control is exercised;
- Engineered to avoid leaking to water bodies and retain waste on site;
- Rapid burial of healthcare waste on site to isolate from animal or human contact.

Untreated hazardous healthcare waste should not be landfilled. It should only be undertaken as a last resort, if there is no other possibility available. Landfilling is preferred to leaving hazardous healthcare waste to accumulate at hospitals or in other public accessible places. More suitable treatment methods should be sought immediately.

Residues of untreated healthcare waste, which has been rendered not infectious, may be landfilled.

x. Landfilling in Municipal Landfills

In situations where hazardous healthcare waste cannot be treated or disposed elsewhere; the following can then only be considered:

- Within the site establish a designated location for hazardous healthcare waste;
- Very strict limited access to these locations;
- Bury the waste rapidly to avoid human or animal contact;
- Investigate and invest in more suitable treatment methods.

xi. Burying Inside Hospital Premises

The procedure should only be considered for remote locations and temporary encampments, largely in disaster areas. The following rules must be applied very strictly.

- Access to the site is restricted and controlled;
- Site lined with low permeable material;
- Only hazardous healthcare waste to be buried;
- Each deposit covered with soil;
- Groundwater pollution must be avoided.

In healthcare establishments applying minimal programs for healthcare waste management, particularly in remote locations, temporary refugee encampments, or areas experiencing exceptional hardship, the safe burying inside the hospital premises may be the only available procedure. Where this cannot be avoided, there should be rigid and basic rules set up and strictly enforced by the hospital management.

xii. Disposal to Land by Encapsulation

This involves the following:

- Fill metal or plastic containers to 75% with waste and fill up with plastic foam, bituminous sand, cement mortar, or clay material;
- When dry, seal containers and, subject to landfill, to restrict access to and reduce mobilization of hazardous substances;
- Can be used for sharps, chemicals, drugs, etc.

This process is cheap, safe and very appropriate to establishments that cannot envisage other methods to treat sharps, chemical and pharmaceutical waste. Encapsulation is not recommended for non-sharp infectious waste. It may be used in combination with oven burning of non-sharp infectious waste. The main advantages of encapsulation are to prevent even more effectively the risk of scavengers obtaining access to the landfilled waste and to reduce mobilization of toxic substances.

xiii. Inertization

This method involves:

- Remove packaging;
- Grind material (road roller)
- Add water, lime and cement;
- Then either, when dry, store or landfill; or, when wet, decant into municipal waste in landfill.

This procedure should be used only for chemical and pharmaceutical waste and incinerator ashes.

VII. HOSPITAL WASTE MANAGEMENT (COST ESTIMATION)

Option 1. Incinerators, Disinfection and Associated Units

For clinical (and general domestic type) waste, when coupled with energy recovery, waste incineration and associated thermal techniques provides an efficient, spatially compact means of bulk waste reduction, which is favored against landfill and, for clinical and infectious waste, provides the only current viable disposal options.

Following a brief history (United Kingdom), Section A; the benefits of incineration are outlined in Section B. Section C indicates the potential for incineration and Section D types including outline costing. By far the greatest benefits are derived from large regional incinerators with combined heat and power, and an example is shown in Section VIII. Section E summarizes alternative facilities.

One of the most important current environmental factors is the advantage of incineration (with combined heat and power) over landfill. Suitable landfill sites are becoming more difficult to obtain. These benefits are discussed in Section VIII.

Section F is the preferred choice for large scale regional incineration, and Section G emphasizes the consultants **Recommendations** (the lead Option) for large scale regional incineration.

The capital costs of incinerators vary widely. The cost of a small incinerator (~300 kg/day) suitable for the Szent Imre hospital would cost US $ ~750,000 to which US $ ~300,000 should be added to recover heat for economic hot water production (current cost US $ 1.9 per m^3) or US $ ~500,000 for an electricity generator (current cost of electricity US $ 0.05 per KW). A large regional incinerator, as indicated in F below, could cost US $ >20 million, but the unit tonnage costs would be less than for a small incinerator.

It is reiterated that strict emission controls would be required for any size of incinerator, but costs for sophisticated and continuous monitoring would be similar.

A. Brief History (United Kingdom)

The first meaningful solid waste incinerator was commissioned at Nottingham in 1874 and by 1912 there were 300 incinerators in the United Kingdom, 76 generating power from waste.

Provision of industrial and hazardous waste incineration capacity was primarily by the major chemical companies requiring in-house facilities, e.g. in the USA, the Dow Chemical Company installed the first rotary kiln in 1948.

The development of large-scale commercial or industrial sector hazardous waste incineration capacity has been largely post-1960.

B. *Benefits of Incineration*

Specific benefits include:

i. A reduction in the volume and weight of waste, especially bulky solids, with a high combustible content. Reduction of better than 90% of volume and 75% of weight of materials going to final landfill is achievable.

ii. Decomposition of certain wastes and detoxification of others to render them more suitable for final disposal, e.g. combustible carcinogens (cytotoxic drugs), pathologically contaminated materials (yellow bags, hazardous and infectious clinical waste), toxic organic compounds, or biologically active materials, which might affect sewage treatment processes, or in direct (as is the case in Budapest) to the receiving water (Danube river basin).

iii. Incineration is preferable to biodegradation of the organic component of waste which, when enclosed in a landfill site, generates methane, if this is not collected as a fuel source. Estimates suggest that landfill gas (methane) may account for >40% of the UK's total methane emissions to the atmosphere.

iv. The recovery of energy from organic wastes with sufficient calorific value.

v. Replacement of fossil-fuel for energy generation with consequent beneficial impacts in terms of the enhanced 'greenhouse' effect.

However it must be stressed that the proposals and subsequent construction of incinerators has in the last two decades met with significant public opposition.

In many countries, proposals for new plant have faced long delays and often refusal, existing plants closed, and even national waste management programs have been delayed or modified following protest (Spain, Australia, etc.). But currently, this is accepted widely as the main disposal route for waste in many parts of mainland Europe.

In all cases, the proposal for an incineration plant will need to demonstrate very clearly its need by means of **best practical environmental option** (BPEO) by, among other factors, identify the optimum balance in terms of emissions and discharges at reasonable cost.

In 1993, the UK's Royal Commission on Environmental Pollution[4] published a report on the incineration of waste which commended incineration as having a more important place within a general strategy of waste disposal techniques.

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[4] Royal Commission on Environmental Pollution, *Incineration of Waste*, 17th Report CMND 2181, HMSO, London, 1993.

C. *Potential for Incineration*

This can be considered in terms of:

i. Policy development;

ii. The economics of incineration;

iii. Environmental impact and risk assessment;

iv. Technology development; and

v. Public acceptance.

In 1993, within the United Kingdom, the quantity of clinical waste incinerated was 400,000 tonnes out of a total of 358 M tonnes, or 0.11%.

D. *Incinerator Types*

It should be noted that those hospitals, prior to the generation of hospital trusts in 1994, and hence the loss of Crown Exemption (1991), now rely (almost exclusively) on regional incinerators operated by specialist contractors. This is because of the extremely high emission controls exerted by the UK Environment Agency.

Also, in 1994, in the UK, costs for industrial clinical and hazardous wastes ranged from US $ 80 to US $ 3000 per tonne. Whereas landfill charges were US $ 86 to US $ 148 per tonne (which was raised substantially since the landfill levy of 1996). (Currently, 1998, US $ 16 per tonne for domestic waste and US $ 3.2 for construction waste — will be increased shortly.)

In the USA, local authorities work together to 'pool' their waste, so as to support plant of sufficient size to keep unit costs manageable. It is noticeable that recent private sector proposals for new plant in the United Kingdom, many are >400,000 tonnes per annum design capacity, and it has been estimated that beyond the minimum required base of 200,000 tonnes per annum, a doubling of capacity can produce a 26% decline in unit costs.

Clinical waste incineration has been following a similar pattern of up-grading, capacity increase, and also joint venture activities and multi-hospital facility provision following the National Health Service loss of Crown Exemption in 1991, and the designation of clinical waste incineration as a prescribed process under Part I of the Environmental Protection Act 1990.

The construction of large plants also means that more effective use can be made if the energy generated to produce heat and electricity.

E. Alternative Thermal Devices to Conventional Incineration

i. Microwave Disinfection Treatment

A Sanitec HG-A 250S microwave disinfection unit was inspected on Wednesday 12 August 1998 at the Chase Farm Hospital, Enfield, England, during the Study Tour (see also Technical Report No. 6, Appendix L) of the three Hungarian experts to the United Kingdom 3–14 August 1998. The manufacturers (USA) produce two versions:

- Sanitec GH-A 250S (250 kg/h) or ~ 1800 tonnes per annum. Cost US $ ~650,000; and
- Sanitec GH-A 100S (100 kg/h) or ~ 750 tones per annum. Cost US $ ~450,000.

The HG-A 250S unit, commissioned in January 1998, disinfects both clinical/infectious wastes from the Chase Farm Hospital, Enfield (~800 beds) and from other hospitals in the London area to make a total disinfection capacity of ~1800 hospital bed equivalent.

The completion costs of disinfection are US $ ~280 per tonne (compare conventional incineration costs of US $ ~400 per tonne) to which US $ ~80 per tonne needs to be added for external transport costs for the hospitals other than Chase Farm.

The operators of the facility at the Chase Farm Hospital (Polkacrest Ltd.) provide a complete contracted out service and have taken responsibility for the whole clinical waste facility. Polkacrest provide all 'yellow' bags, sharps containers, etc., and this is included in the cost of US $ 280 per tonne. The cost of individual containers was not disclosed (commercially confidential).

The disinfection unit firstly shreds the clinical waste and then following stream injection is treated with six sequential 1450 watt microwave units with a total dwell time of 40–50 minutes at 95 °C. The final waste can be further shredded, compacted and deposited in landfill. It is proposed for the future that this 'dry' disinfected waste which has a high calorific value might be usefully utilized as fuel power generation. The unit operates 24 h per day for 6–7 days per week.

Polkacrest would be willing to consider a similar operation in Hungary.

Note: This equipment is unsuitable for hazardous chemicals including cytotoxic pharmaceuticals and radioactive waste.

ii. Pyrolysis

Preliminary details and discussions were with EnviroWise Ltd. (EcoWaste Ltd.) concerning their batch parolysis unit, used largely for non-clinical, but some clinical waste in the USA and Canada. This device has received emission control approval from the United Kingdom Environment Agency (August 1998). Fabrication of this Canadian device is now planned for Birmingham, England, with a further possibility for Hungary.

This batch unit consists of two basic items: a primary combustion chamber, and an after burner unit (secondary chamber).

The basic steps of the operation include:

- The waste is charged into the primary combustion chamber and the door closed. Both the chambers are purged with air, when purging is complete gas oil (or in the case of Hungary waste vegetable oil) burners in the secondary chamber are ignited and operated at full output to raise the temperature to ~860 °C;
- The oil burner in the primary chamber is ignited for ~8 minutes to raise the temperature of the waste to >400 °C;
- Gases from the primary combustion chamber are drawn through the secondary after burner section by natural draft induced by a chimney (flue gas temperature ~400 °C if no heat recovery used);
- Tuyeres in the base of the primary combustion chamber distribute air to the base of the waste material and sustain low intensity combustion throughout the burning cycle;
- The gas from the primary combustion chamber is mixed with additional air and burnt at ~850 °C (can be as high as 1200 °C);
- Once burn-out of the waste is completed, all burners are shut down and the pyrolysis (primary chamber) unit is cooled for 8–10 hours to allow recovery of the solid residues from the primary chamber.

For semi-continuous operation several primary chambers can feed one secondary chamber.

Again, this unit is not suitable for cytotoxic or radioactive waste.

The cost of a 5 tonne/day unit, which for economic reasons should include all the waste generated by the Szent Imre hospital is US $ ~2 million. It is emphasized that because of the very considerable waste vegetable oil available in Hungary the fuel costs should be nil. (Currently cost of diesel in Hungary US $ 0.63 per liter and natural gas US $ 0.13 per m^3; total average disposal cost US $ 7.51 per m^3 — data kindly supplied by Professor K. Simon, Szent Imre hospital, August 1998 in US $).

EnviroWise Limited would be pleased to have an opportunity to introduce a unit(s) into Hungary, ideally commencing with the Szent Imre Hospital.

F. The Case For Large Incineration Facilities

Larger plants have the potential to improve the management, standards of operation, energy recovery and environmental pollution control. Larger plants have the added advantage that they should encourage private sector investment for long term (>15 years) contracts.

Waste heat recovery from combustion plant gases, i.e. from pyrolysis units, can be used to produce steam and/or hot water for hospital heating and if produced on a sufficient scale, steam can be used for district heating, for electricity generation, or for a combination of these.

Energy recovery is also desirable to maximize the contribution incineration can make to reducing emissions of greenhouse gases which would be caused by the alternative burning of carbon-rich fossil fuels, or from methane emissions from landfill sites.

Greater economics of scale may be made:

- If all the generated heat could be used usefully all the year round;
- If combined heat and power is used, due to seasonal variation in the demand for heat being offset by alternative electricity generation. The electricity can be used to drive plant, supply the host hospital, or export to a regional electricity facilitator (i.e. the national grid).

The economic justification for the above may be supported by the need of regional electricity generators to satisfy a *non-fossil fuel obligation* (UK only) for which electricity generation from waste will qualify.

Waste disposal contractors have constructed large incineration plants on industrial sites. Such locations are appropriate for large industrial plants, but if energy is not recovered and used efficiently, as it would be if they were located at hospitals or other energy purchaser sites, the economic and environmental costs can be high.

Building and operating new large incineration plants is a complex process, especially when heat recovery, electricity generation, etc., are added. High capital investment risk is taken by commercial companies, and the consequences of engineering, contractual and other failures have resulted in substantial problems for health authorities. In a spirit of optimism, such risks are sometimes ignored in the appraisal of schemes. It is important that careful checks ensure that private sector companies have made reasonable technical and market assumptions. In their eagerness to enter the market, large companies may make unrealistic assumptions, rendering their bid superficially more attractive. In the longer term, however, if a business is not sustainable on the original conditions, the host hospital may be left with redundant plant and very high disposal costs.

i. Management Responsibilities

Commercial arrangements can be flexible so that the host health undertaking may benefit from one or more of the following potential benefits, depending on its particular requirements, its financial situation, and its negotiations with its contractor and any consortium.

- Waste incineration at low cost;
- A steam or hot water supply generated for the host hospital by the incineration process. This may provide not only more flexibility in steam generation, but also savings in the cost of that steam or hot water;
- Rent from leased land;
- A share in profits gained by the contractor from incinerating imported waste from other hospitals;
- An electrical supply to hospitals, or a share of the profits from sale of electricity to others (if the project scale is of sufficient size);
- Possible savings in electricity charges to hospital supplies, if the amounts supplied to the contractor increase the hospital loads into more favorable purchasing categories;

- Reduced risk of legal action against the health authority or its offices, from the 'duty of care' (see also Technical Report No. 6 — Appendix N), environmental pollution, litter and other implications of environmental law;

- Guaranteed reliable services.

If a consortium of health authorities, each involving a number of hospitals, is formed the waste generators may enter into a contract to provide a guaranteed rate of waste arising for a period of time (e.g. 15 years economic life of the incineration plant).

In return for this, the contributors may benefit from:

- Waste disposal at below market rates;

- Guaranteed reliable service;

- A stronger legal basis for their contract by sharing the host health authority's remedies of a landlord;

- Greater control of waste from 'cradle to grave';

- Long-term contract with consequent minimum management requirements;

- Strength of influence derived from unity of neighboring health authorities/hospitals with common aims.

As an alternative, a hospital manager in contrast to the above arrangements may wish to seek a fixed price, no-risk, no-shared-benefits form of commercial arrangement.

ii. Waste as Income

Hospital managers should view their waste as a source of income, not a cost.

Hospitals need to purchase a number of expensive commodities. The ultimate disposal should be investigated thoroughly so that the most cost-beneficial means can be achieved for their disposal, examples include:

- Silver from x-ray and other photographic development (see also Option 2);
- Calorific value of waste;
- Minimization or miniaturization can incur very substantial cost benefits;
- Recycling;
- Good housekeeping.

Whilst a hospital under no circumstances must compromise on its healthcare, hospital managers should view waste as a salable commodity, not cost on resources and never allow it to become an expensive liability.

iii. Outline Program Guide

The hospital general manager should consider the following:

- Delegate responsibility for all aspects of waste management to a responsible person;

- Appoint independent professional advisers;
- Discuss informally all waste disposal aspects with relevant waste regulators;
- Discuss with neighboring health authorities/hospitals interest in consortium arrangements and rate of waste contributions;
- Investigate plans for compiling ventures with neighboring planning and health authorities/hospitals;
- Discuss informally with planning authority, local community, etc. Obtain opinion on maximum plant size, 'establish use' requirement for environmental assessment, etc.;
- Determine how effectively generated energy could be utilized and costs could be reduced;
- Prepare feasibility study, sketch design and cost estimate;
- Invite first-stage tenders for the various options for waste disposal, based on professional team's performance specification;
- Carry out option appraisal;
- Obtain confirmation of interest of potential consortium members and contribution to established costs of planning application;
- Apply for planning permission;
- Invite competitive tenders and enter into contract;
- Inform pollution inspectorate of reviewing program for compliance with environmental regulations;
- Monitor contractors' progress in applying for waste management licenses, authorization and registration as required by all relevant regulatory authorities.

G. *Mobile Incinerators*

For the record, mobile incinerators were briefly considered by the contractors, but as these are not in use for clinical waste in the United Kingdom, or practical for continuous waste disposal, were not further considered as a viable option for Hungary. This view is reinforced by the World Health Organization, who consider that mobile incinerators only have a role in disaster areas. Furthermore, during the Study Tour by the three Hungarian experts to the United Kingdom 3–14 August 1998, Dr. Bela Ralovich, senior special counselor to the Ministry of Health, indicated that mobile incinerators were not a viable option for Hungary.

In the majority of cases, it is preferable to transport the waste to a fixed (and large) incinerator rather than to transport a mobile incinerator to hospitals generating waste. The costs of setting up and breaking down each incinerators for transport is considerable and involves additional maintenance requirements, provision of fuel and electricity, and severe problems with strict emission controls, which in some EU countries requires continuous monitoring with availability of data on the Internet.

A mobile microwave disinfection facility only requires electricity, water and compaction of the waste and is a far more attractive proposition and this is being explored further with Polkacrest Ltd.

H. Recommendations

Whilst both the microwave disinfection and the pyrolysis units offer certain advantages, e.g. could be installed at the Szent Imre hospital for the treatment of the Szent Imre hospital waste only, or with waste imported from other hospitals. The contractors are firmly of the view that the preferred choice of options outlined above is a regional large scale incinerator as outlined in Section F above.

Option 2. Chemical Waste Disposal (Non-Clinical Waste)

Within the Szent Imre hospital's pathology department, the five principle waste chemicals are acetone and ethanol (see A below), xylenes (see B below), chloroform (see C below), and formaldehyde (see D below). It is emphasized that during the current disposal regime of mixing solvents at the Szent Imre hospital for disposal as hazardous waste that acetone and chloroform could be mixed gives rise to the formation of highly toxic carbonyl chloride gas.

Section E describes processes for the recovery of silver from x-ray film processing. This is a matter of great importance to the Hungarian hospitals as, in the case of the Szent Imre hospital, an initial investment of US $ 24,000 would be required, recoverable over two years. For future years a saving of ~10–15% of their total waste management costs should be achievable.

Section F indicates solutions to the significant problem at the Szent Imre hospital resulting from mercury spillage incurring potentially very serious health and environmental consequences. These originate from three sources:

- Use of mercurochrome. This should be replaced with povidone iodide (manufactured in Hungary). Inquiries made in the United Kingdom regarding comparative costs between mercurochrome and povidone iodide were not possible as mercurochrome was last used in the United Kingdom in the early 1970s;

- Dental drilling. The use of interceptors on the drains from the three dental chairs should overcome the discharges of mercury from this potential source; and

- Thermometer Breakage. This is of paramount importance to the Szent Imre hospital and Section F outlines recommendations for mercury thermometer replacements.

To reiterate, the high thermometer breakage rate leads to possible adverse health effects to both patients and nursing staff and additionally causes mercury pollution (mercury is an EC 'red list' prescribed substance) to the aquatic environment.

Procedures for action for mercury spills are also outlined in Technical Report No. 6 — Appendix M, which are reproduced below for clarity.

The primary solution is to ascertain whether alternative, safer and environmentally more acceptable substances might be used; if not, the following solutions are available.

A. Acetone and Ethanol

In principle, if it were possible to segregate the acetone and ethanol wastes from the chloroform waste; the acetone and ethanol could be discharged to drain. However, it is emphasized that the quantities should not exceed 2 liter/day each. Upon 10-fold dilution, this would not present a fire or explosive hazard. Both acetone and ethanol are readily biodegradable and would present no adverse environmental effects to the receiving sewers, the sewage treatment facility, nor after $>10^5$ dilution to the Danube river. (See also Technical Report No. 1 — Waste Management Master Plan, Section V) It is not possible to indicate the cost saving as the acetone and ethanol are currently co-disposed with the chloroform.

To assist the hospital authority, municipalities and ministerial scientists, details of the toxicology and ecotoxicity are shown in Technical Report No. 6, Appendix K.[5]

A further option is the use to use the acetone and ethanol as fuel for the spirit lamps in both the Pathology department and the nearby Polyclinic where bacteriology is undertaken. Obviously, if acetone and ethanol were to be disposed of as indicated above, there will be **zero costs** involved, i.e. a saving of US $ ~ 140 per tonne.

B. Xylenes

Other than controlled burning on site, there is no alternative than incineration. Controlled burning on site is not advocated, due to both safety and environmental requirements and also capital cost. However, as xylene (and indeed acetone and ethanol) have considerable calorific value, a low price for their incineration should be negotiated.

A further alternative would be to consider in-house recovery. This would incur some capital cost for the distillation/purification equipment, and technician time. There would also be the need to be wary of the explosive/fire hazard.

Xylene might also be used for fuel for hospital ground facilities, e.g. grass cutters, or adding to the hospital's diesel emergency storage tank — if regulators permit.

The collection and bulking of such waste solvents from all the hospitals in the Budapest area might produce a sufficiently large volume to be viable for a chemical recovery facility.

Solvent waste recovery is now a lucrative business within the European Union Member States.

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[5] Richardson, M.L. and Gangolli, S. *Dictionary of Chemicals and their Effects (DOSE)*, The Royal Society of Chemistry, Cambridge, England, 1992—1994, 7 vols., pp. 6853.

In-house recycling might also result in a sub-standard material, which would then waste high-grade medical assessment of slides, etc. The purchase of the requisite analytical chemical equipment to check the purity of the recovered solvents would be prohibitively expensive. It should be noted that this equipment would not normally be used as part of clinical diagnosis.

C. Chloroform

There is no alternative to incineration for the safe disposal of chloroform. It was gratifying to note that during the Training Sessions at the Szent Imre hospital 7–11 November 1998 that chloroform was no longer being used which is in common with that observed during the Study Tour to the United Kingdom 3–14 August 1998 (see Technical Report No. 6 — Appendix K that chloroform is very rarely used in pathology departments in the United Kingdom. Furthermore, chloroform should **not** be mixed with acetone as highly toxic and volatile carbonyl chloride can be formed.

D. Formaldehyde

The consultants were surprised to learn that the Hungarian Ministry of Environment and Regional Planning had stricter regulations than that for the United Kingdom in not permitting the discharge of formaldehyde to drain. (See also Technical Report No. 1 — Waste Management Master Plan, Sections I and V and Section VIII below.)

As the quantity wasted from the Szent Imre hospital is only 1–2 liters per day, this, bearing in mind the dilution factors, i.e. 2 liters in 65,000 m^3/day at the sewage treatment facility or 650 m^3/sec in the Danube river, is negligible. This excludes the deactivation of the ecotoxicological effects of formaldehyde in sewage.

A PEC/PNEC ratio, see Technical Report No. 1 — Waste Management Master Plan, Section V, B, and Technical Report No. 6 — Appendix F showed that the PEC/PNEC ratio was $\approx$0.05, which is considerably $<$ 1.0. Above one, a risk reduction procedure should be instigated. Section V, B is reproduced for clarity.

It was noted that during the Study Tour to the United Kingdom 3–14 August 1998 that most British pathology departments in hospitals discharge waste formaldehyde to drain. During the visit to Thames Water plc., 4 August 1998, their trade effluent expert was agreeable to such discharges. (Note: One of the consultants, Mervyn Richardson, was employed by Thames Water 1975–1989, and this expert was advised by Mervyn Richardson in such matters.)

It is **Recommended** that the concept of simple risk assessments should be development with the Hungarian Ministry of Environment and introduced into Hungarian legislation at the earliest possible opportunity.

Hence, it is **recommended** that this regulation should be relaxed.

An alternative would be to consider oxidizing the formaldehyde under alkali conditions (sodium hydroxide) with hydrogen peroxide, and disposing of the resultant sodium formate.

If the Hungarian Ministry of Environment is not sympathetic to the above, then it is **recommended** that laboratory experiments should be undertaken. Either of the foregoing would result in significant cost savings.

It should be noted that formaldehyde is not listed in Schedule 1, Part 1 (Listed Substances) of the United Kingdom 'The Control of Pollution (Special Waste) Regulation 1990, SI 1980 No. 1709, but see also recommendation that a carcinogen should not be greater than 1% w/w of the waste. The 2 liter/day of formaldehyde represents only 0.0005% of the aqueous waste for the hospital. (See also Technical Report No. 1 — Waste Management Master Plan, Section VI.)

Discharge to drain of the formaldehyde would result in a cost saving to the Pathology department (assuming departmental cost control was operational) of US $ ~140 per annum. This cost has risen by 59% during the period 1995—1997.

B. Formaldehyde (10% Aqueous Solution)

(Reproduced from Technical Report No. 1 — Waste Management Master Plan)

Estimated quantity discarded 500 liters/annum, i.e. ~50 kg H.CHO/annum.

Whilst formaldehyde is a known carcinogen, it is the professional view of the consultants that this small quantity of formaldehyde can be discharged to drain.

The United Kingdom Statutory Instrument 1980, No. 1709 *The Control of Pollution (Special Waste) Regulation 1980*, Schedule 1, Part II (See Section VI, Special Waste), attempts to quantify the meaning of substances which are 'dangerous to life'.

Furthermore, the former London Waste Regulation Authority (now the Environment Agency) recommends that special waste *shall not contain known or probable human carcinogens at a concentration of 1% w/w or more.*

As it would appear that the Hungarian Environmental Regulations are more stringent than the British and EU, consideration should be given to the relaxation of these regulations, at least for such modest discharges from hospitals.

It should be borne in mind that dilution within the Pathology department, and with the further dilution within the overall hospital waste water, that the predicted environment concentration (PEC) in both cases would be <1.

For the record the calculated concentration based on 50 kg H.CHO in the Danube river flow, 650 m^3/sec is ~0.03 μg/l, which is less than the 0.1 μg/l used by Thames Water Authority's Catchment Quality Control studies undertaken by one of the consultants (MLR) 1976—1989.

A predicted environmental concentration of 0.03 μg/l is well below the predicted no effect concentration (PNEC) of most freshwater aquatic organisms, see Part 6 — Appendix K, viz. LC_{50} (96 hr) bullhead 62 μg/l, and bluegill sunfish 100 μg/l, allowing a safety factor of 100 means that the PEC/PNEC ratio is 0.03/0.62 = 0.05, and hence, very significantly less than one. Thus the risk potential to the Danube river from the potential discharges from the Szent Imre hospital is negligible. Furthermore, formaldehyde is readily biodegradable.

If the Hungarian regulatory authorities wish, in the light of the foregoing, to maintain their position, then the laboratory may wish to consider oxidizing the formaldehyde with hydrogen peroxide and sodium hydroxide to yield sodium formate.

A further alternative would be to convert the formaldehyde to paraformaldehyde which has in the United Kingdom a waste re-use potential. However, 50 kg per annum would be too small to make this option viable.

Hence, it is **recommended** that the Hungarian Ministry of Environment and Regional Planning revise their regulations to permit the discharge of 500 liters of 10% formaldehyde solution per annum (i.e. 1—2 liters/day) to drain.

This matter should be included in the International Workshop w/c 2 November 1998 as an example of the value of PEC/PNEC ratios.

It should be remembered that the larger safety consideration is the risk of nasal cancer from an occupational health viewpoint.

It should be noted that according to the analysis undertaken by Spectromass Analytical Laboratory Limited (Budapest) that the formaldehyde in the drinking water at the Szent Imre hospital can be 3.2 — 11 μg/l which is a matter of very considerable concern.

E. Silver Recovery

The Szent Imre hospital operates five major film processing units and some smaller units. Overall, ~400 m^2 of x-ray film per week are exposed and developed, which incurs disposal of ~2500 liters of developer and ~3500 liters of fixer solution as hazardous waste.

In 1997, the hospital incurred a waste disposal charge for these of HUF ~120,000 (US $ ~600), and whilst some silver was recovered, no income was received.

The following should be considered:

- X-ray film normally contains 8–10 g of silver per m^2;
- 50–80% of this silver is removed during processing; or 3–5 g silver per m^2; thus, for 400 m^2 per week, 1.6–3.5 kg of silver is solubilized per week;
- The current price of silver is US $ ~160 per kg;
- Therefore, it should be possible to recover US $ 260–550 weekly, or US $ 12,000–28,000 (HUF 2.5–5.5 million) per annum.

It has been ascertained that units are available, and when placed in-line will recover silver from the photographic solutions, electrolytically, and reduce the silver content of the effluent to <1 mg/l, and would save the costs of disposal of the developer and fixer solutions, which could then be discharged directly to drain.

It should be noted that EC[6] and UK[7] legislation for silver in drinking water is 10 μg/l. Results from the effluent analysis undertaken by Spectromass Analytical Laboratory Ltd., Budapest in 1997, showed that both the potable water and the effluent contained <10 μg/l.

[6] Council Directive of 15 July 1980, relating to the quality of water intended for human consumption (80/778/EC); *Official Journal of the European Community* No. L 229/11, 30.08.1980.
[7] The Water Supply (Water Quality) Regulations 1989, Statutory Instrument SI 1989, No. 1147, HMSO, London.

The simplest unit to achieve silver recovery to <1 mg/l is US $ ~5000. Running costs are low (~200 watts of electricity). If such units were to be installed in-line on the five larger film units, and solution from the smaller units transferred to these units for silver recovery, there would be an initial investment of US $ ~24,000 (HUF ~5 million) requirement. This should be recovered within less than two years. (Equipment costs obtained by Dr. D.H. Lohmann, June 1998.)

Furthermore, the 20–50% silver remaining on the film might be recovered from the film when its storage period (usually five years) has been reached. Thus, it should be possible to recover a further US $ 3000–13,000 (HUF ~0.6–2.5 million) per annum, less any recovery charges per annum by removal of the silver from end-of-date processed film.

It is strongly **recommended** that silver recovery units be acquired and installed to all five major film processing units. The pay-back period for these units should be less than two years. Thereafter, it should be possible to recover HUF ~2.5 million per year, which represents a substantial percentage of the hospital waste disposal costs. Further savings in terms of fixer solutions and from wash waters are feasible. It should also be possible to recover a further HUF ~0.6 million from recovering silver from end-of-date processed film.

F. *Mercury Thermometer Replacement*

i. Broken Mercury Thermometers and Mercury Sphygmomanometers

During the May 1998 waste audit it was reported that 300 mercury thermometers are purchased each month at the Szent Imre hospital to replace the 200 breakages and a further 100 which are 'lost'. This has resulted in mercury, together with mercury from dental fillings, and from the use of mercurochrome being discharged to drain. This was observed from the analyses undertaken by Spectromass Laboratories Ltd., in 1997. In addition to the pollution to the aquatic environment, there is a serious potential health hazard to patients (especially chronic) and to staff from mercury vapor in the wards.

The following indicate viable alternatives:-

ii. Replacement with Electronic Devices

Cost implications

Item	US $	HUF
Cost of mercury thermometer (each)	1.90	356
Per month (200)	380.00	80,000
Per annum (200 x 12)	6840.00	1,440,000
Cost of digital thermometer (each)	11.50	2,410
Initial cost of say 200 at US $ 11.50 each	2300.00	483,000
Cost of mercury sphygmomanometers	66.00	13,800
Cost of aneroid sphygmomanometers	74.00	15,500

It should be possible to obtain at least a 10 % discount from the United Kingdom supplier, who quoted these costs. During the visit to the Chase Farm hospital on 12 August 1998, it was reported that the cost of mercury thermometers was US $ 135 for

150 at a bulk purchase price for the hospital trust, i.e. US $ <1.00 per thermometer. It was noted that the breakage rate was in the order of one per six weeks. Compare the Szent Imre hospital of ~200 per month. The thermometers in use at the Chase Farm hospital also appeared to be considerably more robust than those at the Szent Imre hospital. The Chase Farm hospital, in common with other British hospitals visited in August 1998, had a very strict mercury spillage procedure, as outlined in Technical Report No. 6 — Appendix M, reproduced below for clarity.

iii. Recommendations (Mercury Thermometers)

Therefore, it is **Recommended** that the mercury containing instruments are phased out in favor of mercury-free, electronic devices. Thereby, a major source of environmental mercury contamination and occupational health hazards would be removed. There would remain the problem of residual mercury in the many cracks in the floorings — this should be given high priority for deactivation/collection using flowers of sulfur/zinc dust as outlined in Technical Report No. 6 — Appendix M.

In view of the greater strength of the electronic devices, there will be much lower breakages and less requirement for replacements. As a result there will be cost savings for thermometers, after the initial replacement; and for sphygmomanometers, the savings will be immediate.

The hospital management will need to give very serious through to prevention of 'losses'.

APPENDIX M: MERCURY SPILLAGE

(Reproduced from Technical Report No. 6 — Appendix L)

Metallic mercury is the only liquid metal at room temperature and has a **highly toxic vapor**. Inorganic mercury compounds and organic mercury compounds are all **toxic**.

I. First Action

i. Instruct others to keep well away from the spillage area (where this is possible);
ii. Open windows. **Good ventilation is paramount;**
iii. Decide whether to control the spillage, if small, i.e. broken thermometers; or if large evacuate the building by sounding the fire alarm and calling the emergency services.

II. Protective Clothing

Wear laboratory coat, rubber/plastic gloves, self-contained breathing apparatus or approved canister respirator for mercury vapor.

III. Small Spills

i. If spill is metallic mercury, remove by suction into a plastic bottle. Treat the affected area (floor, table tops, etc.) with a mixture of equal parts of flowers of sulfur and calcium hydroxide in water to form a paste; or, cover the spill with zinc power to form an amalgam.
ii. The mixture, which has the appearance of distemper, should be applied liberally and allowed to dry on the contaminated surfaces.
iii. Allow at least 12 hours to elapse before removing the dried yellow mixture with clean water. Repeat to ensure the surfaces are clean.
iv. If the metallic-mercury spillage is small and spilt into the floor cracks and crevices, it should be made non-volatile immediately by putting zinc dust into the cracks in order to form an amalgam. If the contaminated area is a small room or confined space, monitor for mercury vapor using a mercury vapor detector a day or two after carrying out the spillage procedure to determine the concentration of

mercury in the atmosphere. A chemical reaction tube detector system is suitable for determining any significant contamination remaining.

IV. Large Spills

It is essential to contact the emergency services before any action is taken.
Full details of the toxicology and ecotoxicology can be found in Appendix K, Section V.

G. General Recommendations

The procedures recommended above for disposal of the chemicals used in the pathology department, as indicated above, and which can be implemented immediately will result in an instant economic benefit. The disposal of the water miscible chemicals, viz., acetone, ethanol and formaldehyde, was discussed with all participants at the Training Sessions held at the Szent Imre hospital 7—11 September 1998. There was a basic concurrence with the consultants' advice, but it was stressed that the Hungarian Government Degree No. 102/1996 (VII.12.) Korm, would require to be amended.

The recovery of silver and its sale as scrap silver will result, after a pay back period of two years, in an economic benefit, and which can then be used to reduce the Szent Imre hospital total waste management charges by ~10–15%. It was noted during the Training Session that the Szent Imre hospital would not be allowed to sell scrap silver directly on the open market — only via a licensed dealer.

The breakage of mercury thermometers is a major problem that must receive immediate management attention. The high cost of replacement mercury thermometers is an unnecessary drain on the hospital's scarce financial resources. If even greater importance is the considerable hazard and risks from inhalation of mercury vapor by especially chronic patients and nursing staff; additionally, there is the discharge of mercury, an EC 'prescribed' substance to the aquatic environment. To assist with this acute problem it is proposed that the masonry floors be resurfaced with good quality 'seamless' plastic flooring, with rounded corners onto the adjoining walls.

It is further **recommended** that general housekeeping should be maintained at the highest possible levels.

VIII. OPTIMAL (COST-EFFECTIVE) ACTION AND PRIORITIZATION, INCLUDING REGULATORY ASPECTS

Referring to the options included in Section VII above, Section A develops the important and overall choices that the Government of the Republic of Hungary, the municipalities and any region within Central and Eastern Europe, will need to make when considering disposal of clinical waste, either separately, or in combination with municipal waste. One of the greatest challenges facing such authorities is the question of disposal of waste to landfill versus incineration. These basic issues are addressed in detail in Section A.

It can be observed from Table 14 that incinerators utilizing combined heat and power have very considerable advantage over disposal to landfill, even when methane recovery and energy generation can be practiced.

Figures 1 and 2 indicate the pathways and how energy can be recovered to a cost-effective advantage. One of the aspects of incineration is the strict regulatory requirements for air emissions from incinerators and the United Kingdom limits and these are shown in Table 15.

Emphasis should be given to the management and related aspects outlined in Section VII, Option 1, F, i–iii, and these are further developed in Section A,f, below as a case example of the South-East London combined heat and power station.

Section B develops the cost-effectiveness which can be applied to chemical waste (non-clinical waste) disposal

There are a number of other areas requiring effective and high priority action. From a materialistic, and on health grounds, the quality of the potable water supply to the Szent Imre hospital is of critical importance. This vital aspect, together with outline views on sewage treatment are given in Section C below, outlining the economics of water management.

Section D develops the concept of effective waste management within hospitals by including a job description of a clinical waste control officer.

Section E lists some of the more important EC legislation. From a pragmatic viewpoint in the development of national legislation, simple measures such as PEC/PNEC ratios and gearing of the development of legislation to the country's ability to monitor discharges and enforce the legislation with due regard to training, are high priority issues.

Section F develops the objectives and rationale for training in healthcare waste management. Details are provided in Technical Report No. 4 covering the Training Sessions held at the Szent Imre hospital 7–11 September 1998.

Section G provides suggestions for prioritization.

A. *Landfill Versus Incineration*

There are a number of unpriced environmental costs and benefits often referred to as 'externalities' associated with landfill and incineration; the two main waste disposal options.

Whilst it is fairly straight forward to identify the type of externalities associated with landfill and incineration — such as negative amenity criteria including litter, noise, smell and local disturbance; air and water pollution; global atmospheric and transport effects — they are far more difficult to express in monetary terms.

In 1993, the United Kingdoms Department of the Environment assessed from studies[8,9] that a levy in the range US $ 8–12 per tonne of controlled waste (primarily household, commercial, and

[8] Department of the Environment. *Landfill completion: a technical memorandum providing guidance on assessing the completion of licensed landfills*, 1993, pp. 48, HMSO, London.

industrial waste) to landfill was justified if the international benefits of air pollution displacement from energy recovery was taken into account; and US $ 5–9 per tonne, if only the UK benefit were included.

This deduction reflects the difference between the externalities of landfill and incineration. It is largely influenced by the costs attributed to the global warming effects of methane leakage from landfill sites; and the environmental benefits of displacing energy from fossil fuel combustion with that recovered from the incineration of waste. The extent to which these, or other, elements differing between landfill and incineration externalities might be addressed by other measures would also have implications for the setting of a levy.

Other factors need to be considered, including: whether landfill sites and incinerators are located in urban or rural areas and whether there is energy recovery from landfill or not.

The implication of a levy, which in turn will lead to stricter controls, need to be considered with caution:

- Considerable uncertainty attaches to both the measurement and valuation of waste disposal externalities — these are generally expressed in terms of a range of values. The potential costs and impacts of greenhouse gas emissions are particularly uncertain, given the current lack of understanding concerning the likely impacts of global warning. For this reason the response to any threat of global warming has to be based on a precautionary approach.

- Adverse amenity costs are difficult to include in any estimate. Such costs are invariably associated with the presence of a site or a plant rather than the flow of waste; and that such costs do not vary in practice between incineration and landfill costs.

a. Introduction

Economic instruments have special attractions in the field of solid waste management.

Since there are various options for waste disposal — re-use, recycling, treatment, incineration, landfill, are the main ones — and for the reduction of waste at source, changes in the cost of one disposal route should encourage diversion of waste to other routes.

Governments, and especially those in the Central and Eastern European Region, should begin a process of using price mechanisms to change the flow of waste going to different disposal routes, with a presumption in favor of more waste recycling, through the introduction of recycling credits. Governments should investigate other means to reduce the flow of solid waste and to encourage the remaining flow to the least environmentally damaging disposal routes. Solid wastes charges, especially a landfill levy, are a good candidate.

There is an economic argument that a levy on landfill sites should bear some relationship to the *external costs* associated with landfill. An external effect is any loss of human

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[9] Department of the Environment, *Externalities from landfill and incinerator. A study (Warren Spring Laboratory)*, 1993, pp. 150, HMSO, London.

well-being associated with a process which is not already allowed for in its price, e.g. the lack of amenity from unsightliness, noise or pollution.

Such external costs might include:

- The reduction in amenity value of landfill and incineration sites.
- The contribution that each disposal option makes to global warming risks through release of carbon dioxide, and the added contribution from methane releases from landfill.
- Damage caused by conventional air pollutants (such as sulfur dioxide, nitrogen oxides (NO_X) and particulates from incinerators.
- Damage caused by airborne toxic substances from incinerators, in particular TCDDs.
- Damage caused by leachate from landfills.
- Pollution and accidents associated with the transportation of the waste to landfill and incinerator sites — in this connection, additional costs, including road congestion, road wear and tear and noise might need to be considered.

It should be stressed that both landfill and incineration can result in the recovery of energy. Whilst the economic value of the recovered energy is not an externality (its value affects directly the costs of operating a site and therefore the price charged for the proposal, energy recovery will act to displace the least profitable form of electricity generation in the power generating system). Hence it will displace some pollution from those sources. This is an example of *external benefit*.

It should be remembered that there is now an ultimate lack of landfill sites, partially because of the more environmentally sustainable use of (road) construction materials.

b. Externality

It is suggested that externalities associated with landfill and incineration have the following components:

- Reduction in amenity value of the site. This is likely to vary with the size of the site and to a much less extent on tonnage. This might be called a *fixed externality* component.
- United States information proposes from economic valuation studies, that it is expressed preferably in terms of money values for household per site, rather than money values per tonne of waste.
- Other externalities are most likely to be related directly to the amount of waste that is being disposed of (discarded), e.g. carbon dioxide and methane emissions.

These can be termed *variable externality* components. It is possible to estimate these externalities as a money value per tonne of waste.

c. Methodologies

i. Reduction in Amenity Values

- Estimates can be made, if data exists, for these to be derived from either contingent valuation or hedonic and property price approaches.

- American data suggests fairly consistent valuations per household, and a radius of 6 km from a landfill site as a cut-off. No corresponding distance was found for incinerator sites.

- The US has derived a figure of US $ ~250 per household per year to avoid being located near to a site.[8,9]

ii. Variable Externality

- For other aspects of environmental impact, it is possible to estimate a money value per tonne of waste. This is based on a basic procedure to estimate an *emission* or *input coefficient* per tonne of waste, and to apply a per unit economic value to that coefficient, e.g. if one tonne of waste results in p tonnes carbon dioxide emission, and one tonne of carbon dioxide results in US $ q of economic damage, then one tonne of waste is associated with US $ $p \times q$ of economic damage.

- When estimating externalities relevant to a future design of a levy system, the externality per tonne of waste landfilled needs to be compared with the externality per tonne of waste incinerated. However, the components of the tonne of waste incinerated are different from those in the tonne of waste landfilled. The incinerated tonne contains combustible material (and resulting ash). The landfilled tonne contains combustible as well as non-combustible material. However, when a tonne of waste is incinerated, up to 33% (often less in the case of clinical waste) weight will remain as ash which is then transported to landfill, and this has to be allowed for in the calculations; but the ash can be used usefully for recovering metals or for construction purposes.

- It is necessary to consider how future waste disposal facilities will interact with existing, on-going and future legislation. Future incinerators will require stringent controls over the emission of air, toxic substances (TCDDs etc.), and will generally be of the waste-to-energy type. (This would incur an additional capital cost if individual incinerators were to be considered for isolated hospital sites.) In turn, this effects emission coefficients. Future landfill sites will need to practice methane recovery.

- In order to take into consideration the variations, different scenarios are needed to cover:

  - Urban and rural sites for landfill;
  - landfill with and without methane recovery;
  - urban and regional incinerators with/without combined heat and power.

- The stages in the formulation of these scenarios can include:

Stage 1: Estimate the composition of waste streams to landfill and incinerators.

Stage 2: Estimate the composition of the *average* tonne of waste going to landfill and the *average* (different) tonne of waste going for incineration.

Stage 3: Formulate and calibrate *four landfill* scenarios:

L_1 Existing urban landfill, no energy recovery
L_2 New urban landfill, energy recovery
L_3 Existing rural landfill, no energy recovery
L_4 New rural landfill, energy (electricity) recovery.

Formulate *two incinerator* scenarios:

I_1 New urban incinerator, energy recovery
I_2 New regional incinerator, energy recovery.

Stage 4: Estimate emission to impact coefficients for each of these scenarios per tonne of waste.

Stage 5: Identify the physical impact recovery to the following externalities:

- Reduction in amenity value
- Global warming
- Conventional air pollutants
- Air toxicants (TCDDs, etc.)
- Leachate
- Transportation effects
- Pollution displacement effects

Stage 6: Apply economic valuation to each of these impacts: aggregate these values and express them as net external costs per tonne of waste.

iii. System Boundaries

Impacts include:

- Global warming;
- Ozone depletion;
- Acid rain.

Is the damage to a country confined to that country, or beyond to further countries?

d. Economic Valuation Results

i. Overall Routes

Those for landfill and incineration suggest:

- Landfill sites with energy recovery may be responsible for net external **costs** of between US $ 1.6 and 3.2 per tonne of waste plus a reduction in amenity element;

- Landfill without energy recovery may have net **external costs** of between US \$ 5.5 and 6.5 per tonne plus any reduction in amenity costs.

- New incinerators have net external **benefits** of US \$ 6.4 per tonne waste if account is taken of the air pollution displacement for the whole of the EU Region (this would need to be amended if and when the EU is expanded to include Central and Eastern European countries) and about US \$ 3.2 per tonne of waste if restricted to UK **plus** the reduction of amenity effects, and is a replacement for fossil fuels.

- The difference between the mean net external cost values for landfill and the mean net external benefit value for incineration is of the order of US \$ 8 to 12 per tonne of waste including air pollution displacement from energy recovery for the whole EU Region and US \$ 5 to 10 if restricted to UK.

Tables 14 and 15 indicate the total externality estimates which might be used to promote the setting of a landfill levy.

Table 16 shows differences in the externalities for landfill as compared to incineration.

Table 14. Summary of variable external values for waste going to landfill US \$ / tonne waste in 1993[8,9]

	L_1	L_2	L_3	L_4
Global Pollution				
CO_2 as C	0.52	0.73	0.52	0.73
+ CH_4	3.78	2.18	3.78	2.18
+ Air Pollution	n/a	n/a	n/a	n/a
Transport Impact				
Pollution UK	0.14	0.14	0.61	0.61
Pollution EU	0.16	0.16	0.46	0.46
Accidents	0.73	0.73	0.88	0.88
Leachate	0.72	0	0.72	0
Pollution Displacement				
UK	n/a	1.30	n/a	1.30
EU	n/a	1.82	n/a	1.82
Total Mean				
UK	5.52	2.13	6.50	3.11
EU	5.52	1.65	6.64	2.75

Table 15. Summary of externality values for waste going to incinerator US $ / tonne waste in 1993[8,9]

	I_1	I_2
Global Pollution		
CO_2 as C	4.08	4.08
+ CH_4	n/a	n/a
Air Pollution		
Conventional UK	2.62	2.41
Conventional EU	3.21	1.84
Toxicants	not estimated	—
Transport Impact		
Pollution UK	0.36	0.58
+ EU	0.42	0.67
Pollution Displacement		
UK	10.87	10.87
EU	15.00	15.00
Total		
UK	-3.66	-3.36
EU	-7.01	-6.54

Table 16. Schemes of externality values for landfill and incineration for hypothetical waste disposal situations

	Max. Incineratable tonne to incinerator US $	**Max. Incineratable tonne to landfill US $**	**Max. Landfill tonne to landfill US $**	**Only — 'non-Incineratable' (inert + putrescible) to landfill US $**
L_1	—	7.44	5.66	3.90
L_2	—	2.14	1.60	1.17
L_3	—	8.80	6.78	4.80
I_1	-7.38	—	—	—
I_2	-7.01	—	—	—

There is a difference in the externalities for landfill as compared with incineration for the same average tonne of waste (maximum incineratables) of between US $ 9 and 16 per tonne; and a fairly small reduction in externalities of landfill where incineratables are removed from the waste stream.

Table 17 indicates air emission limits for waste incinerators in the United Kingdom.

Table 17 Air emissions limits for waste incinerators. UK — HMIP limits

	New plant under integrated pollution control mg/m^3
Total organic carbon	20
Particulates	30
Hydrogen chloride	10
Hydrogen fluoride	2
Sulfur dioxide	300
Nitrogen oxides (as NO_2)	350
Total acidity (as SO_3)	—
Cadmium and thallium	0.1
Mercury	0.1
Other heavy metals (Total)	1.0
Dioxins and furans	1 ng/m^3

e. Observations

i. Landfill may appear to yield benefits because land is reclaimed through infilling, permitting the land to be used for purposes or otherwise would have been unable to support. However, from an economic standpoint, this benefit is either non-existent or negligible. The price paid for the landfill site should already include the expected value of future uses of the reclaimed land; hence there is *no* additional benefit to be considered. The current diminishing number of available landfill sites also needs to be considered.

If the future use is one of which yields non-marketed benefits, e.g. a wildlife reserve; in which case the *social* value of the future land use may exceed the *private* value of the land. It would then be legitimate to *add* this difference in value as a benefit to landfill. The relevant calculation is then the discounted value of this difference from the *end* of the life of the landfill site until some further date in the future. The effect of discounting is to make this value almost insignificant.

ii. In considering incinerators for hospitals the paramount criteria is size and the vital requirement for incinerators to generate power.

The additional capital cost for electricity generation plus requirements for:

- Emission monitoring and very strict control;
- Maintenance of both the incinerator and the power plant makes individual incinerators at isolated hospital sites unattractive. However, several hospitals supporting one large central incinerator with power generation plant is attractive, especially if these are designed to accept chemical and other hazardous waste, in addition to clinical waste.
- Strict leachate/flue gas washings control.

iii. However, hospital managers should in all cases look towards waste minimization. Whilst this is difficult for clinical waste, it can be achieved for non-clinical waste and they should institute schemes for recovery of wastes such as glass, paper, plastics, metals, etc.

iv. In the early 1990s in the United Kingdom, 0.1 million tonnes of clinical waste out of a total of 102 million tonnes of waste went to landfill. By 1998, in view of the improved knowledge of the hazard this is likely to be <0.1% or even less. Whereas, 0.2 million tonnes of clinical waste out of a total of 3.9 million tonnes (i.e. 5%) were incinerated.

It is useful to consider the routes involved in landfill (Figure 1) and for incineration (Figure 2).

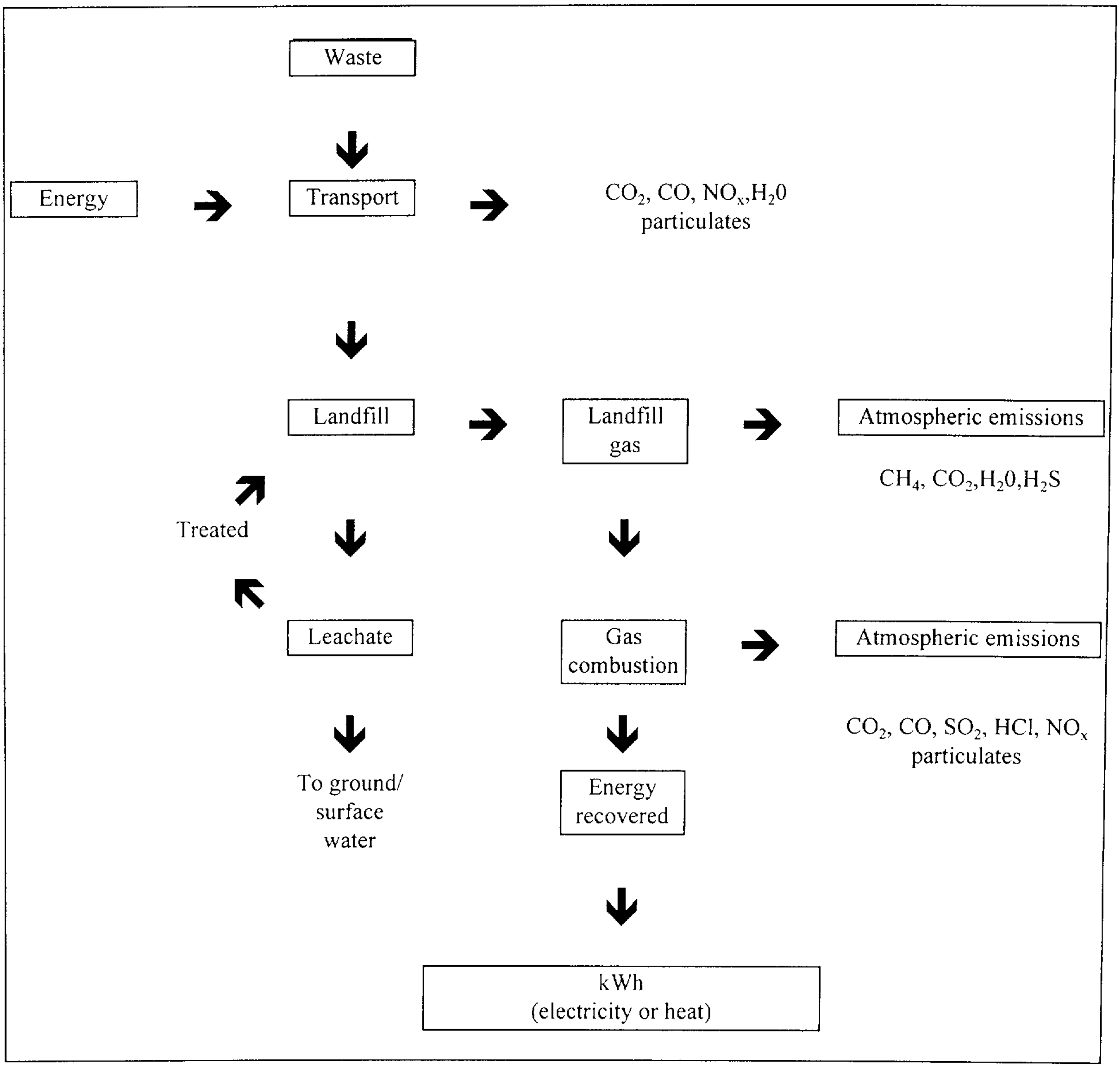

Figure 1. Waste disposal to landfill

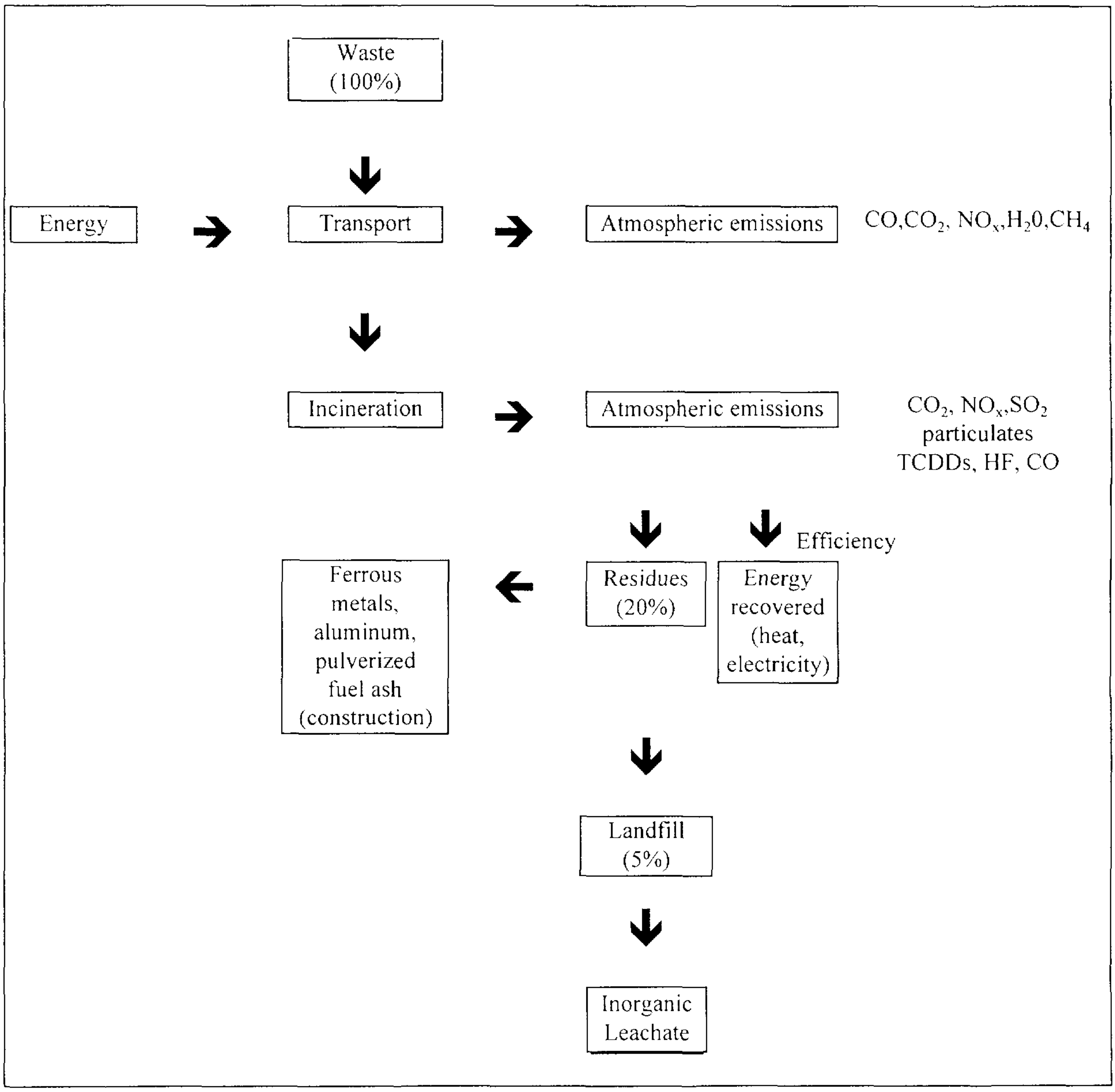

Figure 2. Waste disposal to incinerators

f. Municipal Waste Incineration with Combined Heat and Power

The principle is that combined heat and power (CHP) station can (and should) be fueled with municipal waste to which clinical waste can be added.

Such plants can reduce the volume of waste, down to ~10% and avoid the production of methane and other greenhouse gases, denature chlorofluorocarbons and other pollutants, and produce energy, either in the form of electricity or heat, which can be used by the local population and derive income from this recycled energy.

An example of a recent construction of such a CHP station is the South-East London Combined Heat and Power Station. This was started in January 1996 at a cost of US $ 130 million. The unit burns ~420,000 tonnes of municipal and commercial waste annually at an incinerator temperature of 1000 °C. This facility saves natural resources, as ~3 tonnes of municipal waste generates a similar energy output as ~1 tonne of coal. Considerable recycling is achieved:

- It generates ~35 MW of electricity, of which 3.5 MW is used internally, and the remainder used as power for 35,000 residences, it also has the thermal capacity to heat a further ~7,500.
- Through a system of magnetic separators, 20,000 tonnes of ferrous metals per annum are recovered and recycled into steel.
- There are plans in hand to recover aluminum by flotation.
- The final residue is an inert, biologically inactive solid that has ~10% of the original volume of the waste, which with some fly ash has the potential for recycling for the construction industry.
- The high-temperature incineration, together with the flue-gas treatment meets the requirements of the European Commission[10] and British regulations.[11]

In view of the requirement for size, possibility of electricity generation and strict emission standards (in the UK the Environmental Agency impose 1 ng/m^3 for release of dioxins) it is therefore **NOT RECOMMENDED** that the Szent Imre hospital consider the purchase of an incinerator.

The municipality should, however, consider the purchase as a major investment of a large scale incinerator with combined heat and power.

However, a microwave disinfection unit might be considered as an alternative, see Section VII, Option 1, E, i, or a pyrolysis unit, Option 1, E, ii.

B. Chemical Waste Disposal Management

There are a number of optimal (cost-effective) actions and prioritization that can be made concerning the safe disposal of chemical (non-clinical) waste generated within hospitals. Taking the case of the Szent Imre hospital, and as described in Section VII, many of these chemicals can be discharged to drain or recovery in a highly cost-effective manner.

i. Acetone and Ethanol

After suitable dilution (see also Technical Report No. 1 — Waste Management Master Plan, Section V) can be discharged to drain. The dilution factor is simply to obviate any flammability hazard as both are readily biodegradable. See also Technical Report No. 6 — Appendix K.

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[10] Council Directive 94/67/EC of 16 December 1994 on the incineration of hazardous waste. *Official Journal of the European Communities*, No. L. 365/34 31.12.94.

[11] Environmental Protection. The Environmental Protection (Prescribed Process and Substances), (Amendment) Hazardous Waste Incineration) Regulations 1998. Statutory Instrument 1998 No. 767.

ii. Xylenes

These need to be incinerated, or used as a local fuel source. In the case of incineration, a low cost should be negotiated in view of their high calorific value.

iii. Chloroform

Its use should be replaced (with xylene) wherever practicable.

iv. Formaldehyde

This, too, can be safely discharged to drain at no real cost. Whilst at the Szent Imre hospital, which discharges via a primary treatment sewage facility to the Danube river, a PEC/PNEC ratio was calculated as ≅ 0.05, resulting in a negligible aquatic risk. Formaldehyde in quantities of 1–2 liters per day, normal hospital pathology laboratory's daily disposal quantities are accepted by the United Kingdom water authorities for discharge to drain, albeit that sewage treatment facilities in the United Kingdom are almost totally secondary treatment with many being enhanced for tertiary treatment.

Hence, the restriction imposed by the Hungarian environmental regulations are too severe and require relaxation. Such a process of relaxation will need to include the calculation of a PEC/PNEC ratio to be incorporated into new regulations. (See also Section VII, G.)

v. Silver Recovery from x-ray Film Development

It was surprising to learn during the Waste Audit undertaken at the Szent Imre hospital in May 1998 (see Technical Report No. 2), that certain departments were paying for the disposal of silver.

As indicated in Section VII, E, such expenditure is totally unnecessary and it is very strongly recommended that on-site silver recovery units (cost US $ 5000 per unit — five required) should be purchased forthwith. The pay-back period is estimated as two years, whence a saving of >10% of the total waste management costs should be achieved. (See also Section VII, G.)

vi. Mercury

In addition to the cost implications given in Section VII, F, by far the most important issue is the hazard of mercury vapor inhalation by both (chronic) patients and nursing staff. There are also aquatic environmental consequences as mercury is a prescribed 'red list' substance.

The recommendations outlined in Section VII, F, should be given a very high priority rating.

C. Economics Of Water Management

a. Background — Szent Imre Hospital

The water consumption and costs for drinking water and sewage disposal are shown in Table 18.

Table 18. Water consumption and costs for drinking water and sewage disposal

		1995	1996	1997	1998
Drinking Water	HUF/m^3	39.3	45.0	56.4	68.0
Effluent	HUF/m^3	38.0	47.7	59.4	71.2
Total	HUF/m^3	**77.3**	**92.7**	**115.8**	**139.2**
Volume	(m^3) annual	156,487	119,856	86,540	—
Volume	(m^3) per day	429	328	237	—
Total cost	**HUF**	**12,096,445**	**11,110,651**	**10,021,322**	—

b. **Current Position**

The management at the Szent Imre hospital should be congratulated on having effected a 45% saving in water consumption over the period 1995 to 1997, especially at a time when the costs increased by 50%, with a further increase of 20% in 1998.

As the daily volume is now 237 m^3 for patient numbers of ~1950 plus staff of ~1500, i.e. about 3500, this represents <70 liters per person per day and hence there is little room for further savings, if acceptable hygiene standards are to be maintained.

c. **Further Options**

i. **Maintenance**

It is essential that the engineering staff maintain their vigilance to prevent waste of water from dripping taps, etc., (none were noted by the consultants during their inspection in May 1998).

ii. **Other Sources of Drinking Water**

The hospital could invest in a borehole and treat their own water supplies. However, at an annual volume of now less than 100,000 m^3, the savings are unlikely to be significant. The 1998 cost of water supply assumed a similar consumption of 86,540 m^3 at HUF/m3 68.0, is HUF 5,884,720 or US $ 28,000.

The estimated costs for drilling a borehole and the necessary treatment, if only chlorine disinfection, is likely to be US $ > 1 million.

The sampling for the analyses of both drinking water and effluent samples taken at the Szent Imre hospital in 1997 for detailed analysis by Spectromass Analytical Laboratories Limited, Budapest, were taken through tubing sterilized with formaldehyde and received in 20 ml 'urine' sample tubes closed with natural cork stoppers. Hence the formaldehyde results are invalid and the other organic analyses suspect; this was not the fault of the accredited laboratory.

A series of samples for analysis for haloforms were taken and analyzed by the National Institute of Public Health, Budapest. These results are shown in Table 19.

On Wednesday 9 September 1998 this matter was discussed with both the National Institute of Public Health and by telephone with the Budapest Waterworks, who also regularly undertake haloform analyses. The latter also found results in the order of 10 μg/l total haloforms. (See also Technical Report No. 7 — Inspections of Other Hungarian Hospitals and Incinerators, Section IV, G.) Hence the haloform content of the water supplied to the Szent Imre hospital falls within acceptable EU standards.

Unfortunately, neither the National Institute of Public Health nor the Budapest Waterworks examine water samples for aldehydes.

Table 19 Trihalomethane concentrations in potable water supplies to the hemodialysis unit at the Szent Imre hospital, Budapest

Sampling Date	Concentrations μg/l				
	Chloroform	Bromo dichloro methane	Chloro dibromo methane	Bromoform	Total
1997					
3 March	0.2	<0.5	1.1	1.2	3.0
2 June	2.1	1.5	2.3	0.6	6.5
22 September	1.8	2.2	5.8	2.6	12.4
15 December	0.2	0.75	1.8	1.0	3.75
1998					
16 March	0.3	1.1	2.6	2.0	6.0
15 June	1.1	2.4	3.6	2.0	9.1
Average					8.31

iii. Sewage Disposal

There are few viable alternatives to using the current facilities, i.e. discharge to the primary settlement sewage treatment works at Háros.

At a discharge rate, taking the 1997 figure of 86,540 m^3 and the 1998 cost of HUF/m^3 71.2, i.e. HUF 6,161,648, or US $ 29,234, there is little techno-economic advantage in considering other options.

Other options could include effluent treatment, but even if this included anaerobic digestion with the recovery of methane gas for fuel, the capital cost is estimated to be US $ > 1 million. This would not be recoverable, especially as the municipality would still charge for the discharge of the wastewater.

A further option would be to invest in even more expensive water treatment and recycle/treat the hospital effluent for use as drinking water. It is unlikely that this would be socially acceptable to either patients or staff.

As one of the ward blocks is being considered for redevelopment, the above concept might be explored further, with a used water recovery plant, and dual plumbing so that reused water could be used for toilet flushing and general washing, e.g. for laundry use (assuming the hospital were to invest in their own laundry).

Whilst it was found that the municipality did charge industry on the strength of their effluent, this could not be confirmed for the Szent Imre hospital, which it was deduced was charged on a volume basis only. This volume was the metered input water (drinking water) as there was no measuring device on the effluent channel. As the hospital effluent is basically domestic effluent, this is a fair assumption. In fact the hospital might gain slightly, as outpatients, staff and visitors are likely to contribute more to the effluent flow than the water they consume.

The hospital might wish to take advantage of the fact that the municipality is not charging for effluent strength, i.e. suspended solids or chemical oxygen demand. By investing in a garbage grinder (macerator) the hospital could hence reduce the quantity of the non-clinical waste being sent to landfill. It is stressed that a garbage grinder and subsequent disposal of either clinical or infectious waste cannot be considered on safety grounds under any circumstances.

However, extensive investigations in the United Kingdom have shown that grinding (macerating) of garbage and subsequent discharge to drain is no longer a viable option, largely in view of the considerable on-costs in suspended solids charging, even when this is acceptable to the water companies. Therefore, British equipment is no longer available. Should the hospital wish to pursue this (but it is **not recommended**) it would be necessary to do so locally.

It is suggested that the Hospital Management Board consider the foregoing options, but take note of the high capital costs.

D. Effective Waste Management

The reported total waste generation within the European Union States is estimated to have increased by ~ 10% between 1990 and 1995. However, part of the apparent increase may be the result of improved waste monitoring.

The quantity of waste generated per person per year throughout the Western European Region is estimated to be ~420 kg.

Waste management in most countries continues to be dominated by the perceived cheapest available option: landfill, suitable sites for which are becoming increasingly scarce. Waste minimization and prevention are being recognized increasingly as mere desirable solutions for waste management, but no overall programs in this direction can yet be observed. Recycling tends to be more successful in countries with a strong waste management infrastructure. In many cases, this has lead to lucrative business opportunities for industry.

Priorities in Central and Eastern Europe and in the European Newly Independent States includes improving municipal waste management through better separation of wastes and better landfill management, the introduction of recycling initiatives at local level, and carrying out low-cost mitigation and containment at priority disposal sites.

The only pragmatic means for disposal/treatment of clinical waste remains 'incineration'. This should be large regional incinerators, incorporating combined heat and power, metal separation and use of ash for building construction.

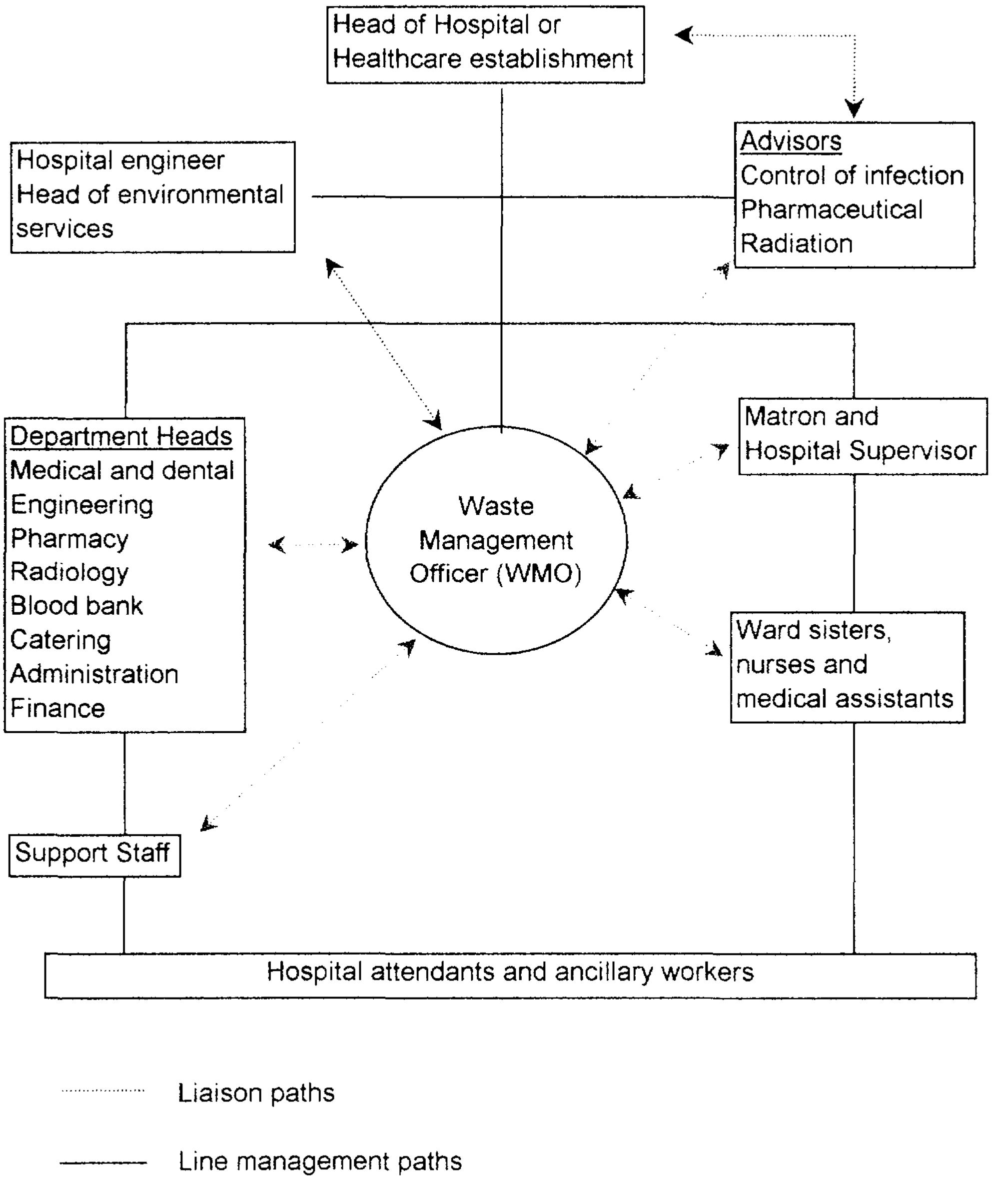

Figure 3. Hospital Waste Management Structure

Source : World Health Organisation, Western Pacific Regional Environmental Health Centre (EHC), 1994

i. Waste Management Plan

The following should be produced:

- Drawings of the establishment showing designated bag holder sites for every ward and department in the healthcare establishment; each bag site shall be appropriately designated as healthcare waste or other waste site;
- Drawings showing the site of the central storage for healthcare waste and separate site for other waste; details of the type of containers, security equipment and arrangements for washings and disinfecting trolleys (e.g. wheeled) should be specified; the document should also address eventual needs for refrigerated facilities;
- Drawings showing the paths of waste collection trolleys through the healthcare establishment, with clearly marked individual routes;
- Drawings showing the type of bag holder to be used in the wards and departments;
- Drawings showings the type of trolley or wheeled container to be used for bag collection;
- Drawings of sharps containers with their specification;
- An estimate of the numbers and cost of bag holders and collection trolleys;
- An estimate of the number of sharps containers and healthcare waste drum containers required annually, categorized into different sizes if appropriate;
- An estimate of the number and cost of yellow and black (blue) plastic bags to be used annually;
- A timetable for the frequency of collection for each trolley route, the type of waste to be collected, the number of wards and departments to be visited on one round and indicating the central storage point in the establishment for that particular waste;
- An estimate of the number of personnel required for waste collection;
- Definitions of the responsibilities, duties and codes of practice for each different categories of personnel of the establishment who, through their daily work, will generate healthcare waste and be involved in the segregation, storage and handling of waste;
- A definition of the responsibilities of hospital attendants and ancillary staff in collection and handling of waste, for each ward and department; where special practices are required, e.g. for radioactive waste or hazardous chemical waste, the stage at which attendants or ancillary staff become involved in waste handling shall be clearly defined;
- Simple diagram (flow chart) showing waste segregation procedure;
- The procedures for segregation, storage and handling of wastes requiring special arrangements , such as autoclaving;

- Outline of monitoring procedures for waste categories and their destination;
- Develop a unit cost control system for each ward, department/unit;
- Training courses and programs;
- Contingency plans, containing instructions on storage or evacuation of healthcare waste in case of breakdown of the treatment unit or when closed down for planned maintenance;
- Emergency procedures.

See Table 12 for an overview of disposal and treatment methods suitable for healthcare waste categories. Figure 3 shows a typical hospital waste management structure clearly defining the vital role of the waste management officer.

ii. Job Description: Waste Management Officer

General description

The designation of the Waste Management Officer applies to a senior manager of the hospital or unit who has been delegated responsibility by the Chief Executive or General Manager for ensuring that the handling and disposal of clinical waste is in accordance with approved practices. His/her position should be indicated clearly on the hospital organogram.

Accountability

The Waste Management Officer is accountable to the Chief Executive or General Manager and is managed on a day-to-day basis by the appropriate Director or Head of Services.

Liaison

The Waste Management Officer will liaise with the Director of Nursing Services or equivalent and the Heads of Clinical Directorates or Departments to ensure compliance with approved procedures for the handling and disposal of clinical waste.

The Waste Management Officer should be a Member (and ideally Secretary) of the Control of Infection Committee (or similar title) and is responsible for drawing attention of their senior officer to departures from approved practice which are not remedial within their sphere of authority. This Committee will consist of all Departmental Heads within the hospital plus an external advisor if necessary.

Designated responsibilities

The responsibilities of the Waste Management Officer are to:

- Keep under review and propose improvements to the clinical waste handling and disposal procedures of the Unit, Board or Authority (Hospital);
- Undertake health, safety and environmental hazard and risk assessments relating to waste disposal;
- Investigate or review incidents reported during the handling of clinical waste;

- Monitor methods of handling, transporting on or off site and disposing of clinical waste;
- Require, appropriate, improvements to observed procedures to bring them into line with approved requirements;
- Identify training requirements by staff grade and discipline;
- Liaise with the training officer in the time tabling, participate in staff induction and post-employment training in the handling and disposal of clinical waste;
- Liaise with the supplies manager to ensure that an appropriate and acceptable range of clinical waste containers, protective clothing and collection and disposal vehicles are available as appropriate;
- Liaise with the services and facilities manager in ensuring that storage and disposal facilities for clinical waste are appropriate and maintained in a satisfactory condition;
- Liaise with the Chief Pharmacist for the appropriate disposal of used pharmaceutical products and to undertake periodic disposal of unusable, out-of-date, or other unwanted pharmaceutical chemicals;
- Liaise with the Director of Occupational Health when conducting surveys to determine, from an occupational health point of view, any shortcomings in the handling of clinical waste; and,
- Represent Unit, Board or Authority Managers in liaison with the Waste Regulation Authority, the local authority and other bodies having responsibilities under Waste Regulations or environmental protection provision of statutes.
- Arrange for facilities and procedures to be regularly audited and the resulting of any audit discussed with the relevant personnel.
- Liaise and establish best practice methods with corresponding waste management officers in other healthcare establishments.

E. EC Legislation

Details of some relevant EC Directives are provided below.

1975	75/442/EEC	Council Directive on Waste
1976	76/464/EEC	Control of Dangerous Substances
1978	78/319/EEC	Council Directive on Toxic and Dangerous Waste
1980	80/778/EEC	Council Directive on Water Quality
1984	84/631/EEC	Council Directive on the Supervision and Control within the European Community of the Transportation and Shipment of Hazardous Wastes
1988	COM88/399/EEC	Draft Council Directive on Hazardous Waste

1989	89/429/EEC	Council Directive on the Reduction of Air Pollution from existing Municipal Incineration Plants
1989	89/934/EEC	A Community Strategy for Waste Management
1990	90/415/EEC	Dangerous Substances Discharged into the Aqueous Environment
1990	90/679/EEC	Council Directive on the Protection of Workers from Biological Agents at Work
1991	91/156/EEC	Framework Directive on Waste
1991	91/271/EEC	Council Directive on Urban Wastewater Treatment
1991	91/689/EEC	Council Directive on Hazardous Wastes
1991	91/679/EEC	Council Directive on the Protection of Workers from the Risks Related to the Exposure to Biological Agents at Work
1991	91/6 130/01/EEC	Draft Council Directive on Landfill
1994	94/67/EEC	Council Directive on the Incineration of Hazardous Waste
1994	94/904/EEC	Council Decision — Definitions of Hazardous Waste

But, perhaps the following, when implemented, will be of greater relevance:

Council Resolution of 24 February 1997 on a Community Strategy for Waste Management, O.J. 11.3.97, No. C 7611.

Only brief details have been furnished on this complex regulatory issue. Details of the EC directives are now available on the Internet, and ministry officials requiring full details are advised to contact their nearest EU delegation offices.

A list of relevant United Kingdom regulations are shown in Technical Report No. 6 — Appendix B. These have not been reproduced here as this could be confusing and misleading; a major revision of all relevant GBR regulations pertaining to the disposal of clinical and other healthcare wastes is expected shortly in the form of a consultative document.

F. *Training in Healthcare Waste Management*

a. Objectives

The training sessions should achieve the following objectives:

- **To raise awareness** on public health and environment hazards that may be associated with inappropriate segregation, storage, collection, transport, handling, treatment and disposal of healthcare waste;

- **To provide information** on hazards and sound management practices of healthcare waste for the formulation of policies and the development or improvement of legislation and technical guidelines;

- **To identify waste management practices and technologies** that are safe, efficient, sustainable, economic and ultimately acceptable; to enable the participants to identify the systems for their particular circumstances;

- **To enable managers** of healthcare establishments **to develop their waste management plans;** and,

- **To enable the Training Session participants to develop training programs** for different categories of staff that handle, treat, or dispose of healthcare waste, i.e. 'train-the-trainer'.

b. Rationale for Training in Healthcare Waste Management

Healthcare waste is special because it has a higher potential for infections and injury than any other type of waste.

Hence, it has to be handled using safe and sound methods wherever and however it is generated.

Inadequate or, worse, incorrect handling of healthcare waste may have serious public health consequences and impact on the environment. Therefore, healthcare waste management is an important and necessary component of environmental health protection.

Hospitals and all related healthcare institutes have responsibilities for implementation a *duty of care* for the environment and public health particularly in relation to the waste they produce. (see also Technical Report No. 6 — Appendix N). They also carry the responsibility to ensure that there are no adverse health and environmental consequences as a result of waste handling, treatment, and disposal activities.

Regrettably, in too many organizations, healthcare waste management is not yet undertaken with a satisfactory degree of safety.

The Training Sessions such as that held at the Szent Imre hospital, Budapest, 7–11 September 1998 should be aimed at transmitting the basic skills for the development and implementation, by a cascade process by means of 'train the trainer' of healthcare waste management policy.

By such means healthcare and research facilities can take the requisite step towards securing a healthy and safe environment for their employees, community and all compartments of the natural environment, e.g. air, soil and especially water.

The following actors can be involved:

- Healthcare and maintenance personnel;

- Patients in hospital, etc.;

- Hospital visitors;

- Workers in support services to healthcare establishments, e.g. laundries, waste handling and transportation;

- Workers (including scavengers) in waste disposal and treatment facilities,;

- Individual generators outside establishments, (patients under home care (including home dialysis) and drug abusers); and,

- Officials of national or local authorities involved in setting of regulations, enforcement or policy makers.

G. *Prioritization*

In view of the diversity of the alternatives outlined in the two options in section VII, an overall prioritization for future action is difficult.

Undoubtedly, the main objective in hospital waste management is to establish that which needs to be done and to work to a definite plan (see Technical Report No. 1 — Waste Management Master Plan) to achieve this through the introduction of a waste management system, (see also Figure 3). This will lay the foundation for future developments and which will normally commence with the least expensive, and then lead to effective 'no-cost' solutions (see iii below)

There is an undeniable requirement to achieve safe disposal of clinical and infectious healthcare waste in a safe manner. Incineration is the proven method of choice.

i. Relating to Option No. 1 — Incineration, Disinfection and Associated Units

- The consultants favor regional large-scale incinerators which can offer excellent 'bought in' facilities as complete services. It is paramount in order to achieve the most effective, and to reduce pollution elsewhere, these are combined heat and power.

- Tables 14–16 indicate clearly that within Europe such incinerators are the most cost-effective (economic) means for safe treatment of hospital hazardous waste. In the long-term, and especially when all 'externalities' are taken into account, the cost is less than sophisticated landfill sites incorporating methane recovery.

- Increasingly and very necessary strict atmospheric emission controls and monitoring also mean that large, well managed, regional incineration facilities can be operated more efficiently than small local incinerators to which strict emission criteria apply.

- The consultants considered two further types of heat treatment — microwave disinfection and pyrolysis.

  ⇒ Microwave disinfection is becoming increasingly accepted and is highly commended. It would be additionally attractive if the compacted and disinfected waste was to be burnt in power stations.

  ⇒ A microwave disinfection unit only requires electricity and a small quantity of water and has no atmospheric emissions to consider and hence becomes an ideal candidate for consideration as a mobile unit.

⇒ The pyrolysis unit considered is in use in a small number of North American and Canadian hospitals, and has now received approval in the United Kingdom. One of the advantages was the capacity to use waste vegetable oil, readily available in Hungary as a fuel source.

- The consultants are firmly again the concept of mobile incinerators, in view of the set up difficulties invariably leading to pollution. Furthermore, the Hungarian Ministry of Health does not favor mobile incinerators.

Hence, within Option 1, the priority is for large regional incineration. However, it is emphasized that hospitals should exert maximum control over waste management and, in good housekeeping, ensure good segregation and also that clinical/infectious waste is transported expeditiously to the disposal facility, e.g. in 72 hours without refrigeration, and as a target, 5 days with refrigeration, especially during hot summer months.

ii. Relating to Option No. 2 — Chemical Waste Disposal (Non-clinical Waste)

The choices of action are easier, in most cases low cost, and revenue can be generated. These actions should be implemented as rapidly as possible:

- The disposal of laboratory water-miscible solvents and formaldehyde can be instituted very rapidly with immediate cost savings.

- The major problem is the rigidity of the Hungarian environmental legislation. Through a consultative mechanism, this should be relaxed to allow risk assessments to be undertaken to ascertain any potential adverse effect to the receiving aquatic environment. The consultants advocate a simple risk assessment procedure using PEC/PNEC ratios and should be incorporated forthwith into Hungarian environmental regulations.

- In parallel with the above, hospitals should take advantage of the highly effective method for recovery of silver from x-ray film processing. A modest investment can readily achieve a profitable return in less than three years.

- The final problem is the breakage of mercury thermometers.

This problem is of monumental importance, particularly in view of the adverse health effects of inhalation of toxic mercury vapor by both (chronic) patients and nursing staff, and discharges to the aquatic environment of an EU 'prescribed' substance.

⇒ In the United Kingdom hospitals visited by the Hungarian Study Group 3 - 14 August 1998, it was noted that the breakage of a mercury thermometer was a rare occurrence. In a hospital of comparative size to the Szent Imre hospital; one breakage in six weeks occurred, against ~ 200 per month, or seven per day at the Szent Imre hospital. If the rigorous precautions used for cleaning up a mercury spill from a broken thermometer applied to British hospitals were applied to the Szent Imre hospital, it would cease to function!

⇒ As a matter of priority the Szent Imre hospital are urged to examine this problem, which could be resolved by replacement of the mercury thermometers with electronic devices, or perhaps purchasing the apparently more robust thermometers available in the United Kingdom. However, attention in drawn to fact that the British hospitals visited had floors covered with 'spongy' plastic covering with rounded corners to the adjacent walls, whereas the Szent Imre hospital floors are masonry - usually badly crazed.

iii. **Waste Management**

In addition to the above, the proposals outlined in the Technical Report No. 1 — Waste Management Master Plan should be adopted, e.g. segregation of waste and, in the case of non-clinical waste, separation into glass, metals, paper, and plastics which can then be recycled profitably. Putrifiables should be deposited in landfill, or ideally incinerated, in combined heat and power large scale incinerators.

Ultimately, Hungarian hospitals could apply for accreditation under ISO 14000 series, but prior to their doing so many improvements in waste management are essential. An early priority should be given to the appointment of a Hospital Waste Manager and a Waste Management Committee.

IX. EVALUATION OF FINANCING OPPORTUNITIES

Within the United Kingdom, the typical cost of waste disposal and management is 3% of the total hospital budget.

A. Incineration

Incineration is the only viable means of disposal and discarding of clinical waste from hospitals and relevant premises. Incineration is expensive and thus it is vital that all clinical waste is carefully segregated to avoid inclusion of material that might be degraded by other means, e.g. to landfill. For definition of waste and associated terms see Technical Report No. 6 — Appendix D.

There are alternatives to classified incinerators, e.g. cement kilns, high temperature metallurgical processes (i.e. iron and steel works) or pulverized fuel thermal power plants. However, these do not need to be considered in Hungary as there is adequate capacity. See Technical Report No. 1 — Waste Management Master Plan, Sections X and XI, and Section IV, E, of this report.

As outlined in the UNIDO report CLT/97/201 *Effective Environmental Management for the Pharmaceutical Chemical Industry Part 5, Disposal of unwanted, obsolete and counterfeit pharmaceuticals*, such methodologies are predominately suitable for difficult situations, e.g. following warfare or natural disaster.

B. Microwave Disinfection

This is a very attractive alternative to incineration and as outlined in Section VI, C, xi, and in Section VII, Option 1, E, i, is a robust compact and less costly alternative to incineration, viz., US $ ~280 per tonne against US $ ~400 per tonne for incineration. The latter figure can, however, be lower when effective combined heat and power facilities are incorporated.

The additional benefits of a microwave facility is that it could be considered as a mobile unit and this is currently under further investigation.

C. Cement Kilns

In view of the outstanding studies undertaken by UNIDO, cement kilns do offer a number of advantages including costs. However, consideration is required over the relevant emission control system in place in cement kilns. These may not in all cases be as high as for incinerators.

Other advantages of the use of cement kilns are the high temperatures and retention times and that clinical waste offers an input of energy.

Cement kilns are not, however, suitable for sharps and needles. Glass can usually be accommodated as it is crushed and melts.

D. Chemical Disinfection

Chemical waste can be rendered less noxious by treatment with acids, alkalis, oxidizing agents, etc; but this is both expensive and results in a final product which can be chemically hazardous to dispose of, and which in itself might need to be achieved by encapsulation (q.v. UNIDO Report CLT/97/201, Part 5).

E. Segregation

The effective management of hospital waste is a matter of very high priority and obviously needs to be considered prior to incineration of waste. Top management needs to ensure that all departments generating waste have both the training and infrastructure support to ensure that specific wastes are deposited in the specified containers. For example, non-clinical waste, which would normally be suitable for containment in a black (blue) bag (total disposal cost for non-hazardous waste US $ 26,930, at 1997); and should not be used in a clinical (infectious) waste yellow bag (total clinical waste disposal cost ~ US $ 25,368, at 1997). See Technical Report No. 2 — Szent Imre Hospital — Waste Audit, and Technical Report No. 6 — Appendix O.

In comparison incineration of clinical infectious waste in the United Kingdom, costs are typically US $ 400–450 per tonne.

At the Szent Imre hospital, it was pleasing to note that kitchen waste (food) was sent to a pig farm.

Considerable additional sources in waste disposal could be achieved by the segregation of non-hazardous waste into paper, glass, plastic, metals and putrifiable waste. Whilst the latter only would be destined for landfill, the other four types of waste should be sent for recycling as is current practice in many Western European countries, e.g. Austria. However, it is appreciated that this is a matter for government or industrial entrepreneurs, as it was apparent that no such recycling activities are available currently in Hungary.

F. Disposal of Chemical Waste

The three departments which generate the greatest quantities of chemical waste are:

- X-ray
- Pathology
- Clinical biochemistry laboratory

i. Photographic Waste

The subject of photographic waste is discussed in depth in Technical Report No. 1 — Waste Management Master Plan and Technical Report No. 2 — Szent Imre Hospital — Waste Audit. See also Section VII, Option No. 2.

It is stressed that the recovery of silver should represent a significant income for hospitals.

Recovery of other photographic chemicals, developers, etc., could be considered, but with the relatively small quantities (as compared to organizations processing movie films, etc.) the capital costs and technical support are unlikely to be advantageous. In this respect, the hospital managers might wish to investigate pooling their photographic waste for it to be treated centrally, or to enter into an agreement with large commercial film processors.

Currently, photographic waste solutions are sent for disposal to SEPTOX. As it is common practice within the United Kingdom for some to be discharged to drain, and to sewage treatment, then there is no logical reason whey this should not be undertaken in Hungary, or indeed in other areas within the Central and Eastern European Region.

The dilution factor between the hospital and the receiving sewage treatment facility is about 240 and the total upon discharge to the Danube river is $>10^7$.

However, bearing in mind that certain aspects of the Hungarian Regulations for discharge to sewer are more strict that those in the United Kingdom, or the European Union, this is a matter for discussion with the Hungarian Ministry of Environment and Regional Planning. The Hungarian Environmental emission standards should be a topic for the International Workshop to be held in the Region at a later phase in the program.

It is stressed that silver recovery must be undertaken from all units; and a far more favorable financial outcome obtained.

Waste film is returned to the supplier for recycling and recovery of silver.

ii. Pathology Department

This department produces waste acetone, chloroform, ethanol, formaldehyde and xylene individually in quantities of up to 500 liters per annum, average 1–2 liters of each, per day.

From a sewage treatment point of view, with the exception of chloroform and xylene, which must be incinerated, the other three, in principle, could be disposed of to drain. It is surprising that the Hungarian sewage disposal regulations impose a restriction on formaldehyde and this matter should be reviewed with the Ministry of Environment and Regional Planning.

Details of the ecotoxicology of these chemicals are given in Technical Report No. 6 — Appendix K.

iii. Clinical Biochemistry

In view of the diversity of the chemicals used in a variety of (complex) test procedures, there would appear to be no alternative but to send these for incineration. Whilst the quantities of individual chemicals are small, the number is large and the possible xenobiotic interaction, equally great or greater. The latter having the propensity to produce chemicals of increased toxicity.

G. Disposal of Wastewaters

This is currently based on the usually accepted premise that the volume of sewage equals to potable water input. As is normal, the cost of sewage disposal is marginally greater (~5%) than the cost of the potable water.

Whilst the Mayor's office, who owns the majority of the hospitals in Budapest, operates a charging scheme for industry, based on a formula such as:

$$\text{Cost} = \text{Volume} \times \frac{\text{(Suspended solids effluent)}}{\text{(suspended solid sewage input)}} + \frac{\text{(COD effluent)}}{\text{(COD sewage input)}} + \text{administrative costs}$$

Such charging does not appear to apply to the Szent Imre hospital. The likely reason for this is that it is assumed that hospital effluent is very similar to normal domestic sewage.

The hospital could consider its own sewage facility but this would not achieve any cost saving, and bearing in mind that the municipal waste facility is only primary settlement, there would be no overall advantage in the receiving water quality. However, the hospital should attempt to reduce input water usage (leakage, wastage) and this in turn would reduce sewage treatment costs.

H. Disposal of Clinical Waste

This is by far the greater cost within waste disposal.

The current process of the hospital waste being transported by the hospital's own transport to a transfer station for onward transmission by the contractor (SEPTOX) to the incinerator at the Korányi hospital appears to work well.

As indicated in Technical Report No. 2 — Szent Imre Hospital, Waste Audit, considerable management input is required to ensure that **only** recognized clinical waste is placed in yellow bags rather than blue bags. This will assist in minimizing the incineration costs. (See also Technical Report No. 6 — Appendix N.)

It is unlikely that any other procedure for disposal of clinical waste as outlined in Section A can be recommended at this stage.

I. Landfill

The landfill sites in the Budapest region are regulated by the Mayor's Office and it would appear that, other than the recycling of paper, plastic, glass and metal referred to above, no feasible savings can be obtained.

J. General Incentives

Department cost control would obviate some of the overall costs in waste disposal as each departmental manager would then have direct control over his budget for waste.

It is therefore **recommended** that a budget line for waste disposal should be generated. (See also Technical Report No. 1 — Waste Management Master Plan, Section XII, which is reproduced for clarity.)

Greater independence in fiscal control by unit managers is of growing importance in hospital management within the United Kingdom and Western Europe, and with Hungary's aspiration to become a European Union member early in the next millennium, very serious and urgent action is advocated.

XII. UNIT COST CONTROL

(reproduced from Technical Report No. 1)

The purpose of departmental costing is to establish and correctly allocate 'costs' of an enterprise and having done so use the results for management control as indicated in Section C below, also to provide data for the preparation of cash flows and preparation of targets for future performance.

A. Prepare Departmental Budgets

It would be necessary to prepare annual total and departmental budgets to be projected on a four weekly basis. The budgets would cover:

i. Direct cost of materials;
ii. Direct cost of wages and salaries;
iii. Overheads including an appropriate share of central administrative costs, preferably with a percentage loading to help cover future capital requirements
iv. Depreciation of major plant and equipment calculated on the estimated useful life of the asset;
v. Obsolescence — the writing off of minor equipment with a short life, e.g. computers;
vi. Interest, actual or notional arising from the financing of capital investment;
vii. Actual or notional charge for rent of space occupied.

B. Coding System

A system of 'coding' would be needed in the central accounts records whereby expenditure incurred could be readily allocated to the individual department.

C. Monthly Cost Reports

The four weekly cost reports and comparisons against budget would require to be monitored (and reasons for variances ascertained) by a member of management staff. This officer would be required to report to a finance committee with recommendations where applicable for action or where relevant for a revision of a department's budget when, for example, experience showed that initial budgets were incorrect, or circumstances had changed.

D. Periodic Revisions

It is usual whilst maintaining the original annual budget to prepare periodic revised forecasts based on experience of actual costs as the year proceeds. These would give early warning of variances between performance and the pre-prepared budgets and supply data for implementation of future years' budgets.

The advantages of departmental costing is that it is a tool for management control and for establishing the accountability of each departmental manager who would be responsible for variations between the four weekly performance and the four weekly budget. Furthermore, performance better than budget by certain departments may point to areas where other departments can be encouraged to improve performance.

(This section was drafted by John R. Antoine, FCA, Sub-contractor).

K. Energy

Savings in heating and lighting could also be achieved by more diligent management control of excessive use of lighting, especially by the increased use of high energy lamps, etc. Whilst obviously adequate heating is essential in wards, areas undertaking clinical procedures: surgery, x-ray, etc., greater economies might be achieved in many underground service corridors, e.g. use of electronically operated doors.

L. Housekeeping

This is perhaps the cheapest and most effective means of savings. It requires a total commitment from top management throughout all medical staff, to janitorial staff, porters, etc. This can only be achieved by good will by all parties.

Simultaneously, visitors should be made aware of the costs of waste and show respect for the high standards of hygiene essential to the running of a hospital. The hospital might benefit from, for example, imposition of litter fines, especially for cigarette ends, etc.

M. External Financing

Improvements can only be made from the scarce availability of external financial aid. This includes the United Nations agencies (including UNIDO), the British Know-How Fund, the European Union PHARE Program, DANIDA, the World Bank and the EBRD.

Within the United Kingdom there is also the Export Credit Guarantee Department within the Department of Trade and Industry. This facility enables British exports to Hungary (and certain other countries) to have the financing guaranteed by the Government of the United Kingdom. This does not mean that the importer is excused payment for their goods or services or interest payments.

The government(s) should be aware that less grant aid finance is now available than a decade ago. Bank loans from the EBRD, the World Bank and other sources of international loans can attract very high interest rates, e.g. up to 20% in view of the high risks involved — this has to be coupled with increasing inflation rate as the States align their currencies with a view to joining the European Union.

Hence, each State will need to look to themselves for sources of internal funding. This can come from improved use of raw materials, more economic use of energy in all forms, waste control/reduction at sources, and otherwise as outlined in this series of Technical Reports.

X. WASTE MANAGEMENT RELATED COSTS

A. Principles of Costing

According to the *Polluter Pays Principle,* each healthcare establishment should pay for the safe treatment and disposal of the waste it generates Furthermore, using unit cost control each department within the hospitals should be aware of the costs and have a budget for waste.

Before planning for a waste management system it should always be made certain that the waste is segregated, which will reduce significantly the quantities of hazardous waste requiring special handling, treatment and disposal.

Adequate sizing of all elements of the system will prevent subsequent costly modifications.

Future tends in waste production, and in legislation becoming more stringent, should be anticipated.

The major activities can be summarized as:

- *Polluter Pays Principle* —

  ⇒ Healthcare establishment pays for the safe disposal of the waste it generates.

- Minimization, segregation and recycling of waste;
- Appropriate sizing of the waste management system; and,
- Anticipate future trends.

B. Internal and External Costs

The construction , operation and maintenance costs of healthcare waste management systems can be represent a significant part of the global budget of a healthcare establishment (in the UK ~3%). It is essential to consider these costs when planning an establishment.

The internal and external costs of waste management have to be considered by the healthcare establishment.

The major activities can be summarized as:

- Internal Costs —

  ⇒ Segregation, packaging, on-site handling and treatment; costs of supplies and labor;

- External costs —

  ⇒ Off-site transport, treatment and final disposal: paid to contractors who provide the service.

The future for developing/industrializing countries must be in the development of autonomous legal entities, which are financially self-sufficient, who appoint their own staff and are responsible for compliance with all relevant legislation. Figure 4 indicates the structure of the British National Health Service (with kind permission of UK Private Healthcare Ltd., Amersham, United Kingdom.

Structure of the National Health Service within the United Kingdom

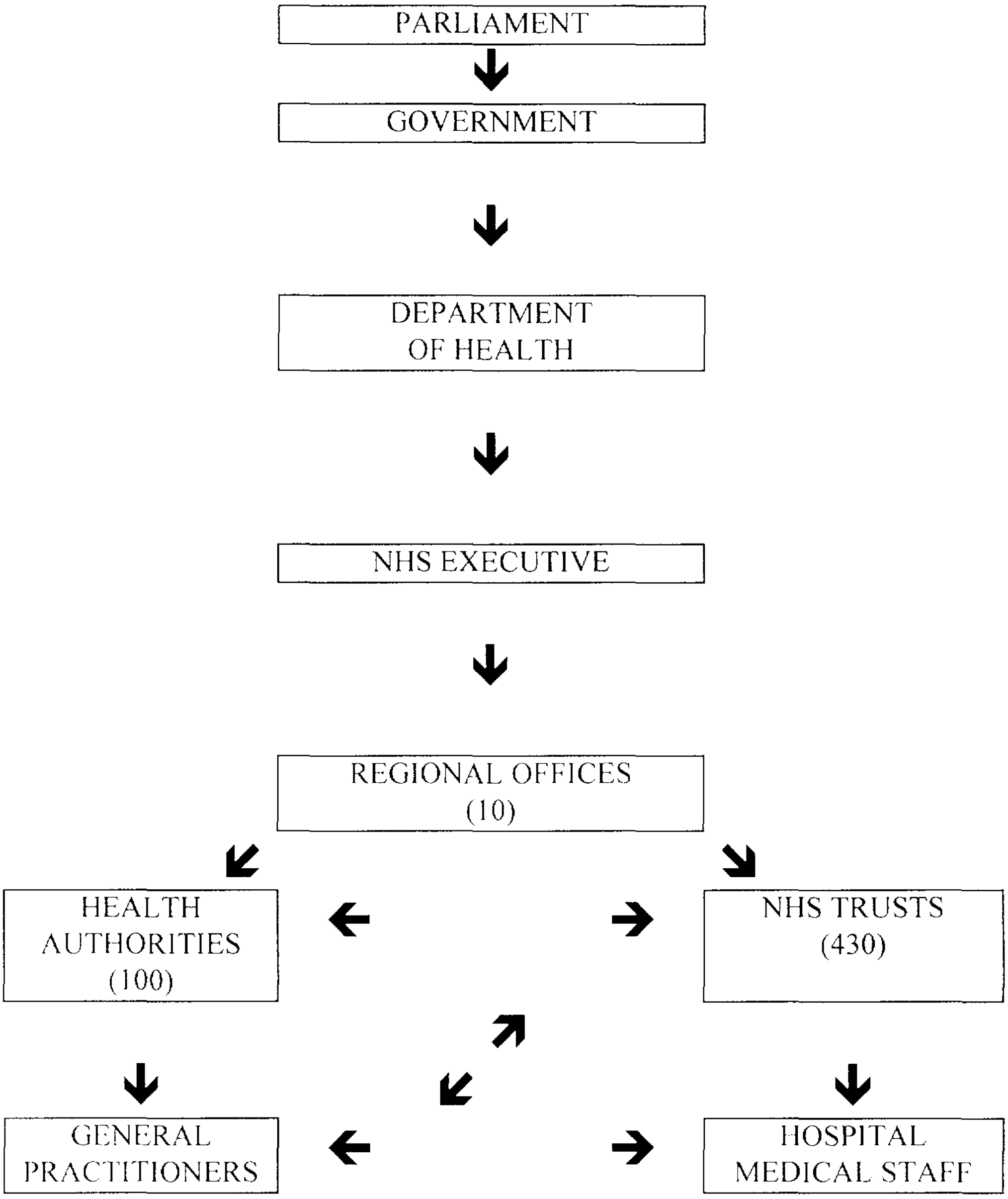

Figure 4. Structure of the NHS

C. *Total Costs of a Waste Management System*

A list of the elements that contribute to the costs related to healthcare waste management costs is shown below, for example of an incinerator.

This list is not exhaustive and can be modified for other technologies and techniques.

- Initial capital investments
  ⇒ Purchase of Equipment;

- Amortization of plant and equipment
  ⇒ Over life time of equipment;

- Operating costs
  ⇒ Costs of labor and consumables;

- Contractual costs
  ⇒ For external services, e.g. transportation, final disposal.

D. *Methods of Financing*

For public healthcare establishments, general revenues may be used for waste management. The treatment and disposal facilities/sites may be constructed and operated from public or private funding. The national authority may require, by regulations, implementation of on-site treatment, compulsorily use of public facilities or allow the choice to use private facilities (e.g. in the USA). Such regulations may restrict certain disposal options or specify the required treatment technology and standards of operation.

Under arrangements with a private company, a private entity finances, builds, owns and operates for example the treatment facility. The company provides collection and disposal services to healthcare establishments and receives payment for such services. The use of private services should be encouraged, in particular for methods other than incineration.

The major activities can be summarized as:

- Public Funding for Investment
  ⇒ Compulsory use of public facilities;

- Private Funding of Investments
  ⇒ Choice of private facilities and services;

- Funding of Investments by the Healthcare Establishment
  ⇒ Use of on-site treatment facility;

- Funding of Investments by Several Healthcare Establishments
  ⇒ Cooperation between establishments to use common facility;

- A combination of these in which one healthcare establishment disposes of waste for others on a contract basis.

E. Use of Private Services

The possible advantages that may result from the use of private waste management services including treatment and disposal are listed below. The reduced level of services refers specifically to reliability, safety, public health risks and environmental aspects.

Also, the private company may increase the service costs due to factors that could not be foreseen (e.g. change of legislation) and which will represent unexpected expenses for the healthcare establishment. Furthermore the Private Sector is able to raise capital more readily that State institutions.

The major activities can be summarized as:

- Advantages

  ⇒ The main advantage is usually the increased efficiency resulting from competition among service providers on the market
  ⇒ Inability of healthcare establishments to raise needed capital
  ⇒ Expected greater efficiency than public facilities
  ⇒ Transfer of risk of operation;

- Possible disadvantages are

  ⇒ Potential loss of control by the public agency
  ⇒ May result in minimum level of services provided
  ⇒ Regular inspection and regulatory control required, and should occur regardless.

F. Contractual Arrangements

The major activities can be summarized as:

- Any agreement with private companies should include the following points —

  ⇒ Prescribe minimal levels of service, (reliability, environmental sustainability, safety, public health risks, expansion)
  ⇒ Methods of dealing with cost increases (inflation, etc.)
  ⇒ Environmental concerns
  ⇒ Transfer of ownership
  ⇒ Quality and regulatory control.

G. Cost Reduction Check List

Cost reduction measures can be taken at different levels of waste management.

To reiterate, the most efficient ways to minimize hazardous healthcare waste production are:

i. Minimization;

ii. Purchase policies and stock control management, i.e. good housekeeping;

iii. Miniaturization, e.g. hyperdermic syringe size (preferably pre-loaded);

iv. Segregation; and in certain circumstances,

v. Recycling of wastes.

Documentation of costs will allow to identify priorities for cost reduction and monitor progress in the achievement of these objectives.

The major activities can be summarized as:

- On-site Waste Management Practices
  ⇒ Minimization, waste segregation, and recycling;
- purchasing policy and stock management;
- Comprehensive Planning
  ⇒ Develop and implement waste management strategy
  ⇒ Consider regional cooperation;
- Cost Accounting and Control;
- Choose Adequate Methods, Technologies and Techniques, e.g. Good Housekeeping;
- Training and Involvement of Personnel for Efficient and Safe implementation.

XI. SUMMARY OF COSTS/SAVING

Option 1: Incineration, Disinfection and Pyrolysis

A. Classical Incineration

Classical incineration suitable for the Szent Imre hospital US $ ~750,000 to which either US $ ~300,000 should be added for heat recovery for hot water provision, or US $ ~500,000 for an electricity generator.

A large regional incinerator, with combined heat and power is likely to cost US $ >20 million.

It is emphasized that similar costs applied for emission monitoring and control for small and large incineration.

B. Microwave Disinfection

US $ ~650,000 for a unit capable of disinfection ~1800 tonnes of clinical waste per annum.

C. Pyrolysis

A 5 tonne/day unit capable of treating all the Szent Imre hospital waste would cost US $ ~2 million to which energy recovery facilities, as indicated in A above, would need to be added.

Option 2: Chemical Waste Disposal (Non-Clinical Waste)

A. Acetone and Ethanol

Discharge to drain **saving** US $ ~140/tonne.

B. Xylene

Marginal savings predicted.

C. Chloroform

Chloroform is no longer used at the Szent Imre hospital's pathology department.

D. Formaldehyde

In view of the PEC/PNEC ratio being ≈0.05' this can be discharged to drain with a saving of US $ ~140/tonne. Relaxation of the Ministry of Environment regulations should be sought with urgency.

E. Silver Recovery

An expenditure of US $ ~24,000 should provide a saving of US $ 12,000–US $ 28,000 per annum after a two-year pay back period.

F. *Mercury Thermometer Replacement*

In addition to a possible saving of up to US $ ~6000 per annum, the immediate problem is adverse occupational health effects from mercury vapor to patients, nursing staff and visitors, plus discharges of an EC 'prescribed' substance. Very urgent management attention is **recommended.**

XII. CONCLUSIONS

It is appropriate that the Hungarian healthcare providers should adopt pro-environmental policies.

Hospitals and related healthcare institutes are in the business of healthcare and its promotion, and a healthier environment means a healthier population. It is not acceptable for hospitals to despoil the environment and thus risk an increase in general ill health.

This Technical Report, when read in conjunction with Technical Report No. 1 — Waste Management Master Plan and Technical Report No. 6 — Appendices B–O, will assist healthcare operators in both Hungary and other States within the Region to:

- Be aware of the consequences of environmental legislation;
- Audit their management systems (see also Technical Report No. 2 — Szent Imre Hospital, Waste Audit);
- Evaluate the significance of their environmental impacts;
- Prioritize their actions by cost or performance improvement;
- Set objectives and targets;
- Compare performance between different sites and time periods;
- Record and demonstrate their performance;
- In the longer term activate ISO 14000 series certification.

In appreciating the core environmental sectors, waste managers will need to consider at least the following:

- Preferred means of thermal treatment of clinical waste (see also Option 1);
- Water management;
- Energy management;
- Discharges to drain, e.g. recovery of silver (see also Option 2);

- Emissions to the atmosphere, especially when there are on-site incinerators;
- Waste management;
- Land management;
- Land contamination;
- General organization; and
- Procurement of supplies.

These sectors can be considered in eight steps:

i. Identification of effects;

ii. Identification of significant effects;

iii. Identification of appropriate legislation;

iv. An examination of management practices and procedures;

v. Monitoring

vi. Good record keeping;

vii. Setting of initial objectives, and strategic goals;

viii. Generation of an environmental policy statement.

It is vital to remember that mankind is living in an increasingly environmentally aware world (this was one of the outcomes of the UNCED Conference held in July 1992). The impact man has on the Earth's environment is becoming more important in every aspect of everyone's lives.

To see how the pace of change is accelerating, it is only necessary to think of sustainable development; today's schoolchildren are tomorrow's healthcare engineers and scientists. For this caring generation, recycling and awareness of pollution are already an integral part of their day to day lives. This is the reality for which everyone must play today to ensure that the environment inherited by these future generations is an asset rather than a liability.

Western Europe, the USA (and Japan) have observed that it is the concern of the general public that has driven governments to take steps, reluctantly in some cases, to improve the environment, to institute recycling schemes, rather than the reverse.

If the healthcare industry in the Region is to survive in anything like its current availability to the sick, and to realize its potential; then the healthcare industry must work harder to take advantage of the people and expertise on offer, and this has to mean increased investment. The highest risk strategy is not to make an investment in effective waste management.

These objectives can be achieved by the early adoption of the selected alternatives indicated in Options No. 1 and 2, described in Section VII. The optimal actions with an indication of prioritization is included in Section VIII, with financial aspects being developed in Sections IX and X.

It is **recommended** that the government(s) should publicize the need for waste control, recycling, reuse and reduction via the media, and also by introduction of these topics into the curricula of primary and secondary education.

The healthcare industry, globally, has as its major objective the improvement of the health of the population. With this in mind, it is a complete contradiction for hospitals to pollute the environment or consume resources unnecessarily. (It was noted (see Technical Report No. 2 — Szent Imre Hospital — Waste Audit) that this hospital was not contributing to such pollution).

The healthcare industry has to lead the world in environmental management. This has to be one of the core activities of a declared outcome of the International Workshop to be held in the Region later in the program.