Final Report

Economic Study of Solvent Recycling and Treatment

Contract No: NWPP-2009-34

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Cork Institute of Technology,

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Executive Summary

1 Introduction

In 2007, 119,000 tonnes of Ireland's hazardous waste generation were organic solvent, and of these, 55,400 tonnes were exported for recovery or disposal. This waste arises primarily from the pharmachem sector, with much smaller quantities of solvent wastes arising from paint manufacture, electronics and medical devices.This lack of self-sufficiency in handling our waste is a cause for economic concern, since it leaves Ireland open to business interruption in the event of closure of export markets or transport disruption, is not in keeping with the proximity principle and conflicts with the objectives of the National Hazardous Waste Management Plan.

It is a recommended objective of the Environmental Protection Agency's (EPA) Second National Hazardous Waste Management Plan 2008-12 to *reduce export and increase indigenous (including on-site) treatment of hazardous waste. To achieve this objective, capacity is required at solvent treatment facilities in Ireland – either solvent recycling (R2), in existing cement kilns or other combustion plant (R1), purpose built incinerators (D10) and/or alternatives (as outlined in section 6.3). Domestic capacity could be provided in either of two locations: on-site of generation, or off-site at commercial facilities in Ireland.*

The Environmental Protection Agency has sought to address these issues, in the first instance, by commisioning a small-scale study on solvent waste, entitled, "Economic Study of Solvent Recycling and Treatment". This was to consist of two main tasks, namely,

Task 1: Consultation with relevant stakeholders on solvent treatment.

Task 2: Assessment of markets for waste solvent within Ireland

Specifically, the specifications sought that,

The Contractor will consult with generators of waste solvents and treatment operators to develop an understanding of current status of the market, the technical feasibility of changing current practices and to consider the potential for minimisation of these waste streams at source. Information from the national waste report will be made available to the contractor to target this consultation. In doing so the Contractor should seek to answer the following questions:

- *Is there scope to increase Irish domestic management of solvent waste arising?*
- *Considering the current technical capacities for treatment in Ireland what economic drivers are there for the continuing export of these wastes?*
- *How might these be made more favourable for domestic treatment?*
- *What is/are the most economically beneficial management option(s) for these wastes?*
- *What impact if any will economies of scale for treatment impact on these options?*
- *What legal, regulatory and economic barriers are there to implementing the most economically beneficial management options domestically within Ireland?*

The contractor will consider the market for waste solvent in line with the accepted waste hierarchy.

2 Outline of Study Methodology

The project team examined extensive waste statistics from sources, such as electronic Pollutant Release and Transfer Registers (PRTRs), electronic and paper Annual Environmental Reports (AERs), and the EPA's own databases.

These were analysed and collated to provide trends in terms of total solvent waste generation, treatment options, and destinations. This analysis also aided the identification of the relevant companies for interview, as part of the stakeholder consultation. For solvent waste generators, these were identified primarily based on quantities of solvent wastes arising.

Stakeholders were consulted to elicit information on existing solvent waste management practices. Separate questionnaires were prepared for generators of solvent waste, for solvent waste management companies, and for the cement industry as a potential outlet (these can be found in Appendix IV). Generators were asked to quantify solvent purchased and recovered on-site, the cost of on-site and off-

site recovery/treatment and to comment on solvent waste management practices (decision making hierarchy, corporate policy, barriers etc.).

The questionnaire for solvent waste management companies focused on issues such as potential for increased material recovery, potential use as a fuel within Ireland, general trends, current operations and charges.

The questionnaire for the cement industry covered considerations related to using solvent waste as a fuel in cement kilns.

The questionnaires were sent in advance and were followed up by site visits (to 12 of the top 14 solvent waste generators and 3 of 4 waste management companies contacted) and/or telephone interview (the remaining 2 waste generators and the fourth waste management company). All cement kiln operators on the island of Ireland were sent the questionnaire and interviewed by phone.

The willingness to participate and supply information varied from those that completed the questionnaire in full (and disclosed waste management cost breakdowns) to companies that would not disclose costs. Divulgence of costs was a particularly sensitive issue with solvent waste management companies, and also with the cement industry; however a number of generators supplied their charges and this allowed us to build a (partial) cost profile.

Some regulatory stakeholders were interviewed – within the EPA and a counterpart in Northern Ireland.

An economic assessment was undertaken using the limited data from respondents. Due to the paucity of this data, further data was sought from a supplier of solvent recovery equipment. All the data were combined and subjected to several scenarios, within a broad span of assumption, to investigate the financial viability of solvent material recovery.

3 Findings

Waste organic solvent in Ireland originates primarily from the pharmachem sector:

- About 96% of the solvent waste arisings occur in this sector;
- 90% of the solvent waste arising is accounted for by less than 20 companies;
- between 50% and 60% of the solvent waste occurs in six companies.

Much of these arisings are managed on-site within the sector, either recovered by distillation for reuse on-site or disposed of by incineration. The scale of recovery on-site is understated by at least 40,000 tonnes per annum, due to ambiguity in the reporting requirements. The majority of the remainder is handled by two waste brokers who also operate blending facilities.

The Pharmachem sector is currently undergoing major change and is reported to be under severe financial pressure. Current products protected by patent will come off patent. Revenues for the existing companies will fall hugely and cost efficiency will be paramount. Bulk production may move to Asian production locations. Reduction in bulk manufacture, improved process efficiencies and a shift to alternative biologically synthesised products may reduce solvent waste arisings, a trend already evident. In contrast, as some sites move towards product development, production campaigns will be shorter and waste mixtures more complex, lacking the economy of scale associated with bulk manufacture that leads to dedicated solvent recovery plant. It might be prudent, therefore, to concentrate efforts, policies, and other measures, on supporting existing infrastructure.

Of the material handled by the solvent waste management companies, some is exported for material recovery, much is exported for disposal, typically by incineration, and the balance is blended in Ireland for subsequent export as fuel in cement kilns. These are licensed to process up to 60,000 – 80,000 tonnes per annum. In 2008, nearly 24,000 tonnes were blended for fuel. A small quantity (about 3,000 tonnes) originating in the Republic of Ireland has been burned in Northern Ireland on a once-off basis. The role of Northern Ireland would appear to be solely as a potential outlet, with little solvent waste arising there and its being simpler to send the waste to Britain, avoiding the need for TFS controls. No cement kiln in the Republic of Ireland is currently licensed to use waste solvent as fuel, though two are imminently applying for such permission. Should use of solvent waste in cement kilns become practiced, it would easily absorb the waste arisings, with the available waste solvent in 2008 amounting to only 4% of the cement sector’s energy needs. Since there is little solvent use outside of the pharmaceutical manufacturing sector, there is almost no demand for lower quality solvent, except a small market in biodiesel production and in vehicle refinishing. The waste management chain has

evolved to favour blending of many waste streams, of variable calorific value, to produce a more homogenous fuel.

The current practice of assigning "temporary / storage" waste codes (R12/13; D12/13) and attributing Ireland as the treatment destination, though the material is actually exported after blending, confuses the waste statistics. An apparent rise in indigenous treatment in the last few years is false, since the final destination is abroad. Dealing with solvent wastes within Ireland brings several key benefits:

- Reduced transport reduces costs and safety and environmental risks; transport costs are a significant portion of off-site treatment costs and treatment in Ireland would bring savings in the range €1,000 - €2,000 per tanker of waste;
- Indigenous treatment enhances security of supply to waste management processes, avoiding interruption due to sea crossing or exporting issues;
- Recovering solvent for material reuse saves resources, enhances security of supply of needed process materials and may reduce costs;
- Using waste solvent as a substitute for fossil fuel reduces external energy demand;
- Increased local activity consolidates employment and supports the economy.

However much these may be desirable, there are conflicting barriers to their achievement. Product quality issues dominate this sector. Hence reuse of recovered solvents may be restricted to the originating process or prohibited altogether. The need to segregate solvent wastes may be frustrated by limited tankage or piping. Accumulation of a sufficient volume of solvent that is economic to recover may be confounded by short production campaigns. Nevertheless, there are instances where it has been economic to enter into contracts with external recovery parties to process specific solvent, and where reuse of solvent in any manufacturing process or in cleaning operations has been acceptable.

Use of blended solvent in cement kilns in Ireland is a low cost option, with a potential cost of €36 per tonne. Exporting material for recovery and reuse, even abroad, is better at €24 per tonne – if a credit can be obtained by the waste generator. However, this is not always the case and there is even variation for similar materials between different generators. Information sharing between generators might facilitate their securing better terms. Use of waste solvent as a substitute for existing fossil fuel use in boilers, thermal oxidisers or incinerators on site would also bring financial benefits. There was some concern among generators about the IPPC licensing viability of this, with many being unware that two sites already use waste solvent in thermal oxidisers and a third uses its solvent waste in its boiler. Again, information sharing would clarify this. Declassification of waste to fuel appears to be a problem and there are concerns among generators that the application of the Waste Incineration Directive may prompt lower emission values and increased monitoring, even if the waste is cleaner than the fossil fuel already in use.

Best of all options is the recovery of solvent for reuse in Ireland, which has major savings over the purchase and treatment of fresh solvent. The available cost information from sites operating solvent recovery units was highly variable and, in some cases, appeared to reflect the recovery plant carrying a major burden of overheads associated with the main plant. Use was therefore made of equipment vendor estimates to suggest savings of €198 - €235 per tonne processed. A sensitivity analysis of the various assumptions was conducted to challenge these findings and still suggests that reasonable payback periods can be obtained. Achieving reuse of recovered solvent requires overcoming the barriers discussed above and may entail greater outsourcing of recovery capacity to other pharmaceutical sites with underused capacity. Quantifying this is not easy due to the many complicating factors: a coincidence of solvent production and need at the originating site with available capacity in tankage and distillation at the second, and satisfaction of quality and business strategy concerns. This has been already achieved in two instances by plants within the same corporation and in a third case by two unconnected sites – demonstrating such an arrangement is possible. Cost savings and a need to secure solvent supply were factors promoting these co-operations.

There is a small merchant recovery plant in existence, but its capacity is underutilised, with its experiencing difficulty in obtaining feedstock from the pharmaceutical sites. This illustrates one barrier to establishing an independent large scale recovery plant. The second, even more significant, is the relative absence of a secondary solvent market and the reluctance to reuse externally processed waste solvent. Without an outlet in the pharmaceutical sector, such a plant must carry the transport cost burden of shipping product to the UK or further. The existing merchant recovery plant sells its

recovered methanol to an indigenous biodiesel plant and a mixture of other solvents as "standard thinners" to the vehicle refinishing industry.

After reviewing these findings and considering the traditional and newer interpretations of the waste management hierarchy in conjunction with the three pillars of sustainable development, the following are the preferred options:

- On-site material recovery for material reuse
- Off-site (Ireland, another pharma plant) material recovery for reuse
- Off-site (Ireland, existing merchant recovery plant) material recovery for reuse
- Off-site (abroad, existing merchant recovery plant, credit obtained) material recovery for reuse
- On-site use of waste solvent as fuel in boiler / thermal oxidiser / incinerator
- Off-site (Ireland) use of waste solvent as fuel in cement kilns
- On-site incineration
- Off-site incineration

Within these there is a "sub-option", which is not an end in itself, of adopting measures to pre-concentrate solvent waste on site, with appropriate treatment of the residue and subsequent beneficial use of the more concentrated solvent stream.

A detailed presentation of conclusions is provided in Chapter 9. The responses to the first two questions in the Terms of Reference are as follows:

- *Is there scope to increase Irish domestic management of solvent waste arising?*

A significant amount of material recovery is already taking place in Ireland and there is available distillation capacity for more – if companies are willing and allowed to use capacity outside their own sites. Material is currently blended and exported, though there is a local market that could consume all blended fuel. Even if off-site treatment is eventually required, some on-site pre-treatment or concentration could reduce costs to generators.

- *Considering the current technical capacities for treatment in Ireland what economic drivers are there for the continuing export of these wastes?*

The existing broker business model seems focused on export of solvent waste, but this could be refocused if there were outlets in Ireland, with an anticipated cost saving for the generators through reduction of transport charges. Achieving this requires licensing of market outlets, cement kilns in particular.

4 Recommendations

A clearer, and more correct, picture of waste arisings will ensue if the EPA issues clear guidelines on the reporting of solvent recovered on-site for material reuse (R2). The present practice counts material that is definitely not intended to be discarded. The permanent classification by blenders of solvent under the "temporary / storage" categories of R12/13 is not conducive to good management, either for the EPA or the waste originators. The current practice implies an indigenous end treatment that does not exist and obscures the fate of the waste from the originators, who may have cost and policy concerns about the final destination.

Recommendation	Actors
Clear guidelines should be provided by EPA in quantifying and reporting the quantity of R2 material.	EPA
Solvent waste management companies should be obliged by EPA to communicate to generators the end fate of solvent classified under interim classifications.	Solvent waste management companies
Trans-Frontier Shipment (TFS) reporting requirements should be reviewed to avoid the	National TFS

use of interim or storage codes (R12/13 or D12/13) Waste classified as R12/13 or D12/13 in their PRTR should be updated by Licensees in the following year's Annual Environmental Report to reflect the final destination and fate of the waste.	Office IPPC Licencees

Many of the improvements sought must originate with the waste generators. Several positive innovations have taken place and actively sharing this information would benefit others. Since the pharmaceutical sector is the dominant originator of solvent waste, the EPA should maintain a continuing dialogue, in addition to its enforcement role, with the individual companies and with the sector. The EPA, in conjunction with the industrial support agencies, should encourage solvent waste reduction, by facilitating the exchange of experience and promoting available state funding mechanisms for process improvements with a view to avoiding waste. While the on-going responsibility for this may lie with the industrial support agencies, the EPA, as promoter of the National Hazardous Waste Management Plan, may be appropriate to initiate such an activity. In addition, it has experience of stimulating specific technological actions in this area under the auspices of the Cleaner Greener Production Programme and of promoting networking activity under the Local Authority Prevention Demonstration Programme (now Local Authority Prevention Network). Information sharing benefits companies and regulators alike.

Recommendation	Actors
A regular (perhaps three occasions per year) information exchange should take place between the pharmachem sector, EPA and industrial support agencies A generator "solvent recovery forum" should be promoted by EPA or the industrial support agencies to facilitate information exchange ….. on pre-recovery and recovery practices. ……on best practice on solvent reuse. ……on recovery capacity. ……including a benchmarking of on-site recovery costs. ……including a benchmarking of off-site recovery/treatment costs. EPA should consider facilitating an annual supply chain meeting of brokers and end fuel consumers to link with the "solvent recovery forum" and other generators. EPA and the industrial support agencies should promote existing available funding mechanisms for process improvements. Preconcentration of waste streams into a higher value fraction and reduced volume difficult waste should be promoted via existing industrial supports for capital investment and research.	Pharmachem companies EPA IDA EI Solvent waste management companies Cement operators Merchant recovery

Regulation protects the environment, but it also provides a context for business decision-making. Along with lack of knowledge of innovations that have taken place, there are perceptions of what may or may not be acceptable – and these perceptions, when incorrect, are themselves barriers to progress. Clear, consistent guidelines and regulation are required from the EPA to orient decisions to the desired end.

Recommendation	Actors
In order to resolve any incorrect perceptions or lack of clarity, EPA should state that it has no objection in principle to: the recovery of solvent waste from one company, by another company, the use of waste solvent as fuel in lieu of supplementary fossil fuel where material recovery is not feasible, and that any licence application to do so will be actively considered, in the context of the current waste hierarchy, national policy and regulation and any site specific factors. Treatment within Ireland should continue to be encouraged by EPA or the industrial	EPA

support agencies. Clear guidelines should be provided by EPA in relation to the classification of waste treated in incinerators as R1 or D10. Clear guidelines should be provided by EPA in relation to the determination of End-of-Waste status of processed materials. EPA should provide a clear definition of "fuel" when derived from waste. Where waste is burned as fuel, the Waste Incineration Directive should be consistently applied by EPA, reflecting the waste composition and likely emissions. A review of the records of waste contractor facilities by EPA may help in determining the nature of the activities being carried out and ensure that dilution as forbidden under BAT is not occurring. Concentrated streams should not be diluted. Clear EPA guidelines should specify this. Weak streams should not be concentrated by blending. This should be specified by clear EPA guidelines.	

A detailed presentation of 23 recommendations is provided in Chapter 10 and these are linked with consideration of the waste management hierarchy and sustainable development in the associated Roadmap, in Chapter 11. In addition, a graphical integration of the recommendations and the relevant actors is provided. The responses to the remaining questions in the Terms of Reference are as follows:

- *How might these (economic drivers) be made more favourable for domestic treatment?*

  Information sharing among the generators (who are also often recovery operators) would demonstrate the potential to address quality regulatory barriers and would present opportunities to share available distillation capacity. Many of the recommendations relate to highlighting existing practices that are not well known. Comments are made below in relation to adjusting the environmental regulatory barriers.

- *What is/are the most economically beneficial management option(s) for these wastes?*

  Individual solvent waste generators should firstly study the economic feasibility of recovering and reusing their solvent, using conditions proven to be applicable to their specific operations – assuming they can reuse their own solvent. Achievement of this is most financially attractive. If this is not possible, they should seek to negotiate favourable terms for the export and subsequent recovery of their waste. Finally, if material recovery is not viable, use of the waste as a fuel, either on-site or in Irish cement kilns should be pursued.

- *What impact if any will economies of scale for treatment impact on these options?*

  Establishing a new merchant recovery plant is considered to be a high-risk venture, in view of uncertainty in securing feedstock and difficulties in securing a market, in spite of being a superficially financially attractive proposition. The changing structure of the sector in Ireland, allied with a downward trend in solvent wastes, suggests the market is contracting. There may be niche opportunities related to the major solvents in use: methanol, propanol, toluene, and tetrahydrofuran.

- *What legal, regulatory and economic barriers are there to implementing the most economically beneficial management options domestically within Ireland?*

  Clear, consistent guidelines and regulation are required from EPA in relation to classifying waste, defining end-of-waste criteria, regulating the emissions from waste burned as fuel, and in tracing the path of waste, from generator via broker to eventual fate.

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GLOSSARY

AER	Annual Environmental Report
API	Active Pharmaceutical Ingredient
BAT	Best Available Techniques
BREF	BAT reference document
CFT	Call for Tender
CHP	Combined Heat & Power
CIP	Clean in place
CN	Combined Nomenclature
CSO	Central Statistics Office
CTC	Clean Technology Centre
C.V.	Calorific Value
DEHLG	Department of the Environment, Heritage and Local Government
EI	Enterprise Ireland
ELV	Emission Limit Value
EPA	Environmental Protection Agency
EPS	EPS Consulting
ETS	European Trading Scheme
EWC	European Waste Catalogue
FDA	US Food & Drug Administration
GHG	Green House Gases
HFO	Heavy Fuel Oil
IDA	Industrial Development Agency
IPPC	Integrated Pollution Prevention Control
NAP	National Allocation Plan
ND	Not determined
PRTR	Pollutant Release and Transfer Register
RDF	Refuse derived fuel
SLF	Secondary liquid fuel
SRU	Solvent Recovery Unit
STRIVE	Science, Technology, Research and Innovation for the Environment
TFS	Transfrontier Shipment
TOs	Thermal Oxidisers
t.p.a	Tonnes per annum
WID	Waste Incineration Directive
WT	Waste Transfer
WWTP	Wastewater treatment plant

CFCs	Chlorofluorocarbons
CO	Carbon Monoxide
CO_2	Carbon Dioxide
DCM	Dichloromethane (methylene chloride)
HCFCs	Hydrochlorofluorocarbons
HCl	Hydrogen Chloride
HF	Hydrogen Fluoride
IPA	Isopropyl alcohol
MIBK	Methyl isobutyl ketone
NOx	Oxides of Nitrogen
PCB	Polychlorinated biphenyls
PCDD/F	Dioxins and Furans
PCP	Pentachlorinated phenol
POP	Persistant Organic Pollutant
SO_2	Sulphur Dioxide
THF	Tetrahydrofuran
TOC	Total Organic Carbon

1. INTRODUCTION

1.1 Sources of Waste Solvent

In 2007, 119,000 tonnes of Ireland's hazardous waste generation were organic solvent[1] and of these, 55,400 tonnes were exported for recovery or disposal. This waste arises primarily from the pharmachem sector, with much smaller quantities of solvent wastes arising from paint manufacture, electronics and medical devices, etc. This lack of self-sufficiency in handling our waste is a cause for economic concern[2], since it leaves Ireland open to business interruption in the event of closure of export markets or transport disruption, is not in keeping with the proximity principle and conflicts with the objectives of the National Hazardous Waste Management Plan.

The pharmaceutical manufacturing industry is a significant part of Ireland's economy, with the chemical synthesis segment of this sector being a major user of organic solvent and subsequently a large producer of waste solvent for recovery or disposal. This sector does undertake considerable recovery for reuse, but experiences barriers to the reuse of this solvent including:

- product quality requirements are very high, demanding validated high purity from any recovered solvent,
- processes require a large number of solvents leading to a wide range of solvent mixtures, the separation of which can be expensive and complicated. Solvent recovery is not the primary business focus of production facilities.

Similar issues have been identified in the Swiss industry[3], though they have a policy of self-sufficiency in principle and have opportunities for reuse of solvent outside of the pharmaceutical industry. There are few other economic sectors in Ireland that use solvent as either an ancillary or raw material, hence there is limited opportunity to down-cycle solvent to less demanding process requirements, e.g. in biodiesel, paint production, printing or as a cleaning material (all of which have potential environmental concerns themselves). Nevertheless, some waste generators do recover solvent and there are some indigenous uses for material recovery of waste solvent.

1.2 Opportunities for Solvent Waste Recycling and Treatment

An alternative route to achieve recovery is energy recovery, whereby solvent, much of which has high calorific value, may be used as fuel substitute, e.g. in cement kilns, boilers or electricity generation. Much of the exported solvent is recovered as fuel, but some of this may be confined to fuel saving within hazardous waste incinerators. Local entrepreneurs have developed solvent blending capability to produce fuel (16,573 tonnes in 2007, nearly 24,000 tones in 2008), but this is exported.

It is a recommended objective of the EPA's Second National Hazardous Waste Management Plan 2008-12 to *reduce export and increase indigenous (including on-site) treatment of hazardous waste. To achieve this objective, capacity is required at solvent treatment facilities in Ireland – either solvent recycling (R2), in existing cement kilns or other combustion plant (R1), purpose built incinerators (D10) and/or alternatives (as outlined in section 6.3). Domestic capacity could be provided in either of two locations: on-site of generation, or off-site at commercial facilities in Ireland.*

Within the call for tender, the EPA states:

"There is clearly a quantity of solvent waste that could be treated commercially in Ireland. The options to achieve this are as follows:

- *recycling – i.e. distillation or other physico-chemical treatment resulting in a recycled solvent suitable for reuse;*
- *co-incineration and energy recovery in cement kilns or electricity/heat generation facilities; and*

---

[1] EPA, National Waste Report 2007, Table 22, p23, EPA, 2009

[2] Forfas, Waste management benchmarking analysis and policy priorities, 2008

[3] Seyler,C., et al. Waste solvent management as an element of green chemistry: A comprehensive study on the Swiss chemical industry. Industrial & Engineering Chemistry Research, 2006, 45(22): 7700–7709.

incineration – i.e. combustion in dedicated incineration plant with recovery of energy.

The order of their presentation reflects the accepted waste hierarchy, namely that preference should be given to recovery, and especially recycling; minimising the disposal of waste; and treating waste for disposal as close as possible to its place of generation.

In the interest of promoting self-sufficiency and maximising fossil fuel substitution, the plan recommends that the combustion of blended solvent should take place in Ireland, within the constraints of planning requirements, IPPC licences and the Waste Incineration Directive, in preference to export. Indigenous cement kilns were suggested as possible suitable users of blended solvent, although power stations or other combustion plant were also identified as potential users of these products."

While the waste hierarchy has been accepted for many years, consideration must be given to assessing if it is universally applicable. Solvent recovery by distillation is energy intensive and such processing itself has negative environmental effects. Hence down-cycling of waste solvent to fuel may be environmentally as well as economically preferable.

Figure 1.1 illustrates the Waste Management Hierarchy.

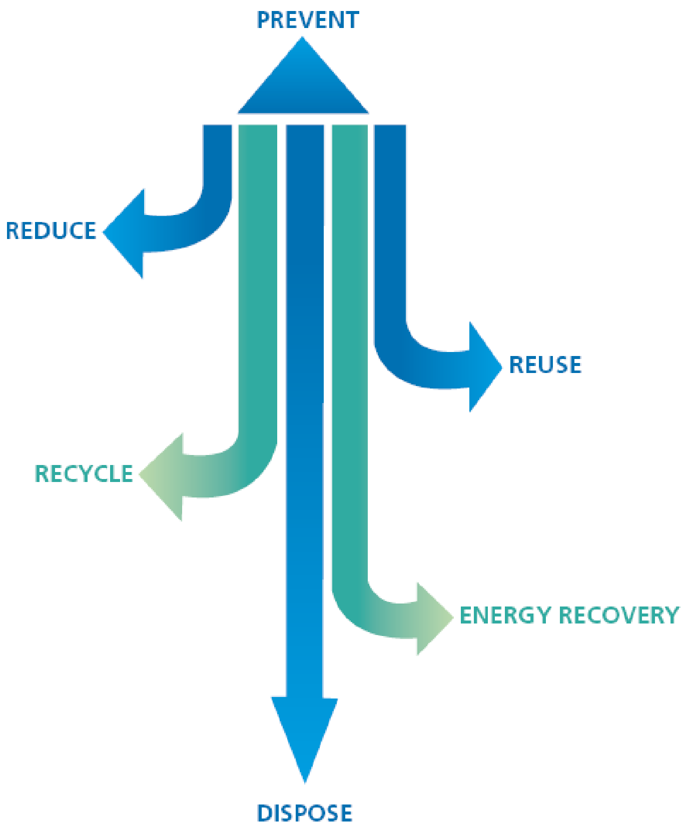

Figure 1.1: Waste Management Hierarchy (Derham, 2009)

1.3 Future Developments in Waste Solvent generation

Detailed studies have been undertaken by Capello[4] of the Swiss solvent waste management system and more recently, the same author[5] has provided "rules of thumb" to guide management. These provide some insight, but must be interpreted cautiously. Not only are they based on Swiss industrial practice, there are critical assumptions integrated into the modelling procedure that might not be valid

[4] Capello, C., Environmental assessment of waste solvent treatment in the Swiss chemicals industry, PhD thesis, 2006, ETH Zurich, Switzerland.

[5] Capello, C., et al, Environmental assessment of waste solvent treatment options. Part II: General rules of thumb and specific recommendations, Journal of Industrial Ecology, 2008, 12, 1, 111-127.

with Irish solvent mixtures, e.g. binary, typically non-azeotropic, systems are the basis for the study. This study suggests that distillation is clearly preferable for more “sophisticated” solvents, e.g. THF, MIBK, DCM, because of the avoidance of virgin solvent production; cement-kiln fuel use is preferable to incineration if coal is the existing fuel. However, the recovery rate and technology specifics e.g. need for entrainers[6], use of batch rather than continuous operations, are important. “Rules of thumb” must be interpreted in light of local specifics.

Similarly the validity of the proximity principle must be considered. As pointed out in the call for tender, in the absence of an Irish market for recovered solvent, the impacts of transport followed by recovery are similar to those of recovery followed by transport. The economies of scale enjoyed by foreign recovery operations, plus ready and established access to markets seeking a diverse range of solvent purity, are advantages that are not easily achieved in Ireland.

A likely trend, but one that cannot be accurately predicted, is that the face of the pharmaceutical manufacturing sector in Ireland will change dramatically over the next ten or so years. One associated effect of this change will be that the quantities of organic solvents imported, and the quantities of solvent wastes produced, will fall dramatically. Key issues are:

(a) Current products protected by patent will come off-patent. They will still be used, but since they will now be considered “generic”, they can be manufactured by any competent operator. Revenues for the existing companies will fall hugely and cost efficiency will be paramount. Bulk production may move from Ireland to locations such as India and China. This migration will lead to vastly reduced production – and therefore, to decreased solvent use.

(b) Product development facilities will probably remain in Ireland, but now associated with shorter campaigns of specialised batches. This may lead to more complex mixtures of solvent waste, lacking the economy of scale of prolonged manufacture that would favour solvent recovery. Irish sites may be less significant for global bulk supply, but more important as process developers.

(c) The move towards “greener chemistry”, involving fewer reactions steps, optimised processing conditions, continuous operation, more sophisticated technologies, will also lead to lower solvent use. Existing Irish production facilities may be involved in developing new, more efficient, pathways for existing products.

(d) The move towards water based systems, whether for cleaning or, more importantly, for biological synthesis of desired products, also leads to less solvent waste. A number of the stakeholders commented that corporate strategy favours biological synthesis for the future.

These observations are speculative but based on reported sectoral issues (see associated box below) and stakeholder observations. They clearly have implications for the supply of solvent waste to any reprocessing activity. It might be prudent, therefore, to concentrate efforts, policies, and other measures, on supporting existing infrastructure.

Excerpts from media reports on structural changes in the sector:

India’s Cipla is in talks with a number of global pharma players, including Pfizer, about potential generics supply deals.

The discussions fit with Big Pharma’s increasing focus on generics that, this year alone, has seen Sanofi Aventis acquire Laboratorios Kendrick and Medley, GlaxoSmithKline (GSK) buy shares in Aspen Pharmacare and Novartis purchase Ebewe Pharma’s non-branded injectables unit.

Most recently, GSK formed a pact with India's Dr Reddy’s, focused on supplying non-branded drugs to emerging markets.

Source: http://www.in-pharmatechnologist.com/Industry-Drivers/Generics-hot-up-Cipla-in-talks-with-Big-Pharma-Takeda-mulls-M-As

India's drug manufacturing industry is tipped to grow 10 per cent over the next three years as more pharma firms shift operations there to cut costs, says a research report.

India's pharma market is thriving again after decades in oblivion, now ranking fourth in the world, largely thanks to efforts by the government towards legal reform, raising manufacturing standards and reducing bureaucracy.

6 Addition of another solvent to a mixture, where the new solvent has a particular affinity for one or more of the original mixture components and facilitates separation

India's attractiveness as a global location for both pharma contract services and as a place to set up operations can also be attributed to the growing pool of skilled professionals in this sector, as well as low cost base, providing firms with increased competitiveness and profitability.
Source: http://www.in-pharmatechnologist.com/Processing-QC/India-s-drug-makers-set-for-business-influx

AstraZeneca will outsource the manufacture of all drug APIs under an operating plan discussed last week.
The UK drug major said the move will provide both cost and flexibility benefits and highlighted the Asian manufacturing sector, particularly in China and India, as one of the most important sources.
Source: http://www.in-pharmatechnologist.com/Materials-Formulation/AZ-to-outsource-all-API-production-in-7-years

The recent wave of M&A will lead to manufacturing over-capacity at pharma companies but only a small number of these sites will be sold to CMOs, in part because of the facilities' suboptimal locations, according to a report.
Many pharma companies are facing manufacturing overcapacity, or more accurately an excess of unsuitable production facilities, caused by a combination of mergers and acquisitions (M&A), globalisation and changes in requirements, such as the rise in biologics.
Tellingly, 80 per cent of survey respondents, who consisted of real estate leaders in each of the top ten global pharma companies, said that their manufacturing capacity was in suboptimal locations.
Respondents listed availability of skilled labour, robust regulation, government support, presence of existing pharma manufacturing, transport infrastructure and partners, such as CMOs, being located in the area as they key criteria for selecting a manufacturing location.
CBRE predicts that the sites pharma offloads will mainly be commercial scale manufacturing plants, which struggle to compete against Asia and Eastern Europe, with pilot plants remaining in established markets for scale-up processes.
Source: http://www.in-pharmatechnologist.com/Industry-Drivers/Few-pharma-plants-will-be-sold-to-CMOs-report

1.4 Scope of the Work

The call for tender describes the following tasks:

"Task 1: Consultation on solvent treatment.

The Contractor will consult with generators of waste solvents and treatment operators to develop an understanding of current status of the market, the technical feasibility of changing current practices and to consider the potential for minimisation of these waste streams at source. Information from the national waste report will be made available to the contractor to target this consultation. The contractor shall during the consultation obtain an understanding of any potential contamination of the waste solvents and any limitations this may place on the treatment options for the waste. These consultations should also elicit information on the generators' perspectives and attitudes to changing the current management practices in Ireland and any non-technical barriers that they envisage.

Task 2: Assessment of markets for waste solvent within Ireland

The contractor will consider the market for waste solvent in line with the accepted waste hierarchy. In doing so the Contractor will quantify and report the constituent costs and overall costs associated with the current management practices for these waste streams and the likely costs of redirecting these solvent wastes to recycling; co-incineration and energy recovery; or incineration in Ireland. These should include inter alia solvent treatment operator's costs including capital & operating cost per tonne, transportation costs, other gate fees (e.g. incineration) and levies; and waste generators' costs including storage and transport costs, brokerage costs and treatment costs. This consideration should be based on real market information where available and will require the Contractor to communicate with the current operators in the Irish market. The Contractor will rank the potential diversion routes based on the waste hierarchy, technical feasibility and economic benefit of each alternative route. If any routes are unrealistic the contractor shall define the issues with those approaches.

In doing so the Contractor should seek to answer the following questions:

- *Is there scope to increase Irish domestic management of solvent waste arising?*[7]

[7] The Irish scope can be increased – see section (Chapters 8&9)

- *Considering the current technical capacities for treatment in Ireland what economic drivers are there for the continuing export of these wastes?*[8]
- *How might these be made more favourable for domestic treatment?*[9]
- *What is/are the most economically beneficial management option(s) for these wastes?*[10]
- *What impact if any will economies of scale for treatment impact on these options?*[11]
- *What legal, regulatory and economic barriers are there to implementing the most economically beneficial management options domestically within Ireland?*[12]

The above questions have been addressed. The footnotes give some indication of where the primary answers can be found in the document.

Based on the ranked potential diversion routes, the Contractor will consider the barriers to the implementation of these recommendations and shall set out a roadmap of actions that would need to be taken to make the change in waste solvent management practice possible.

Task 3: End of Project Report

The contractor shall prepare a project report on completion of the project containing a summary of the stakeholder consultations containing an overview of the current market and management practices for waste solvent in Ireland and setting out the detailed costings for the various routes and a comparison with costs for existing practices. The report shall include a ranking of the potential diversion routes and an analysis of the barriers to implementing these various treatment routes for waste solvent. The report shall also contain an overall evaluation of the project and recommendations on actions that could be taken to promote Irish domestic management of waste solvents in the context of the most economically beneficial management options."

[8] There appear to be no economic barriers – rather custom and practice

[9] See recommendations (Chapter 10)

[10] In accordance with the hierarchy – see stakeholder consultation (Chapter 5) and recommendations (Chapter 10)

[11] There is sufficient capacity in Ireland. Supply likely to decrease – see stakeholder consultations (Chapter 5) and recommendations in Chapter 10

[12] These have been considered and are outlined in the conclusions (Chapter 9)

1.5 The Flow of Work and Structure of the Report

1.5.1 Flow of Work

Figure 1.2 illustrates how the work was approached for this project:

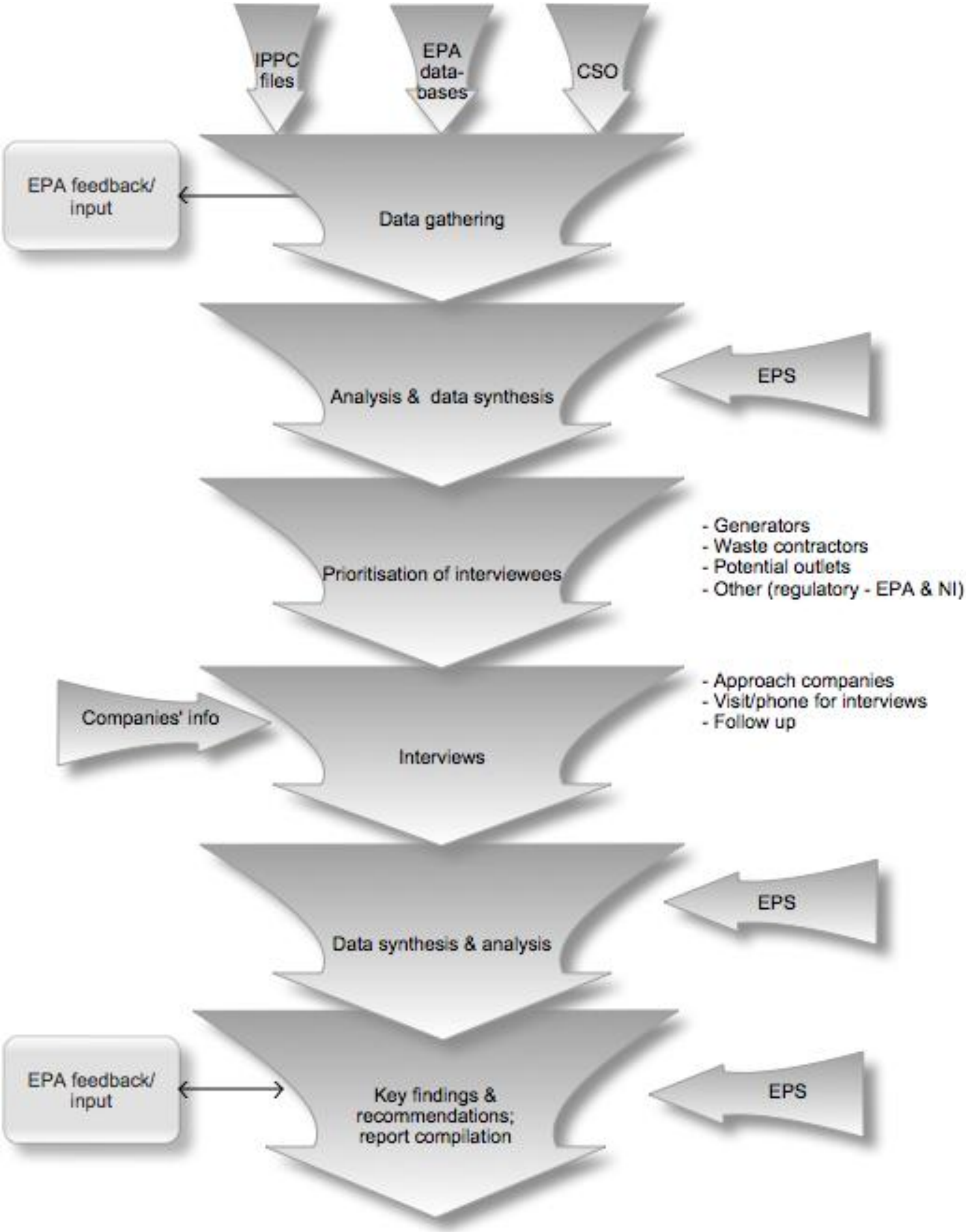

Figure 1.2 Approach to the Work

1.5.2 *Structure of the report*

The structure of the report can be summarised as follows:

Figure 1.3 Structure of Report

2. SOLVENT FLOW MODEL

Figure 2.1 shows the flow of solvent in a typical pharmaceutical or other solvent using production site that has on-site solvent recovery. As can be seen the mass balance envelope can be drawn in a number of locations:

- Balance 1: this balance takes account of the fresh solvent entering the site on the input side. The output side consists of waste solvent that is either sent off-site for any operation or disposed of on-site.
- Balance 2: this balance is around the production plant, and because of where it is drawn it takes into account on the input side both fresh solvent entering the site and solvent that has been recovered on-site and is subsequently reused. This recovery can be in a dedicated solvent recovery unit (SRU) or it can be a simple distillation within a process vessel. The output side takes account of all waste solvent coming from the production plant, including waste solvent that will be subsequently recovered on-site and reused.

As can be seen in the simplified example given in the diagram, exactly where the mass balance envelope is drawn will have an effect on the numbers – the output in 'balance 1' is 100 tonnes and in 'balance 2' is 600 tonnes.

Through our review of the sites reporting information and interviews we have ascertained that some sites are utilising 'balance 1', whereas others are utilising 'balance 2'. In addition to this, it would appear EPA inspectors are not consistent in recommending either method. A recommendation on a consistent, uniform reporting method across all sites is proposed (reference Recommendations section).

A recommended alternative, single method of calculation and reporting may be seen with reference to Figure 2.2.

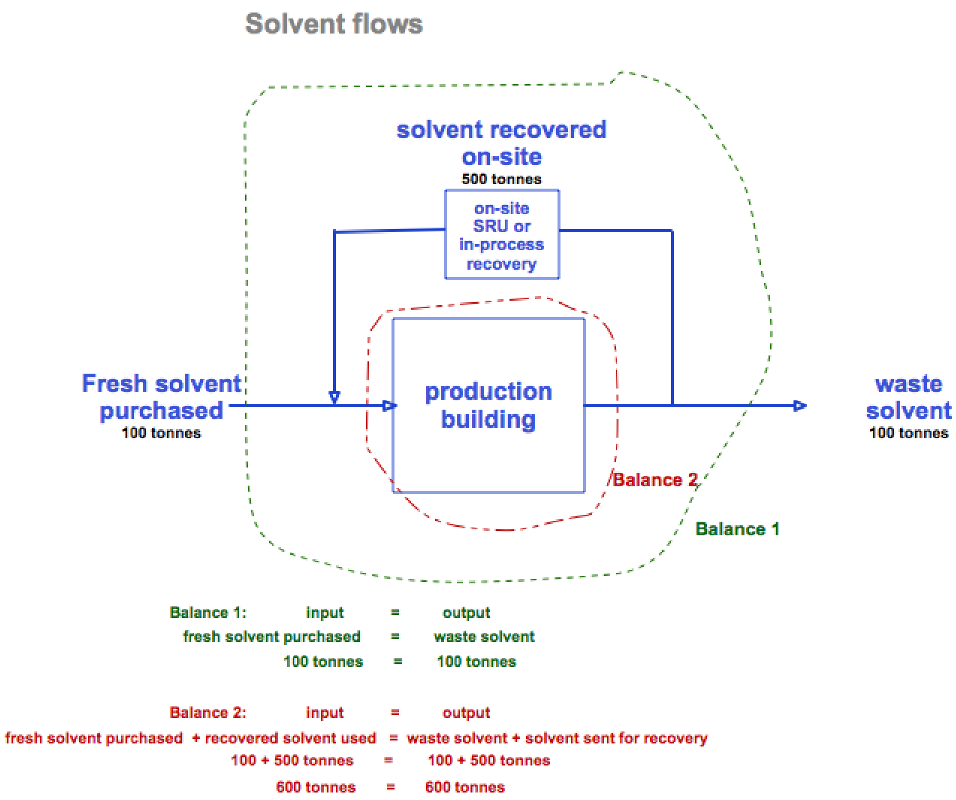

Figure 2.1: Solvent Flow in a typical site[13]

[13] This is a simplified diagram, and ignores emissions to air, accumulation on-site, etc. its function is to illustrate the two types of calculation procedures which are currently in use.

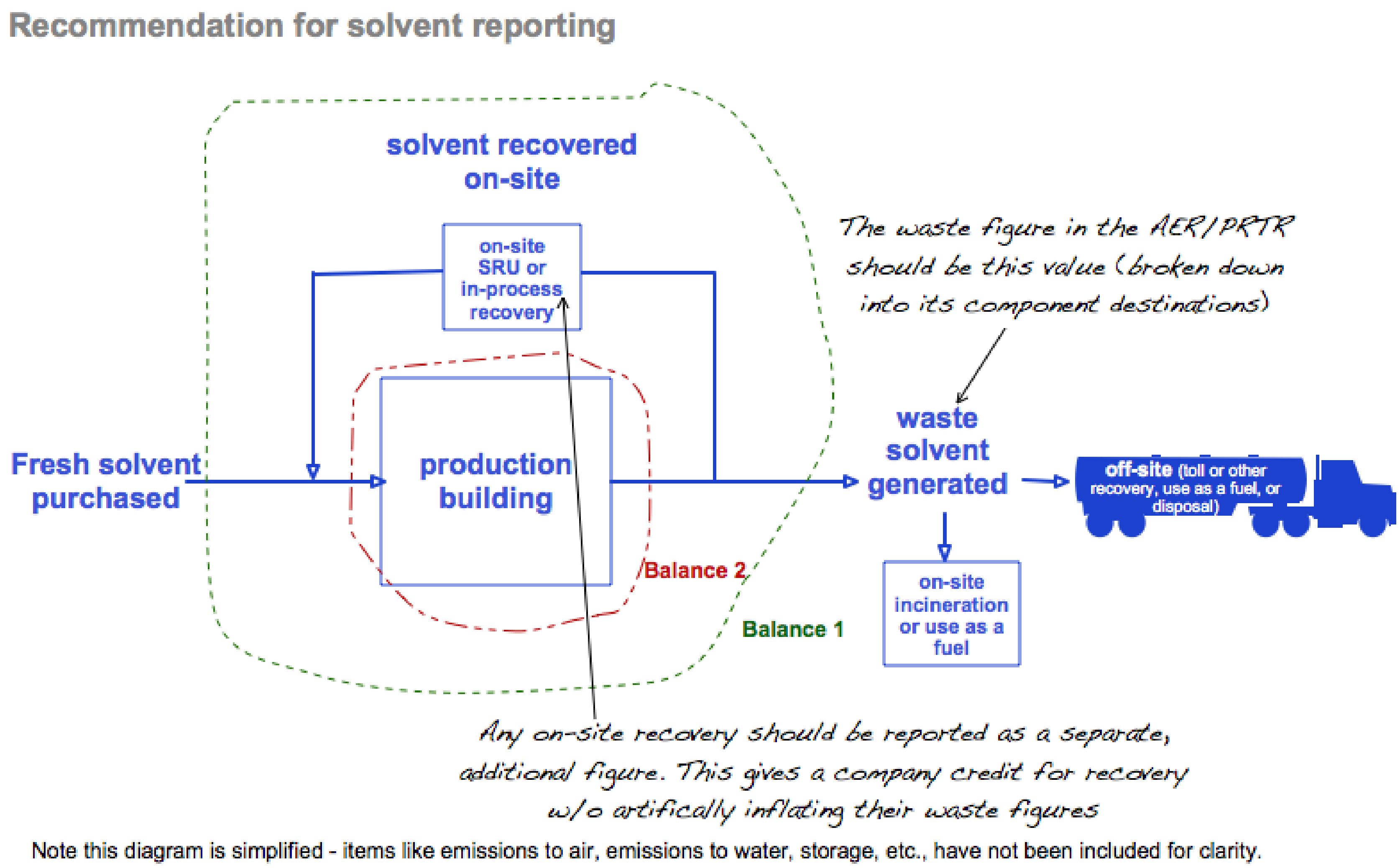

Figure 2.2: Recommended Solvent Balance Method for calculation and Reporting

3. IMPORT OF SOLVENTS

3.1 Review Of Trade Statistics Data

Since there is no indigenous solvent production, waste solvent must originate as imported solvent. Waste solvent may be diluted with water, so consideration of the quantities of solvent imported provides information on actual usage levels. We have obtained import/export data for a wide range of commodities with CN numbers potentially related to solvents. There are three confounding factors:

Firstly, it is not possible to obtain a breakdown of the destination of these commodities within Ireland, hence one is forced to assume that the destination is the pharmaceutical manufacturing industry. As may be seen when considering the waste solvent arisings, this assumption is well grounded.

Secondly, some substances that have CN numbers in the range associated with solvents may instead be reagents. A table listing the top 20 (22) solvents (& reagents) imported in 2008, with tonnage and value data and potential non-solvent applications, is presented in Appendix I.

Thirdly, the inclusion of undenatured alcohol has the potential to distort the statistics significantly, since this may be destined for the beverages sector. Omitting ethanol, whether denatured or not, the general picture is as shown in Figure 3.1:

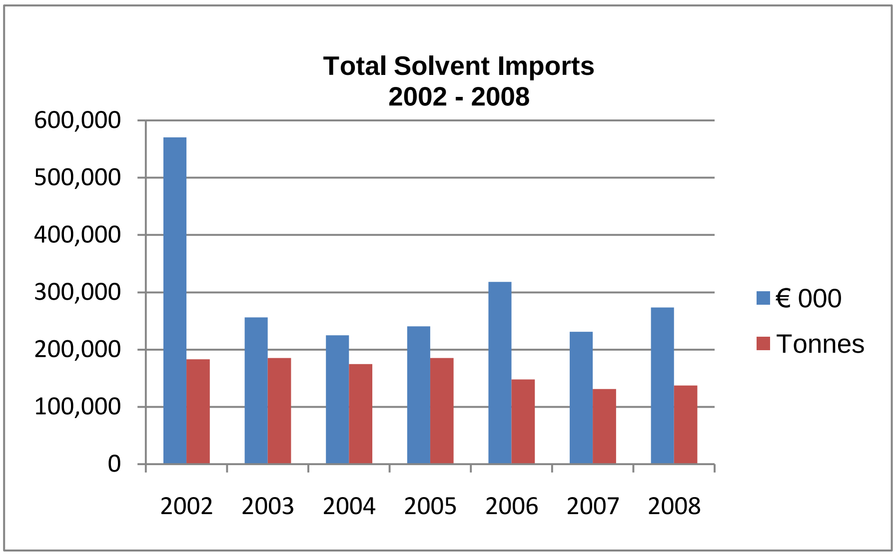

Figure 3.1: Total Solvent Imports (2002 – 2008)

Much of the fluctuations in value are accounted by the import of materials that, judging by their unit value, are intermediate products[14] rather than solvents. The quantities are less influenced by this and suggest a decrease of 25% from 2002 to 2008 – but this must be interpreted cautiously and is examined further below.

A detailed ranking of solvents (& some reagents), is shown in Figure 3.2. Further consideration of the identity of these solvents demonstrates that four solvents: methanol, propanol, toluene and tetrahydrofuran are most significant, as shown in Figure 3.3. While values will fluctuate from year to year, using the CSO import data for 2008, the unit values of the main solvents is shown in Table 3.1.

Table 3.1 Unit value of major solvents, derived from CSO 2008 import data

Solvent	Unit value, €/tonne
Methanol	364
Propanol	1,026
Toluene	705
Tetrahydrofuran	2,016
Ethyl acetate	937

[14] Substances which, though not the final product for human consumption, possess a relatively complicated molecular structure that facilitates their use in an advanced stage of the synthesis pathway

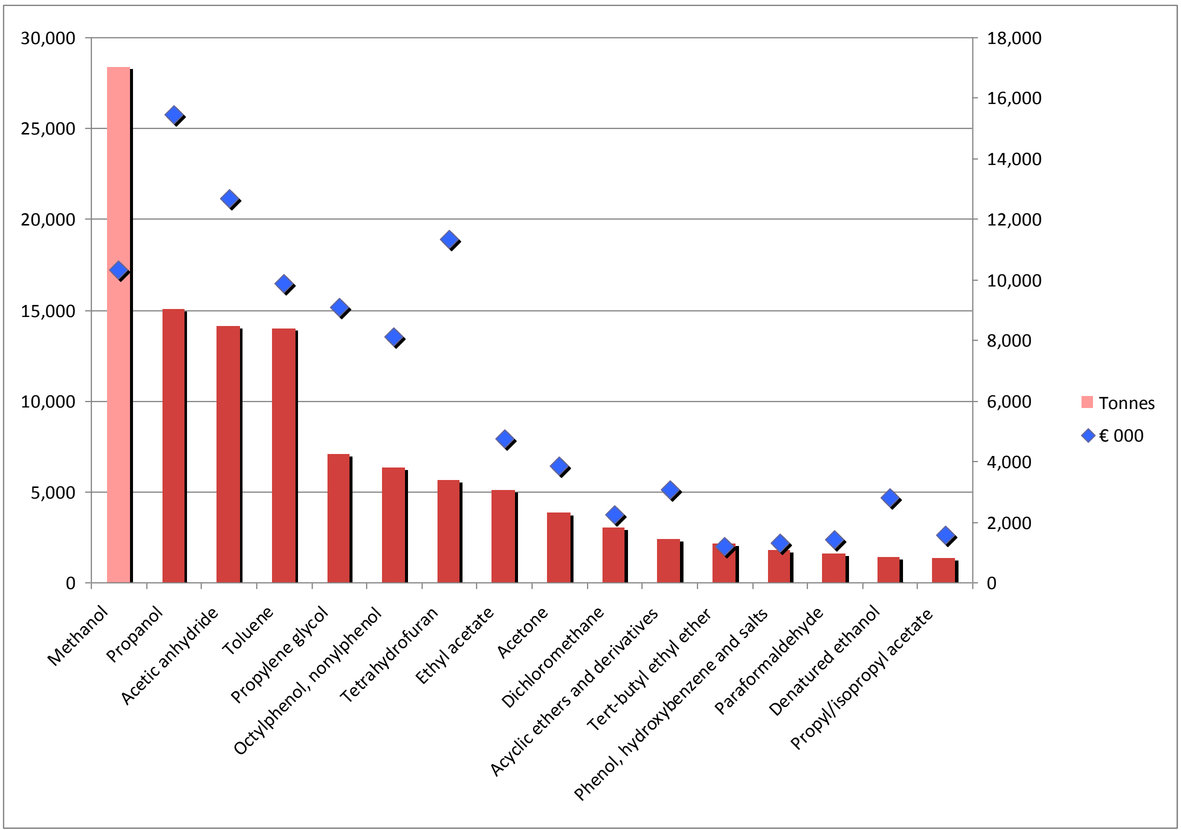

Figure 3.2: Top 20 solvents (Tonnage and value) imported in 2008

Methanol is commonly used as a cleaning solvent and is also used outside the pharmaceutical manufacturing sector in the synthesis of biodiesel.

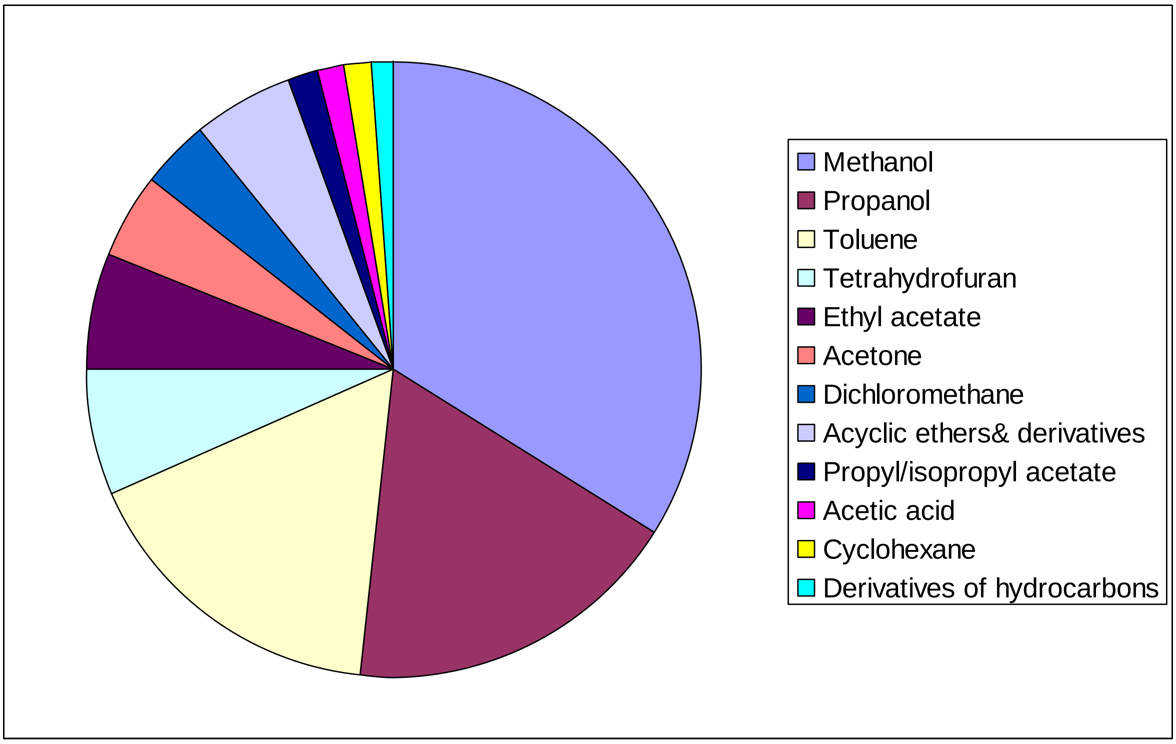

Figure 3.3: Major solvent imports (by tonnage) in 2008

Trends in solvent usage were examined by considering the period 2002 – 2008, as shown in Figure 3.4 (for 12 solvents).

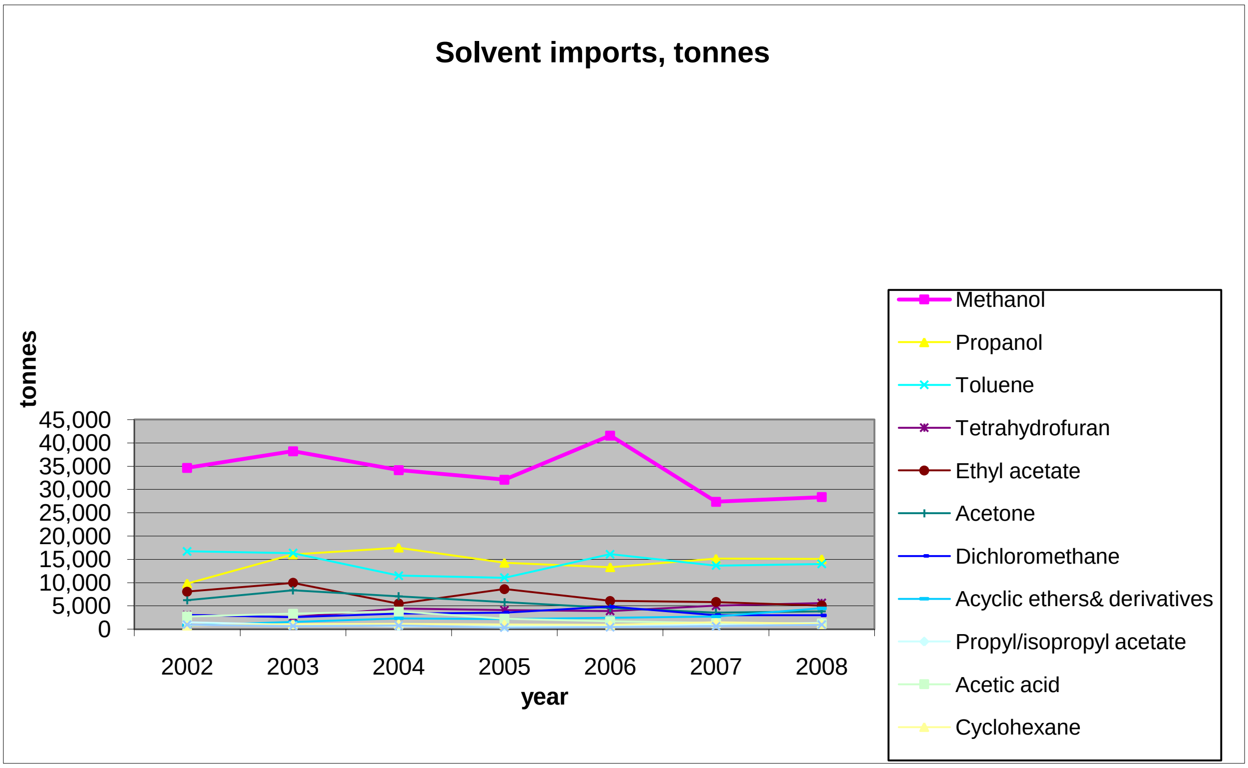

Figure 3.4: Major solvent imports (by tonnage) in 2002 - 2008

Note the data is obtained from CSO statistics, but the toluene data reflects an unpublished revision, following CTC querying. Omitting the top three solvents (methanol, propanol and toluene) to allow closer examination leads to Figure 3.5:

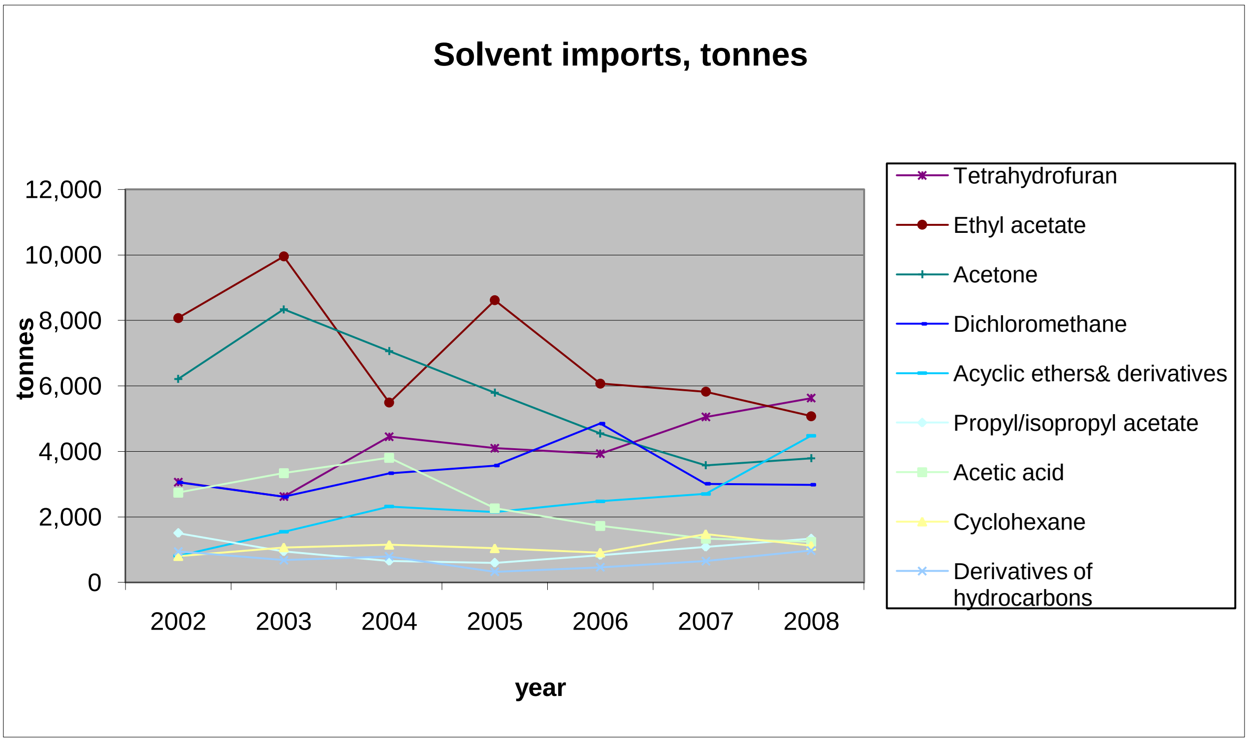

Figure 3.5: Lesser solvent imports (by tonnage) in 2002 – 2008

Considering this data, it may be concluded that:

(i) tetrahydrofuran and acyclic ethers imports are rising; acyclic ethers may find an application in gasoline blending;

(ii) other larger-volume solvent imports are static or falling;

(iii) dichloromethane is the only chlorinated solvent used in larger quantities.

Hence, the quantity of valuable solvent arising as waste is decreasing. Potential factors leading to this were discussed in Section 1.3, and may range from improved efficiency, the adoption of greener chemistry or structural changes in the Irish pharmaceutical manufacturing sector – changing from bulk manufacture to development or launch sites.

The data details are available in Appendix I.

4 WASTE STATISTICS

4.1 Overview

Solvent wastes are reported under differing headings in the National Waste Reports.

Solvent wastes have also been determined from various CTC studies of Annual Environmental Reports (AERs), and from electronic Pollutant Release and Transfer Registers (PRTRs).

Finally, solvent wastes are reported by the industry, under the Responsible Care programme.

There are differences between all these sets of data – which have not yet been satisfactorily reconciled.

4.2 Overall waste statistics

4.2.1 National Waste Reports data

Tables 4.1 – 4.5 give the breakdowns according to different categories and fates.

Table 4.1: Location of treatment of Total Solvent Wastes arisings, 2004 - 2008

Total Waste Solvents					
	2004	**2005**	**2006**	**2007**	**2008**
On-site at Industry	66,335		66,126	60,192	53,218
Offsite in Ireland	1,076		1,863	19,924	31,412
Exported	93,751	89,361	48,929	55,414	67,304
Unreported	26				
Total	**161,188**		**116,916**	**118,957**	**127,948**

The above data suggests a dramatic increase in solvent treatment off-site in Ireland. However, closer examination will reveal this largely reflects the accumulation and blending of solvents for export and subsequent use as a fuel. This identifes a weakness in reporting, whereby the final fate of waste is not communicated to the originating generators.

Table 4.2: Location of treatment of reported non-halogenated waste solvents, 2004 - 2008[15]

Waste Solvents – non halogenated					
	2004	**2005**	**2006**	**2007**	**2008**
On-site at Industry	63,351		31,141	44,347	48,150
Offsite in Ireland	1,072		1,821	17,704	23,667
Exported	87,295	81,229	39,058	48,671	58,611
Unreported					
Total	**151,718**		**72,020**	**94,224**[16]	**107,515**[17]

15 Table 28 National Waste Report 2008, Table 22 National Waste Report 2007, Table 40 National Waste Report 2006, Table 20 National Waste Report 2005, Table 13 Interim National Waste Report 2003

16 A total of 16,573 tonnes of waste solvent (halogenated and non-halogenated) was blended at facilities in Ireland prior to export for use as fuel in cement kilns and incinerators. The blended solvents were exported as a waste. These quantities are correctly counted in both the 'treated off-site in Ireland' column and the 'exported' columns. However, they have been discounted in the 'total' column to avoid double counting in the total amount of hazardous waste generated.

17 A total of 23,986 t of waste solvent (1,073 t of halogenated solvent and 22,913 t of non-halogenated solvent) was blended at facilities in Ireland prior to export for use as fuel in cement kilns and incinerators. The blended solvents were exported as a waste.

Table 4.3: Halogenated Solvent Wastes arisings, 2004 - 2008

Halogenated Waste Solvents (where specified)					
	2004	**2005**	**2006**	**2007**	**2008**
On-site at Industry	2,984		34,985	15,845	5,068
Offsite in Ireland	4		42	2,220	7,745
Exported	6456	8,132	9,871	6,743	8,693
Unreported	26				
Total	**9,470**		**44,896**	**24,733**	**20,433**

Table 4.3 suggests there has been a major change in the arisings of halogenated waste. Detailed examination of the reported data from companies demonstrates that the large quantities of on-site treatment originate with two companies that were incinerating waste. Considering that the import of halogenated solvents did not show the same major difference during the period suggests that highly dilute, probably aqueous, mixtures account for the peaks. A detailed Table of the halogenated waste arisings from the "90% companies" (see later) over the period 2002 – 2008 is available in Appendix I.

Table 4.4: Other possibly relevant solvent waste streams – Paints, Oils, and Varnishes[18]

Paint, ink and varnish waste (including packaging)					
	2004	**2005**	**2006**	**2007**	**2008**
On-site at Industry	387		4	7	6
Offsite in Ireland	3,357		928	517	924
Exported	4,111	1,701	3,045	2,805	4,843
Total	**7,855**	**1,701**	**3,977**	**3,329**	**5,773**

Table 4.5: Other possibly relevant solvent waste streams[19]

Industrial hazardous waste (other)					
	2004	**2005**	**2006**	**2007**	**2008**
On-site at Industry	3,879		3,753	4,698	4,776
Offsite in Ireland	2,112		2,441	2,709	5,869
Exported	10,902	19,675	11,801	33,854	33,154
Total	**16,893**		**17,995**	**41,261**	**43,799**

Tables 4.4 and 4.5 demonstrate the significance of solvents relative to other industrial hazardous wastes.

These quantities are correctly counted in both the 'treated off-site in Ireland' column and the 'exported' columns. However, they have been discounted in the 'total' column to avoid double counting in the total amount of hazardous waste generated.

18 Table 28 National Waste Report 2008, Table 22 National Waste Report 2007, Table 40 National Waste Report 2006, Table 20 National Waste Report 2005, Table 13 Interim National Waste Report 2003

19 Table 28 National Waste Report 2008, Table 22 National Waste Report 2007, Table 40 National Waste Report 2006, Table 20 National Waste Report 2005, Table 13 Interim National Waste Report 2003

4.2.2 IPPC Company Waste Analysis:

A detailed assessment of the solvent waste generation by IPPC licenced companies was undertaken for the years 2002 to 2008. This assessment was confined to relevant solvent type EWC codes.

Information Sources:

For the years 2002 to 2006 information was sourced from the AERs. For 2007 and 2008 the information was sourced from the PRTR database, and supplied by the EPA.

For the years 2002 to 2006, members of the project team had undertaken an annual study of the solvent waste, generated by specific companies in the Pharmachem sector. This study analysed the quantity and type of solvent waste from 39 companies that were, at the time, members of the PharmaChemical Ireland group. These previous studies covered all types of hazardous waste, and as a result had to be reviewed to only include the relevant EWC codes.

Total Solvent Waste Generation:

Table 4.6 outlines the total quantity and location of treatment of solvent waste generated, by all IPPC licenced companies, for the more recent years of 2007 and 2008

Table 4.6 Quantity and location of treatment of solvent waste from all IPPC licenced companies

	2007 (tonnes)	**2008 (tonnes)**
ONSITE		
Recovery	38,682	45,891
Disposal	15,787	22,893
OFFSITE – IRELAND		
Recovery	27,311	21,828
Disposal	10,417	10,685
ABROAD		
Recovery	37,989	27,066
Disposal	26,730	22,294
TOTAL	**154,990**	**147,669**[20]

4.3 Company waste statistics

A detailed analysis of 39 pharmachem companies was originally undertaken for the years 2002 to 2006 inclusive. This exercise was repeated for 2007 and 2008, to provide the opportunity for comparison between these companies, over a timeline of seven years. In both 2007 and 2008 these companies accounted for 95% of the total solvent waste generated by all IPPC licenced companies

Table 4.7 shows the breakdown of the total quantity of solvent waste generated and its location of treatment, for the 39 pharmachem companies.

[20] Note in 2007 and 2008, 1925.62 and 2988.38 tonnes of solvent waste respectively from one facility were disposed offsite in another facility. The disposal site recorded this waste in its onsite disposal value. This value is correctly recorded in both onsite and offsite disposal figures, but is not included within the total figure.

Table 4.7 Quantity and location of treatment of solvent waste from relevant pharmachem companies

	2002	2003	2004	2005	2006	2007	2008
RECOVERED							
On-site at Industry	48,813	39,110	32,266	39,983	36,996	38,495	44,822
Offsite in Ireland	70	0.3	761	7,277	783	26,857	21,076
Abroad	51,958	46,426	46,364	52,122	40,129	34,364	25,075
Location unknown				1,616			
Total	**100,841**	**85,536**	**79,391**	**100,998**	**77,908**	**99,716**	**90,973**
DISPOSED							
On-site at Industry	39,839	34,656	39,369	29,362	35,878	15,787	22,893
Offsite in Ireland	0	899	2,876	3,011	76	9,221	9,048
Abroad	27,669	36,868	35,703	21,548	38,320	24,728	19,830
Location unknown				603			
Total	**67,508**	**72,423**	**77,948**	**54524**	**74,274**	**49,736**	**51,771**
Undetermined			155		252		
TOTAL	**168,349**	**157,959**	**155,422**[21]	**153,901**	**149,997**	**147,526**	**139,756**[12]

Figures 4.1 - 4.3 provide a graphical representation of the above information.

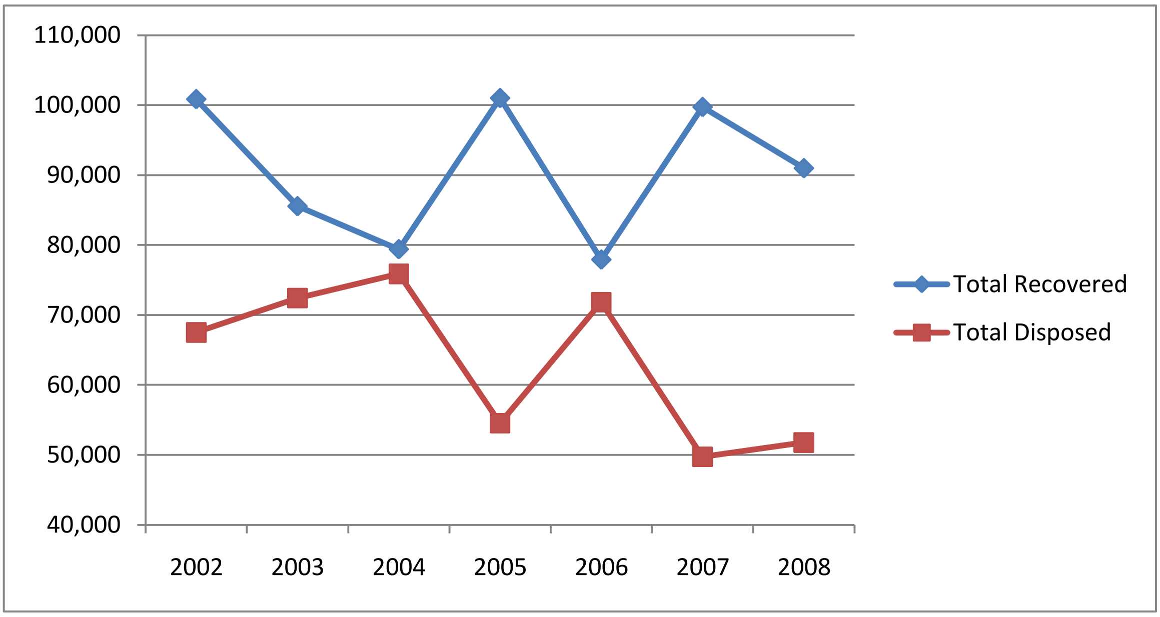

Figure 4.1 Total solvent waste recovered and disposed, 2002 – 2008

[21] Note for years 2004 – 2008 inclusive solvent waste from one facility was disposed offsite in another facility. The disposal site recorded this waste in its onsite disposal value. This value is correctly recorded in both onsite and offsite disposal figures, but is not included within the total figure.

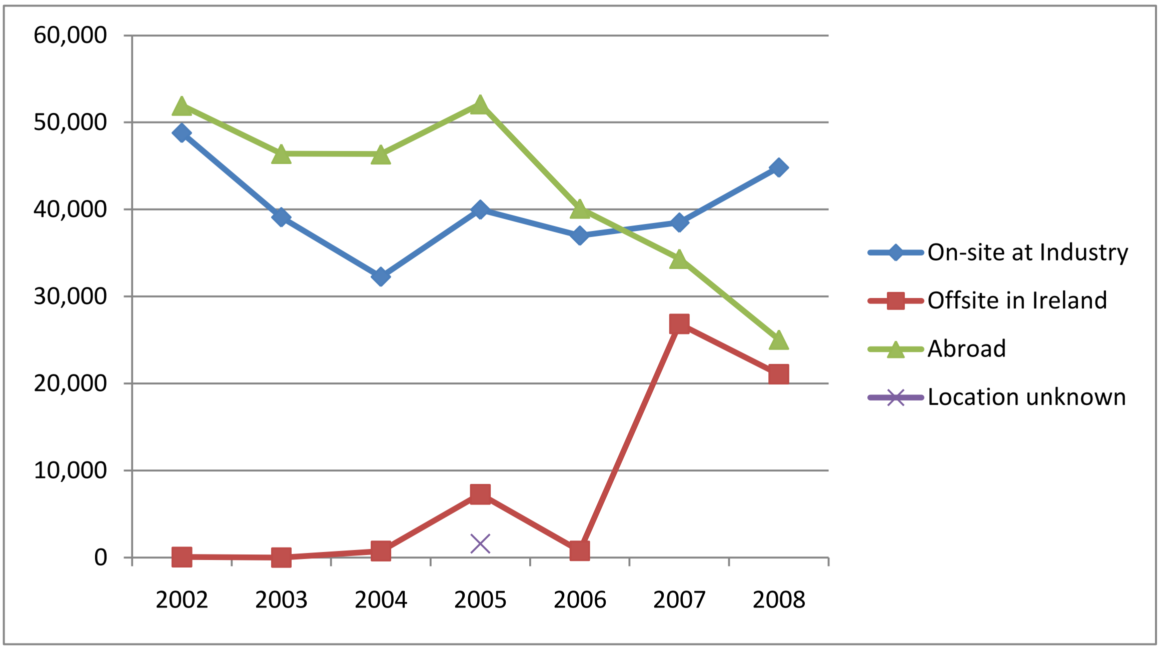

Figure 4.2: Location of Treatment of Solvent Waste Recovered, 2002 – 2008

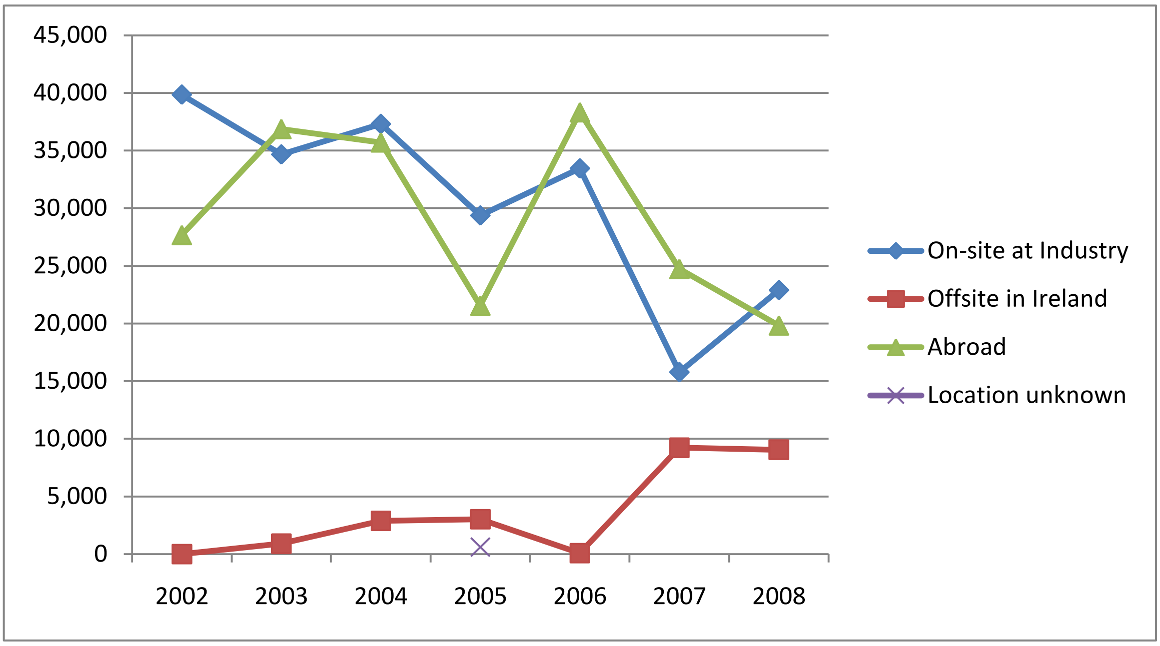

Figure 4.3: Location of Treatment of Solvent Waste Disposed, 2002 – 2008

The above Figures 4.2 and 4.3 again demonstrate the difficulties presented by the failure to communicate the eventual fate of the waste to the generators. The sudden rise in recovery offsite in Ireland reflects belending of solvent for use as a fuel abroad.

4.3.1 Summary of pharmachem company specific analysis for 2007 and 2008:

The overall waste statistics were analysed for the most recent years of 2007 and 2008. In 2007 over 96% of solvent waste generated by all IPPC licenced companies originated from the pharmachem sector. In 2008 this proportion was relatively constant at 97%.

The pharmachem sector is comprised of a small number of companies. In 2008 only 19 companies accounted for 90% of the total solvent waste generated. In 2007 18 companies accounted for this proportion. These companies are herein referred to as the '90% companies'

The total solvent waste generated by the 90% companies is outlined in Table 4.8.

The prominence of a small number of companies is also important to note. In 2007 over 58% of solvent waste was accounted for by six companies. In 2008, these companies accounted for over 53% of the solvent waste.

From the above analysis it can be seen that the Pharmachem sector accounts for the majority of the solvent waste generated by IPPC licensed companies. The small remainder of the solvent waste was generated by a limited number of industries including computer component, medical devices and packaging manufacturing facilities.

Table 4.8: Total solvent waste generated (tonnes) by 90% companies

	2002	2003	2004	2005	2006	2007	2008
Company A	11,420	15,224	14,931	16,836	17,934	20,948	16,181
Company B	34,172	19,684	16,628	12,148	13,180	11,355	14,035
Company C	15,845	15,392	13,069	14,950	14,015	12,607	13,630
Company D	14,149	16,969	22,488	18,090	14,210	12,946	12,680
Company E	31,709	28,818	23,097	23,069	19,578	20,374	11,704
Company F	9,467	6,885	7,610	7,201	5,294	10,061	10,926
Company G	17,277	16,344	12,220	13,986	12,169	11,727	10,161
Company H	7,726	9,442	8,588	8,471	8,748	9,383	7,912
Company I	-	-	-	-	-	1,814	6,425
Company J	-	-	2,177	ND	7,011	5,051	5,952
Company K	2,971	2,696	1,765	2,219	ND	2,339	5,400
Company L	2,708	4,672	3,799	3,919	3,726	2,066	4,405
Company M	2,884	3,071	3,914	0	3,905	4,720	4,314
Company N	5,022	3,429	6,170	19,308	8,698	5,669	2,522
Company O	1,614	2,304	2,870	3,207	3,072	3,162	2,361
Company P	577	2,525	1,583	2,953	2,161	1,673	2,014
Company Q	3,047	2,659	2,308	2,325	2,605	2,337	1,718
Company R	0	1,442	1,536	1,761	1,989	1,917	1,626
Company S	2,893	2,554	2,811	2,139	2,420	1,694	1,591
Total	**163,481**	**154,110**	**147,564**	**152,582**	**140,715**	**141,843**	**135,557**

4.4 Responsible Care Reporting

PharmaChemical Ireland is the representative body for the pharmaceutical and chemical manufacturing sectors in Ireland. Responsible Care® is the chemical industry's global voluntary initiative under which Irish companies, through their national association, PharmaChemical Ireland, work together to continuously improve their health, safety and environmental performance, and to communicate with stakeholders about their products and processes. PharmaChemical produces its annual Responsible Care report outlining the performance of the sector using indicators and metrics over the previous three years. In the Responsible Care 2007 report, a reduction of 4% in hazardous waste for on/off site disposal for the three years from 2004 through 2006 (there was a small increase for 2006 over 2005) is reported. In the same period production volume output was down by 9%. Total hazardous waste generation (for disposal) in 2006 was of the order of 70,000 tonnes.

Figures 4.4 – 4.6 give data from the three reports up to 2007. The 2008 Responsible Care Report is not publicly available.

Figure 4.4: Hazardous Waste from the 2005 Responsible Care Report © Pharmachem Ireland

Figure 4.5: Hazardous Waste from the 2006 Responsible Care Report © Pharmachem Ireland

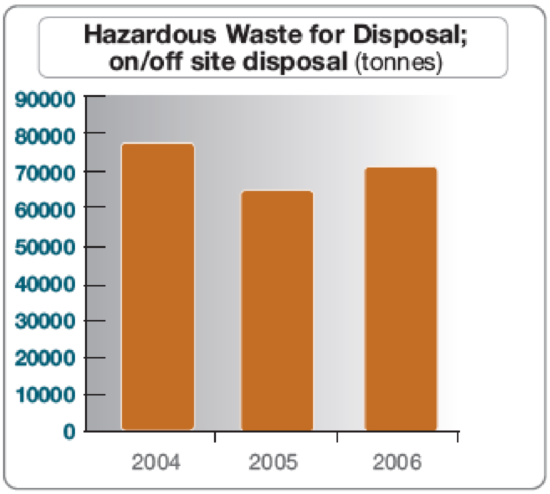

Figure 4.6: Hazardous Waste from the 2007 Responsible Care Report © Pharmachem Ireland

There is apparent inconsistency in the data included in the Responsible Care reports from year to year. Taking the hazardous waste for disposal (on/off site disposal) for the year 2004, the quantity reported is c.100,000 tonnes (in the 2005 report), c.69,000 tonnes (2006 report) and c.77,000 tonnes (2007 report).

The variances from year to year in the Pharmachemical Ireland Responsible Care (RC) reported data may be down to an individual company(s) changing the way they collate data or a change in the reporting protocol or may reflect changes in their membership (for example Pfizer Loughbeg and Ringaskiddy are not listed on their website[22] as current members but they were members during the previous RC reporting years referenced above; 2005, 2006 and 2007). Not all Responsible Care reporting companies are IPPC licensed (e.g. Fournier Pharma, Genzyme Ireland and Gilead were non-IPPC PharmaChemical members in 2007 that contributed to the 2007 RC report). Comparison of AER and RC reported data in the chart below indicate that in two of the three reported years (2004 and 2006), quantities of hazardous waste disposed reported to EPA, exceeded those reported under Responsible Care, by 10% and 11% respectively. The CTC has requested the Responsible Care reporting protocol from Pharmachemical Ireland but has not received same to date.

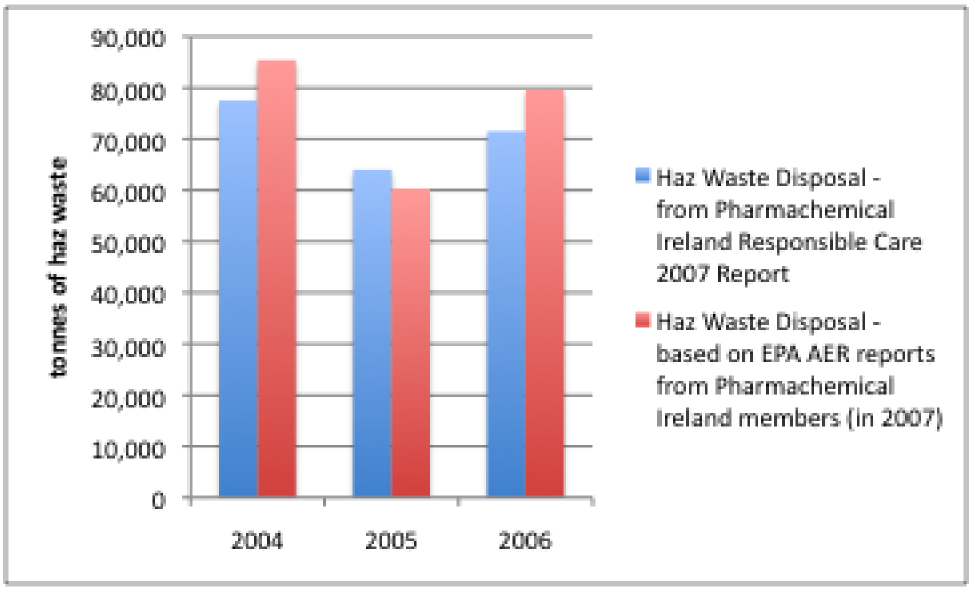

Fig.4.7: Comparison of hazardous waste reported to EPA in IPPC AERs and reported in Responsible Care Reports by Pharmachemical Ireland members.

22 http://www.pharmachemicalireland.ie/Sectors/PCI/PCI.nsf/vPages/About_us~members-directory?OpenDocument

5 STAKEHOLDER CONSULTATION

5.1 Overview

The call for tenders puts particular emphasis on stakeholder consultation, with a view to eliciting real market data. The call states:

"The Contractor will consult with generators of waste solvents and treatment operators to develop an understanding of current status of the market, the technical feasibility of changing current practices and to consider the potential for minimisation of these waste streams at source. Information from the national waste report will be made available to the contractor to target this consultation. The contractor shall during the consultation obtain an understanding of any potential contamination of the waste solvents and any limitations this may place on the treatment options for the waste. These consultations should also elicit information on the generators' perspectives and attitudes to changing the current management practices in Ireland and any non-technical barriers that they envisage."

The project team interviewed a number of major stakeholders. These included:

- waste solvent generators (**14**)
- waste contractors (**3**)
- potential outlets (**4**)
- equipment suppliers (**1**)
- Environmental Protection Agency staff (**2**)
- Northern Ireland Regulators (**1**)

In total 28 stakeholders were consulted. These are listed in Table 5.1. The list includes all major generators (80 % of solvent waste production) and all Cement Manufacturers (North and South).

Table 5.1: List of Stakeholders consulted, and their affiliation

No.	Company / individual	Stakeholder category
1	Swords Laboratories	Solvent Waste generator
2	BMS Cruisrath	Solvent Waste generator
3	Pfizer Ringaskiddy	Solvent Waste generator
4	Pfizer Little Island	Solvent Waste generator
5	Roche	Solvent Waste generator
6	Eli Lilly	Solvent Waste generator
7	GSK	Solvent Waste generator
8	Cognis	Solvent Waste generator
9	Mallinckrodt (Covidien)	Solvent Waste generator
10	Novartis	Solvent Waste generator

11	Hovione	Solvent Waste generator
12	Merck Sharpe and Dohme	Solvent Waste generator
13	Vistakon	Solvent Waste generator
14	Millipore	Solvent Waste generator
15	Veolia	Waste Contractor
16	Indaver	Waste Contractor
17	Soltec	Waste Contractor
18	Rilta	Waste Contractor
19	Kühni	Equipment Supplier
20	Allison Townley, (Dept of Environment, Northern Ireland; & TFS Office)	Regulator
21	John Doheny (EPA, OEE inspector for cement kiln and power generatuion)	Regulator
22	Brian Meaney (EPA, Licensing)	Regulator
23	Irish Cement	Potential Outlet
24	Lagan Cement	Potential Outlet
25,26,27	Quinn (Cement kilns x 2: Cavan and Fermanagh; glass furnace: Fermanagh)	Potential Outlet
28	Lafarge Cement, Tyrone	Potential Outlet

The principal findings from these consultations are summarised in the following sections.

5.2 Stakeholder Input

As summarised earlier, the stakeholders may be broken down into five categories. These are:

- Solvent waste producers
- Waste contractors
- Potential solvent waste outlets
- Regulators
- Equipment Supplier

Each of these categories is summarised, and an overview given.

5.3 Solvent Waste producers

In the main, the waste producers have a favourable opinion towards burning of waste solvents in boilers or thermal oxidisers. The WID causes difficulties in this respect (for example, burning a 50:50 mixture of solvent and Heavy Fuel Oil has caused one company difficulties with SO_2 ELVs – even though the sulphur comes solely from the HFO). Some have considered but not pursued this option as a result of either perceived or actual regulatory (EPA) or public perception barriers.

Many companies cite lack of storage capacity as a barrier to increased material recovery. Storage is expensive, and may also cause difficulties with regulators.

The nature of API production is tending towards many different products and shorter campaigns of each for many sites. This can hinder the amounts which can be segregated for material recovery.

Companies are seemingly unaware of what similar companies are doing – particularly with respect to costs of waste contractors. This may lead to some companies paying for high calorific value wastes, while others are credited for their waste solvent.

The willingness to recover solvent from other non-sister sites in on-site recovery facilities may be there. In one case it is already in practice for the recent shortages regarding acetonitrile.

Most sites that carry out recovery for reuse (either on-site or via toll recovery facilities like Veolia's material recovery facility in Garston, Liverpool or Soltec in Mullingar) only reuse the solvent for the same API process from which it originated. From the companies interviewed, there was one exception to this, where all recovered solvent had been validated to be reused in *any* process.

The vast majority (but not all) of those interviewed looked favourably on the use of cement kilns in Ireland for use of solvent waste as a fuel. Transport costs are a significant portion of off-site treatment costs and treatment in Ireland would bring savings in the range €1,000 - €2,000 per tanker of waste.

Halogenated solvents are a decreasing, and small portion of the overall waste – some sites are now halogenated-solvent-free. This reflects concerns raised some years ago about the use of halogenated solvents and the progress in adopting greener solvents.

5.4 Waste contractors

Blending for use as a fuel is the business model adopted by the major players in the solvent waste industry. The practice of blending is widespread, and may lead to wastes being misclassified (e.g. D10 vs R1), or classified with one of the "storage" codes (e.g. R13).

Waste contractors were reluctant to talk about costs.

The role of Northern Ireland would appear to be solely as a potential outlet. The requirement for TFS between North and South, and the absence of a TFS requirement between the North and Britain, means many of the waste contractors in the South do not compete for business in the North.

5.5 Potential solvent waste outlets

The cement industry is keen to use solvent wastes as a fuel. One concern is security and consistency of supply. The industry would prefer to deal with waste contractors / brokers – rather than directly with solvent waste producers (this sentiment is echoed by many solvent waste producers). This requirement for consistency may lead to the promotion of blending (effectively dilution), which may not be environmentally beneficial from a life cycle perspective. Standard specifications for fuels may help in this area.

The quantities of solvent wastes generated are small compared to cement requirements (even within the South alone) – so there is no possibility of the market drying up. Even in the projected downturn, solvent wastes have a total calorific value which is only some 4% of the industry requirement in the South.

5.6 Regulators

A number of personnel within the EPA were spoken to who have key expertise and experience in particular topics – namely licensing and enforcement in relation to cement kilns, power generation, and incineration.

The contact within the North's TFS office was also spoken to in relation to solvent waste being generated within the North (small - mainly related to metal-working), and potential outlets in the North (was used and may be used again in cement).

5.7 Equipment Supplier

Kühni, a Swiss company, now part of Sulzer, specialise in thermal separation processes for the pharmaceutical and chemical process industry. They have supplied process equipment and complete

solvent recovery process plants to the Irish pharmaceutical and chemical sector. Based on their experience, two cases for solvent recovery can be defined:

a) Toll manufacturer (merchant recoverer). This is the traditional business where a simplified technology (mostly batchwise) is used. There is a very good utilization of the investment but the risk of cross contamination with other chemicals refrains pharmaceutical companies from reusing the recovered solvent. Such solvent will be mainly reused in paint or thinner. The costs are around €110-170 per tonne depending on the complexity of the separation.

b) Own recovery; the pharmaceutical uses a dedicated plant for the recover of each of its own solvents. The investment is higher and utilization is typically lower, but the acceptance for own reuse is much higher as the cross contamination is under control. The costs are around €75 to 140/ton. The costs are lower than external due to the reduction of the cost of transport, storage, cleaning and profit. "*External recoverers have to make money, internal recoverers are saving money".*

The capital cost of the own recovery unit have been estimated to be €1m (0.8t/hr throughput) and that of the merchant recoverer €2.3m (3t/hr throughput). The own recovery unit will be a dedicated unit with a smaller capacity and will be written off within 10 years. The merchant recoverer will be a large multipurpose unit and will be written off within 15 years. However the dedicated plant will have a lower utilization than a multipurpose unit. The capital cost includes the equipment, engineering, steel structure, piping, instrument and control, insulation and civil work. It is assumed that storages and utilities (steam, cooling water) are available.

Kühni have modified a plant in an IPPC licensed pharma facility in Ireland to facilitate acetonitrile waste solvent recovery from another IPPC licensed facility for recovery for reuse in the waste generator's process. This was handled under an IPPC review that was already underway. The recovery facility was allowed to trial the recovery of up to 600 tpa of acetonitrile under its existing licence.

The Kühni representative commented in a telephone conversation on the pharma industry focusing on the use of waste solvent as a fuel (specifically referencing acetone) and not looking at its greater value when reused as a solvent (when comparing to cost of "standard fuel").

5.8 Summary of Stakeholder Inputs

Clearly defined guidelines with respect to recovery and use as a fuel would be advantageous. All three sectors (producers, contractors, and potential outlets) seem to prefer the use of intermediaries – as opposed to direct dealings between producers and users. This, clearly, can present some conflict of interest with the best overall environmental outcome.

TFS Regulation is a barrier to importing solvents from Northern Ireland. Some of the Irish waste management companies indicated they tend to leave the Northern Ireland market alone as there is no TFS barrier between the North and mainland Britain. However the amount of solvent being generated in Northern Ireland is relatively small in any case. Northern Ireland has in the past used solvents from the Republic as a fuel in one of the cement kilns and may do so again in future. TFS is not regarded as a barrier by these outlets, once it is worth their while in terms of waste quantities and reliability.

Comments of interest or relevance arising from on-site interviews, telephone communications and questionnaire returns are included in *Table 5.2* below. The comments have been grouped under common headings to reflect their opinions on a variety of topics relevant to solvent waste management:

Table 5.2 Selected Stakeholder Comments

Individual Comments from Stakeholder Consultation

Hierarchy

The primary site waste management strategy is to use the site solvent recovery facility to recover and reuse process solvents. When this is not technically feasible due to capacity or technology issues, waste streams are assessed for suitability as a supplementary food source to the site waste water treatment plant. The next option is to send excess solvent material to commercial recovery facilities in the UK. Streams that are not technically suitable for recovery are sent to commercial incineration facilities with heat recovery.

The main criteria for onsite recovery is, if solvent streams can be separated, recovered onsite and reused within a specific process or preferably in all processes.

Each process would be assigned a number of tanks and various streams would be assigned a specific tank, this strategy is to maximise the % of waste streams for either on or offsite recovery.

Disposal strategy that waste solvent streams were not to be used as supplementary fuel for UK cement kilns. Only streams suitable for direct recovery and reuse, are sent to solvent recovery in UK.

Pharmachem companies sending good quality solvent waste for blending as a fuel that could be used in solvent recovery

Barriers (regulatory and technical)

Regulatory - Filing

The use of recovered solvents in the final API step may be restricted. One FDA filing has been made, but it is difficult to get approval for changes.

Any change in solvent recovery / supply has to be approved using a Process Change Request, laboratory use tests, validation of product manufactured, it is estimated that it costs circa €200,000 in time and effort to implement a Process Change Request.

Quality: In the drug filing applications, there are sometimes restrictions on the type (virgin versus recovered) and supplier of a solvent. Some solvents may be used for intermediate processing, but not for final step processing.

Filing for US Food & Drug Administration (FDA) or other worldwide authorities is a barrier to recovery. There must be huge volumes and savings involved to justify it.

Filing will take about 1 year and will probably attract an audit. Therefore implementing recovery must be cost effective.

Regulatory - EPA

EPA can be one of the barriers – mentioned in several sites. This would appear to be anticipated difficulty as well as actual encountered difficulty ("not worth it for some things").

No licence provision to allow waste to be taken on site for treatment/recovery.

EPA did not care if waste was exported for incineration or incinerated in Ireland.

The idea of taking waste from another site and using it as a fuel, EPA enforcement were not as amenable to it.

They count recovered solvent each time as EPA told them to do it this way. Feels it shows them as generating more waste then they actually are.

Regulatory – Environmental

Stack emission ELV's restrict the waste streams incinerated on site.

Cement plant: says can only use secondary liquid fuel as a substitute for main fuel – can't use for start up because of emissions.

If a recommendation on an incineration levy is implemented would this make pharma on-site

incineration less attractive?

It will be a substitute for the solid fuel, because gas oil is used as an igniter fuel in situations like reheating after having cooled down the kiln, and in these modes they couldn't comply with WID. Since it is classed as a waste, WID applies. Otherwise there would be advantages in using solvent waste as a substitute fuel for both solid fuel and gas oil.

Technical

Recent experience has indicated that the impurity profile of an API may be impacted by the presence of trace contaminants in recovered solvents (the concentration of impurities may increase with the continual recovery of solvents).

Cement companies would require a waste licence to blend on-site and would also require a lab to analyze the incoming waste; therefore there is still a need for off-site blending.

Current incinerator design limits the quantity of water that can be burned (as it increases CO levels). There is a 5-year payback on the investment required to burn on-site as a fuel. Salt content is also an issue and where burned there would be a requirement to have an electrostatic precipitator to comply with the ELV. Limiting parameters in terms of on-site waste to energy plant (incinerator) are inorganics and water content (CO issues as described).

Smaller recovery plant compared to those on-site may be able to make smaller quantities of material more feasible.

Wanted to emphasise the highly variable nature of the waste tanks as a result of the varied processes. Makes material recovery more difficult.

Waste needs a certain volume – you need a high volume stream to justify; there are other waste streams that could be recovered but cannot separate because of components in the stream.

Solvent recovery column was designed in 2000 for major solvents in use at the time. Solvent mix has changed somewhat.

WWTP is at the limit or beyond in terms of solvent it can take. (note other sites have spare WWTP capacity).

Once cement plant is up and running well on a particular fuel mix, they want to leave well enough alone. They don't want to be switching from one type of waste or fuel to the next too often. It must also be worth their while in terms of making plant changes to handle a particular type of alternative fuel.

Public perception

Overcome barriers to solvent waste use as a fuel by public consultation (ref to Kinnegad plant licence to burn fats).

Cement industry has an issue with being seen as a waste disposal facility.

Cement industry will use a waste broker and will not deal directly with pharma companies. Will get fuel in a ready to use form.

Public perception is a potential main barrier. Working proactively on this and have done in the past. Perceptions can be addressed through education.

Solvent waste is hazardous waste, but it is hazardous primarily because it is flammable.

Economic

New tank cost is a factor. Tanks – many sites mentioned tanks limiting the amount that can be sent for material recovery.

The use of other types of alternative fuels in co-incineration (meat & bone meal, RDF) avoids the application of a landfill tax. However solvent waste is cleaner and easier to handle.

Methanol used in cleaning not recovered (incinerated on-site). Use in CIP therefore would need separate tanks to reuse for dedicated product, because of API contamination (tanks not cheap).

Under WID, dioxin monitoring is expensive – only have trace levels compared to limit. No chlorinated materials.

It sometimes comes close for cost of recovery vs. incineration, but they factor in having men idle on the recovery plant.

Companies may export even if cement kilns here take it – it will be down to economics.

Industry tradition and perception

In terms of sites using other sites' recovery facilities feels very few industry wide would do it.

In recent weeks Soltec approached them and have taken a sample of their off-site waste for potential recovery. Company doesn't know much about them and wants to be sure of all outlets for waste before they use them.

Brokers will route to maximise fuel blending.

Many sites have restricted themselves to recovery for reuse in a particular process only.

Feels pharma companies would want more than one outlet for security reasons and so would no rely solely on 1 outlet (i.e. Irish cement).

Feels many sites are over classifying their waste in terms of labelling for transport and so on and being over-cautious in saying something is solvent, e.g. a waste labelled as methanol (and flammable, etc.) may in fact be mostly aqueous.

Thinks that solvent waste unlikely to be used in the immediate future in the powergen sector, as at the moment this sector is focussing more on biofuels.

Global Downturn

The plant is a bit uncertain at the moment. Are being affected by global downturn.

Feels the economic downturn is having a severe effect on the availability of SLF (secondary liquid fuel) like engine oil, chemical sector waste, etc. Feels cement plants in England currently have the same trouble trying to source something consistent in terms of alternative fuels.

Industry trends and Global Competition

Good for next year – can't see after that. Have lost a lot to China, Puerto Rico etc.

All processes and products are currently small scale and various different ones. Types of process now are like that – varied and small amounts.

Carrying out shorter campaigns and more of these. They no longer have a major product that generates consistent wastes.

Corporate strategy/philosophy is to move away from API chemical manufacture and more into biological processes.

Being flexible is a big thing for the site for competing vs. Singapore, USA, etc.

Supply Issues

There is talk that acetone as a solvent may be in supply difficulties in 2010.

Stream c.v. is so variable, also quantities.

A constant & consistent supply does seem to be the issue for cement kilns.

If just one cement operation on the island decides to use it there will be nothing else left.

Wouldn't look at something unless they had a 5 to 10 year projection that they could get it. They look at all things like if the c.v. goes down or if they can't get it.

Feels the amounts of SLF that are being generated on an all-island basis are small, relatively speaking.

In the long term think volumes/availability will be a barrier.

Previously could not get enough information in terms of quality/specification, or availability

Ceased using solvent - could not get enough solvent waste.

Opportunities

It's not out of the question to recover for someone else in future.

The site can recover solvents for reuse under the conditions in the IPPC licence. There are no environmental regulatory inhibitions to conducting solvent recovery.

In terms of solvent recovery it is all down to setting a specification and meeting it. Why not set the specification and people will meet it.

Heat recovery from on-site use as a fuel in the incinerator is the source of steam for on-site solvent recovery.

Would like to utilise own high c.v. solvent as a fuel on-site.

Would like to utilise high c.v. solvent from another site as a fuel in on-site incinerator (replacing gas usage).

On a pilot scale looking at stripper units and 7 to 8 other technologies for waste stream treatment.

Would be interested in outlets in Ireland as transport is the major component of cost for off-site disposal.

Never any local issues when they applied under WID (were concerned that there might be).

Feels they could be upping the amount of solvent they recover. Are looking to do more off-site. Good both from a cost and an environmental angle.

If the cement kilns in Ireland became available, would have no problem in sending wastes there.

If Indaver incinerator in Ringaskiddy comes on-stream would also come into play in terms of options but would still be down to cost.

Are now looking to pool solvent from a number of different waste streams and have it available for another process.

Are looking at a pre-treatment vessel; currently commissioning a decanter replacement.

Water based waste containing small quantities of solvents are treated in the WWTP provided the in house specification is met.

Location of treatment facility affects transport cost.

Site using excess steam from incineration to recover solvent.

This is one big issue that is often not fully understood by everyone – coal is a very dirty fuel. Solvent waste will be advantageous in that using a light solvent fuel in a kiln gives a very controlled, much cleaner burn. Only recently is it being appreciated how much mercury and cadmium there is in coal.

It would be a lot cheaper to deal with the solvent waste in Ireland, as transport cost is then reduced.

Seems it will be no problem for the wastes to meet the specs being set by cement industry.

Feel "end of waste", treat as a product, may come into play.

Would preferentially use solvent over conventional fuel – high c.v. and is a liquid and easier to use across all fuels, not just alternatives.

Think harmonised EU standards for fuel specs will be developed in the long term.

Feel there should be a minimum requirement for fuel specification to avoid it being labelled as incineration. There should be quality standards.

Main factors in determining existing waste management practices

Solvents such as THF have a financial benefit in recovering.

Ease of recovery – e.g. methanol ex cleaning.

Equipment availability during different process campaigns.

Some recoveries require multi steps to achieve required quality specification.

Some process streams are not feasible to recover onsite due to –

lack of storage tanks

solvent recovery equipment in use for other processes

recovery to meet quality specifications not feasible

costs of recovery may be excessive

Methanol may be cheap, but the cost of incinerating it afterwards is not.

Feasibility of recycling/recovery; water content important in deciding treatment route; does waste contain chlorine source; can it be incinerated on site (spec for on site waste in place); solids content important in decision to incinerate on site. Stack ELVs for on-site incinerator have a huge effect on what is allowed to be burned. Site is risk averse. Will burn on-site streams with a good c.v., low solids, and low chlorine and ship off the rest.

Recovered solvent is a source of material. Solvent recovery viability is down to if there is enough volume to make it worthwhile. If small scale, not worth it.

Recover only where you can reuse.

Recover where economically viable; then incinerate on-site; then off-site. Inorganic salts are the usual limiting factor for on-site incinerator.

Feels if they couldn't burn their waste they would shut because of cost. Thinks it is more environmentally beneficial anyway than shipping it to burn elsewhere while they would have to get additional fuel to burn to supply energy to site.

Recover where feasible. Have 15 to 20 products so can't segregate every waste. Aqueous vs. organic – try to optimise this. Brokers will route to maximise fuel blending.

Waste solvent is sent for either recovery (SRM Rye) or incineration (D10 AVG in Germany), depending on price. It is currently going for incineration as incineration is cheaper at the moment.

Reasons for recovery are primarily financial. Recovery leads to waste disposal avoidance, cost of solvent purchasing avoidance (said prices of their solvents are going up); also have a large on-site WWTP to deal with non-recovered solvent.

Main costs are transport and end treatment.

They recover as much DCM as possible. Only burn where can't recover. Apart from cost, guaranteed delivery is other factor in recovery. DCM supply can sometimes be patchy.

Blending site can take everything in right proportion that blending will bring within (the cement kiln customer fuel) specification.

Cleaner Production

There is an API yield improvement programme in place.

Solvent substitutions in processes are evaluated, e.g. forthcoming demonstration replacement of acetonitrile with heptane.

Waste streams from new process introductions are evaluated to check opportunities for onsite recovery.

Where possible, water is used for equipment train cleaning. Next option is to use methanol.

Every pharma site will be looking at this area, percentage yield and so on.

No chlorinated solvents in use on-site.

Only 1 chlorinated solvent will be in use on-site next year and for a short time only.

Technology transfer to the site of new processes, environment section involved at the

development stage - determining fate of streams, e.g. multiple tanks; chemically characterising waste.

Reviewed existing batch sheets to see how all waste streams are handled to see if alternative practices could be implemented.

A solvent selection guide is used where any new processes are assessed for recovery potential.

Cost per waste stream is charged back to each particular product on-site.

Trying to reduce the number of water washes from 8 down to 5. 35- 45% reduction.

Solvents for cleaning now virtually all gone – use potassium hydroxide and phosphoric acid solutions and sprayballs.

Strip one stream methanol that is mid-range (too concentrated for waste water treatment plant and too much water for straight incineration). Then streams go to waste water treatment plant and to incinerator for use as a fuel.

A whole group of projects on organic solvent waste minimisation in place.

Have taken out lots of isolations. They have a modifications group.

Poor Practices

Solvent waste from different processes are pumped to one low calorific value (CV) and one high c.v. solvent waste storage tanks. The tank contents are then send offsite for fuel blending.

Rely on advice from waste broker on where they can send their waste.

Nothing in place re waste minimisation.

Polar and non-polar waste kept separate historically to avoid crashing out of organic constituents (may mitigate against solvent recovery for reuse).

Activity costing attributes site overhead to SRU operating costs (inflating the true cost of solvent recovery).

No in-process recovery. Do not even reuse washes.

Very few amounts going for material recovery off-site (mostly use as a fuel).

Historic and Future Trends in Solvent Waste

The product portfolio has been relatively constant over the past 5 to 10 years, some new process introductions may account for 10 to 20% of the waste streams. This plant is both a commercialization and a supply site. Therefore, a number of low volume APIs for clinical trials may be manufactured and it is not feasible to develop onsite recoveries. There is a practical volume of waste and reuse opportunities required for solvent to make it a feasible option to do onsite recovery.

Waste streams from large volume, long term processes are evaluated for onsite recovery.

Pharmachem companies may pull out of manufacturing in Ireland. Already in talks to have 3-4 multinationals group together for manufacturing purposes; reducing number of overall manufacturing sites.

Market for recovered solvents decreasing due to increased use of water based paints, inks and adhesives in EU.

Increase in oil prices will result in decreased availability of solvent for recovery (as it will be used as a fuel). Commodity market economics apply.

There is a market for toluene, acetone, IPA and ethyl acetate in thinners for bodyshops.

Within solvent waste generation sites internal recovery and distillation has increased (waste mgt hierarchy).

Cement industry; use as a supplementary fuel. Amount dependent on total cement production and fuel substitution rate, calorific value and nature of the solvent waste. 30,000

tonnes exported that could be used in the Irish market.

Commercialisation in the pharmachem sector will reduce solvent waste volumes.

Chlorinated solvent waste (mostly DCM) reducing (directive driven + changes in API products).

Expect solvent waste volumes to grow over the next couple of years. Turned corner in downturn. New API plants opening; biopharma plants an important part of the sector.

Recent Environment Agency, UK, report promoting cement kiln recovery over heat recovery from incineration.

With a D code a country can object to such coded waste entering or exiting. No such problem with R coded waste coming into Ireland for recovery here (if we had the infrastructure). We could deal with own waste and import waste for recovery on the open market.

Concern over National Hazardous Waste Incinerator (Indaver Ringaskiddy) using solvent as a fuel (R1 rather than D10).

In the past shipped large volumes with high water content from the site. Alternative not given consideration.

On-site segregation of solvent waste streams has come on in a big way in recent years.

Apart from incineration on-site, solvent shipped off-site for incineration is handled in three c.v. brackets, but all goes for D10. Sent off-site because of high sulphates, API content.

6 USE OF WASTE SOLVENT IN CEMENT KILNS

In recent years the cement industry has investigated the use of alternatives to fossil fuels. In 2004 in Europe, 6.1 million tonnes of different types of wastes were used as fuels in cement kilns. Of these wastes, about one million tonnes were hazardous[23]. The primary fuels used in the manufacture of cement in Ireland are coal and petcoke.

Smaller quantities of gasoil are used as fuel in the start-up of cement kilns. Gasoil, or whichever other fuel is being used during start-up cannot be substituted by waste materials, as the required WID temperatures would not be reached. Therefore gasoil is not incuded within the energy usage estimation in the remainder of this section. The total quantities of petcoke and coal used by the cement industry in 2006 were available to the team. Scaling up, based on clinker production, the quantity of petcoke and coal usage in 2007 was estimated to be equivalent to approximately 16,432,000,000 MJ.

The manufacture of cement is expected to reduce substantially due to the slowdown in the construction industry and the economy as a whole. The ‘Review of the Construction Industry 2008 and Outlook 2009–2011’, commissioned by DEHLG and prepared by DKM Economic Consultants, provides an assessment of the future trends in construction volume. This report outlined that in 2008 construction volume had decreased by 10.3% from 2007 values. It also outlined that the construction volume in 2010 was expected to decrease further by 23.8% from 2008 values. Many would view this to be an optimistic estimate of the decline in construction volume. Using this estimate, the potential energy demand would equate to 11,127,000,000 MJ in 2010.

The cement industry uses significant quantities of energy in the production of clinker. As a means of comparison, if the majority of solvent imported into Ireland in 2008 was used as a fuel in cement kilns, it would only equate to 38% of the energy used by this industry in 2007.

In 2008, almost 2,384 tonnes of waste solvent was recovered abroad under the code of R1: use as a fuel (other than in direct incineration) or other means to generate energy. In addition a further 17,485 tonnes was treated using the recovery codes R12 and R13. These codes apply to waste that is exchanged and or accumulated for subsequent treatment using another type of recovery operation, R1 to R11. From discussions with relevant parties, it can be determined that the majority of waste assigned with an R12 or R13 code, is inevitably blended and treated under the R1 code. Therefore, in 2008, a quantity of roughly 19,770 tonnes was potentially available for use as fuel in cement kilns.

It must be noted that a proportion of waste solvent, which is disposed of under the waste code D10: incineration on land, may be suitable for use as fuel in cement kilns. In 2008 over 20,898 tonnes of waste was sent for incineration abroad. The composition and calorific value of this waste may be uncertain in comparison to waste solvent that is used as a fuel. Therefore the energy content of waste incinerated on land is not included in the remainder of this assessment.

Information was obtained from a limited number of companies on the average solvent composition of relevant waste streams. Applying a suitable calorific value and waste tonnage, a crude estimate of the total energy potentially available in the waste stream was made. This estimated that the 19,770 tonnes of solvent waste had a potential to provide 440,000,000 MJ of energy.

In summary, using the (perhaps optimistic) prediction for cement production in 2010:

- the available waste solvent in 2008 would account for only 4% of fuel requirements.
  energy contribution from solvent waste: 440,000,000 MJ
  fuel requirement by cement kilns: 11,127,000,000 MJ

It seems clear, then, that this market will always be able to cope with pharma solvent waste output.

[23] Draft Integrated Pollution Prevention and Control document on Best Available Techniques (BAT) in the Cement, Lime and Magnesium Oxide Manufacturing Industries, European IPPC Bureau, May 2009

7 REGULATORY ASPECTS OF USE OF WASTE AS A FUEL

7.1 Use as a Fuel

7.1.1 Co-incineration under the Waste Incineration Directive

The Waste Incineration Directive[24] (WID) allows waste to be co-incinerated in other processes. The requirements for co-incineration (and indeed incineration) are:

- Operate under permit (i.e. IPPC or waste licence must include the WID co-incineration requirements). The permit will list the categories of waste which can be burned.
- Meet emission limit values in air emissions and any water from waste gas cleaning.
- Meet minimum temperature and residence time requirements.
- Meet monitoring requirements.
- Meet specified waste delivery and reception procedures.

An important proviso under WID is that, in a co-incineration plant, if more than 40% of the resulting heat release comes from hazardous waste (as set out under Article 7 of WID), the emission limit values for incineration (set out in Annex V) apply. Some of these are more strict – e.g. NOx and dust, and also require half-hourly limit values to be met.

For co-incineration, the temperature and residence time requirements are:

- That the temperature of the gas is raised in a controlled and homogeneous fashion, and even under the most unfavourable conditions, to a temperature of 850 °C for 2 seconds;
- If hazardous wastes with a content of more than 1 % of halogenated organic substances, expressed as chlorine, are co-incinerated, the temperature has to be raised to 1100 °C for the same residence time.

Plants must operate an automatic system to prevent feeding of the waste into the system:

- at start-up, until the temperature of 850 °C or 1100 °C has been reached;
- whenever the temperature of 850 °C or 1100 °C is not maintained;
- whenever the continuous measurements show that any emission limit value is exceeded.

There are specific additional requirements in relation to incineration and co-incineration of ***hazardous*** waste:

- The licence will list the amounts of each category of waste which can be burned and any associated limitations in terms of content (e.g. calorific value, chlorine, heavy metals, etc.).
- The waste delivery and reception procedures include additional requirements such as TFS documentation checks and waste sampling and analysis.

7.1.2 Exemptions under the Waste Incineration Directive

The WID allows some exemptions in relation to the specific requirements for hazardous waste. Of particular relevance to solvent waste (and similar wastes like oils) is the fact that combustible liquid wastes do not have to meet WID *hazardous waste* requirements (but still have to meet WID *waste* requirements) where they:

- Are PCB-free, are not classed as hazardous due to other constituents, and have a c.v. of 30 MJ/kg minimum; or
- Cannot cause emissions other than, or greater than, those from gasoil combustion.

The exact wording of this exemption is shown in Appendix III(a).

The WID also allows exemptions in relation to some processes burning certain wastes but none of these are relevant to solvents.

[24] Directive 2000/76/EC on the incineration of waste amended by Regulation (EC) No 1137/2008.

7.1.3 Combustion Processes under the Waste Incineration Directive

Special provisions are set out in the WID for combustion processes co-incinerating waste. Emission limit values are set depending on the primary fuel used (solid, biomass and liquid fuels – note gas is not included). If a combustion plant comes under the more recent large combustion plant Directive (2001/80/EC), then the more stringent ELVs under this latter Directive apply.

7.1.4 Other Industrial Sectors under the Waste Incineration Directive

Special provisions are also set out in the WID for industrial sectors co-incinerating waste not covered by the provisions for cement or combustion processes. Limits are just in relation to dioxins and furans, and the metals mercury, thallium and cadmium.

7.1.5 Existing applications of the WID to Co-incineration in Ireland

Aside from the application of the incineration requirements of the WID to incineration plants, the WID co-incineration requirements have been applied to a number of IPPC installations that utilise waste solvent on-site as a substitute for fossil fuel use. Their licences incorporate the requirements of the WID in relation to such operations. These sites that are co-incinerating (as opposed to incinerating) solvent waste include:

- Schering Plough Avondale – authorised (May 2007) to burn waste solvents in the thermal oxidiser (TO) (now referred to as the Liquid Vapour Incinerator), as a fuel substitute for natural gas.
- Sigma Aldrich – authorised (December 2007) to burn waste solvents in the TO, as a fuel substitute for natural gas or gasoil.
- Cognis – authorised to use production residues as fuel in the site's CHP plant.

During the interviews at least one other site expressed an interest in utilising high c.v. waste as a fossil fuel substitute in boilers and/or TOs. Another site expressed interest in utilising high c.v. waste from another site for fossil fuel substitution in their incinerator.

7.2 Cement Kilns

7.2.1 Cement Kilns and the waste incineration Directive

The WID requirements for co-incineration in cement kilns must meet all of the WID co-incineration requirements but it does set separate specific emission limit values (see table 7.1).

Table 7.1: ELVs for cement kilns

Pollutant	***ELVs (mg/m^3 daily average values at standard conditions)***	
	Co-incineration in cement kilns	***Existing BAT for cement manufacture***
Total dust	30	20 – 100 (existing plants) 20 – 30 (new plants)
HCl	10	
HF	1	
NO_x ^{f}	800 (existing plants) 500 (new plants)	500 – 1800 (existing plants) 500 – 800 (new plants) 200 – 500 #
SO_2	50 †	200 – 400 200 - 750
TOC	10 †	
Cd + Tl	0.05	
Hg	0.05	

Sb + As + Pb + Cr + Co + Cu + Mn + Ni + V	0.5	
Dioxins and furans	0.1 ng/m^3	

† Exemptions are allowed where these do not result from waste incineration.

Where SNCR (selective non-catalytic reduction) is BAT.

ƒ The WID splits out the ELV for NO_x for existing and new cement kilns. Cement kilns which are in operation, are IPPC licensed, and which start co-incinerating waste after 28th December 2004 are not to be regarded as new plants.

In summary, for cement plants to commence using waste as fuels:

- The site's licence will have to reflect the WID requirements.
- The ELVs will have to be revised, likely downward based on above table, with additional parameters added.
- Waste can only be used where WID requirements are met, i.e. once 850 °C or 1100 °C is reached.

The nature of cement kilns is that the temperature and residence time requirements can be met straightforwardly. There will be additional cost such as dioxin and furan monitoring, which is relatively expensive. But the cost savings in terms of fuel are likely to absorb this in any case. The only limit would appear to be when it can be used, i.e. once the required temperature is reached.

7.2.2 Cement Kilns, use of waste as a fuel, and BAT

The original BREF for cement was one of the first BREF documents published[25]. A draft revision of the BREF for cement was published in May 2009[26]. The BREF document addresses the use of waste as a fuel. The draft revised BREF states that after suitable treatment, individual waste fractions can meet the requirements for environmentally compatible re-use in cement plants.

In relation to co-incinerating waste, under the draft revised BREF, BAT is to meet the requirements of the WID, and in particular BAT is to:

- Use the appropriate feed points that will meet the temperature and residence time requirements and feed wastes continuously and constantly.
- Operate so that the gas is raised in a controlled and homogeneous fashion, even under the most un-favourable conditions, to 850 °C for 2 seconds.
- Raise the temperature to 1100 °C, for hazardous waste with >1 % (as Cl) of halogenated organic substances.
- Stop co-incinerating waste for operations such as start-ups and/or shutdowns when appropriate temperatures and residence times cannot be reached.
- Apply safety management for the storage, handling, & feeding of hazardous waste materials, such as using a risk based approach according to the source and type of waste.
- Apply appropriate labelling, checking, sampling and testing of waste to be handled.

The draft revised BREF is quite favourable towards the use of waste as a fuel. It cites gas retention times and temperatures which easily fulfill WID requirements. More detail from the draft revised BREF in relation to the use of waste as a fuel in cement manufacture is shown in Appendix III(b).

The BREF also shows some examples of specifications from Germany and Austria for solvent waste as a fuel in cement kilns[27]. These are mostly in relation to metals limits and are based on voluntary commitments from the waste industry. Calorific values are also set for some waste streams. A similar standard could be applied here in Ireland. Note that an international standard that has been developed by CEN, the European Committee for Standardisation: CEN/TC 343 'Solid Recovered Fuels' (also noted in the BREF).

25 IPPC Reference Document on Best Available Techniques in the Cement and Lime Manufacturing Industries, December 2001.

26 IPPC Draft Reference Document on Best Available Techniques in the Cement, Lime and Magnesium Oxide Manufacturing Industries, May 2009.

27 'Guideline for Waste Fuels' by the Federal Ministry of Austria.

7.3 Relevance of the Waste Framework Directive and End-of-waste criteria

Under the revised Waste Framework Directive 2008/98/EC, the definition of waste is unchanged[28], but it does specify conditions under which an object is to be considered a by-product and not waste. It also specifies conditions for the end-of-waste status for waste recovery/recycling operations. Specific criteria are to be developed at the EU level for aggregates, paper, glass, metal, tyres and textiles at the least. Member states are also free to develop their own criteria for other waste streams and these have to be formally notified to the Commission.

The Directive revises the waste management hierarchy as follows:

"The following waste hierarchy shall apply as a priority order in waste prevention and management legislation and policy:
(a) prevention;
(b) preparing for re-use;
(c) recycling;
(d) other recovery, e.g. energy recovery; and
(e) disposal."

The Directive clarifies the definition of recovery and disposal.

> 'Disposal' means *"any operation which is not recovery even where the operation has as a secondary consequence the reclamation of substances or energy".*

The list of disposal operations set out in Annex I is the same as before.

A revised definition of recovery is set out:

> 'recovery' means *"any operation the principal result of which is waste serving a useful purpose by replacing other materials which would otherwise have been used to fulfill a particular function, or waste being prepared to fulfill that function, in the plant or in the wider economy".*

The list of recovery operations set out in Annex II is the same as before but is now supplemented by efficiency criteria for distinction between use as a fuel and municipal waste incineration.

The definition of 'reuse' is introduced: "re-use means any operation by which products or components that are not waste are used again for the same purpose for which they were conceived".

7.3.1 By-product vs waste

The revised Waste Framework Directive sets out the following provision in relation to a waste being considered a by-product (see Appendix III(c) for exact wording):

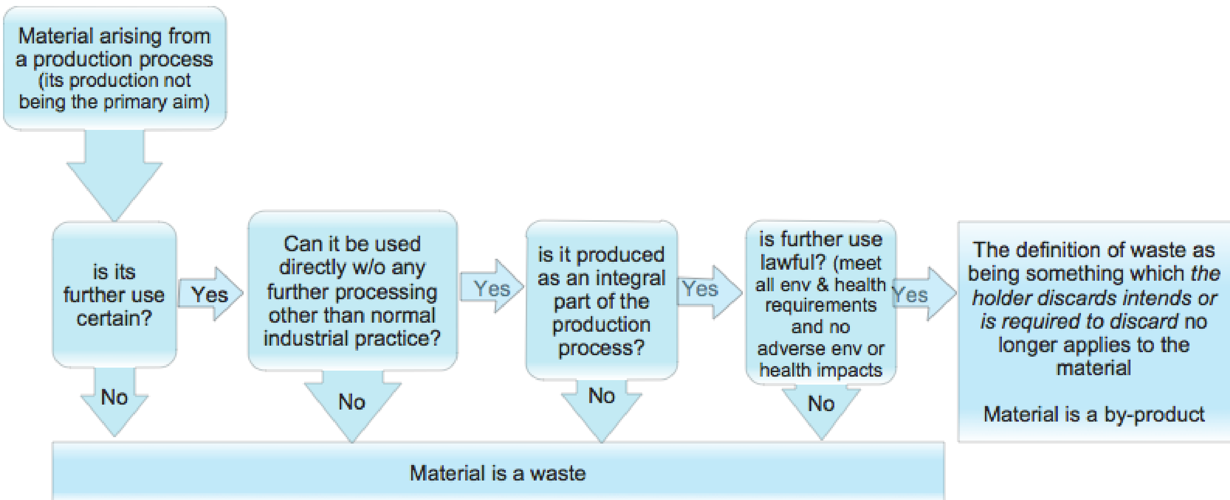

Figure 7.1: By-product versus waste under the revised Waste Framework Directive

[28] Point 1 of Article 3 defines waste and is the same as before in the older Waste Framework Directive: *"'waste' means any substance or object which the holder discards or intends or is required to discard".*

The important aspect of the above is that once all of these criteria are met the relevance of whether a person is discarding the material or not is no longer applicable in determining if it is a waste.

It is envisaged that criteria will be developed which will have to be met in order for particular substances or objects to be regarded as a by-product and not a waste.

From the point of view of waste organic solvent – this is material arising as an integral part of the API production process, while its production is not the primary aim. Regarding the other criteria:

- Is its further use certain?
- Can it be used directly w/o any further processing other than normal industrial practice?
- Is further use lawful?

It is the opinion of the authors that in terms of material recovery (either on-site or off-site) two of these criteria are fulfilled: further use is certain in that the industry recovers only that which it will use; and further use will be lawful in that the material will be recovered to a specification akin to virgin material for reuse in the process as a solvent. The one criterion which has to be determined is whether solvent recovery constitutes “normal industrial practice” rather than “further processing”. Whether solvent recovery takes place in the production vessels as an integral part of the process, in dedicated on-site solvent recovery plant, or off-site will also have an impact on such considerations.

It is the opinion of the authors that in terms of use as a fuel on-site, certain solvent by-products/residues could meet all of the above, but only where particular criteria were set (e.g. c.v., water content, etc.) in order to both satisfy guarantee of use and ensuring this use is lawful. Use as a fuel will be lawful where no emissions occur or abatement is required that is not typical of an equivalent conventional fuel.

If solvent going for use as a fuel on-site is confirmed as a by-product, the implications of this include:

- Emissions would not have to meet WID as long as no adverse environmental or health impacts.
- There would be REACH implications, but by-products are exempted from certain, but not all, REACH requirements. Exemptions include registration, downstream users, and evaluation requirements.

In terms of use as a fuel off-site, the end-of-waste criteria may be more applicable (see next section).

7.3.2 End-of-Waste Criteria

The revised Waste Framework Directive sets out provisions in relation to end-of-waste. The essence of this provision is that waste that has undergone a recovery/recycling operation will cease to be considered a waste once specified criteria are met. These criteria are to be developed at an EU level and will take into account (see Appendix III(d) for exact wording):

- If it is commonly used;
- If a market demand exists;
- If technical requirements for the purpose are met & product standards are met;
- If its use will not lead to overall adverse health or environmental impacts.

However the Directive also allows Member States to decide, case by case, whether certain waste has ceased to be waste, taking into account the applicable case law.

Again, the important aspect of the above is that once these criteria are met the relevance of whether a person is discarding the material or not is no longer applicable in determining if it is a waste.

From the point of view of waste solvent, blending off-site for use as a fuel could be considered to fulfill some of the end-of-waste criteria: solvent waste is commonly used as a fuel throughout the EU, a market demand exists as evidenced by cement companies in Ireland moving to use such fuels. A clear definition of “fuel” when derived from waste would help address the third condition. To satisfy the fourth condition, use as a fuel should not lead to overall adverse health or environmental impacts where any emissions that occur or any abatement required is no different than that of an equivalent conventional fuel. As part of the above, whether blending is a (complete) recovery needs to be determined. In this context it should also be noted that the preamble to the revised Waste Framework Directive states that “for the purposes of reaching end-of-waste status, a recovery operation may be as simple as the checking of waste to verify that it fulfils the end-of-waste criteria”.

If solvent blended as a fuel is confirmed as meeting end-of-waste criteria, the implications of this include:

- WID requirements would not have to be met, albeit the requirement to "not lead to overall adverse health or environmental impacts" may result in fuel compositional requirements being specified or emission limits being met. It should be noted that there will be REACH implications for materials declared as products.

In general it should be noted that the EPA has no interest in applying the burden of 'waste' to materials that can be usefully and economically reused without risk to the environment and in a way that conserves other natural resources.

7.3.3 Application of the WID in light of the 2008 revised Waste Framework Directive

In light of article 5(1) of the revised Waste Framework Directive 2008/98/EC, the authors have the following interpretation:

- The role of "discard" in determining if something is a waste or a by-product should no longer come into play; it should solely be on the basis of the 4 conditions set out in article 5(1) being met (as set out above). This is because Article 5(1) states that such an item "may be regarded as not being waste referred to in point (1) of Article 3", i.e. may be regarded as not being an object which the holder discards or intends or is required to discard.
- If that by-product is for example solvent resulting from a pharmaceutical production process, then its use as a fuel would not have to meet the WID requirements where all 4 conditions of article 5(1) are met.
- However, in light of the last condition of article 5(1), it presumably can be at the discretion of the EPA to include in licences such conditions that the specific use to which the waste is put to does "not lead to overall adverse environmental or human health impacts".

In the case of solvent residues being taken and blended and subsequently sold on to the cement industry for use as a fuel, it is possible that end-of-waste criteria developed under Article 6(1) could be applied to such a stream.

7.4 Solvent Blending for Use as a Fuel

The BREF for waste treatments[29] deals with BAT for blending of wastes for use as a fuel in general. In the BAT for the preparation of waste to be used as fuel, BAT is to have a close relationship with the user to ensure a transfer of the knowledge on composition is achieved and to have a quality assurance system to guarantee characteristics of the fuel produced. BAT is to use carbon treatment for low contaminated water and thermal treatment for highly polluted water. (See Appendix III(e) for more detailed extracts from the BREF document).

Section 2.1.5 of the waste treatments BREF is on "blending and mixing". In particular the BREF states that blending and mixing "*should not be confused with dilution*"; also that "*blending and mixing are processes carried out because it is a technical requirement from the WT facility to guarantee a homogeneous and stable feedstock and not techniques to facilitate acceptance of waste*". Finally this section also states that "*the mixing of wastes must be prevented from leading to a lower level of processing waste than the best possible level of waste management or from leading to the application of non- environmentally sound waste management*". (See Appendix III(f) for more detailed extracts from the BREF document).

7.5 Blending Plants in Ireland

The licences for blending operations in Ireland, which are subject to audit and inspection, include a condition in relation to what is allowed in terms of blending. Essentially blending must be carried out in accordance with the procedures that the licensees have developed.

General record keeping requirements include details of any approved mixing, as well as tonnage and EWC codes of wastes brought on-site and sent off-site, including fate. (See Appendix III(g) for more detailed extracts from these licence conditions).

Thus a review of the records of these facilities may help in determining the nature of the activities being carried out and ensure that dilution as forbidden under BAT is not occurring.

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[29] IPPC Reference Document on Best Available Techniques for the Waste Treatments Industries, European Commission, August 2006.

8 ECONOMICS OF SOLVENT RECOVERY AND DISPOSAL

8.1 Introduction

This section of the report seeks to shed light on the economic and technical aspects of the feasibility of increased distillation or recycling of solvents in Ireland.

As set out in the Project Terms of Reference, the aim is to try to identify and quantify the costs associated with the current management practices for solvent waste streams and the likely costs of redirecting these solvent wastes to recycling, co-incineration and energy recovery, or incineration in Ireland.

The following section, therefore, summarises the findings of the research on the costs of different recovery/disposal options. It is based on figures supplied by waste generators, by waste management companies and capital equipment suppliers. It has to be noted, however, that many companies have been either unable or unwilling to supply cost data, and therefore, in some instances, the consultants have had to rely on somewhat limited information. Nevertheless, the results of the analysis have provided some interesting insights.

8.2 Commercial Material Recovery – In Ireland

a) Soltec

A single commercial waste treatment company, Soltec, is authorised to accept waste solvents for recycling by distillation. Soltec tends to focus primarily on recovering methanol for use in bio-diesel, and solvents such as toluene, IPA,and ethyl acetate which can be blended and sold to the vehicle refinishing industry as “standard thinners”.

The company operates two recovery stills and is licensed to process some 5,000 tonne per year. However, the company reports that it is currently operating at only 20% of capacity due to difficulties in obtaining solvent waste.[30]

According to figures provided by the company, they charge €100 per tonnes for solvent recovery. In addition, the company estimates that the cost of transport to its facility in Mullingar should be no more than €800 per tanker, or €36 per tonne based on a standard 22 tonne tanker. This suggests, therefore, that a generator of waste solvent would incur a cost of €136 per tonne if it was to use Soltec.

It is also interesting to note, however, that Soltec reported that the actual cost of recovering solvent is closer to €150 per tonne if costs for labour, energy and residual waste disposal are included. While Soltec did not provide a breakdown of revenue and costs, nevertheless, as shown in Table 8.1, the recovery process would appear to be potentially very profitable. The estimates contained in this table are based on the following assumptions:

- that for every tonne of waste solvent that Soltec takes in, it manages to recover 80% solvent
- that it manages to sell the recovered material – in this case methanol - at a discount to the price of the virgin solvent (i.e. €250/tonne versus €360/tonne),
- that it supplies methanol to a facility in Killarney involved in the production of bio-diesel and incurs an additional cost of €36 per tonne in transporting the recovered solvent to Kerry.

On this basis, it would appear that Soltec has the potential to achieve a profit of some €114 on each tonne of waste solvent that it takes in for recovery.

30 In 2008, it processed 1,066 tonnes of waste solvents, which produced 836 tonnes of recycled product and 218 tonnes of waste for disposal.

Table 8.1: Input/Outpost Costs for a Waste Contractor

	€/tonne
Income	
Gate Fee	100
Recovered Solvent – Methanol 80%	200
Total	**300**
Costs	
Cost of Recovery, including residual waste disposal	150
Transport	36
Total	**186**
Surplus	**114**

It should be stressed that Table 8.1 has been produced for illustrative purposes only and has not been derived from actual figures provided by Soltec. Nevertheless, it does underline the fact that, if secondary markets exist for the recovered solvent, then solvent recovery is potentially profitable (in this example, a profit of €114 per tonne is achieved for an outlay of €186 per tonne). Moreover, on the basis of these numbers, there would appear to be scope for Soltec to reduce its gate fee – as rival facilities in the UK appear to be doing - and still achieve a surplus.

The company has noted that it faces difficulties in securing sufficient volumes of waste solvent to enable it to operate at, or near, capacity. There would seem to be, therefore, reluctance on the part of waste solvent generators in the pharmaceutical sector to use this facility – although a number of companies have used Soltec in the past. This may be partly due to concerns about quality - as it would appear that the Soltec facility is a relatively un-sophisticated operation, which may not have the equipment necessary to recover complicated mixed solvent wastes or achieve very high purity. However, as the estimates shown below indicate, there may also be economic reasons why many companies continue to export waste solvent for recovery rather than recovering in Ireland.

While it would appear that a facility such as the Soltec facility will have difficulties in offering a comprehensive local solvent recovery solution to the Irish pharmaceutical sector, there would, nevertheless, appear to be opportunities for such a facility to fill a niche in the market. This is particularly true in relation to providing methanol for local bio-diesel production, which has the potential for significant growth in coming years.

b) Large Scale Independent Commercial Recovery

Ireland's present off site recovery infrastructure is clearly limited. In view of the fact that significant volumes of waste solvent are being exported each year, one has to consider whether it would be feasible to establish a large-scale distillation or recycling facility in Ireland and if so, who might be in a position to invest.

According to a supplier of the necessary plant and equipment, this would require a capital investment of approximately €2.3 million[31] for a plant with a maximum capacity of 25,000 tonnes per annum[32], which would be of a similar scale to SRM's facility in Rye. Such a plant would typically be based on a simplified technology (mostly batch), and whilst capacity utilisation would tend to be high, the risk of cross-contamination with other chemicals may limit the potential uses for the recovered solvent.

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31 This is assumed to be a large multi-purpose unit which will be written off over 15 years. The capital costs include the equipment, engineering, steel structure, piping, instrument and control, insulation and civil work.

32 The plant has a capacity of 3 tonnes per hour or 70 tonnes a day on a 3-shift basis. If the plant is working flat out, 7 days a week for 50 weeks a year, then the total capacity is over 25,000 tonnes.

Table 8.2 provides some rough estimates of the financial viability of such a facility, with different levels of capacity utilisation. It must be stressed, however, that in deriving these estimates, a number of broad assumptions have had to be made.

- Firstly, according to Kühni, the typical cost of using a merchant waste recovery facility to treat waste solvent is in the region of €110 to €170 per tonne, depending on the complexity of the recovery operation. However, this includes transport and profit and therefore for the purposes of estimating a typical gate fee, a figure of €100 per tonne has been assumed. This is in line with the figure charged by Soltec, but as indicated below, depending on the value of the recovered solvent, gate fees can be negligible or indeed negative.
- Secondly, the value of the recovered solvent will also vary but for the purposes of these estimates, it has been assumed to average €0.5 per kg or €500 per tonne.
- Thirdly, in the absence of more specific numbers, Soltec's estimates of the cost of recovery have been used as these include labour, energy and residual waste disposal costs.
- The same level of costs has been assumed for the different levels of capacity utilisation, although of course, in reality, unit costs are likely to fall as output increases.
- Kühni has suggested that such as plant would typically be written off within 15 years. However, in line with the Revenue Commissioners' recommendations[33], it has been assumed that the capital equipment cost is depreciated by 12.5% a year on a straight line basis.
- It should be stressed that no figures have been included to cover the cost of supporting infrastructure such as premises, storage, connecting pipework etc., and these could add significantly to the overall cost of operating a recovery facility.
- Finally, transport and handling costs to the UK have also been included as it is assumed that a significant proportion of the recovered solvent would have to be exported due to limited market scale in Ireland.

Table 8.2: Financial aspects of a Solvent Recovery Operation in Ireland

Capacity Utilisation	**30%**	**50%**	**80%**
Tonnes of waste solvent processed	7,500	12,500	20,000
Tonnes of solvent recovered (80%)	6,000	10,000	16,000
Income			
Gate Fee (€100/tonne)	€750,000	€1,250,000	€2,000,000
Recovered Solvent (€500/tonne)	€3,000,000	€5,000,000	€8,000,000
Total	**€3,750,000**	**€6,250,000**	**€10,000,000**
Costs			
Cost of Recovery, including residual waste disposal (€150/tonne)	€1,125,000	€1,875,000	€3,000,000
Depreciation	€287,500	€287,500	€287,500
Transport/handling to UK (€120/tonne)	€720,000	€1.200,000	€1,920,000
Total	**€2,132,500**	**€3,362,500**	**€5,207,500**
Surplus	**€1,617,500**	**€2,887,500**	**€4,792,500**
Surplus/Tonne of Waste Processed	**€215**	**€231**	**€240**
Payback Period	**14-15 months**	**8-9 months**	**5-6 months**

[33] Starting in Business: A Revenue Guide. June 2007, page 12, Revenue Commissioners

Based on these estimates it would appear that a large scale independent facility has the potential to be extremely profitable, with a very short pay-back period.[34] However, it has to be stressed again that the estimates that these calculations are based on are drawn from a number of different sources and are not, necessarily, representative of the actual revenue and costs incurred by a real facility (and of course, additional costs such as premises, storage tanks etc have not been included). Nevertheless, this does illustrate the potential value of material recovery – and indeed, even if a zero gate fee were charged, then this facility would still be achieving a healthy profit.

So why then, has nobody invested in such a facility in Ireland?

Firstly, it is extremely unlikely, given the difficulties that the current commercial waste solvent recovery operator faces in securing waste solvent, that they would be in a position to expand their operations to enable Ireland to become effectively self-sufficient in terms of recovery capacity, without substantial investment.

Secondly, the other main commercial players in the market, Indaver and Veolia, have developed business models which favour the recovery of waste solvent as blended fuels rather than material recovery. And indeed, one of these companies is tied in to a material recovery facility in the UK and is therefore unlikely to invest in competing capacity in Ireland.

Thirdly, given the current economic climate, and the uncertainty that exists in the sector, then the likelihood of an independent third party investing in the development of a large scale recovery facility would appear to be remote.

Before contemplating such an investment there are a two main critical factors that would need to be taken into account, namely:

- the likelihood of securing sufficient volumes of waste, and on a consistent basis, to ensure that the plant can operate at or near optimum capacity. As demonstrated elsewhere in the report, the total volume of waste solvent being generated can be highly variable from year to year, and indeed, the underlying trend in volumes generated is downwards. Moreover, the pharmaceutical manufacturing sector is facing significant changes at present and the future scale and nature of the business in Ireland is uncertain. This raises concerns about potential security of supply and this is a key issue that would need to be addressed in assessing the potential viability of such a facility. Given the difficulties that the existing operator faces, then this would certainly constitute a major risk to any potential business.
- the availability of secondary markets for recycled solvents. It would appear that here too, significant risks exist as the Irish market for recycled solvents is limited (and mainly involves the paint industry and car body shops). For this reason, therefore, recycled solvents would have to be exported, most probably to the UK. As there are already a number of large-scale solvent recyclers in the UK, then competition is likely to be intense, and of course, the Irish facility would also have to incur additional transport costs simply to reach its customers[35]. This is likely to pose a further potential barrier to any investor.

In view of all of these factors; the significant risk attached to any potential investment and the competition from other operators, it would seem unlikely that any business would secure funding for such a venture at this point in time.

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34 The payback period is the time taken to recover the initial investment. So a €1m investment that will make a profit of €200,000 a year has a payback period of five years. In this example, the payback period on an initial investment of €2.3 million could be a matter of months, depending on the level of capacity utilisation that is assumed.

35 Environmentally the location of solvent recycling is neutral in its effect. There is little difference between exporting waste solvent for recycling in the UK and exporting recycled solvent for sale in the UK. However, commercially, as an Irish recovery facility would have to incur the transport costs to ship the recovered material to the UK, they would have a higher cost relative to product that is recovered and sold in the UK.

c) Industry Sponsored Facility

A further option that should be considered is for the pharmaceutical companies to share their existing recovery capacity to provide a local solution. As indicated below, many in-house Solvent Recovery Units (SRUs) are not operating at full capacity at the present time. Moreover, as the capital investment is already in place, this could potentially offer an economically attractive alternative.

It is understood, that small number of waste generators are authorised to accept waste solvents for recycling and have either done so, or are doing so, on an internal corporation basis.

In addition, it has also emerged that a small pharmaceutical company, which is licensed to accept solvent for recovery from others, has already processed 660 tonnes for another company. To put this in context, it is worth noting that this is more than half of the total volume of waste solvent that Soltec processed in 2008. It is not known on what commercial basis this arrangement has taken place. However, the commercial (and environmental) benefits are likely to be significant. For example, as the SRUs used by the pharmaceutical companies tend to be more specialised than those used by the commercial operators, there is likely to be less risk of cross-contamination and, therefore, the probability of recovering solvent which can be re-used by the waste generator in a production process is likely to be greater. This, of course, represents a significant saving for the company. In addition, the costs involved in transporting the waste solvent and the recovered solvent are also likely to be significantly lower.

d) Transport and Handling Costs

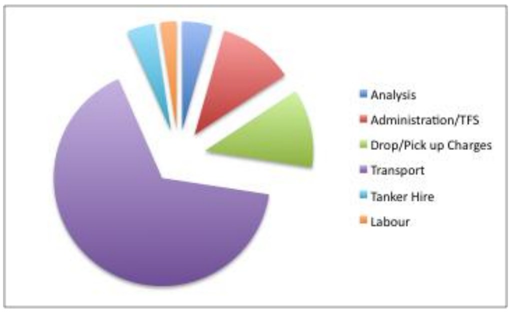
The main benefit for Irish businesses in being able to use local recovery facilities is clearly the saving in transport costs – which form a significant element of the overall costs of waste solvent treatment or disposal.

As indicated above, it typically costs €800 for a 22 tonne tanker anywhere in Ireland. According to industry reports, the transport costs associated with sending a 22 tonne tanker to the UK can vary from €1,600 to €2,500, while the costs of shipping to the Continent are typically in the region of €2,800 to €3,000.

One company was able to provide a more detailed breakdown of the costs that they had incurred for a number of shipments. These are shown in the Table 8.3. This includes an allocation for analysing the waste, for paperwork including TFS, for tanker hire as well as drop and pick-up charges and also labour costs. In this example, the transport element alone is reported to be €1,800 for a 22 tonne tanker and amounted to two-thirds of the costs:

Table 8.3: Sample Costs for Solvent Waste Handling (€ per tonne)

	Cost (€) /tonne
Analysis	5.5
Administration/TFS	14.0
Drop/Pick up Charges	14.5
Transport	81.8
Tanker Hire	5.2
Labour	3.0
Total Transport/Handling	**124.0**



8.3 Commercial Material Recovery – Export

Evidence from a number of companies interviewed during the course of this study suggests that companies sending waste solvent for recovery tend to use facilities in the UK (e.g. SRM in Rye or Sunderland). Based on the figures provided it would appear that at least one company is being credited for the waste it sends for recovery. This company reported that "charges" can vary from a cost of €5 per tonne for a mother liquor that goes for recovery, to a

maximum credit of €175 per tonne – but typically it received a credit of €100 per tonne. It should be noted, however, that this was one of only a very small number of companies that reported receiving a credit. In the other cases reported, it would appear that the main costs associated with shipping to the UK were related to transport and administration (e.g. TFS), and that, in general, gate fees were zero. (This would seem to suggest perhaps that some waste generators may not be aware of the potential value of their waste to the recovery operators, and that they could, perhaps, negotiate somewhat better terms than they are achieving at this point in time.)

This also contrasts sharply with the current situation in Ireland, where companies are being charged a gate fee of €100 per tonne. While this may partly reflect the composition of the waste solvents sent to the UK for recovery, it does underline the potential value of the waste stream - if secondary markets exist - and may also help to explain why waste solvent is continuing to the shipped to the UK. Even on the basis of a zero gate fee, then the transport and handling costs of shipping the material to the UK are likely to be approximately €124 per tonne. This is still lower than the €136 per tonne currently being charged in Ireland. And of course, if one can achieve a credit of €100 per tonne for waste solvent, then the cost of recovery falls to just €24 per tonne.

One other finding is worth highlighting in relation to exports for recovery to the UK. One company, for example, noted that they ship approximately 5,000 tonnes of acetonitrile to SRM in Rye for recovery. In this instance, recovery is ring-fenced through the use of dedicated tanks and the recovered solvent is shipped back to Ireland for re-use in the production process. What is of note, however, is the fact that the company claims that it can recover the solvent for one third the price of virgin acetonitrile solvent – despite the fact that it is not only incurring the cost of recovery but also two sets of transport costs. It would appear that in this instance, the waste generating company concentrates the solvent waste onsite before shipping for final recovery, so the waste is likely to be of a higher value. [36]

8.4 Material Recovery – In-house

A small number of companies provided information on the costs of operating their in-house recovery facilities. This reflected the fact that, in many instances, detailed costs were not available for the SRU as they were simply absorbed into the overall running costs of the plant. This also meant that many companies were unaware of the costs of in-house recovery relative to other treatment or disposal options.

For those companies that were able to provide estimates of the operating costs of their SRUs, there was a very signification degree of variation between the figures – from €1,150/tonne of solvent recovered to €3,690/tonne. These are clearly significantly higher than the comparable costs for alternative recovery options. They also contrast sharply with figures provided by Kühni, an equipment supplier, which suggests that in-house recovery should cost in the region of €75-€140 per tonne.

It is not possible, therefore, to rely on the figures obtained from the limited sample of companies to arrive at any conclusions about the actual cost of recovery in-house. What is clear, however, from the information that has been obtained, is that accounting practices vary from site to site and, in some instances, very significant allocations have been made for total plant overheads which are likely to have over-inflated the actual or direct costs associated with solvent recovery. Moreover, in all instances, the SRU was not operating anywhere near full capacity - and that will of course impact significantly on unit costs.

[36] The economics, in this instance, may have been distorted by a world shortage of acetonitrile. Starting in October 2008, the worldwide supply of acetonitrile was low because Chinese production was shut down for the Olympics. Furthermore, a U.S. factory was damaged in Texas during Hurricane Ike. Owing to the global economic slowdown, the production of acrylonitrile that is used in acrylic fibres and acrylonitrile-butadiene-styrene (ABS) resins also decreased. Because acetonitrile is a by-product in the production of acrylonitrile, its production has also decreased. The global shortage of acetonitrile continued to be exacerbated through early 2009.

Based on the feedback from the companies interviewed, it is clear that, in many instances, the choice to recover in-house is not based on a rigorous assessment limited to the relative financial costs and benefits. Indeed, a number of companies reported that the decision to recover in-house was a strategic decision based on issues such as security of supply of critical solvents, the avoidance of perceived handling and transaction costs and minimising transport risks.

The price of virgin solvent was also identified as a significant driver to in-house recovery. This is important because in looking at the costs and benefits of alternative recovery/options, the value of the recovered solvent should be offset against the actual costs of recovery to give a picture of the net-cost of recovery for the business. It would appear, however, that while companies acknowledge this benefit, very few companies have any formal accounting procedures to capture this fact.

While the price of the virgin solvent was a key driver in the decision to recover, it would also appear that for some companies, the total quantity of solvent arising - and future projections for arisings - is another important factor in determining the desirability of recovery. This means that the cost of solvent is absorbed into the total cost (i.e. the combination of unit cost and quantity) and this can mean that a cheap solvent such as methanol may be favoured for recovery, even though the cost of recovery may be similar, or indeed more expensive, that the price of virgin solvent.

Table 8.4: Cost/benefit example of in-house recovery

Capacity Utilisation	**30%**	**<50%**	**75%**
Tonnes of waste solvent processed	2,000	3,000	5,000
Tonnes of solvent recovered (80%)	1,600	2,400	4,000
Savings			
Recovered Solvent (€500/tonne)	€800,000	€1,200,000	€2,000,000
Total	**€800,000**	**€1,200,000**	**€2,000,000**
Costs			
Cost of Recovery (€140/tonne)	€280,000	€420,000	€700,000
Depreciation	€125,000	€125,000	€125,000
Total	**€405,000**	**€545,000**	**€825,000**
Surplus	**€395,000**	**€655,000**	**€1,175,000**
Net “Saving” Per Tonne of Waste Processed	**€198**	**€218**	**€235**
Payback Period	**23-24 months**	**15-16 months**	**9-10 months**

While it has not been possible to develop a detailed picture of the relative costs and benefits of in-house recovery from actual company data, Table 8.4 has been devised for illustrative purposes. The estimates contained in the table are based on figures provided by a leading equipment supplier. Kühni estimate that the capital cost of an in-house recovery unit for the

pharmaceutical sector is in the region of €1 million, which would typically be written down within a 10 year period. (In line with the Revenue Commissioners' recommendations, it has been assumed that the capital equipment cost is depreciated by 12.5% a year on a straight line basis). The maximum capacity of such as unit is reported to be 0.8 tonnes an hour, which would mean a total annual capacity of 6,700 tonnes (assuming it was operating virtually flat out for 24 hours a day, 7 days a week). However, Kühni also noted that utilisation rates within the pharmaceutical sector tend to be relatively low. For this reason, a number of different utilisation rates have been used in the table to illustrate the potential impact on operating costs and savings. Moreover, as indicated above, Kühni estimate that the typical cost of operating such a facility should be in the region of €75 to €140 per tonne. Table 8.4 assumes the higher figure, but at the same time, no other costs, such as storage costs, pipe-work etc have been taken into account. It has also been assumed that the "saving" to the company of using recovered solvent rather than virgin solvent is equivalent to €500 per tonne. This estimate could, of course, be higher or lower depending on the solvent in question.

Whilst acknowledging that these estimates are based on the assumptions outlined above, nevertheless, the results would seem to underline the potential benefits of in-house recovery and that the SRU could deliver savings for the company of between €198 and €235 per tonne of waste solvent processed. These figures would also suggest that the pay-back period for investing in the necessary capital investment is relatively short (in our example, the payback period for an investment of €1 million would be two years or less depending on the level of capacity utilisation assumed). In order to explore this potential further, and to highlight the magnitude of the assumptions applied, a sensitivity analysis was undertaken to determine the combination of utilisation and installed cost that would lead to payback periods of 3 and 5 years. This attempts to make allowance for the realisation that the Kühni estimate may represent a minor fraction of the total installed cost of a recovery system.

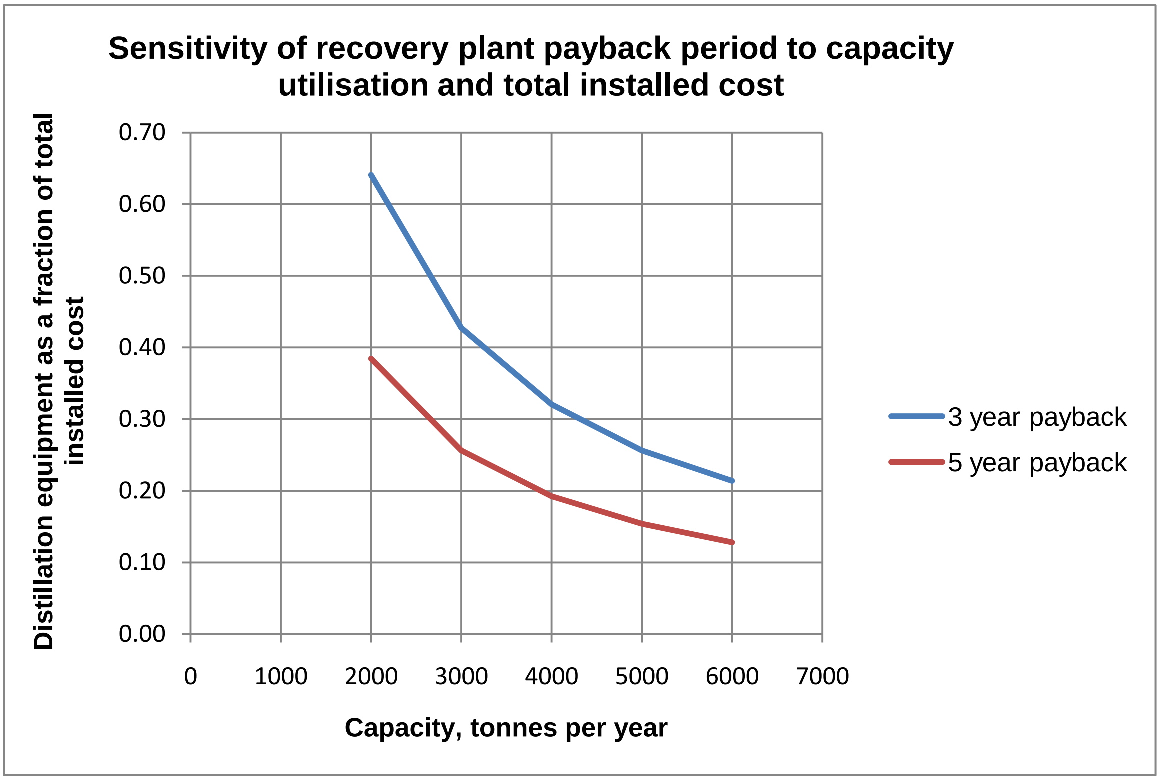


Figure 8.1 Sensitivity of recovery plant payback period to capacity utilisation and installed plant cost

Any combination of capacity and fraction of total installed cost that lies above a selected line will provide a payback period better than the selected period (3 or 5 years).

Table 8.5: Assumptions used in sensitivity analysis

Assumption	Comment
Kühni capital cost €1,000,000 for plant	Varies from >10% to >60% of the total installed cost in the above figure
Maximum capacity, 6,700 tonnes per year	Varies from 1,000 to 6,000 tonnes per year in the above figure
80% recovery of desired solvent from feedstock	Presumes a feedstock containing a very high proportion of the desired solvent
Cost of recovery, €140 per tonne processed	Chosen at the upper end of the Kühni suggested range
Cost of treatment of residues (20%) neglected	Neglected since there are so many other uncertainties. Inclusion of this will lengthen the payback period
Value of avoided solvent purchase, €500 per tonne	Referring to Table 3.1, this is greater than methanol's value, but significantly less than other solvents
Depreciation	Neglected, since this is a simple payback analysis
Time value of money	Neglected, since this is a simple payback analysis, and furthermore, short payback periods are considered.

While not universally conclusive, this again demonstrates that examination of the potential of in-house recovery should be assessed by waste generators.

8.5 Recovery as Fuel

Where material recovery is not possible, the next best solution is recovery as a fuel. The Second National Hazardous Waste Management Plan recommends that, in the interest of promoting self-sufficiency and maximising fossil fuel substitution, that the combustion of blended solvent should take place in Ireland, within the constraints of planning requirements, IPPC licences and the Waste Incineration Directive - in preference to exporting.

Both Veolia and Indaver have invested in capacity to blend waste solvents to optimise their calorific value for subsequent use as fuel. The total operational blending capacity in Ireland is reported to be in the region of 66,000 tonnes per annum. However, it would appear that at the present time, only a proportion of this capacity is actually being used.

The vast majority of blended waste solvents are being exported to the UK for use in cement kilns. According to estimates provided by waste generators, the cost associated with this option is approximately €124 per tonne. This simply reflects the transport and handlings costs associated with shipping the blended solvent to the UK – as the fuel has a value to the cement kilns there are no gate fees payable.

There is evidence that indigenous cement kilns are interested in using blended solvent as a fuel in their operations and, indeed, one facility in Northern Ireland has already done so. If this market was to develop, then this would obviously mean significant savings in transport costs for Irish waste solvent generators. Whilst one waste management company cited a potential issue with the use of blended solvents and emission limits under the WID (which would require an investment of €2 to €3 million to overcome), the cement companies themselves reported that they can accept the fuel now.

8.6 Incineration

A number of the companies interviewed have facilities on-site, and use these to dispose of waste solvents. Only one company was able to provide estimates of the costs of this option; namely €1,340 per tonne for incineration and €1,250 per tonne for waste to the WWTP.

It was noted that the cost of incineration has come way down in recent years. It was IR£1,000 per tonne 10 years ago, but has now fallen to €150 to €350 per tonne excluding transport. Transport costs can vary from €113 per tonne to €135 per tonne depending on

whether the waste is being shipped to the UK or the Continent. It would appear that many companies have a number of approved incinerators that they use, as there can be capacity bottle-necks from time to time.

Moreover, while incineration is clearly the dearest option for waste generators, it would appear that in some instances, the choice to incinerate is determined, at least in part, by a desire to eliminate any risk from APIs in the waste solvent and therefore, there are factors other than costs at play.

The proposed hazardous waste incinerator at Ringaskiddy would obviously provide a local solution for waste generators and would significantly reduce the costs associated with transporting waste abroad for incineration. If one was to assume a similar level of gate fees to that charged by facilities in the UK (i.e €150), and taking account of the lower transport costs that would be incurred, then this would suggest a disposal cost of approximately €186 per tonne.

8.7 Summary

Table 8.5 summarises the cost estimates for the various recovery/disposal options available to waste generators in Ireland and ranks each category in order of cost. The following are not considered, but could be relevant in the future:

- Material recovery at an off-site pharma company (as has already occurred). Since access to a market for recovered solvent in Ireland is very difficult, this presumes that the generator will accept the recovered solvent for reuse.
- On-site fuel recovery, as substitute fuel for thermal oxidisers, boilers, or incinerators, has not been costed. This avoids transport and treatment costs but does not bring the benefit of avoided solvent purchase.
- Off-site fuel recovery in power stations has not been costed, as the current trend favours cement kilns in preference.
- Imposition of an incineration levy (as has been mooted by Minister for Environment, Heritage & Local Government. An amount of €20 - €38 per tonne was announced on 19 November 2009, but it is not apparent if would apply only to municipal solid waste or only to merchant incinerators).

Table 8.6: Cost estimates (€/tonne) for various recovery/disposal options available to waste generators in Ireland.

Option	Gate Fee	Transport/ Handling Costs	Total Cost/Tonne	
			Lowest Estimated Cost	Highest Estimated Cost
Material Recovery – In House	0	0	Net Saving (+€198)	Net Saving (+€235)
Material Recovery with credit - Export	-€100 - €0	€124	€24	€124
Material Recovery – IRL (Soltec)	€100	€36	€136	€136
Fuel Recovery – IRL cement kiln	€0	€36	€36	€36
Fuel Recovery - Export	€0	€124	€124	€124
Incineration – Domestic on-site	€150	€36	€186	€186
Incineration - Export	€150-€350	€113-€135	€263	€485

These results would seem to suggest that:

- It has not been possible to arrive at any estimates of the cost of in-house recovery based on the information provided by pharmaceutical companies. Unit costs reported are very high relative to other treatment/disposal routes, but this appears to be due to internal accounting procedures. It has not, therefore, been possible to provide estimates of the operating costs for an existing facility.
- However, based on figures provided by Kühni, it would appear that in-house material recovery has the potential to deliver very real economic benefits to waste generators. Based on estimates of the cost of in-house recovery provided by Kühni and taking account of the potential "income" or savings that can be achieved by the company in terms of the value of recovered solvent, then an in-house SRU may generate a significant net saving for the company.
- The cost of domestic commercial material recovery appears to be high relative to export – particularly, if companies are being credited for the value of the recovered solvent. This is based on the single merchant recovery facility. The financial basis for the recovery operations between individual pharma companies is unknown.
- The option to burn blended solvent in Irish cement kilns would deliver very real cost savings for Irish waste generators, due to the reduction in transport costs.
- While the cost of incineration has come down significantly in recent years, it is still by far the highest cost option, without the threat of a levy.

8.8 Emissions Trading

The Emissions Trading Scheme (ETS) is one of the EU's main policy instruments to reduce green house gas emissions. It was first introduced on a pilot basis in January 2005 but is being implemented in a number of phases or 'trading periods.'

- ***Phase 1: 1 January 2005 to 31 December 2007*** was a three-year pilot phase
- ***Phase 2: 1 January 2008 to 31 December 2012*** which coincides with the five-year period during which the EU and its Member States must comply with emission targets agreed under the Kyoto Protocol.
- ***Phase 3: 1 January 2013 to 31 December 2020****.* This longer trading period is intended to provide greater predictability and thereby facilitate long-term investment in emission reductions.

The scheme works on a "Cap and Trade" basis. This means that all 27 EU governments are required to set an emission limit for all installations covered by the scheme (these tend to be large energy users such as large industrial sites, power generation companies etc). Each installation is allocated emission allowances for the particular commitment period. One allowance equates to one tonne of CO_2. The number of allowances allocated to each installation for any given trading period is determined on the basis of a National Allocation Plan (NAP).

The limit or 'cap' on the total number of allowances creates the scarcity needed for trading. Companies that keep their emissions below the level of their allocated allowances can sell their excess allowances at a price determined by supply and demand on the market at that time (e.g. carbon is currently trading at close to €14 a tonne). Those facing difficulty in remaining within their allowance limit have a choice between investing in more efficient technology to reduce emissions or buying extra allowances on the market.

In Ireland, some 100 installations, including the cement facilities, are covered by the EU ETS. From January 2013, these operators will have to comply with tougher EU rules governing greenhouse gas (GHG) emissions reduction targets as provided for in Directive 2009/29/EC of 23rd April 2009. Under this Directive, the EU has agreed to reduce GHG emissions from the ETS (traded) sector by 21% in 2020 compared to 2005 levels.

- While Irish cement manufacturers are unlikely to be struggling to keep their emissions within their allocated limits at the present time, there is of course a pressure on them in the medium to long term to put measures in place to minimise their emissions. Moreover, as unused carbon allowances constitute a valuable asset for the operator. they also have a strong incentive to switch to less carbon intensive fuels – as any savings have a direct economic value to the business.

9 CONCLUSIONS

9.1 Solvent waste arisings

As discussed in the body of the report, the vast majority of solvent waste arising in the IPPC regulated sector is in the pharmachem sector. In view of the IPPC and Solvent Regulations thresholds, it is unlikely that a significant amount of solvent waste exists outside of the pharmachem sector. Waste in this sector is considered to be well managed, and individual companies are subject to corporate and IPPC Licence aims of reducing waste. These drivers, combined with structural changes in the sector, have lead to a decreasing amount of reported waste. There is a sectoral organisation, Pharmachemical Ireland, which subscribes to the Responsible Care programme and has published reports that demonstrate a reducing amount of hazardous waste (likely solvent). However, the data for previous years has been modified and, as yet, Pharmachemical Ireland has not provided the reporting protocol.

The use of chlorinated solvents, once considered to be a significant concern, has reduced to a small proportion of solvent usage in the sector. The value of chlorinated solvent is such that waste is likely to be recovered in preference to disposal by incineration, where feasible.

Conclusions	**1**	**The pharmachem sector overwhelmingly dominates the waste solvent stream.**
	2	**The quantity of solvent waste arising appears to be decreasing.**
	3	**Chlorinated solvent waste is a small fraction of the total solvent waste produced.**

9.2 Solvent waste composition

Since the waste originates from many generators, operating many processes, there can be a very wide variation in waste composition. Many streams may contain intermediate or final pharmaceutical products, and generators may have a policy that these should be disposed of by incineration, notwithstanding the very high fraction of solvent that may be present. Since component solubility may change radically on combination with other solvents, there may be restrictions to accumulating different materials for recovery.

While many of the solvents are individually immiscible with water, water may be present if

- the waste is a mixture containing one solvent in which water is soluble
- “immiscibile” may actually mean sparingly miscible,
- there may be physical entrainment of water in the solvent and
- phase separations may be conservative, with a significant water stream allowed to remain with the solvent phase.

A number of companies, but not all, undertake simple distillation to concentrate a waste stream prior to off-site treatment. Potentially, this reduces their costs by substituting internal energy costs for external treatment.

Aqueous streams may contain very little undesired component, but at a level which renders the stream unsuitable for biological waste water treatment. Hence streams containing 99% water may be sent for incineration, with an associated demand for supplementary fuel. One generator installed a membrane separation system to concentrate a waste stream prior to incineration, with the residue consigned to biological waste water treatment, with economic benefits. Recently, solvent resistant membranes have been developed that might allow a similar action on solvent rich streams, i.e. concentration of a stream for incineration with diversion of the reminder to recovery. These technologies may merit continued investigation.

Conclusions	**4**	**Solvent wastes may contain selectively soluble materials or intermediate / final pharmaceutical products.**
	5	**Solvent waste may contain a very significant fraction of water, suggesting preconcentration is desirable.**

9.3 Data quality

A number of ambiguities and anomalies have emerged on reviewing the reported data in EPA files and considering the responses from the various actors in the solvent waste management chain.

9.3.1 Understatement of the extent of recovery

There are three possible generic locations at which solvent may be recovered:

(a) within the production building or process originating the solvent, for reuse by the next batch or stage;

(b) via an on-site solvent recovery unit, which may be dedicated to a single solvent, building or process; or may be general purpose, used for multiple solvents, production buildings or processes;

(c) or via an off-site solvent recovery unit, likely to be multipurpose and operated by another enterprise.

Undoubtedly, location (c) should require reporting of the solvent production as waste. It would be unusual to report (a) as producing waste. This leaves (b) as an ambiguous area. EPA appears to adopt what would be widely construed as a strict definition, requiring reporting of this solvent throughput as waste. Since recovery will be achieved at the expense of energy, there is some merit in this requirement. However, this is not consistently applied by the EPA for all licensees. Hence the quantity of solvent reported as recovered for material reuse on-site (R2) is substantially understated. Probably a further 40,000 tonnes per annum is actually recovered on site – corresponding to location (b) above. This is not in the reported statistics because some of the relevant licensees were advised by their inspector not to report, since the large values would “distort” the national waste statistics. This is pragmatic advice, but it “undersells” the level of recovery already achieved. At the very least, a consistent approach should be followed.

Conclusion	**6**	**The reported data is ambiguous and understates the extent of material recovery (R2) in Ireland.**

9.3.2 Ambiguity in classification of waste treated in an incinerator as R1 (reuse as fuel) or D10 (destruction)

Most solvents in use in the pharmachem sector are flammable, possessing a significant calorific value. Even if they become waste associated with a significant amount of water, the waste stream may still be flammable. As waste, this flammability will immediately lead to their classification as hazardous waste. They are also likely to contain production intermediates or products that would themselves be hazardous because of their toxicity. Hence, the waste may be consigned to destruction by incineration. The solvent fraction may then contribute to the fuel source necessary to combust any non-flammable content, though a supplementary fuel (gas or diesel, typically) may be required if a convenient waste mix cannot be achieved. If some heat recovery is present, there is a temptation to classify the waste as R1, rather than D10. The Waste Framework Directive has introduced a specification for the required heat recovery efficiency before the classification of incineration as “recovery” may be applied. We have not seen evidence that such detailed scrutiny has been applied to the classification of solvent waste streams and their incineration in Ireland. Streams have been classified as D10 where heat recovery exists and as R1 where the extent of heat recovery is limited. Clearly there is inconsistency.

A further concern exists where streams of widely varying calorific value are blended. Blending a stream with a very high calorific value (nearly all solvents) with a stream containing a very high proportion of water may result in a stream with a sufficiently high calorific value to be considered fuel, but this confuses the original classification of the low calorific value stream that might have been assigned D10. Furthermore, its use as a fuel

carries the burden of vaporising the water fraction, thereby reducing the available energy content.

Conclusion	**7**	**Reporting of solvent waste treatment as R1 or D10 is ambiguous.**

9.3.3 Prolonged use of interim classifications: R12/13; D12/13

Substantial quantities of solvent waste are classified under interim categories by the generators. These reflect the reports provided to the generators by the waste brokers. However, the waste brokers are typically intermediaries and consign the waste onwards after blending, usually for incineration or reuse as fuel. While they are licensed to store material at their sites, the allowed period is finite e.g. 6 months. Hence a final fate should be eventually available.

Conclusion	**8**	**The prolonged use of interim classifications: R12/13; D12/13 is ambiguous; the final fate should be provided.**

9.4 Material recovery and reuse of solvents (R2)

9.4.1 Reuse of solvent

The pharmachem sector is the only significant consumer of solvent in Ireland. In other countries there is likely to be a market for solvent of lesser quality specification, e.g. the paint sector: industrial, car, possibly domestic. This is largely absent in Ireland. There are a number of operational details inhibiting the reuse of solvent on the originating site:

(a) Typically, solvent will be returned only to the originating process. Since there are economies of scale, material may be accumulated before recovery, by which time the manufacturing production campaign may have moved on and the demand for the solvent lies in the distant future.

(b) Segregation of solvent wastes will require adequate tankage and may even be inhibited by the need to segregate the contents of pipelines from the production area to waste storage.

(c) Some sites are now undertaking a “launch” or “late process development” role in their corporations, developing processes which will not become long-term manufacturing activities on that site. Optimising solvent recovery seems to be a responsibility of the long-term manufacturing sites. Volume, i.e. gross value as the product of quantity and unit cost, is the significant factor in determining if recovery is viable.

(d) Finally, a perceptional barrier is that companies may not see waste recovery as part of their core business.

The typical quality demands in manufacturing pharmaceuticals may raise barriers to the reuse of solvent, but this study has determined that these barriers can be overcome if there is an economic imperative - considerable recovery is actually undertaken. As has been discussed already, the quantity of solvent recovered in Ireland has been understated. The economic advantages are: reduced material costs, reduced transport costs, avoidance of supply interruptions, and avoidance of transport and transfer risks.

Several case studies demonstrate the achievements possible:

- Acetonitrile was seen to be a costly solvent, in global short supply. One generator contracted a UK recovery company to accept and process its waste, keeping it segregated and returning it to the originator. A second company contracted Sigma-Aldrich in Ireland to recover the same solvent for them.
- Several companies have utilises recovery facilities in the UK for solvent re-used on-site.
- Pfizer Ringaskiddy recovered solvent for other Pfizer sites’ processes.
- One company combines its recovered cleaning solvent for reuse in any process.

- Another company combines its recovered solvent for reuse in any process except pre-launch trials.

The wider recognition of these achievements and a desire to emulate them would reduce the barriers to solvent reuse in the sector.

Conclusions	**9**	**Most, but not all, recovered solvent is reused in the originating process.**
	10	**A number of barriers: perceived quality issues; limits on tank capacity; pipeline constraints; the shift towards manufacturing sites in Ireland acting as "launch" sites, without prolonged production campaigns; militate against material recovery, R2.**
	11	**Recovery and reuse of solvent achieves self-sufficiency: enhancing security of supply of needed solvent and satisfying the general environmental goal of dealing with waste close to source.**

9.4.2 Distillation capacity in Ireland

So far, we have concluded that distillation is more practiced than recognised and that recovery can be provided at off-site locations in Ireland. In the course of the stakeholder interviews, it became clear that the sole merchant recovery operation, Soltec, operates at approximately 20% of capacity (1,000 tpa versus 5,000 tpa) and has difficulty obtaining feedstock. This may arise from the apparent lack of sophistication of its equipment (reported as simple batch stills, without rectification) or from a reputation perception. At least one pharmachem company has used Soltec, but others expressed a reluctance to do so. There is less likely to be a reluctance to use a company that is closer to the pharmachem manufacturing environment, e.g. Sigma Aldrich. Another site reported it was at full capacity – but based on a 5 day week. One might presume that there might be spare capacity in the Pfizer Ringaskiddy distillation plant, with the sale of other Pfizer manufacturing sites[37]. Recovery of solvent by one site for another site has been licensed by EPA and one presumes that wider adoption of this approach could be facilitated. This would ensure better utilisation of existing capital investment. The scale of available distillation capacity has not been quantified in this study. To do so is complex, requiring simultaneous consideration of distillation column capacity, tankage, and production schedules – assuming recovered solvent will be reused by the originator.

The earlier chapter on economics assessed the business case for establishing a new independent recovery operation in Ireland. At first sight, the economics of recovery are favourable, but a new operator would be faced by difficulties in securing a long-term feedstock and without a dependable market in the Irish pharmachem sector, would face a major challenge is selling into export markets. Furthermore, it would compete with existing under-used capacity. Therefore it was concluded that the business case for a new entrant is high risk.

Conclusions	**12**	**There is unused solvent distillation capacity in Ireland.**
	13	**Already, pharma sites have recovered waste for other pharma sites.**
	14	**Investing in a new merchant recovery facility, would be a high-risk venture, while superficially very profitable.**
	15	**There may be niche opportunites for inter-company agreements, or for merchant recovery of high volume solvents**

[37] However, There is not much spare capacity currently in the Pfizer Ringaskiddy distillation plant, as even with the sale of another Pfizer manufacturing site, solvent for a third Pfizer site is to increase instead. However, Pfizer Ringaskiddy did indicate that beyond next year there might be capacity and are not averse to the idea of recovering for non-Pfizer sites.

		besides methanol: propanol, toluene, tetrahydrofuran, ethyl acetate.

9.5 Financial factors

This study attempted to quantify the costs of recovery and treatment. Limited data was provided and such as was provided is inadequate to draw firm conclusions. However some useful insights have been obtained.

Waste is handled by one of two brokers: Veolia or Indaver. In effect, there is a duopoly. As anticipated, these were unwilling to provide data that was commercially significant. The 12 waste generators that were consulted were able or willing to provide varying levels of data. In one case, the waste management agreement is negotiated for both the UK and Ireland combined and they do not know the cost details. Others did not have the details to hand and have promised relevant values. Still others are unwilling, citing commercial confidentiality. As will be shown below, this lack of information sharing appears to result in greater costs to the generators.

9.5.1 Cost of distillation in Ireland

As has been discussed in the chapter on economics, the costs of distillation vary widely across the sector. In an effort to reconcile these, the consultants made contact with Kühni (now part of Sulzer), a renowned supplier of solvent recovery distillation plant. The operating costs suggested by Kühni are lower than the reported Irish costs, which in some cases appear to exceed the purchase cost of virgin solvent. There are three possible reasons for this:

(i) The Kühni costs are biased in favour of recovery, since they supply this type of plant;

(ii) The Irish costs reflect higher wage, fuel, etc., rates;

(iii) The cost allocation model adopted in the Irish plants is inappropriate.

The reality may be a combination of all three, and this warrants further investigation. Our earlier analysis indicated that material recovery brings very significant savings: €210 - €250 per tonne, based on a simplified assessment, using assumptions that are open to challenge.

Conclusion	**16**	**The cost of distillation recovery in Ireland appears to be unclear and subject to carrying high overhead burden – yet is likely to bring major savings, possibly as high as €210 - €250 per tonne.**

9.5.2 Cost of treatment abroad

There are multiple cost factors in sending material abroad for treatment. It is the aim of the generators to minimise costs, and of the brokers to maximise profit. Transport is a very significant element of the total cost. If solvent were treated in Ireland, it is likely that the transport cost would lie between one-third and one-half of the present transport cost. Some generators, but not all, receive a credit for the treatment portion of the cost, i.e. they receive money, rather than pay. However, this is not universal. The variation may arise due to the detailed composition of the waste, or may be due to skilful negotiation. Brokers have the opportunity to blend wastes, so that lower grade material may be combined with high grade material to produce a blend that still satisfies the end receiver's specification, whether for R2, R1 or D10. Overall, waste treatment costs have been reducing over the last ten years and generators may feel that they have benefited, but be unaware of the extent of possible benefit. The waste brokers have close business relationships with the final waste receivers, some of whom will be partner companies. The generators do not have this advantage.

If solvent is not recovered on-site and if generators can obtain a credit for their waste, exporting solvent for material recovery may prove to be the least cost alternative. However, if the credit is absent, this will not be the economically preferred alternative.

Conclusions	**17**	**While most companies must pay for material recovery of**

solvent that is traded on, a few obtain credit for the material.

18 Transport costs are a significant portion of waste treatment costs and are a major motivator to achieving treatment in Ireland.

19 If solvent is not recovered on-site and if generators can obtain a credit for their waste, exporting solvent for material recovery may prove to be the least cost alternative. However, if the credit is absent, this will not be the economically preferred alternative.

9.6 Market for solvent waste fuel

Recent years have seen the emergence of blending operations by the two main waste brokers, with a subsequent export of the waste to be used as a fuel, likely in UK cement kilns. Cement companies on the island of Ireland have shown interest in securing this material. Lafarge in Northern Ireland has burned more than 3,000 tonne of waste solvent, and Irish Cement has applied for planning permission (and will seek an IPPC licence review) to burn solvent at their Limerick plant. Lagan Cement is also seeking to burn solvent. The cement industry in Ireland would readily absorb any solvent waste. Irish Cement alone has indicated that they are seeking 50,000 tonnes per annum, representing about 30% of their fuel needs. As has been shown in the earlier chapter, adding in the potential consumption by Quinn and Lagan, it is clear that the solvent waste would have a ready outlet, even with a substantial reduction in the market for cement production. Irish Cement Ltd. has indicated that they would prefer to operate through a waste broker as intermediary, rather than engage in blending and substantial storage themselves. This approach allows them to minimise capital investment and avoid extending into the technical area of fuel blending. It also seems to match the strategic aims of the brokers, who have invested in supplying the fuel chain. A blending capacity of 60,000 – 80,000 tonnes per annum is available in Ireland. One of the blenders has a specific licensed limit on blending capacity, while the other has a limit on the total amount of hazardous waste to be processed on site, with a lower value for blending indicated in the licence application.

In contrast, one large waste solvent generator does not allow its waste to be consigned to incineration in cement kilns. They are concerned about reputational risk, in light of instances of poor cement kiln performance in the UK and adverse publicity.

In addition to cement kilns, the planned merchant incinerators, two of which are promoted by Indaver, one of the waste brokers, would provide a market for fuel. Existing incinerators at the sites of waste generators could also benefit from the use of high calorific solvent waste as a substitute for fossil fuel consumption.

Finally, solvent waste fuel could be used in boilers. One waste solvent generator is currently licensed to burn its own waste in a boiler in accordance with the Waste Incineration Directive specifications, and at considerable economic benefit. They maintain that the viability of their business is dependent on this reuse of waste as fuel. A second generator discussed the possibility of burning their non-halogenated waste solvent with EPA. They decided it would be uneconomic to do so if presented with the requirement for dioxin monitoring – consequent on the interpretation of the Waste Incineration Directive.

There is likely to be further interest in generators burning their own waste, for energy recovery. The stakeholder consultations elicited that some interested parties were unaware this practice is currently licensed – both for the boiler application mentioned above and as a substitute for supplementary fuel in thermal oxidisers.

Describing the combustion of solvent waste as "reuse as fuel" presumes that the environment is adequately protected and either the waste has been declassified as waste, or that the scale of energy recovery is sufficient to warrant considering the solvent waste as fuel. Declassification of waste requires clear guidelines and if the material is still considered waste, its classification as R1 or D10 also requires clarity. Irrespective of the combustion process, "waste" should be subject to the Waste Incineration Directive – but interpreted to reflect the nature of the waste. In spite of all these apparent hurdles, it must be recognised that substituting high calorific solvent waste is preferable to using supplementary fossil fuel from an environmental perspective, presuming the recovery of the waste as reusable solvent is not

economically feasible. If a waste can be shown to be as good as a primary fuel and requires no additional emissions abatement, there is a strong case for its reclassification.

From an economic perspective, if material recovery is not viable, as was shown in the earlier chapter, the use of waste solvent as fuel in Ireland presents the least cost to the generators, costing €36 per tonne, due to the reduced transport cost.

Conclusions	**20**	**There is significant existing demand in Ireland for waste solvent as fuel, from cement kilns, and existing hazardous waste incinerators.**
	21	**There is significant potential demand for waste solvent as fuel, from proposed merchant incinerators.**
	22	**The existing waste brokers are oriented to directing waste solvent to fuel.**
	23	**Some generators are unwilling to provide waste solvent as fuel due to reputational risk.**
	24	**Waste declassification, or classification as R1 or D10, requires clarification.**
	25	**Application of the Waste Incineration Directive should reflect the waste composition.**
	26	**If material recovery is not viable, the use of waste solvent as fuel in Ireland presents the least cost to the generators, due to reduced transport costs.**

9.7 Summary

A significant amount of material recovery is already taking place in Ireland and there is available distillation capacity for more – if companies are willing and allowed to use capacity outside their own sites. Material is currently blended and exported, though there is a local market that could consume all blended fuel. Treating solvent within Ireland would conform to the environmental policy objective of satisfying the proximity principle and would conform to the economic policy of self-sufficiency while reducing costs to the generators. Achieving these goals requires policies and measures that are clear and consistent. Many of the barriers are perceived rather than actual, and the proposed measures are regulatory and informative rather than directly economic. The potential for a new entrant to the solvent distillation business is uncertain. A supplier of solvent recovery plant indicated there is a very short payback time associated with a new distillation plant. Even allowing for exaggeration and the need to provide the associated utilities, building such a plant seems attractive. However, both the feedstock and the end use lie in the pharmaceutical sector. The future nature of the sector in Ireland is uncertain, and there is already surplus distillation capacity. The risk element of such a plant is uncertain, whereas an existing operator can either use its surplus capacity or relatively easily expand its operations.

9.7.1 Summary of Conclusions by type

Trends

Conclusions	**1**	**The pharmachem sector overwhelmingly dominates the waste solvent stream.**
	2	**The quantity of solvent waste arising appears to be decreasing.**
	3	**Chlorinated solvent waste is a small fraction of the total.**

Solvent waste composition issues

Conclusions	**4**	**Solvent wastes may contain selectively soluble materials or intermediate / final pharmaceutical products.**

	5	**Solvent waste may contain a very significant fraction of water, suggesting preconcentration is desirable.**

Data quality issues

Conclusion	**6**	**The reported data is ambiguous and understates the extent of material recovery (R2) in Ireland.**
Conclusion	**7**	**Reporting of incinerated waste as R1 or D10 is ambiguous.**
Conclusion	**8**	**The prolonged use of interim classifications: R12/13; D12/13 is ambiguous.**

Current solvent reuse

Conclusions	**9**	**Most, but not all, recovered solvent is reused in the originating process.**
	10	**A number of barriers: perceived quality issues; limits on tank capacity; pipeline constraints; the shift towards manufacturing sites in Ireland acting as “launch” sites, without prolonged production campaigns; militate against material recovery, R2.**
	11	**Recovery and reuse of solvent achieves self-sufficiency: enhancing security of supply of needed solvent and satisfying the general environmental goal of dealing with waste close to source.**

Distillation capacity

Conclusions	**12**	**There is unused solvent distillation capacity in Ireland.**
	13	**Already, pharma sites have recovered waste for other pharma sites.**
	14	**Investing in a new merchant recovery facility, would be a high-risk venture, while superficially very profitable.**
	15	**There may be niche opportunites for inter-company agreements, or for merchant recovery of high volume solvents besides methanol: propanol, toluene, tetrahydrofuran, ethyl acetate.**

Financial issues

Conclusion	**16**	**The cost of distillation recovery in Ireland appears to be unclear and subject to carrying high overhead burden – yet is likely to bring major savings, possibly as high as €210 - €250 per tonne.**
	17	**While most companies must pay for material recovery of solvent that is traded on, a few obtain credit for the material.**
	18	**Transport costs are a significant portion of waste treatment costs and are a major motivator to achieving treatment in Ireland.**
	19	**If solvent is not recovered on-site and if generators can obtain a credit for their waste, exporting solvent for material recovery may prove to be the least cost alternative. However, if the credit is absent, this will not be the**

		economically preferred alternative.

Fuel use issues

Conclusions	**20**	**There is significant existing demand in Ireland for waste solvent as fuel, from cement kilns, and existing hazardous waste incinerators.**
	21	**There is significant potential demand for waste solvent as fuel, from proposed merchant incinerators.**
	22	**The existing waste brokers are oriented to directing waste solvent to fuel.**
	23	**Some generators are unwilling to provide waste solvent as fuel due to reputational risk.**
	24	**Waste declassification, or classification as R1 or D10, requires clarification.**
	25	**Application of the Waste Incineration Directive should reflect the waste composition.**
	26	**If material recovery is not viable, the use of waste solvent as fuel in Ireland presents the least cost to the generators, due to reduced transport costs.**

10 RECOMMENDATIONS

10.1 Solvent waste arisings

Since the pharmaceutical sector is the dominant originator of solvent waste, the EPA should maintain a continuing dialogue, in addition to its enforcement role, with the individual companies and with the sector. The EPA, in conjunction with the industrial support agencies, should encourage solvent waste reduction, by facilitating the exchange of experience and promoting available state funding mechanisms for process improvements with a view to avoiding waste. While the on-going responsibility for this may lie with the industrial support agencies, the EPA, as promoter of the National Hazardous Waste Management Plan, may be appropriate to initiate such an activity. In addition, it has experience of stimulating specific technological actions in this area under the auspices of the Cleaner Greener Production Programme and of promoting networking activity under the Local Authority Prevention Network (formerly Local Authority Prevention Demonstration Programme). Information sharing benefits companies and regulators alike.

Recommendation	**1**	**A regular (perhaps three occasions per year) information exchange should take place between the pharmachem sector, EPA and industrial support agencies.**
	2	**EPA and the industrial support agencies should promote existing available funding mechanisms for process improvements.**

10.2 Solvent waste composition

Solvent waste streams may need pre-treatment prior to recovery. For example, concentration or removal of salts, APIs or water may be beneficial. Some aqueous streams containing low quantities of organics can be biologically degraded. These changes may require R&D and use of developing technologies, or may only need simple distillation. The optimum methods in each case should be explored. Current R&D and other support measures could help, in this regard. The exchange of information between actors would also be helpful.

Recommendations	**3**	**Preconcentration of waste streams into a higher value fraction and reduced volume difficult waste should be promoted via existing industrial supports for capital investment and research.**
	4	**A generator "solvent recovery forum" should be promoted by EPA or the industrial support agencies to facilitate information exchange on pre-recovery and recovery practices.**

10.3 Data quality

While reporting is an administrative burden, effective and efficient management is impossible without a sound basis for decision making – hence the underlying data must be of high quality.

10.3.1 Understatement of the extent of recovery

Material recovery is a preferred waste management strategy and the achievements of licensees should be recognised – something than can only be possible if the recovery is reported. However, the classification of this solvent throughput as "waste" is indeed severe. There is no intention on the part of the generator to discard the material, instead the aim is to reuse it. Therefore it seems inappropriate to continue to classify on-site recovery as "waste".

Recommendation	**5**	**Clear guidelines should be provided by EPA in quantifying and reporting the quantity of R2 material. (see suggested reporting in Figure 2.2).**

10.3.2 Ambiguity in classification of waste treated in an incinerator as R1 (reuse as fuel) or D10 (destruction)

Recovery of energy should be favoured and avoiding the use of supplementary fuel encouraged. Both reduce the global energy demand and should be considered to be worthwhile - assuming the recovery of the material as solvent for reuse is not economically feasible. The extent of heat recovery necessary to merit the classification of R1 must be elaborated to include efficiency measures and to consider the implications of avoided fuel use.

Blending a stream with a very high calorific value (nearly all solvents) with a stream containing a very high proportion of water may result in a stream with a sufficiently high calorific value to be considered fuel, but this confuses the original classification of the low calorific value stream that might have been assigned D10. Furthermore, its use as a fuel carries the burden of vaporising the water fraction, thereby reducing the available energy content.

Recommendations	**6**	**Clear guidelines should be provided by EPA in relation to the classification of waste treated in incinerators as R1 or D10.**
	7	**Concentrated streams should not be diluted. Clear EPA guidelines should specify this.**
	8	**Weak streams should not be concentrated by blending. This should be specified by clear EPA guidelines.**

10.3.3 Prolonged use of interim classifications: R12/13; D12/13

Substantial quantities of solvent waste are classified under interim categories by the generators. A final fate should be eventually available and reported. Furthermore, there should be a reconciliation between the classification of the initial wastes, which should reflect their suitability for disposal or recovery, and their final fate after blending. This will be conducive to good economic as well as environmental management. The waste generators might be able to identify opportunities for savings in treatment charges if they recognise the final fate of their waste. Unfortunately, this will increase the reporting burden on waste generators, since each Annual Environmental Report may require a modification to the previous year's Report. However, we believe the clarity achieved by reflecting the final fate will benefit both the waste generators and the EPA in their management of solvent waste.

Recommendation	**9**	**Solvent waste management companies should be obliged by EPA to communicate to generators the end fate of solvent classified under interim classifications.**
	10	**Trans-Frontier Shipment (TFS) reporting requirements should be reviewed by the National TFS Office to avoid the use of interim or storage codes (R12/13 or D12/13).**
	11	**Waste classified as R12/13 or D12/13 in their PRTR should be updated by Licensees in the following year's Annual Environmental Report to reflect the final destination and fate of the waste.**

10.4 Material recovery and reuse of solvents (R2)

10.4.1 Reuse of solvent

In spite of barriers, considerable recovery is undertaken. There are real technical barriers, but there are also perceived barriers, which have been overcome by some generators. A sharing of this knowledge would be a low-cost measure to provide recognition for the successes achieved and act as a stimulus to others to seek similar outcomes.

Recommendations	**12**	**A "solvent recovery forum" should be promoted by EPA or the industrial support agencies to facilitate information exchange on best practice on solvent reuse.**

10.4.2 Distillation capacity in Ireland

At first sight, the economics of recovery are favourable, but a new operator would be faced by difficulties in securing a long-term feedstock and without a dependable market in the Irish pharmachem sector, would face a major challenge is selling into export markets. Furthermore, it would compete with existing under-used capacity. Therefore it was concluded that the business case for a new entrant is high risk and the primary scope for increased recovery lies in existing or possibly modified/expanded plant. Existing regulation of "waste" may inhibit reprocessing of material for reuse.

Recommendations	**13**	**EPA should state that it has no objection in principle to the recovery of solvent waste from one company, by another company, and that any licence application to do so will be actively considered, in the context of the current waste hierarchy, national policy and regulation and any site specific factors.**
	14	**A "solvent recovery forum" should be promoted by EPA or the industrial support agencies to facilitate information exchange on recovery capacity.**
	15	**Clear guidelines should be provided by EPA in relation to the determination of End-of-Waste status of processed materials**

10.5 Financial factors

Stakeholder consultation has provided very limited data on recovery costs, but suggested that the cost allocation systems in use are placing undue burdens on the apparent viability of recovery in Irish sites.

Recommendation	**16**	**A "solvent recovery forum" should be promoted by EPA or the industrial support agencies to facilitate information exchange, including a benchmarking of on-site recovery costs.**

Notwithstanding the potential availability of recovery capacity in Ireland, material is exported for recovery. However, costs for some generators appear to be higher than for others, for no obvious financial justification.

Recommendations	**17**	**Treatment within Ireland should continue to be encouraged by EPA or the industrial support agencies.**
	18	**A "solvent recovery forum" should be promoted by EPA or the industrial support agencies to facilitate information exchange, including a benchmarking of off-site recovery/treatment costs.**

10.6 Market for solvent waste fuel

If material recovery is not viable, use of waste solvent as fuel in Ireland presents the least cost to generators. However, this must be done in accordance with regulation. There is potential for environmental and economic benefit, but also for abuse. EPA should provide clear, consistent guidelines on the use of waste solvent as fuel.

Recommendations	**(6)**	**Clear guidelines should be provided by EPA in relation to the classification of waste treated in incinerators as R1 or D10.**
	19	**EPA should state that it has no objection in principle to the the use of waste solvent as fuel in lieu of supplementary fossil fuel where material recovery is not feasible, and that any licence application to do so will be actively considered, in the context of the current waste hierarchy, national policy and regulation and any site specific factors.**
	20	**Where waste is burned as fuel, the WID should be consistently applied by EPA, reflecting the waste composition and likely emissions.**
	21	**EPA should consider facilitating an annual supply chain meeting of brokers and end fuel consumers to link with the "solvent recovery forum" and other generators.**
	22	**A review of the records of waste contractor facilities by EPA may help in determining the nature of the activities being carried out and ensure that dilution as forbidden under BAT is not occurring.**
	23	**EPA should provide a clear definition of "fuel" when derived from waste.**

10.7 Analysis of Recommendations by Type

Information Exchange / education

There are several instances where the barriers associated with "received wisdom" have been overcome. Addressing these does not require significant new knowledge, but rather a sharing of existing. The EPA or the industrial development agencies should facilitate this.

Recommendations	**1**	**A regular (perhaps three occasions per year) information exchange should take place between the pharmachem sector, EPA and industrial support agencies.**
		A generator "solvent recovery forum" should be promoted by EPA or the industrial support agencies to facilitate information exchange
	4	**….. on pre-recovery and recovery practices.**
	12	**……on best practice on solvent reuse.**
	14	**……on recovery capacity.**
	16	**……including a benchmarking of on-site recovery costs.**
	18	**……including a benchmarking of recovery/treatment costs.**
	21	**EPA should consider facilitating an annual supply chain meeting of brokers and end fuel consumers to link with the "solvent recovery forum" and other generators.**

R & D and technologies

Companies should be encouraged to use existing aid support schemes for research and process development, to investigate opportunities to avoid or reduce waste, to introduce new technologies to recover energy from incineration, and to pre-concentrate waste prior to its disposal, on-site or offsite, or its off-site recovery.

Recommendations	**2**	**EPA and the industrial support agencies should promote existing available funding mechanisms for process improvements.**
	3	**Preconcentration of waste streams into a higher value fraction and reduced volume difficult waste should be promoted via existing industrial supports for capital investment and research.**
	17	**Treatment within Ireland should continue to be encouraged by EPA or the industrial support agencies.**

Policy and Guidance

The proposed measures fall within the scope of the EPA, since the EPA regulates the IPPC and waste sectors. Neither an increase in regulation nor a relaxation of regulation is required. Instead, regulatory flexibility, allied with clear statements, is proposed:

Recommendation	**5**	**Clear guidelines should be provided by EPA in quantifying and reporting the quantity of R2 material. (see suggested reporting in Figure 2.2).**
	6	**Clear guidelines should be provided by EPA in relation to the classification of waste treated in incinerators as R1 or D10.**
	13	**EPA should state that it has no objection in principle to the recovery of solvent waste from one company, by another company, and that any licence application to do so will be actively considered, in the context of the current waste hierarchy, national policy and regulation and any site specific factors.**
	15	**Clear guidelines should be provided by EPA in relation to the determination of End-of-Waste status of processed materials**
	19	**EPA should state that it has no objection in principle to the the use of waste solvent as fuel in lieu of supplementary fossil fuel where material recovery is not feasible, and that any licence application to do so will be actively considered, in the context of the current waste hierarchy, national policy and regulation and any site specific factors.**
	20	**Where waste is burned as fuel, the WID should be consistently applied by EPA, reflecting the waste composition and likely emissions.**
	22	**A review of the records of waste contractor facilities by EPA may help in determining the nature of the activities being carried out and ensure that dilution as forbidden under BAT is not occurring.**
	23	**EPA should provide a clear definition of "fuel" when derived from waste.**

Regulation

Recommendations	**7**	**Concentrated streams should not be diluted. Clear EPA guidelines should specify this.**
	8	**Weak streams should not be concentrated by blending. This should be specified by clear EPA guidelines.**
	9	**Solvent waste management companies should be obliged by EPA to communicate to generators the end fate of solvent classified under interim classifications.**
	11	**Waste classified as R12/13 or D12/13 in their PRTR should be updated by Licensees in the following year's Annual Environmental Report to reflect the final destination and fate of the waste.**
	20	**Where waste is burned as fuel, the WID should be consistently applied by EPA, reflecting the waste composition and likely emissions.**
	22	**A review of the records of waste contractor facilities by EPA may help in determining the nature of the activities being carried out and ensure that dilution as forbidden under BAT is not occurring.**

11 ROADMAP FOR DEALING WITH SOLVENT WASTES IN IRELAND

Dealing with solvent wastes within Ireland brings several key benefits:

- Reduced transport reduces costs and safety and environmental risks;
- Indigenous treatment avoids interruption in the waste management chain;
- Recovering solvent for material reuse saves resources, enhances security of supply of needed process materials and may reduce costs;
- Using waste solvent as a substitute for fossil fuel reduces external energy demand;
- Increased local activity consolidates employment and supports the economy.

However much these may be desirable, there are conflicting barriers to their achievement.

Table 11.1 applies the Waste Management Hierarchy, in traditional form and as more recently elaborated, to develop the preferred waste management options – cross-referencing with recommendation number. Clearly, not all recommendations are suitable for this type of classification (e.g. establishment of an information exchange forum, development of guidelines).

Table 11.2 extends the argument by considering the three pillars of sustainable development: Economic, Environmental and Social Considerations, and applying them to solvent waste management.

Finally, *Table 11.3* considers the preferred options:

- On-site material recovery for material reuse
- Off-site (Ireland, another pharma plant) material recovery for reuse
- Off-site (Ireland, existing merchant recovery plant) material recovery for reuse
- Off-site (Abroad, existing merchant recovery plant) material recovery for reuse
- On-site use of waste solvent as fuel in boiler / thermal oxidiser / incinerator
- Off-site (Ireland) use of waste solvent as fuel in cement kilns

and identifies the barriers to their implementation with suggested measures to address these barriers, Where appropriate, the measures are cross-referenced with the recommendations presented in Chapter 10.

Many of the necessary measures will be internal to the waste generators. These can be influenced by the external context, e.g. facilitating information sharing; clear, consistent policy guidelines and regulation from EPA; grant-aid to stimulate technological investigation. These integrate to re-orient perceptions and business direction.

Figure 11.1 is a pictorial representation of the actions needed, and the stakeholders to which they apply. Recommendations from the study are cross-referenced by reference number. While the on-going responsibility for some of these may lie with the industrial support agencies, the EPA, as promoter of the National Hazardous Waste Management Plan, may be appropriate to initiate such activities.

When implemented, these recommendations will achieve the desired benefits.

Table 11.1: Some options for dealing with solvent waste – according to the Waste Management Hierarchy

Traditional Hierarchy	New Hierarchy	Operation / procedure	Comment	Recommendation No.
Elimination / Prevention	Prevention	Downsizing of sector Green Chemistry Aqueous cleaners	These will result in a decrease in solvent imports and solvent waste. It is not possible to predict the impact – but it is likely to be large.	2
Reduction		Reduced number of process steps	As above, but lower impact	2
The overall result of the above will be lower quantities of solvent waste. This will affect the required infrastructure.				
Reuse		Recovery of solvent for reuse in process	This is preferably done in-house. Has a ramification for definition of waste and concept of 'end-of-waste'.	15
	Preparing for re-use	Pre-concentration of waste streams into a higher value fraction and reduced volume difficult waste should be promoted via existing industrial supports for capital investment and research.	New and improved technologies for purification and concentration should be promoted by economic instruments (STRIVE, other grants), altered guidance and regulation.	2, 3,17
Recycling	Recycling	In this context, taken as being recovery off-site.	Recovery by other producing plants, which have spare capacity, may be preferred by producers to recovery by independent operators. There appears to be underused capacity within Ireland which could address current arisings.	3, 13, 14, 16, 18
Treatment	Other recovery, e.g. energy recovery	Treatment within Ireland should be encouraged.	In the first instance, consideration should be given to use as a virgin fuel substitute on-site. This will require a review of regulatory practices – but appears to be consistent with the New Waste Framework Directive. A lower option would be use as a fuel off-site, e.g. in cement kilns.	19, 23
Disposal	Disposal	On-site incineration as a priority over off-site incineration	It should be noted that some separation techniques (in preparation for recovery) could result in an increased load to the wastewater treatment plant.	5

Table 11.2: Application of the three pillars of sustainable development to solvent waste management.

Preferred Option	Operation	End-use/destination	Economic	Environmental	Social
1	Elimination/Reduction	Substitution with water. Green process chemistry.	**+** Lower overall cost (replacing virgin solvent with water or reducing number of process steps)	**+** Cleaner production (material substitution; waste and energy reduction)	**+** Reduced risk from water-based process, solvent transport.
2	On-site recovery	Originating process/any process	**+** Lower overall cost than virgin solvent	**+** Cleaner production	**+** Reduced risk from eliminating waste transport
		Originating cleaning/any cleaning	**+** Lower overall cost than virgin solvent	**+** Cleaner production	**+** Reduced risk from eliminating waste transport
3	Concentration on-site	For recovery off-site	**+** Volume reduction and solvent concentration resulting in transport & recovery cost reduction	**+** reduction in transport emissions greater than on-site energy use in concentration. Proximity principle.	**+** reduction in transport with associated risk reduction of public exposure, on-site employment
		For use as a fuel	**-** may be more costly than sending for recovery	**+** reduction in CO_2 emissions (when replacing fossil fuel)	**-** 'burning waste' may have negative image for cement industry and with the public
4	Recovery off-site	Downcycling (use in paint, as thinners, in inks and adhesives manufacture) in Ireland	**+** reduction in transport (vs. overseas), home employment	**+** Higher up the waste management hierarchy than use as a fuel and incineration	**+** Employment at home. National self-sufficiency.

Preferred Option	Operation	End-use/destination	Economic	Environmental	Social
		Downcycling (use in paint, as thinners, in inks and adhesives manufacture) abroad	**-** costlier than sending for recovery	**+** Higher up the waste management hierarchy than use as a fuel and incineration	**+** Lowering the environmental footprint of secondary products.
		Return to site for re-use (e.g. ring-fencing of acetonitrile) in Ireland	**+** reduction in transport vs. recovery abroad	**+** Reuse	**+** Employment at home. National self-sufficiency.
		Return to site for re-use (e.g. ring-fencing of acetonitrile) from abroad	**+** Lower overall cost than virgin solvent	**+** Reuse	**+** Better public perception than disposal.
5	On-site fuel	Incinerator/thermal oxidizer (with or without heat recovery)	**+** Fossil fuel cost savings	**+** reduction in CO_2 emissions (when replacing fossil fuel)	**+** Reduced risk from eliminating waste transport **-** 'burning waste' may have negative image for company with the public.
		Use in boiler	**+** Fossil fuel cost savings	**+** reduction in CO_2 emissions (when replacing fossil fuel)	**+** Reduced risk from eliminating waste transport **-** 'burning waste' may have negative image for company with the public.

Preferred Option	Operation	End-use/destination	Economic	Environmental	Social
6	Use as fuel off-site	Sales (cement kilns)	**-** recoverable solvent may be lost to the company	**+** reduction in CO_2 emissions (when replacing fossil fuel)	**-** 'burning waste' may have negative image for cement industry and with the public
		Return to site for use as a fuel	**-** recoverable solvent may be lost to the company	**+** reduction in CO_2 emissions (when replacing fossil fuel)	**-** 'burning waste' may have negative image for company with the public. Associate it with incineration.

Table 11.3: Barriers opposing and measures addressing the preferred options

On-site material recovery for material reuse		
Barrier	**Addressing measure**	
Quality concerns about reuse in originating process	Information exchange on practice at other sites; internal review of quality requirements	3 12
Quality concerns about reuse in any other process on site	Information exchange on practice at other sites; internal review of quality requirements segregating solvents from one process to another	3 12
Perception that recovery is not core business		
Lack of reuse requirement due to short production campaigns	Information exchange on practice at other sites; internal review of quality requirements segregating solvents from one process to another	12
Insufficient volume accumulated for economic recovery		
Lack of tank capacity on site for segregated storage		
Inability to segregate waste stream transfers via pipelines		
Cost accounting on site lacks clarity in benefits of recovery or allocates an excessive amount of overheads	Information exchange on practice at other sites; adoption of activity based costing and other environmental management accounting practices	16
Lack of technical capacity in recovery equipment	EPA and the industrial support agencies should continue to promote existing available funding mechanisms for process improvements	2 3
Definition of material as waste and associated reporting requirement; perception of "waste".	Clear guidelines should be provided by EPA in quantifying and reporting the quantity of R2 material.	5
Off-site (Ireland, another pharma plant) material recovery for reuse		
Barrier	**Addressing measure**	
Quality concerns about reuse in originating process	Information exchange on practice at other sites; internal review of quality requirements	3 12 14
Quality concerns about reuse in any other process on site	Information exchange on practice at other sites; internal review of quality requirements segregating solvents from one process to another	3 12 14
Quality concerns about accepting recovered waste from an outside source	Information exchange on practice at other sites; internal review of quality requirements	3 12 14

Off-site (Ireland, another pharma plant) material recovery for reuse …. continued		
Barrier	**Addressing measure**	
Perception that offering a recovery service is not core business		
Lack of reuse requirement due to short production campaigns	Information exchange on practice at other sites; internal review of quality requirements segregating solvents from one process to another	12
Insufficient volume accumulated for economic recovery		
Lack of tank capacity on site for segregated storage	Tanker off-site to recovery unit	
Inability to segregate waste stream transfers via pipelines		
Lack of IPPC licence approval to accept solvent from another site	Licensee to seek approval, followed by EPA assessment	13
Persistent classification of material as "waste" after recovery	EPA policy guidelines on "end of waste" status	15
Transport costs	Pre-concentration of waste streams into a higher value fraction and reduced volume difficult waste should be promoted via existing industrial supports for capital investment and research	2 3 4
Off-site (Ireland, existing merchant recovery plant) material recovery for reuse		
Barrier	**Addressing measure**	
Quality concerns about reuse in originating process	Information exchange on practice at other sites	12 14 18
Quality concerns about reuse in any other process on site	Information exchange on practice at other sites	12 14 18
Quality concerns about capability of existing merchant recovery plant	Assistance, if appropriate, from industrial support agencies	2 3 17
Lack of reuse requirement due to short production campaigns	Niche market opportunity for selected solvents with local market e.g. methanol; or major solvents e.g. propanol, toluene, THF, ethyl acetate	2 3 17
Insufficient volume accumulated for economic recovery		
Lack of tank capacity on site for segregated storage	Tanker off-site to recovery unit	
Inability to segregate waste stream transfers via pipelines		

Off-site (Abroad, existing merchant recovery plant) material recovery for reuse		
Barrier	**Addressing measure**	
Financially viable only if credit obtained for waste solvent	Information exchange on price availability	18 21
On-site use of waste solvent as fuel in boiler / thermal oxidiser / incinerator		
Barrier	**Addressing measure**	
Perceived licensing restriction	Information exchange on practice at other sites	
Ambiguity in classification of waste	Clear guidelines should be provided by EPA in relation to the classification of waste treated in incinerators as R1 or D10; definition of "fuel"	6 23
Expense in conforming with requirements of Waste Incineration Directive, e.g. dioxin monitoring, reduced emission limit values e.g. SO_2	EPA examination of licence, reflecting specific waste composition	19 20
Off-site (Ireland) use of waste solvent as fuel in cement kilns		
Barrier	**Addressing measure**	
Cement kilns not currently licensed in Ireland	EPA licensing of cement kilns, on application	19 20 23
Poor reputation based on experience at some kilns abroad	Robust EPA enforcement	19 20

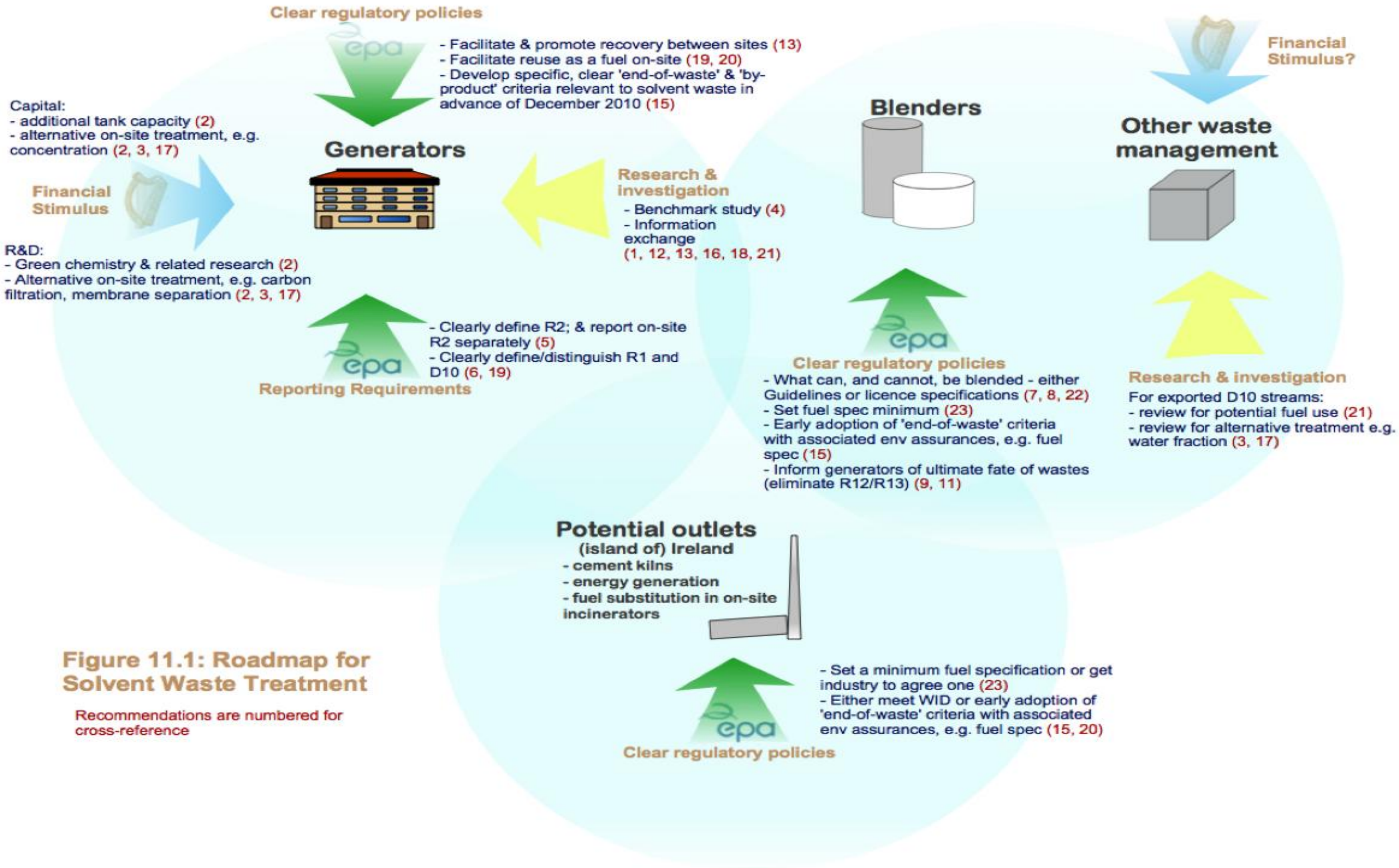


Figure 11.1: Roadmap for solvent waste treatment

APPENDIX I

Table A.1 indicates the top 20 (22 including ethanol) substances in use and their possible non-solvent application. This is clarified graphically in Figure 3.2.

Table A.1: Top 20 (22) Solvents (& reagents) Imported in 2008

Solvent			YEAR Data Jan-Dec 2008	
		CN	€ 000	tonnes
Undenatured ethanol	Beverages	22071000	20,054	20,380
Denatured ethanol		22072000	2,822	1,367
Methanol		29051100	10,333	28,371
Propanol		29051200	15,440	15,053
Acetic anhydride	Reagent, but possibly in excess	29152400	12,696	14,093
Toluene		29023000	9,864	13,998
Propylene glycol	Multiple uses	29053200	9,081	7,066
Octylphenol, nonylphenol	Reagent (ink, adhesives, LIX)	29071300	8,111	6,274
Tetrahydrofuran		29321100	11,344	5,628
Ethyl acetate		29153100	4,756	5,077
Acetone		29141100	3,868	3,791
Dichloromethane		29031200	2,244	2,980
Acyclic ethers and derivatives		29091990	3,056	2,348
Tert-butyl ethyl ether	Petrol additive	29091910	1,192	2,132
Phenol, hydroxybenzene and salts	reagent	29071100	1,310	1,756
Paraformaldehyde	reagent	29126000	1,406	1,534
Propyl/isopropyl acetate		29153910	1,580	1,335
Acetic acid	Multiple uses: reagent, cleaning additive, etc	29152100	969	1,237
Glycerol	Multiple uses, probably not solvent	29054500	2,137	1,218
Cyclohexane		29021100	1,154	1,119
Derivatives of hydrocarbons		29041000	1,665	973
lauryl/cetyl/stearyl alcohol	Solid reagent, surfactant use	29051700	1,243	881
Total Top 20, excluding ethanol			103,449	116,864
% of Total "Solvents"			37.79%	85.18%

Table A.2: Trends in imports of major solvents (& reagents), tonnes

CN	Solvent	2002	2003	2004	2005	2006	2007	2008
29051100	Methanol	34,657	38,197	34,157	32,096	41,562	27,371	28,371
29051200	Propanol	9,818	16,045	17,512	14,262	13,310	15,139	15,053
29023000	Toluene	16,706	16,344	23,516	43,462	16,083	13,668	13,998
29321100	Tetrahydrofuran	3,064	2,621	4,451	4,097	3,927	5,051	5,628
29153100	Ethyl acetate	8,072	9,955	5,490	8,616	6,074	5,821	5,077
29141100	Acetone	6,211	8,340	7,065	5,795	4,548	3,575	3,791
29031200	Dichloromethane	3,056	2,614	3,331	3,565	4,853	3,009	2,980
29091900	Acyclic ethers& derivatives	811	1,546	2,317	2,151	2,477	2,703	4,480
29153910	Propyl/isopropyl acetate	1,508	943	651	595	830	1,084	1,335
29152100	Acetic acid	2,740	3,336	3,804	2,264	1,726	1,334	1,237
29021100	Cyclohexane	802	1,068	1,147	1,041	912	1,474	1,119
29041000	Derivatives of hydrocarbons	942	681	795	324	459	652	973
29152400	Acetic anhydride	23,912	23,771	20,322	19,402	13,221	14,137	14,093
29071300	Octylphenol, nonylphenol	8,137	5,569	7,754	6,884	6,002	5,028	6,274
29053200	Propylene glycol	3,537	4,405	4,617	6,376	5,932	6,508	7,066

In view of concerns about the use of chlorinated solvents, we examined these in some more detail. Very little chlorinated solvents are used. Table A.3 shows the 2008 data which may be taken as indicative.

Table A.3: Tonnes of chlorinated solvents imported in 2008

Solvent	**CN number**	**tonnes**
Dichloromethane	2903 12 00	2980
Tetrachloroethylene "perchloroethylene"	2903 23 00	298
Dichloroethane	2903 15 00	286
Saturated chlorinated derivatives of acyclic hydrocarbons	2903 19 80	171
Unsaturated chlorinated derivatives of acyclic hydrocarbons	2903 29 00	97
Chloromethane "methyl chloride" and chloroethane "ethyl chloride"	2903 11 00	35
Trichloroethylene	2903 22 00	35
Chlorobenzene	2903 61 00	18
1,1,1-Trichloroethane "methylchloroform"	2903 19 10	6
Trichloromethane (chloroform)	2903 13 00	4
TOTAL		3930

Table A.4: Tonnes of halogenated waste arisings from the 90% companies, 2002 – 2008

	2002 (tonnes)	2003 (tonnes)	2004 (tonnes)	2005 (tonnes)	2006 (tonnes)	2007 (tonnes)	2008 (tonnes)
Company A	0	0	0	0	0	3.66	4.04
Company B	ND	ND	ND	ND	11,626.18	11,008.00	2,360.00
Company C	0	212.99	145.60	141.69	221.62	142.94	307.32
Company D	273.27	411.02	948.96	440.38	275.12	39.37	38.02
Company E	4,318.20	5,380.74	1,016.51	1,708.20	17,425.71	3,944.71	693.76
Company F	136.17	163.00	0.43	4.41	698.09	511.44	771.03
Company G	0	34.59	7.40	0.00	126.20	0.00	95.68
Company H	107.81	85.89	102.10	100.80	106.36	107.25	101.32
Company J	0	0	1,419.88	NR	4,970.89	2,501.02	4,200.36
Company L	2,215.51	2,322.76	2,489.29	2,298.53	2,684.27	1,134.90	3,647.19
Company M	0	0	0	0	0	52.00	0
Company N	2,222.72	1,300.20	1,267.82	1,821.13	2,072.48	2,030.01	348.94
Company O	1,278.58	1,931.00	2,286.07	2,601.85	1,990.53	2,151.72	1,804.05
Company P	0	58.06	53.00	423.51	0.00	1.08	2.10
Company Q	225.00	384.30	525.10	514.30	590.90	328.40	230.26
Company R	0.00	541.70	634.85	916.47	890.44	926.23	918.42
Company S	0	0	0	119.44	65.08	21.30	0

ND = Not determined – 07 5 03 and 07 05 04 EWC codes recorded as combined figure

APPENDIX II

RELEVANT EWC CODES

CODE	DESCRIPTION
03 02 01	Non-halogenated organic wood preservatives
03 02 02	Organochlorinated wood preservatives
04 01 03	Degreasing wastes containing solvents without a liquid phase
04 02 14	Wastes from finishing containing organic solvents
07 01 01	Aqueous washing liquids and mother liquors
07 01 03	Organic halogenated solvents, washing liquids and mother liquors
07 01 04	Other organic solvents, washing liquids and mother liquors
07 01 07	Halogenated still bottoms and reaction residues
07 01 08	Other still bottoms and reaction residues
07 02 03	Organic halogenated solvents, washing liquids and mother liquors
07 02 04	Other organic solvents, washing liquids and mother liquors
07 02 07	Halogenated still bottoms and reaction residues
07 02 08	Other still bottoms and reaction residues
07 03 03	Organic halogenated solvents, washing liquids and mother liquors
07 03 04	Other organic solvents, washing liquids and mother liquors
07 03 07	Halogenated still bottoms and reaction residues
07 03 08	Other still bottoms and reaction residues
07 04 03	Organic halogenated solvents, washing liquids and mother liquors
07 04 04	Other organic solvents, washing liquids and mother liquids
07 04 07	Halogenated still bottoms and reaction residues
07 04 08	Other still bottoms and reaction residues
07 05 01	Aqueous washing liquids and mother liquors
07 05 03	Organic halogenated solvents, washing liquids and mother liquors
07 05 04	Other organic solvents, washing liquids and mother liquors
07 05 07	Halogenated still bottoms and reaction residues
07 05 08	Other still bottoms and reaction residues
07 06 07	Halogenated still bottoms and reaction residues
07 06 08	Other sill bottoms and reaction residues
07 07 03	Organic halogenated solvents, washing liquids and mother liquors
07 07 04	Other organic solvents, washing liquids and mother liquors
07 07 07	Halogenated still bottoms and reaction residues
07 07 08	Other still bottoms and reaction residues
08 01 11	Waste paint and varnish containing organic solvents or other dangerous substances
08 01 12	Waste paint and varnish other than those mentioned in 08 01 11
08 01 13	Sludges from paint or varnish containing organic solvents or other dangerous substances

08 01 17	Wastes from paint or varnish removal containing organic solvents or other dangerous substances
08 01 19	Aqueous suspensions containing paint or varnish containing organic solvents or other dangerous substances
08 01 21	Waste paint or varnish remover
08 03 12	Waste ink containing dangerous substances
08 03 14	Ink sludges containing dangerous substances
08 04 09	Waste adhesives and sealants containing organic solvents or other dangerous substances
08 04 11	Adhesive and sealant sludges containing organic solvents or other dangerous substances
08 04 13	Aqueous sludges containing adhesives or sealants containing organic solvents or other dangerous substances
08 04 15	Aqueous liquid waste containing adhesives or sealants containing organic solvents or other dangerous substances
09 01 03	Solvent-based developer solutions
11 01 13	Degreasing wastes containing dangerous substances
14 06 02	Other halogenated solvents and solvent mixtures
14 06 03	Other solvents and solvent mixtures
16 03 05	Organic wastes containing dangerous substances
16 03 06	Organic wastes other than those mentioned in 16 03 05
16 05 08	Discarded organic chemicals consisting of or containing dangerous substances
20 01 13	Solvents
20 01 27	Paint, inks, adhesives and resins containing dangerous substances
20 01 28	Paint, inks, adhesives and resins other than those mentioned in 20 01 27

APPENDIX III

Appendix III(a) ***Detailed wording on certain exemptions for particular wastes***

"For the following hazardous wastes, the specific requirements for hazardous waste in this Directive shall not apply:

(a) combustible liquid wastes including waste oils as defined in Article 1 of Council Directive 75/439/EEC of 16 June 1975 on the disposal of waste oils provided that they meet the following criteria:

(i) the mass content of polychlorinated aromatic hydrocarbons, e.g. polychlorinated biphenyls (PCB) or pentachlorinated phenol (PCP) amounts to concentrations not higher than those set out in the relevant Community legislation;

(ii) these wastes are not rendered hazardous by virtue of containing other constituents listed in Annex II to Directive 91/689/EEC in quantities or in concentrations which are inconsistent with the achievement of the objectives set out in Article 4 of Directive 75/442/EEC;

(iii) the net calorific value amounts to at least 30 MJ per kilogramme,

(b) any combustible liquid wastes which cannot cause, in the flue gas directly resulting from their combustion, emissions other than those from gasoil as defined in Article 1(1) of Directive 93/12/EEC (3) or a higher concentration of emissions than those resulting from the combustion of gasoil as so defined".

Appendix III(b) ***BREF discussion on use of waste as a fuel in cement manufacture***

"Different types of waste materials can replace primary raw materials and/or fossil fuels in cement manufacturing and will contribute to saving natural resources. Basically, characteristics of the clinker burning process itself allow environmental beneficial waste-to-energy and material recycling applications. The essential process characteristics for the use of waste can be summarised as follows:

- *maximum temperatures of approx. 2000 °C (main firing system, flame temperature) in rotary kilns*
- *gas retention times of about 8 seconds at temperatures above 1200 °C in rotary kilns*
- *material temperatures of about 1450 °C in the sintering zone of the rotary kiln*
- *oxidising gas atmosphere in the rotary kiln*
- *gas retention time in the secondary firing system of more than 2 seconds at temperatures of above 850 °C; in the precalciner, the retention times are correspondingly longer and temperatures are higher*
- *solids temperatures of 850 °C in the secondary firing system and/or the calciner*
- *uniform burnout conditions for load fluctuations due to the high temperatures at sufficiently long retention times*

- *destruction of organic pollutants due to the high temperatures at sufficiently long retention times*
- *sorption of gaseous components like HF, HCl, SO_2 on alkaline reactants*
- *high retention capacity for particle-bound heavy metals*
- *short retention times of exhaust gases in the temperature range known to lead to 'de-novo-synthesis' of PCDD/F*
- *complete utilisation of fuel ashes as clinker components and hence, simultaneous material recycling (e.g. also as a component of the raw material) and energy recovery*
- *product specific wastes are not generated due to a complete material utilisation into the clinker matrix; however, some cement plants in Europe dispose of bypass dust*
- *chemical-mineralogical incorporation of non-volatile heavy metals into the clinker matrix"*

Appendix III(c) ***Revised Waste Framework Directive provision in relation to a waste being considered a by-product***

Article 5(1) "A substance or object, resulting from a production process, the primary aim of which is not the production of that item, may be regarded as not being waste referred to in point (1) of Article 3 but as being a by-product only if the following conditions are met:

(a) further use of the substance or object is certain;

(b) the substance or object can be used directly without any further processing other than normal industrial practice;

(c) the substance or object is produced as an integral part of a production process; and

(d) further use is lawful, i.e. the substance or object fulfils all relevant product, environmental and health protection requirements for the specific use and will not lead to overall adverse environmental or human health impacts. "

Appendix III(d) ***Revised Waste Framework Directive provision in relation to end-of-waste criteria***

Article 6(1). "Certain specified waste shall cease to be waste within the meaning of point (1) of Article 3 when it has undergone a recovery, including recycling, operation and complies with specific criteria to be developed in accordance with the following conditions:

(a) the substance or object is commonly used for specific purposes;

(b) a market or demand exists for such a substance or object;

(c) the substance or object fulfils the technical requirements for the specific purposes and meets the existing legislation and standards applicable to products;

(d) the use of the substance or object will not lead to overall adverse environmental or human health impacts.

The criteria shall include limit values for pollutants where necessary and shall take into account any possible adverse environmental effects of the substance or object."

Appendix III(e) ***BREF document on BAT for preparation of waste to be used as fuel***

"For the preparation of waste to be used as fuel, BAT is to:

117. try to have a close relationship with the waste fuel user in order that a proper transfer of the knowledge of the waste fuel composition is carried out (see Section 4.5.1)

118. have a quality assurance system to guarantee the characteristics of the waste fuel produced (see Section 4.5.1)

119. manufacture different type of waste fuels according to the type of user (e.g. cement kilns, different power plants), to the type of furnace (e.g. grate firing, blow feeding) and to the type of waste used to manufacture the waste (e.g. hazardous waste, municipal solid waste) (see Section 4.5.2)

120. when producing waste fuel from hazardous waste, use activated carbon treatment for low contaminated water and thermal treatment for highly polluted water (see Sections 4.5.6 and 4.7). In this context, thermal treatment relates to any thermal treatment in Section 4.7.6 or incineration which is not covered in this document

121. when producing waste fuel from hazardous waste, ensure correct follow-up of the rules concerning electrostatic and flammability hazards for safety reasons (see Sections 4.1.2.7 and 4.1.7)."

Appendix III(f) ***BREF document on blending and mixing***

"Wastes, once produced, should in principle be kept separate from other wastes. The reasons for this are that the re-use/recovery of homogenous streams are generally easier than that for composite streams. Under certain conditions, however, different waste streams can be processed just as well, or sometimes even better if they are composite. In this section, it is explored the different rules that may be applied on whether or not mixing/blending may be allowed and under what conditions this should be carried out.

Purpose

Due to the heterogeneous nature of waste, blending and mixing are required in most waste treatment operations in order to guarantee a homogeneous and stable feedstock of the wastes that will be finally processed. The term 'blending' is used more for mixing liquids than for solids, unless mixing a solid into a liquid. The term 'mixing' is used more for solids and semi solid materials (e.g. pasty material).

Certain types of wastes will require prior mixing or blending before treatment. For example, the concentration of waste constituents can vary considerably because of differences in incoming waste strengths. This is particularly true at most commercial treatment facilities. Mixing can control such variations to a range that will not upset the performance of the subsequent unit treatment processes. ***However, this issue should not be confused with dilution and this is the reason why these treatments are many times prohibited*** *(e.g. hazardous waste and landfill Directives) over a wide range of concentrations. Blending and mixing are processes carried out because it is a technical*

requirement from the WT facility to guarantee a homogeneous and stable feedstock and not techniques to facilitate acceptance of waste.

As is prescribed in the Hazardous Waste Directive 91/689/EEC, mixing and blending operations are not permitted unless this is explicitly established in the licence of a collector or processor.

An exemption from the permit requirement may be applied by the competent authority if establishments or undertakings carry out waste recovery and if competent authorities have established general rules for each type of mixing and blending laying down the types and quantities of waste and the conditions under which the mixing and blending may be applied and if Art 4 of the Waste Framework Directive is taken into account by establishing these general rules for the concerning establishments and undertakings. In this exemption case, registration of the establishments and undertakings is mandatory in order to ensure that the establishments and undertaking comply with the stated general rules. The following basic principles apply for granting such a licence:

• the mixing of wastes must be prevented from leading to a risk to human health and adverse effects on the environment

• mixing must be prevented from leading to any of the wastes to be mixed being treated or processed to a lower quality level than is desirable

• the mixing of wastes must be prevented from leading to environmental damage by the diffuse dispersal of environmentally hazardous substances.

The following elaboration of the basic principles for the mixing of waste applies to both hazardous and non-hazardous waste. Hazardous wastes must be kept separate from one another. Mixing can only be permitted if it will not result in risks to humans and the environment, and if there will be no problems with safety due to the mixing for all types of operations (for example safety risks for workers, neighbours of the plant etc.). Article 2, paragraph 3 of the Hazardous Waste Directive states that such an operation can only take place if a licence has been granted.

Conditions may be attached to a licence, making it possible for the hazardous wastes referred to in the licence to be mixed with other (hazardous) wastes, preparations and other products referred to in the licence. ***Where the primary function of mixing wastes is to achieve dilution of a specific species in order to comply with less stringent regulations, this is prohibited.*** *Within the boundaries of the licence for mixing and blending, the waste treatment manager is responsible for writing and applying operational guidelines on mixing and blending. Firstly, the basic principles for granting a licence are elaborated. Secondly, principles and considerations are given for writing operational guidelines for mixing and blending given these boundaries of a permit."*

This section carries on as follows:

"Process description

The basic principles referred to above in the purpose section (risk prevention, substandard processing and prevention of diffuse dispersal), have, as their main objective, protection of human health and of the environment against harmful influences and promotion of the recovery of wastes within these boundary conditions. For the sake of a high level of protection and effective supervision, these general basic principles need to be translated, in licensing

procedures, into operational criteria on the basis of which it can be clearly determined if the mixing/blending of wastes can be allowed. The following elaboration of the basic principles is prescriptive:

- *the mixing of substances that react strongly with each other (heat, fire, gas formation) or explosive substances (explosion) must be prevented. Mixing must be prevented from giving rise to risks to human health and the environment, both during the mixing operation itself, and during the subsequent treatment process. For licensing purposes, this means that the acceptance and processing policy of licence-holders is drawn up in such a way that, before wastes are combined, it is assessed whether this combination can take place safely. This can be achieved by carrying out compatibility tests before mixing/blending for any purpose for any type of waste*
- *the mixing of wastes must be prevented from leading to a lower level of processing waste than the best possible level of waste management or from leading to the application of non- environmentally sound waste management. This means, for example, that if a recovery operation is the minimum standard of processing a waste stream mixing of such wastes with other wastes in order to bring the mixture to any disposal route shall not be accepted. For instance, the mixing of liquid wastes or clinical wastes with other wastes for the purpose of landfilling is not permitted. Mixing of wastes with POP content above the low POP content (as defined under the Basel and Stockholm Treaties) with another material solely for the purpose of generating a mixture with POP content below the defined low POP content is not allowed because this is not environmentally sound the mixing of wastes must be prevented from leading to the undesired diffuse dispersal of environmentally hazardous substances. The effects of diffuse dispersal are determined by the type and concentrations of environmentally hazardous substances in combination with the processing route to be chosen, the emissions occurring and the quality and purpose of the residual substances released. In combination, it must be assessed what the negative consequences are of processing the environmentally hazardous substances concerned with regard to emissions into the soil, water, air or in residual substances and how these negative consequences compare with the environmental effects of another processing route. This assessment must also take into consideration the cyclical character of future re-use.*

Users

Blending and mixing is typically applied only when quality and analytical values of the waste inputs are under or equal to the values of acceptance in the planned output treatment plant. These operations take place in all waste treatment activities (biological treatment, fuel preparation, contaminated soils, waste oils, etc.), and sometimes are quite specific to each WT activity. Some of these issues are also covered in the individual sections for each WT activity."

Segregation and compatibility testing (section 4.1.5)

Driving force for implementation

Hazardous waste Directive (91/689/EEC) and waste Directive (75/442/EEC) provide the EC legislation framework for the mixing and blending of waste.

Some countries define national rules (e.g. in some countries it is absolutely forbidden to mix slag/bottom ash from different sources).

Mixing and blending rules on an operational level are within the boundaries of the permit and other (legal and voluntary) obligations and are written and applied under the responsibility of the waste treatment operator. They take into account risk and safety approaches in order to:

• avoid accidents, which may cause risks to human health and adverse effects on the environment

• prevent technical and mechanical incidents which can cause damage to installations.

So, blending and mixing rules on an operational level are generally linked with:

• regulations in the permit (non-authorised wastes, obligations to keep wastes separated)

• regulations dedicated to safety

• internal and operational procedures (for example, quality control, ISO 14000 certification)

• pre-acceptance and acceptance procedures

• prescription of compatibility tests (during pre-acceptance and acceptance procedures).

Appendix III (g) Extracts from Irish Licences on blending and mixing

"Mixing and Blending of Wastes

Mixing and blending of waste shall only occur following completion of compatibility and confirmatory tests agreed by the Agency and outlined in Attachment D of the application. These procedures shall ensure:

(a) that the compatibility of any waste to be bulked, blended or otherwise mixed is established prior to such mixing taking place.

(b) as far as possible, the identification of any chemical reaction hazards and potentially abnormal, or unusual situations and put in place procedures for dealing with these matters."

"A full record, which shall be open to inspection by authorised persons of the Agency at all times, shall be kept by the licensee on matters relating to the waste management operations and practices at this site. This record shall be maintained on a monthly basis and shall as a minimum contain details of the following:

i) The tonnages and EWC Code for the waste materials (and raw material as appropriate) imported and/or sent off-site for disposal/recovery.

ii) The method of dealing with the waste (including inter alia waste processing stream assignment), sampling and testing results where applicable, and client's declaration of constituents of waste material.

…

iv) Details of the ultimate disposal/recovery destination facility for the waste and its appropriateness to accept the consigned waste stream, to include its permit/licence details and issuing authority, if required.

v) Written confirmation of the acceptance and disposal/recovery of any hazardous waste consignments sent off-site.

….

viii) Details of any approved waste mixing and details of any testing and analysis of mixed and/or blended waste prior to removal off-site for disposal/recovery.

ix) The results of any waste analyses required under Schedule C: Control & Monitoring, of this licence.

x) The tonnages and EWC Code for the waste materials recovered on-site."

"A record shall be kept of each consignment of wastewater (including inter alia internal tanker washings, scrubber wastewater), and/or contaminated storm water removed from the facility. The record shall include the following: -

a) the name of the carrier;

b) the date and time of removal of wastewater, and/or contaminated storm water from the facility;

c) the volume of wastewater, and/or contaminated storm water, in cubic metres, removed from the facility on each occasion;

d) the name and address of the Waste Water Treatment Plant to which the trade effluent, and/or contaminated storm water was transported; and

e) any incidents or spillages of wastewater, and/or contaminated storm water during its removal or transportation."

"Mixing and Blending of Waste Reports

i) Maintenance of records of all chemical reaction hazard evaluation reports shall be held at the facility for at least three years.

ii) Records shall be maintained of all of mixing and blending and compatibility tests carried out for at least three years."

APPENDIX IV

Solvent Waste Recycling and Treatment Questionnaire

Dear

The Environmental Protection Agency has engaged CTC, in conjunction with EPS Consulting, to examine the economic and technical barriers inhibiting distillation or recycling (as material or energy), or treatment of organic solvent in Ireland. The potential for national reuse, achieving greater self-sufficiency and reducing business risks associated with export will be reviewed as part of the study.

Waste solvent is recognised as a well-managed hazardous waste stream, but the quantities arising are very significant in national terms. The National Hazardous Waste Management Plan seeks to reduce waste arisings, to encourage reuse or recycling and finally to ensure proper disposal. This is to be done in a manner consistent with the need to minimise environmental, social and economic impacts of hazardous waste generation and management and the desire to promote national self-sufficiency.

This study will examine the waste arisings (source, quantity, composition, trends), existing reuse and recovery practice and trends, and the potential to beneficially reuse or recover waste solvent nationally, as a material or energy source, either at the point of origin or off-site in related or different activities. The study will recommend changes, if appropriate, and provide a road-map to achieve these changes. A clear understanding of current practice in relation to solvent waste management, future projections and technical and economic data will be critical to provide a sound basis for recommendations. We aim to identify:

- best practice
- alternative treatment routes for waste solvent in Ireland, e.g. as fuel
- barriers to progress with a view to resolving them
- potential actions that could benefit the sector

We have already gathered and reviewed data publicly available from EPA files. We would appreciate your co-operation in providing us with additional data relevant to this project. We will contact you to arrange either a meeting or a telephone call to further explain our objectives and to assist you in providing the necessary data. The attached document details the information we seek and the associated rationale. If you have any questions please feel free to contact me.

Yours Sincerely,

Eileen O'Leary

Senior consultant

Clean Technology Centre

Email eileen.oleary@ctc-cork.ie

Telephone 021 4344864

Q. 1 Please indicate the 2008 quantities of solvent purchased and recovered on-site. Consider only those solvents used at a quantity of 10 tonnes or greater. Please add any solvents not already listed.

(This identifies the main solvents in use, those recovered, and linked with Q. 3 clarifies the complexity of processing. We recognise there will be variations from one year to the next. Please point these out to us in the interview.)

Solvent	CAS number	Quantity purchased (2008) tonnes	Quantity recovered on-site (2008) tonnes
Acetic acid	64-19-7		
Acetic anhydride	108-24-7		
Acetone, DMK, dimethyl ketone	67-64-1		
Acetonitrile, ACN	75-05-8		
Benzaldehyde	100-52-7		
Benzyl alcohol	100-51-6		
Butanol, n-butanol, butyl alcohol	71-36-3		
Sec-butanol, butan-2-ol	78-92-2		
Butyl acetate	123-86-4		
Butylene glycol	110-63-4		
Chlorobenzene	108-90-7		
Cyclohexane	110-82-7		
Cyclohexanone	108-94-1		
Dichloromethane, DCM, methylene dichloride	75-09-2		
Dimethyl sulfoxide (DMSO)	67-68-5		
Dimethylformamide (DMF)	68-12-2		
Ethanol, ethyl alcohol, EtOH	64-17-5		
Ethyl acetate, EtAc	141-78-6		
Ethyl benzene	100-41-4		
Ethyl ether, diethyl ether, ether	60-29-7		
Ethylene glycol dimethyl ether, DME, Dimethoxyethane	110-71-4		
Ethylene glycol monoethyl ether, 2-Ethoxyethanol, cellosolve	110-80-5		
Formaldehyde	50-00-0		

Solvent	CAS	Quantity purchased (2008) tonnes	Quantity recovered on-site (2008) tonnes
Formic acid	64-18-6		
Heptane	142-82-5		
Hexane	110-54-3		
Isoamyl acetate	123-92-2		
Isobutanol, isobutyl alcohol	78-83-1		
Isobutyl acetate	123-92-2		
Isohexane, 2-Methylpentane	73513-42-5		
Isopropanol, IPA, isopropyl alcohol	67-63-0		
Isopropyl acetate	108-21-4		
Methanol, methyl alcohol	67-56-1		
Methyl acetate	79-20-9		
Methyl cyclohexane	108-87-2		
Methyl ethyl ketone (MEK)	78-93-3		
Methyl formate, methyl methanoate	107-31-3		
Methyl isobutyl ketone (MIBK)	108-10-1		
Methyl tert-butyl ether (MTBE)	1634-04-4		
N-Methylpyrrolidone (NMP)	872-50-4		
Monochlorobenzene	108-90-7		
Pentane	109-66-0		
Pentanol, n-amyl alcohol	71-41-0		
Propanol, propyl alcohol, n-propanol	71-23-8		
Propionaldehyde, propanal	123-38-6		
tert-Amylalcohol, 2-Methyl-2-butanol	75-85-4		
Tetrahydrofuran (THF),	109-99-9		
Toluene, methylbenzene	108-88-3		
Xylene (s)	1330-20-7		
OTHERS PLEASE LIST			

Q. 2 Which of these organic solvents do you use as cleaning solvents?

(Please indicate if you use a mixture and the composition)

Q. 3 Please summarise the number of process steps undertaken on site and number of "products" i.e. intermediate or final products, shipped off-site?

(The aim of this question is to get an understanding of the complexity of processing.

For example: if you produce 6 products, with 5, 5, 4, 7, 8, 6 steps respectively; you have a total of 35 steps.)

Number of process steps undertaken	
Number of "products"	

Q. 4 Please describe your solvent waste storage practices including the extent of waste stream segregation or otherwise. If convenient, use the following table to record the data.

(This questions aims to provide insight into the level of segregation undertaken and constraints imposed by storage. You might segregate waste by major solvent constituent; chlorinated versus non-chlorinated wastes; "high" solvent concentration versus "watery" wastes, etc.)

Waste type / designation	Number of tanks	Total tank volume

Q.5 Please provide 2008 data (preferably as a spreadsheet) on the quantities and **compositions** of waste solvent shipped **off-site** for recovery or disposal.

(This data will already be available on-site to satisfy your IPPC licence. In order to reduce the burden of your processing the data, please provide us with your shipment records – we will analyse the data. While we have obtained totals from AER data, the purpose of this question is to identify the "quality" of waste solvent and the extent to which segregation is already in place.)

Q.6 Cost of solvent waste sent **off-site** (for disposal, use as a fuel, or material recovery). Can you provide the cost per tonne for each type of waste/route. Use several tables as needed.

Can you further break down this cost, e.g. by allocating 100% of the costs across each element, or by ranking the individual elements. For example, you might say that on-site operations, etc., represent 10% of total costs; analysis 5%, etc. If you cannot estimate a percentage, you might suggest that final disposal charges are most significant, followed by transport, etc.

Comment if desired on the availability or otherwise of a detailed cost breakdown.

(This question is critical in determining the cost constituents of current waste disposal)

This table is repeated at the end of the document

Solvent waste type:		
Fate off-site (please tick):	disposal / use as a fuel / material recovery	
Total cost € / tonne (include a range if more appropriate)		
Key Cost breakdown	In-house cost € / tonne	Externally invoiced cost € / tonne
- Pre-treatment - Storage - Analysis - Operations and maintenance - Transport - Brokers' fees - Final disposal/treatment charges - Insurance and emergency response - Other costs (please specify)		

Q. 7 Please describe any existing organic solvent waste minimisation programmes in place, and/ or planned, and successes achieved (supporting data can be appended)?

(The aim of this question is to identify and preferably quantify the past achievements and future projections to reduce solvent waste)

Q. 8 What do you see as the main factors in determining existing waste management practices, i.e. why are you managing your solvent wastes via the current routes?

(The aim is get an insight into the decision process to recover or dispose on-site or offsite)

Q. 9 Have you, in the past, changed your solvent waste management practices or do you currently envisage changing them in the future?

(The aim is to identify trends in waste management)

Q. 10 What technical inhibitions are there to change?
(The aim is to identify barriers that might be addressed as an outcome of this study)

Q. 11 What regulatory inhibitions are there to change?
(The aim is to identify barriers that might be addressed as an outcome of this study).

Q. 12 Any additional information you feel may be relevant to the study?

ON-SITE RECOVERY QUESTIONNAIRE

Q. 1 Do you have any relevant corporate policies on solvent waste recycling, whether local or global (supporting data can be appended)?

(This seeks to identify the trends in your company and if there are specific corporate targets)

Q. 2 Do you recover solvents using manufacturing process vessels and equipment (i.e. in-process as opposed to a "solvent recovery system") and if yes please provide details?

Considering your solvent recovery system:

Q. 3 Please describe your equipment (batch/continuous; dedicated to a single solvent or multipurpose; type (packed column; plate column wiped film evaporator; thin film evaporator); reboiler/ direct steam injection; material limitations; pressure or vacuum capability; etc.).

(This is needed to ascertain the level of complexity of equipment available for recovery operations. Whether the plant is batch or continuous is particularly important)

Q. 4 Do you segregate solvent so that it is returned, after recovery, only to the originating process? Or do you accumulate solvent from different processes prior to recovery?

Please tick: process specific recovery / recovery from multiple processes

Q. 5 For solvents that are recovered, to what specification and from what mixtures?

Solvent	Cleaning or process solvent?	Specification	Source mixture

Q. 6 Do you recover azeotropic mixtures:

Not at all	
By addition of a further component	
By pressure swing distillation	
By pervaporation	
Use of other non-distillation processes, e.g. adsorption on molecular sieve; absorption into glycol; etc., please specify	

Q. 7 Recovery equipment utilisation:

How many single solvent “campaigns” and what is the typical duration in each year?	
What is the overall equipment utilisation?	
What is the capacity of the equipment: kg per hour / day?	

Q.8 Energy requirements: what is the reboiler energy source? Steam / electricity

Q.9 If steam, what is the source and what is the associated unit cost?

Unit cost, € / tonne steam	
Steam source (please tick)	
CHP	waste-fired boiler
gas fired boiler	incinerator waste heat recovery
oil-fired boiler	process heat recovery

Q. 10 If electricity, what is the associated unit cost?

Q. 11 Solvent Recovery Storage

Please describe the available tanks for solvent to be recovered and recovered solvent:

Solvent	Number of tanks x tank volume

Q. 12 For solvents recovered on-site, please elaborate the following information:

Solvent	Specific energy requirement (kg steam / kg solvent) (kWh electricity / kg solvent)	Cost of fresh solvent € / kg solvent

Q. 13 Can you provide the cost of **on-site** solvent recovery per tonne for each type of solvent. Use several tables as needed.

Can you further break down this cost, e.g. by allocating 100% of the costs across each element, or by ranking the individual elements. For example, you might say that energy represents 30% of total costs; capital depreciation 20%; analysis 5%, etc. If you cannot estimate a percentage, you might suggest that capital costs are most significant, followed by maintenance, or whatever.

Comment if desired on the availability or otherwise of a detailed cost breakdown.

(This question is critical in determining the cost constituents of current waste recovery)

Solvent		
Total recovery cost € / tonne		
Cost breakdown	**Cost (€/tonne)**	**Considered as a fixed or variable cost?**
Capital cost allocation (depreciation)		
Operating cost- - Steam - Electricity - Manpower - Consumables - Maintenance - Other		

Q. 14 Have you considered any recovery processes other than distillation? If so, what process and why were they not adopted? If you have adopted an alternative approach, what are the advantages (particularly economic)?

Q. 15 Are there any other advantages to having recovery in-house?

(e.g. avoiding transport, ensuring adequate supply available on site)

Q. 16 What barriers (technical, regulatory, economic) are there to increasing the quantity of solvent waste recovered?

Q. 17 Have you considered concentrating organic solvent waste streams prior to disposal, i.e. not for recovery? If so, what cost advantages has this brought?

Q. 18 Any additional information you feel may be relevant to the study?

COST TABLE (Q6) REPEATED FOR CONVENIENCE. COPY AS MUCH AS REQUIRED.

Solvent waste type:		
Fate off-site (please tick):	disposal / use as a fuel / material recovery	
Total cost € / tonne (include a range if relevant)		
Key Cost breakdown	In-house cost € / tonne	Externally invoiced cost € / tonne
- Pre-treatment - Storage - Analysis - Operations and maintenance - Transport - Brokers' fees - Final disposal/treatment charges - Insurance and emergency response - Other costs (please specify)		

Solvent waste type:		
Fate off-site (please tick):	disposal / use as a fuel / material recovery	
Total cost € / tonne (include a range if relevant)		
Key Cost breakdown	In-house cost € / tonne	Externally invoiced cost € / tonne
- Pre-treatment - Storage - Analysis - Operations and maintenance - Transport - Brokers' fees - Final disposal/treatment charges - Insurance and emergency response - Other costs (please specify)		

Solvent Waste Recycling and Treatment (with on-site incineration) Questionnaire

Dear

The Environmental Protection Agency has engaged CTC, in conjunction with EPS Consulting, to examine the economic and technical barriers inhibiting distillation or recycling (as material or energy), or treatment of organic solvent in Ireland. The potential for national reuse, achieving greater self-sufficiency and reducing business risks associated with export will be reviewed as part of the study.

Waste solvent is recognised as a well-managed hazardous waste stream, but the quantities arising are very significant in national terms. The National Hazardous Waste Management Plan seeks to reduce waste arisings, to encourage reuse or recycling and finally to ensure proper disposal. This is to be done in a manner consistent with the need to minimise environmental, social and economic impacts of hazardous waste generation and management and the desire to promote national self-sufficiency.

This study will examine the waste arisings (source, quantity, composition, trends), existing reuse and recovery practice and trends, and the potential to beneficially reuse or recover waste solvent nationally, as a material or energy source, either at the point of origin or off-site in related or different activities. The study will recommend changes, if appropriate, and provide a road-map to achieve these changes. A clear understanding of current practice in relation to solvent waste management, future projections and technical and economic data will be critical to provide a sound basis for recommendations. We aim to identify:

- best practice
- alternative treatment routes for waste solvent in Ireland, e.g. as fuel
- barriers to progress with a view to resolving them
- potential actions that could benefit the sector

We have already gathered and reviewed data publicly available from EPA files. We would appreciate your co-operation in providing us with additional data relevant to this project. We will contact you to arrange either a meeting or a telephone call to further explain our objectives and to assist you in providing the necessary data. The attached document details the information we seek and the associated rationale. If you have any questions please feel free to contact me.

Yours Sincerely,

Eileen O'Leary

Senior consultant

Clean Technology Centre

Email eileen.oleary@ctc-cork.ie

Telephone 021 4344864

Q. 1 Please indicate the 2008 quantities of solvent purchased and recovered on-site. Consider only those solvents used at a quantity of 10 tonnes or greater. Please add any solvents not already listed.

(This identifies the main solvents in use, those recovered, and linked with Q. 3 clarifies the complexity of processing. We recognise there will be variations from one year to the next. Please point these out to us in the interview.)

Solvent	CAS number	Quantity purchased (2008) tonnes	Quantity recovered on-site (2008) tonnes
Acetic acid	64-19-7		
Acetic anhydride	108-24-7		
Acetone, DMK, dimethyl ketone	67-64-1		
Acetonitrile, ACN	75-05-8		
Benzaldehyde	100-52-7		
Benzyl alcohol	100-51-6		
Butanol, n-butanol, butyl alcohol	71-36-3		
Sec-butanol, butan-2-ol	78-92-2		
Butyl acetate	123-86-4		
Butylene glycol	110-63-4		
Chlorobenzene	108-90-7		
Cyclohexane	110-82-7		
Cyclohexanone	108-94-1		
Dichloromethane, DCM, methylene dichloride	75-09-2		
Dimethyl sulfoxide (DMSO)	67-68-5		
Dimethylformamide (DMF)	68-12-2		
Ethanol, ethyl alcohol, EtOH	64-17-5		
Ethyl acetate, EtAc	141-78-6		
Ethyl benzene	100-41-4		
Ethyl ether, diethyl ether, ether	60-29-7		
Ethylene glycol dimethyl ether, DME, Dimethoxyethane	110-71-4		
Ethylene glycol monoethyl ether, 2-Ethoxyethanol, cellosolve	110-80-5		
Formaldehyde	50-00-0		

Solvent	CAS	Quantity purchased (2008) tonnes	Quantity recovered on-site (2008) tonnes
Formic acid	64-18-6		
Heptane	142-82-5		
Hexane	110-54-3		
Isoamyl acetate	123-92-2		
Isobutanol, isobutyl alcohol	78-83-1		
Isobutyl acetate	123-92-2		
Isohexane, 2-Methylpentane	73513-42-5		
Isopropanol, IPA, isopropyl alcohol	67-63-0		
Isopropyl acetate	108-21-4		
Methanol, methyl alcohol	67-56-1		
Methyl acetate	79-20-9		
Methyl cyclohexane	108-87-2		
Methyl ethyl ketone (MEK)	78-93-3		
Methyl formate, methyl methanoate	107-31-3		
Methyl isobutyl ketone (MIBK)	108-10-1		
Methyl tert-butyl ether (MTBE)	1634-04-4		
N-Methylpyrrolidone (NMP)	872-50-4		
Monochlorobenzene	108-90-7		
Pentane	109-66-0		
Pentanol, n-amyl alcohol	71-41-0		
Propanol, propyl alcohol, n-propanol	71-23-8		
Propionaldehyde, propanal	123-38-6		
tert-Amylalcohol, 2-Methyl-2-butanol	75-85-4		
Tetrahydrofuran (THF),	109-99-9		
Toluene, methylbenzene	108-88-3		
Xylene (s)	1330-20-7		
OTHERS PLEASE LIST			

Q. 2 Which of these organic solvents do you use as cleaning solvents?

(Please indicate if you use a mixture and the composition)

Q. 3 Please summarise the number of process steps undertaken on site and number of "products" i.e. intermediate or final products, shipped off-site?

(The aim of this question is to get an understanding of the complexity of processing.

For example: if you produce 6 products, with 5, 5, 4, 7, 8, 6 steps respectively; you have a total of 35 steps.)

Number of process steps undertaken	
Number of "products"	

Q. 4 Please describe your solvent waste storage practices including the extent of waste stream segregation or otherwise. If convenient, use the following table to record the data.

(This questions aims to provide insight into the level of segregation undertaken and constraints imposed by storage. You might segregate waste by major solvent constituent; chlorinated versus non-chlorinated wastes; "high" solvent concentration versus "watery" wastes, etc.)

Waste type / designation	Number of tanks	Total tank volume

Q.5 Please provide 2008 data (preferably as a spreadsheet) on the quantities and **compositions** of waste solvent shipped **off-site** for recovery or disposal.

(This data will already be available on-site to satisfy your IPPC licence. In order to reduce the burden of your processing the data, please provide us with your shipment records – we will analyse the data. While we have obtained totals from AER data, the purpose of this question is to identify the "quality" of waste solvent and the extent to which segregation is already in place.)

Q.6 Can you provide the cost per tonne of waste **incinerated on-site**.

Cost for on-site incineration € / tonne (include a range if more appropriate)	

Q.7 Cost of solvent waste sent **off-site** (for disposal, use as a fuel, or material recovery). Can you provide the cost per tonne for each type of waste/route. Use several tables as needed.

Can you further break down this cost, e.g. by allocating 100% of the costs across each element, or by ranking the individual elements. For example, you might say that on-site operations, etc., represent 10% of total costs; analysis 5%, etc. If you cannot estimate a percentage, you might suggest that final disposal charges are most significant, followed by transport, etc.

Comment if desired on the availability or otherwise of a detailed cost breakdown.

(This question is critical in determining the cost constituents of current waste disposal)

This table is repeated at the end of the document

Solvent waste type:		
Fate off-site (please tick):	disposal / use as a fuel / material recovery	
Total cost € / tonne (include a range if more appropriate)		
Key Cost breakdown	In-house cost € / tonne	Externally invoiced cost € / tonne
- Pre-treatment - Storage - Analysis - Operations and maintenance - Transport - Brokers' fees - Final disposal/treatment charges - Insurance and emergency response - Other costs (please specify)		

Q. 8 Please describe any existing organic solvent waste minimisation programmes in place, and/ or planned, and successes achieved (supporting data can be appended)?

(The aim of this question is to identify and preferably quantify the past achievements and future projections to reduce solvent waste)

Q. 9 What do you see as the main factors in determining existing waste management practices, i.e. why are you managing your solvent wastes via the current routes?

(The aim is get an insight into the decision process to recover or dispose on-site or offsite)

Q. 10 Have you, in the past, changed your solvent waste management practices or do you currently envisage changing them in the future?

(The aim is to identify trends in waste management)

Q. 11 What technical inhibitions are there to change?

(The aim is to identify barriers that might be addressed as an outcome of this study)

Q. 12 What regulatory inhibitions are there to change?

(The aim is to identify barriers that might be addressed as an outcome of this study).

Q. 13 Any additional information you feel may be relevant to the study?

COST TABLE (Q7) REPEATED FOR CONVENIENCE. COPY AS MUCH AS REQUIRED.

Solvent waste type:		
Fate off-site (please tick):	disposal / use as a fuel / material recovery	
Total cost € / tonne (include a range if relevant)		
Key Cost breakdown	In-house cost € / tonne	Externally invoiced cost € / tonne
- Pre-treatment - Storage - Analysis - Operations and maintenance - Transport - Brokers' fees - Final disposal/treatment charges - Insurance and emergency response - Other costs (please specify)		

Solvent waste type:		
Fate off-site (please tick):	disposal / use as a fuel / material recovery	
Total cost € / tonne (include a range if relevant)		
Key Cost breakdown	In-house cost € / tonne	Externally invoiced cost € / tonne
- Pre-treatment - Storage - Analysis - Operations and maintenance - Transport - Brokers' fees - Final disposal/treatment charges - Insurance and emergency response - Other costs (please specify)		

Solvent Waste Study Questionnaire (for Waste Management Companies)

The Environmental Protection Agency has engaged CTC, in conjunction with EPS Consulting, to examine the economic and technical barriers inhibiting distillation or recycling (as material or energy), or treatment of organic solvent in Ireland. The potential for national reuse, achieving greater self-sufficiency and reducing business risks associated with export will be reviewed as part of the study.

Waste solvent is recognised as a well-managed hazardous waste stream, but the quantities arising are very significant in national terms. The National Hazardous Waste Management Plan seeks to reduce waste arisings, to encourage reuse or recycling and finally to ensure proper disposal. This is to be done in a manner consistent with the need to minimise environmental, social and economic impacts of hazardous waste generation and management and the desire to promote national or all-island self-sufficiency.

This study will examine the waste arisings (source, quantity, composition, trends), existing reuse and recovery practice and trends, and the potential to beneficially reuse or recover waste solvent nationally or all-island, as a material or energy source, either at the point of origin or off-site in related or different activities. The study will recommend changes, if appropriate, and provide a road-map to achieve these changes. A clear understanding of current practice in relation to solvent waste management, future projections and technical and economic data will be critical to provide a sound basis for recommendations. We aim to identify:

- best practice
- alternative treatment routes for waste solvent in Ireland or on the island of Ireland, e.g. as fuel
- barriers to progress with a view to resolving them
- potential actions that could benefit the sector

We have already gathered and reviewed data publicly available from EPA files. We would appreciate your co-operation in providing us with additional data relevant to this project. We will contact you to arrange either a meeting or a telephone call to further explain our objectives and to assist you in providing the necessary data. The attached document details the information we seek and the associated rationale. If you have any questions please feel free to contact me.

Yours Sincerely,

Eileen O'Leary

Senior consultant

Clean Technology Centre

Email eileen.oleary@ctc-cork.ie

Telephone 021 4344864

Use as a Fuel within Ireland

Q.1 What do you see as the likely market for solvent waste as a fuel within Ireland - by sector / application / amounts / scale of market?

Q2. What barriers do you see to the acceptance of solvent waste as a fuel in Ireland? How could these be overcome?

Q3. What factors have influenced the acceptability of your fuel product abroad?

Q4. Methanol is a major solvent purchase in Ireland. Have you considered markets for its use in biodiesel production (here or abroad)?

Q5. Are there any other secondary markets?

Criteria for Use as a fuel

Q6. What are the current criteria used for the following:

	Criteria (e.g. calorific value (CV) range, max. halogenated content, max. water content, max. metals content, max. particulates content, any other constraints/ requirements)
Solvent waste that can be input to blending facility	
Blended fuel product	
Solvent waste that is directly exported for use as a fuel	

Q7. Can you list the reasons why some waste solvent is not acceptable as fuel and indicate which are the more common reasons? (e.g. too high water content, too high halogen content, too low calorific value, too high salts content, etc.)

General Trends

Q8. What changes do you expect in the market (either supply of waste or outlets for waste) in the next 5 years.

(supply of waste - e.g. quantities; suitability for recovery/reuse.
outlets for waste - e.g. location, type of facility, reliability/availability, preference for selected solvents or waste streams, etc.)

Q9. What is the sense about the security / reliability of existing waste outlets for Ireland?

Current Operation

Q10. What is current storage capacity (volume) for waste solvent and blended product?

Typical Range of Charges

Q11. While it is acknowledged that the following will be highly variable (with time, quantities, frequencies, water content, contaminants, solvent type, destination, etc.), can you provide an indicative range of charges for each of the following routes:

Route	**Range of charges (€ per tonne)**
Use of solvent waste as a fuel (R1)	Approx € to €
Material recovery of solvent waste (R2)	Approx € to €
Incineration of solvent-containing waste (D10)	Approx € to €

Q12. While it is acknowledged that the following will be variable, can you provide an indicative distribution of costs across the following categories:

Category	Transport	Storage	Disposal / recovery operation	Other
Approx split	%	%	%	%

EPA Study on Solvent Waste Recycling and Treatment

QUESTIONNAIRE FOR CEMENT COMPANIES

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Waste solvent is recognised as a well-managed hazardous waste stream, but the quantities arising are very significant in national terms. The National Hazardous Waste Management Plan seeks to reduce waste arisings, to encourage reuse or recycling and finally to ensure proper disposal. This is to be done in a manner consistent with the need to minimise environmental, social and economic impacts of hazardous waste generation and management and the desire to promote national self-sufficiency.

This study is to examine the waste arisings (source, quantity, composition, trends), existing reuse and recovery practice and trends, and the potential to beneficially reuse or recover waste solvent nationally or within the island of Ireland, as a material or energy source, either at the point of origin or off-site in related or different activities. The study will recommend changes, if appropriate, and provide a road-map to achieve these changes. A clear understanding of current practice in relation to solvent waste management, future projections and technical and economic data will be critical to provide a sound basis for recommendations. We aim to identify:

- best practice
- alternative treatment routes for waste solvent in Ireland, e.g. as fuel
- barriers to progress with a view to resolving them
- potential actions that could benefit the sector

We are consulting with solvent waste generators, waste management companies and potential users within Ireland as part of this study.

Cement Kilns

Q1. What are the current fuel(s) used?

Fuel	**Yes?**	**Cost/tonne**	**Approx Usage as a % of all fuels use (%)**
Coal			
Pet coke			
Fuel oil			
Meat & bone meal			
Wood & timber residues			
Solid recovered fuel			
Tyre derived fuel			
Agricultural residues (energy crops, etc.)			
Tallow			

Q2. Has the use of organic solvent waste as a fuel ever been considered by the site? (if considered and rejected, say reasons why its use was rejected)

Q3. If you are currently considering the use of organic solvent waste, what are the potential advantages and barriers?

Q4. What would be the technical specifications in relation to such solvent waste as a fuel?

	State specification, if any
Min. calorific value	
Max. halogenated content	
Max. particulates content	
Max. water content	
Max heavy metals content	
Others?	

Q5. What quantity of organic solvent waste would be anticipated to be used as a fuel per annum? or alternatively, what ratio of fuel would be accounted for by solvent waste?

Q6 What is the anticipated cost of solvent waste per tonne?

Q7. What benefits would using organic solvent waste as fuel bring to the site ?

Q8. What modifications to plant or practice would be required in order to use organic solvent waste as fuel?