Material Flow Accounts (MFA) – Demonstration for Ireland
2001-EEO/DS-(1/1)

FINAL REPORT

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GLOSSARY OF TERMS

For precise definitions of the mass balance terms in this report please refer to Section 3.6 (Identification of indicators).

DMC	Domestic Material Consumption
DMI	Direct Material Input
DMO	Direct Material Output
DPO	Domestic Processed Output
GDP	Gross Domestic Product
GHG	Greenhouse Gas
MFA	Material Flow Accounts / Accounting
NAS	Net Addition to Stocks
NPV	Net Production Value
PIOT	Physical Input Output Table
PTB	Physical Trade Balance
RME	Raw Material Equivalent
SNA	System of National Accounts
TDO	Total Domestic Output
TMC	Total Material Consumption
TMI	Total Material Input
TMO	Total Material Output
TMR	Total Material Requirement
WRI	World Resources Institute

EXECUTIVE SUMMARY

INTRODUCTION AND BACKGROUND

Currently, countries measure their economic growth and performance through the System of National Accounts (SNA). These financial accounts measure the total economic transactions in an economy. Indicators such as Gross Domestic Product (GDP) provide information on whether national income is growing or declining. There is no equivalent system for measuring the physical “transactions” in an economy. Policy and other decision makers have very little idea of the material requirements of modern economies and few indicators of where, or when, physical constraints are likely to be reached.

One set of tools that can be used is material flow accounting (MFA) - accounting for the physical flow of materials through our economy and society.

Material flow accounts (MFAs) are:

> **accounts in physical units** (usually in tonnes),
> **of the extraction, import, production, export, consumption, recycling and disposal of specific materials** (e.g. water, fossil fuel, minerals, products, etc,)
> **within a defined area** (e.g. a country or region).

It has been recommended by the World Resources Institute that Governments set up a set of national accounts in physical terms using material flow accounting that run parallel to the Sytem of National Accounts.

Many countries have produced material flow accounts for different substances and regions, and use them as indicators for policy making. To date, Ireland has not produced such national or regional accounts. This project represents a first attempt at generating material flow accounts for Ireland.

Ireland has undertaken a commitment to sustainable development. Appropriate monitoring tools are necessary in order to:

– Measure progress towards sustainable development.
– Make/review policies and decisions toward sustainability.

Material flow accounting is a suitable monitoring tool that can be utilised.

OBJECTIVES OF THE STUDY

The long term aim should be to develop national physical accounts for all major material flows in Ireland. This desk study serves as a first step in identifying available methodologies, demonstrating material flow accounts in an Irish situation, establishing the capability to produce flow accounts within Ireland, and identifying major data gaps for the future production of such accounts.

The main objectives of the study are:

- Review existing methodologies for material flow accounts (MFA) and select/tailor the methodology for Ireland
- Demonstrate the methodology for two pilot cases:

  - national fossil fuel flow accounts, together with derived indicators, and
  - water flow accounts for a region
- Identify data gaps for a complete set of national material flow accounts
- Evaluate the applicability of MFA in Ireland and any policy implications.

Although not part of the original specification, this report also attempts a first quantification of Total Material Flows in Ireland. This can be regarded as an extension of the data gap analysis.

REVIEW OF EXISTING MATERIAL FLOW ACCOUNTING METHODOLOGIES

The review was carried out in two parts, viz.

(i) Examination of selected European MFA methodologies

(ii) Examination of existing MFA software

European Methodologies

In total, eight methodologies were reviewed. These were on a European level and also at country specific levels. At the European level the following were examined:

- the Eurostat methodological guide for economy wide material flows
- the EU Total Material Requirement Study carried out by the European Environment Agency.

The methodologies used by the following countries were examined:

- Germany
- Austria
- the Netherlands
- United Kingdom
- Sweden
- Finland.

For national accounts of any physical flows in Ireland, a methodology based on the Eurostat methodological guide should be used. This will allow for comparability on a European level. For accounts other than those on a national level, e.g. regional or company level accounts, there is more flexibility in the type of methodology that can be used. Some of the graphical tools utilised by other countries, such as Sankey diagrams, can be useful for illustration and interpretation of the accounts.

Software Review

Nine suites of software were identified and examined. Where demonstration versions were available, these were obtained and tested.

The types of software packages that have been reviewed can be broken down into two main categories:

- Those that perform calculations ***and*** illustrate results.
- Those that illustrate results only.

The calculation/illustration software packages are less suitable for national and regional flow accounts and more suitable to company level material flows. They go into a level of calculation and detail that is not necessary/applicable for national or regional material flow accounting.

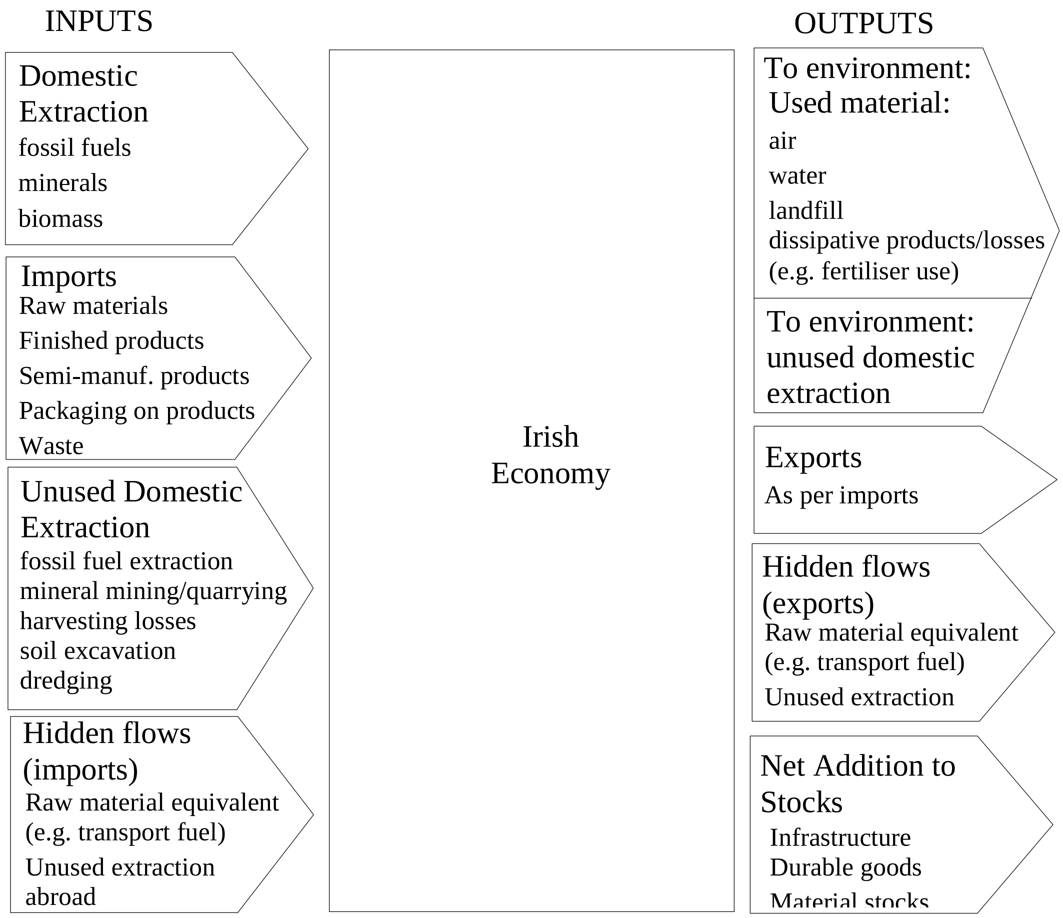
Illustration only packages can be useful to illustrate the results of material flow accounting while the actual MFA data is stored in a package such as Microsoft Excel. This has been borne out by the fact MFAs for a number of other countries are compiled in Excel. One such package was chosen for the illustration of the Irish methodology.

DRAFT IRISH METHODOLOGY FOR THE GENERATION OF MATERIAL FLOW ACCOUNTS

A draft methodology has been developed and recommended to be employed for conducting material flow accounts and balances for Ireland ***for all materials***. This methodology is later demonstrated in the fossil fuels case study (section 4). The methodology is based on the Eurostat guidelines. For the river basin case study (section 5), a modification of the method is used, since several terms and aspects of the methodology do not apply on a local (i.e. non national) level.

The main aspects of the recommended methodology are:

MFA Inputs and Outputs. These are divided into the following components, which are subsequently sun-divided, as follows:



Each of the terms is described and explained.

Data Sources for Irish MFA. These are presented in diagrammatic form.

Identification of Indicators. A list of indicators and their relationships is presented. The main indicators are:

- Input Indicators
  - DMI (Direct Material Input) = domestic extraction + imports
  - TMI (Total Material Input) = DMI + unused domestic extraction
  - TMR (Total Material Requirement) = TMI + hidden flows (imports)
- Output Indicators
  - DPO (Domestic Processed Output) = used material emitted to the environment
  - TDO (Total Domestic Output) = DPO + unused extraction
  - DMO (Direct Material Output) = DPO + exports
  - TMO (Total Material Output) = TDO + exports
- Consumption Indicators
  - DMC (Domestic Material Consumption) = DMI - exports
  - TMC (Total Material Consumption) = TMR - exports - hidden flows (exports)
  - PTB (Physical Trade Balance) = imports – exports
  - NAS (Net Additions to Stock).

DEMONSTRATION OF METHODOLOGY: CASE STUDY – NATIONAL FOSSIL FUEL FLOW ACCOUNTS

The first of two case studies involved the demonstration of the material flow accounting methodology and generation of material flow accounts and associated indicators for fossil fuels used in Ireland.

The outcome of this task is a set of physical accounts for fossil fuels used in Ireland for the years 2000, 1996, and 1990. It covers fossil fuel inputs, uses in various sectors, and associated emissions. Input, output and consumption indicators have also been calculated. The results have been sumarised in a set of Excel files. The Irish Indicators have been compared with those of other countries. These comparisons are summarized as follows.

Irish DMI and DMC - Country Comparison

The following table illustrates the results of the fossil fuel case study and compares it with certain indicators recently compiled for each of the Member States based on European and international statistics (Jan 2003).

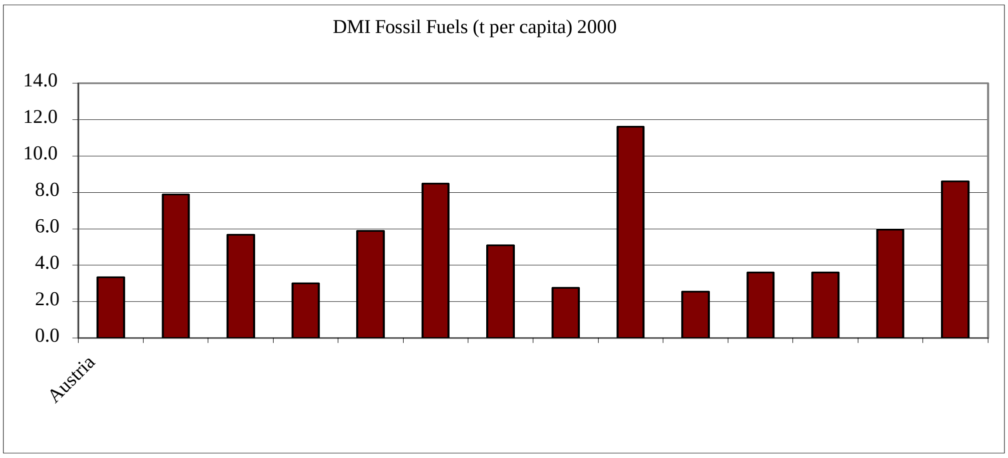
	As calculated in this project			ETC-WMF calculation[1]		
	2000	*1996*	*1990*	*2000*	*1996*	*1990*
Irish Fossil Fuel extraction ('000 t)	5,385	7,629	8,324	6,107	7,230	8,456
Irish Fossil Fuel imports ('000 t)	13,967	10,841	9,025	12,478	9,639	8,595
Irish Fossil Fuel DMI ('000 t)	19,352	18,471	17,349	18,585	16,869	17,051
Irish Fossil Fuel DMI (tonnes per capita)	5.1	5.1	4.9	4.9	4.6	4.9
Irish Fossil Fuel DMC ('000 t)	18,159	17,565	16,742	16,734	15,275	15,863
Irish Fossil Fuel DMC (tonnes per capita)	4.8	4.8	4.7	4.4	4.2	4.5

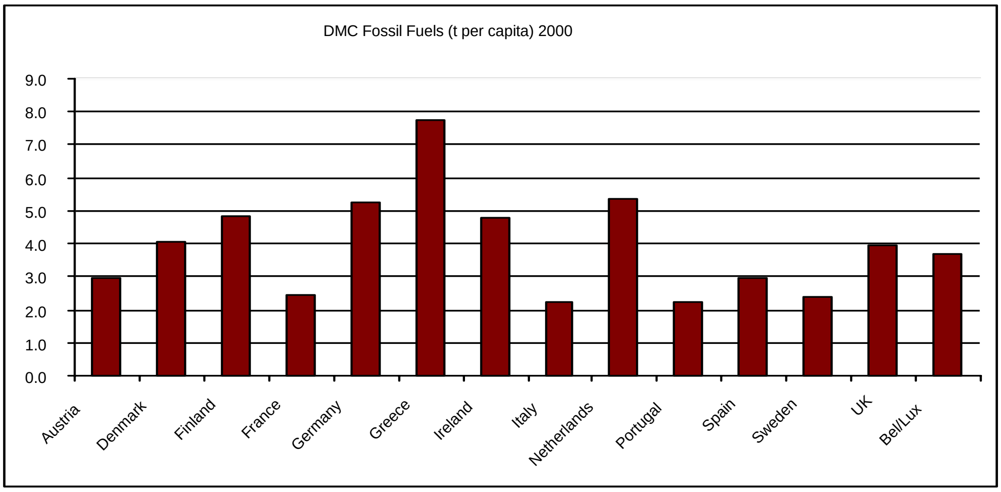
Ireland is above the EU average for DMI. This means the per capita input of fossil fuels from imports and domestic extraction into Ireland's economy is somewhat higher than the EU average.

Ireland is well below the EU average for TMI and TMR for fossil fuels. This means that, taking the unused extraction associated with domestic and imported fossil fuels into account, as well as the fossil fuel input into the economy, Ireland is well below the EU average. This implies that the unused extraction associated with Ireland's domestic extraction and imports is low in comparison with other Member States. While a detailed breakdown on the sources of the EU figures is not available, one reason for this significant difference is likely to be the limited amount of domestic extraction of fossil fuels which occurs in Ireland, which is virtually all used in the Irish economy. Conversely, some EU Member States would have significant fossil fuel domestic extraction, which would increase both the TMI and TMR figures, because these indicators do not subtract exports, or hidden flows associated with exports.

Ireland's position relative to other EU countries in terms of DMI, Direct Material Input (domestic extraction plus imports) and DMC, Domestic Material Consumption (domestic extraction plus imports minus exports) is illustrated below.

[1] Input from the European Topic Centre on Waste and Material Flows (ETC-WMF) into the Kiev report - Moll 2003 Datasheet http://waste.eionet.eu.int/mf/4.





As can be seen, Ireland is joint fifth highest out of all EU countries in terms of DMC. This means Ireland has the fifth highest fossil fuel consumption per capita in the EU**.**

DEMONSTRATION OF METHODOLOGY: CASE STUDY – REGIONAL WATER FLOW ACCOUNTS

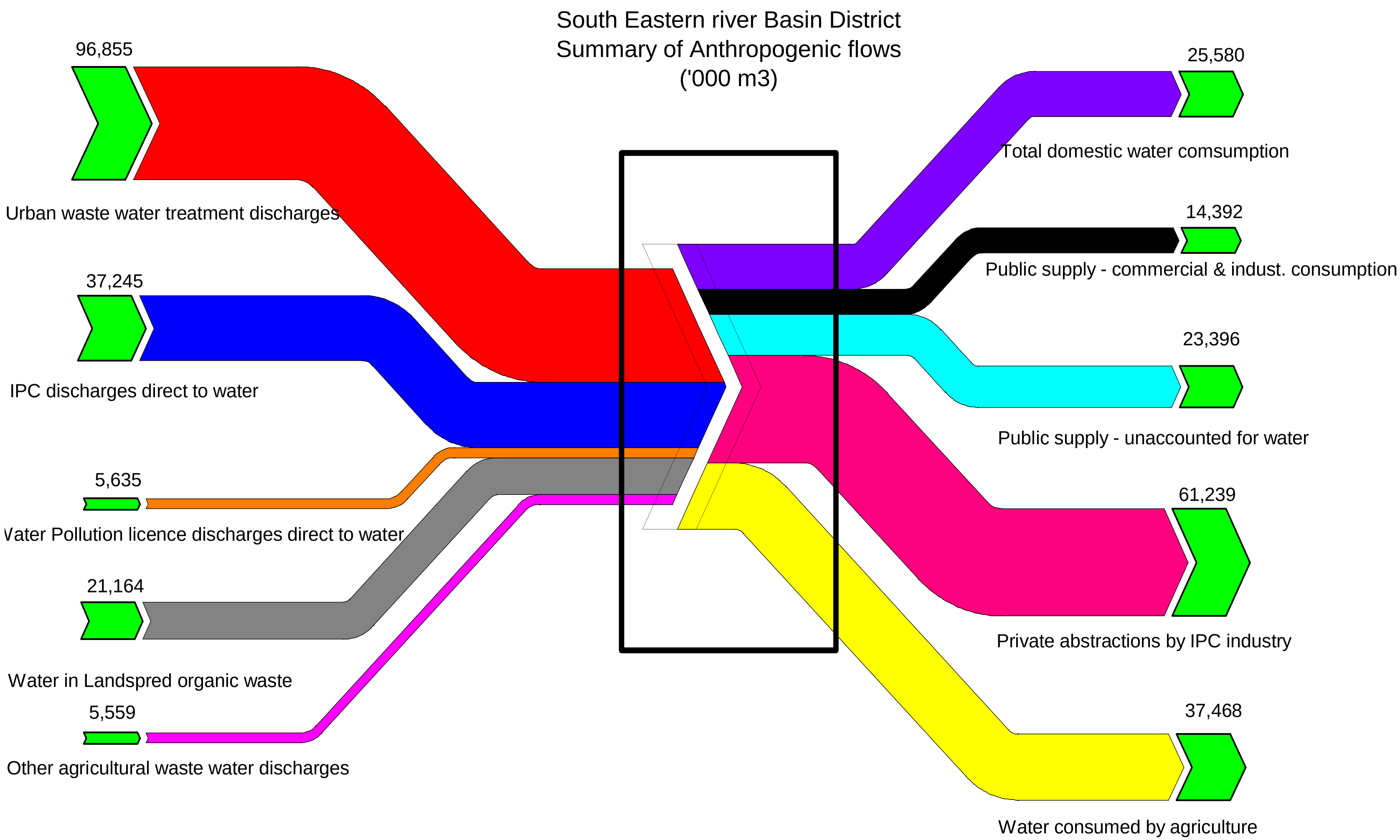
The second of two case studies involved the demonstration of the material flow accounting methodology and generation of water flow accounts for a particular region within Ireland.

Ireland has been divided into five river basin districts for the implementation of the Water Framework Directive. The South Eastern River Basin District (SERBD) is the region that is furthermost along in implementation of the Directive since it was the first SERBD project launched. Hence this is the river basin district chosen for demonstration of water flow accounts.

The South Eastern River Basin District covers the combined river basins of the rivers Slaney, Barrow, Nore and Suir, as well as a number of other smaller rivers near the coast. Counties Carlow, Kilkenny, Laois, Tipperary South, and Wexford are included in this river basin district (RBD) as well as parts of Kildare, Offaly, Tipperary North, Waterford, Wicklow and a very small part of Limerick.

All water flows into and out of the river basin district are taken into account in drawing up the water flow accounts. This includes both natural and anthropological flows of water. The boundary for the water flow accounts consists of the geographical area of the river basin district (RBD) as well as flows into and out of water bodies within the RBD itself. A schematic of the RBD and associated flows is shown below:

Where data was available, each of these flows was determined and the overall MFA presented in the form of a Sankey diagrams. A summary Sankey diagram is shown overleaf. A more detailed Sankey diagram can be seen in section 5.


South Eastern river Basin District
Summary of Anthropogenic flows
('000 m3)
96,855
Urban waste water treatment discharges
37,245
IPC discharges direct to water
5,635
Vater Pollution licence discharges direct to water
21,164
Water in Landspred organic waste
5,559
Other agricultural waste water discharges
25,580
Total domestic water comsumption
14,392
Public supply - commercial & indust. consumption
23,396
Public supply - unaccounted for water
61,239
Private abstractions by IPC industry
37,468
Water consumed by agriculture

TOTAL MATERIAL FLOWS IN IRELAND

The data sources available for calculating flows of all materials in Ireland have been assessed and an initial estimate of such flows made - where data availability permits.

In addition to data gaps and data reliability, comments are made in relation to any differences between national sources of data and data that has been used in Eurostat estimates of material flows and indicators for Ireland, for example, data from FAO (Food and Agricultural Organisation of the UN).

Data sources, data gaps & data reliability have been examined for the following areas of the Irish material flow scenario:

- Domestic Extraction
  - Agricultural biomass
  - Biomass from fishing
  - Biomass from forestry
  - Fossil fuels
  - Minerals
- Imports and Exports (bar fossil fuels which are covered in section 4)
- Unused Domestic Extraction
  - Harvesting losses
  - Fossil fuels
  - Minerals
- Material Outputs to the Environment
  - Landfill
  - Air
  - Water
  - Dissipative Use of Products

A preliminary estimate of Total Material Flows in Ireland for the year 2000 is as follows:

2000					
Inputs			**Outputs**		
	000 tonnes	**000 tonnes**		**000 tonnes**	**000 tonnes**
Domestic extraction		**107,419**	**To Environment - Used Material**		**119,494**
biomass	64,293		Air	47,059	
Fossil Fuels	5,385		Landfill	8,278	
Minerals	37,741		Water	-	
Imports		**44,487**	Dissipative product use	64,158	
Fossil Fuels	13,967		Dissipative losses	NE	
All other materials/products	30,452		**To env.- unused domestic extraction**		**11,699**
waste	68		Fossil fuel extraction	1,237	
Unused Domestic extraction		**11,699**	Mineral mining/quarrying	NE	
Fossil fuel extraction	1,237		Harvesting losses	10,462	
Mineral mining/quarrying	NE		Soil excavation	NE	
Harvesting losses	10,462		Dredging	NE	
Soil excavation	NE		**Exports**		**13,686**
Dredging	NE		All other materials/products	11,986	
Hidden Flows (Imports)		**NE**	Fossil Fuels	1,193	
biomass	NE		waste	508	
Fossil Fuels	8,715		**Hidden flows (exports)**		**NE**
Minerals	NE		biomass	NE	
Items for Balancing		**29,992**	Fossil Fuels	211	
Oxygen for combustion	29,992		Minerals	NE	
			Net Addition to Stocks (NAS)		**NE**
			Infrastructure	NE	
			Durable goods	NE	
			Material stocks	65	

Based on these flows, preliminary estimates of certain indicators for the same year have been made. These are shown below:

Indicators			**10^6 tonne 2000**	**tonne / capita 2000**
DMI	(Direct Material Input)	Domestic extraction + imports	151,906	39.0
DMC	(Domestic Material Consumption)	DMI - exports	138,220	35.5
PTB	(Physical Trade Balance)	Imports - exports	30,800	7.9
DPO	(Domestic Processed Output)	Used material flows to the Environment	119,494	30.7
DMO	(Direct Material Output)	Used material flows to the Environment + Exports	133,181	34.2

When compared to other countries, the Irish estimates of DMI and DMC are at the upper end. This shows Ireland has a stronger connection between material resource use and economic activity than other EU countries. However not all of the estimates for the other countries include the same extent of products as have been included in the Irish figure in this study (see discussion in Section 6.7.3). DMI is an illustration of the weight of actual material that goes into the Irish economy. It includes material that will be consumed within Ireland, as well as other materials that will go into products and ultimately be exported. Whereas DMC is an illustration of the weight of actual material that is consumed within Ireland. Reducing the values of DMI ad DMC while maintaining or increasing fiscal activity, is to move in the direction of sustainability.

EVALUATION AND RECOMMENDATIONS

The whole concept of Material Flow Accounts is embedded in the principles of measurement and reporting. A concerted effort should be made to improve the quality of data, and to enhance its transparency. The continuing evaluation and improvement of data must work in conjunction with performance improvement measures (prevention, recycling, etc.).

MFA provides a basis for policy decisions, and for the framing of environmental improvement programmes. Economic policies are set with regard to economic indicators (GDP, GNP, etc.). The monetary flow through society has been much analysed. In a similar manner, the economic policies of the future must be based on evaluation of the material and energy flows.

It is essential to decouple economic and material intensity. To do this requires an ongoing and accurate evaluation of material and energy flows.

Conclusions Regarding MFA Applicability in Ireland

The following conclusions can be drawn in relation to the applicability of material flow accounting in Ireland:

- national total material flows are a key input into international and, in particular, European reporting protocols (for example the Kiev Report). Many countries have been engaged in such accounting for several years. Ireland needs to develop a well defined set of MFAs to meet reporting requirements.
- in addition to national total material flows for Ireland there are a number of areas, where the methodology could be applied, including
    - Specific stream accounts (packaging, wastes, plastics, WEEE, etc,). This should be based on prioritisation of important streams.
    - Sector specific MFAs – preferably by NACE sector. This should be accompanied by prioritisation of important sectors.
    - Regional MFAs. In particular, some pilot studies should be carried out to determine the typical 'ecological footprint' of different types of region (urban – small and large, rural, semi-rural).
    - Waste management facilities.
    - Industrial sites (voluntary exemplars could be used for a base-line study – wherein material and energy balances, normally presented under IPPC licensing reporting requirements could be evaluated in a different way).

The overall aim (in a medium – 5-10 year scenario) should be to present a hierarchy of data. This would feed from

- Overall national accounts for specific streams
- Regional accounts
- Sector specific accounts

- Site-specific accounts
- Waste and energy management

All of the above could feed into the various reporting requirements (international protocols, European requirements, national reporting requirements, such as the State of the Environment Report, the National Waste Database, etc.)

Recommendations for Future Data Sourcing

The following is a list of recommendations in relation to future data sourcing for total material flows for the Irish economy:

- There are a number of data gaps in relation to material flows in Ireland, in particular some of the domestic extraction data. Some of the initial estimates in chapter 6 should be refined through contact with the industries involved. It should be noted that other countries have also experienced similar problems in obtaining data.
- In relation to hidden flows, national MFAs carried out elsewhere in the main tend to use international factors. It may be more appropriate to generate specific factors for the Irish situation for some of the major flows.
- The concept of ***confidential information*** constitutes a barrier to information gathering. Whilst it is recognised that financial confidentiality has a role to play in a competitive market, it should be possible for government and state organizations to provide information which will simultaneously give statistical data and protect economic interest.

Implications for Irish Policies

Implications for Irish policies include the following:

- the use of the Sankey illustration tool could be applicable for presenting a wide range of environmental data.
- policy decisions and planning can be based on an accurate representation of environmental flows (see above for the link between GDP and MFA, etc.).
- the formulation of future research programmes can be linked to information provision. It is possible to envisage a national development programme, which evaluates economic, environmental, and social parameters in a similar manner, and which uses the results of all three to produce cogent policies and programmes consistent with the three pillars of Sustainable Development. MFA is an important tool in this regard.

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1 INTRODUCTION

1.1 Introduction and Definition

Material flow accounts (MFAs) are:

accounts in physical units (usually in tonnes),
of the extraction, import, production, export, consumption, recycling, and disposal of specific materials (e.g. water, fossil fuel, minerals, products, etc,)
within a defined area (e.g. a country or region).

Currently, countries measure their economic growth and performance through the System of National Accounts (SNA). These financial accounts measure the total economic transactions in an economy. Indicators such as Gross Domestic Product (GDP) provide information on whether national income is growing or declining. There is no equivalent system for measuring the physical "transactions" in an economy.

Policy and other decision makers have very little idea of the material requirements of modern economies and few indicators of where, or when, physical constraints are likely to be reached.

A study covering Austria, Germany, Japan, the Netherlands, and the United States found that physical accounts are urgently needed, because our knowledge of resource use and waste outputs is surprisingly limited (WRI 2000). It has been recommended by the World Resources Institute that Governments set up a parallel set of national accounts in physical terms using material flow accounting.

Ireland has undertaken a commitment to sustainable development. Appropriate monitoring tools are necessary in order to:

- Measure progress towards sustainable development.
- Make/review policies and decisions toward sustainability.

One such set of monitoring tools is material flow accounting (MFA) - accounting for the physical flow of materials through our economy and society.

Current planning does not generally take account of regional material flows – at least to any great extent. For development to be sustainable, however, this is paramount.

In order to take safe steps toward sustainability, economic and societal actors need simple and practical navigation instruments that measure the ecological impact potential of human activities, products and services. This need extends from the macro-level (nations) through the meso-level (industrial sectors, regions) to the micro-level (processes, products, individual enterprise). Such an approach reflects the adages: "what you cannot measure, you cannot manage" and "what gets measured, gets managed".

There is a clear need for impact measurement, with the support of a model that identifies the origins of the activities that produce the impacts, and allows the *a priori* determination of the effects of changes in the system. Material Flow Accounts allow assessment of the flows into and out of an economy, or part of an economy. These include resource flows (imports, exports, generation and consumption). Since the efficient consumption of resources is required for the decoupling of economic growth and material and energy requirements, there is an obvious consequence in terms of sustainable development. MFAs can also include specific environmental factors, such as emissions of greenhouse gases, discharge to waters, etc.

Material flow accounts can be used to provide sufficient information in order to monitor the existing situation and trends, plan and control improvement measures, facilitate comparison of alternatives, and highlight/discover certain flows that may be of specific relevance in the future.

Not every EU country has developed material flow accounts to date. However, Ireland is somewhat behind other developed countries, especially considering the United States and the Soviet Union published such accounts in the 1970s.

1.2 Objectives

The main objectives of the study are:

- Review existing methodologies for material flow accounts (MFA) and select/tailor the methodology for Ireland
- Demonstrate the methodology for two pilot cases:
  - national fossil fuel flow accounts, together with derived indicators, and
  - water flow accounts for a region
- Identify data gaps for a complete set of national material flow accounts
- Evaluate the applicability of MFA in Ireland and any policy implications.

Although not part of the original specification, this report also attempts a first quantification of Total Material Flows in Ireland. This can be regarded as an extension of the gap analysis.

1.3 Expected Benefits

The benefits of MFAs are based on the principle that 'what is not measured cannot be controlled'. We would never dream of trying to run an economy without a comprehensive set of economic indicators and accounts. Similarly, we cannot hope to reduce the environmental footprint of our activities without clear indications of our impacts, in terms of material and energy flows.

The specific benefits of a Material Flow Accounts pilot project are to test a methodology and to produce a first set of early accounts. The long term aim should be to develop comprehensive accounts for a range of flows. These can be used to assess current environmental impacts, and, based on these, to make decisions for improvement. Specific examples of potential future use are as follows:

National Physical Accounts

The long term aim should be to develop national physical accounts for all major material flows in Ireland. This desk study serves as a first step in identifying available methodologies, demonstrating material flow accounts in an Irish situation, establishing the capability to produce flow accounts within Ireland, and identifying major data gaps for the future production of such accounts.

MFA Methodology

As well as being used for establishing a basis for national physical accounts, the MFA methodology researched as part of the study can be utilised in other situations:

- in diverse applications such as fertiliser use and eutrophication, waste management, packaging, specific products such as steel or cement, and agricultural or forestry production.
- on different scales:
  - municipal regions
  - government departments
  - manufacturing companies

National Fossil Fuel Flow Accounts

Demonstration of the methodology to the flow of fossil fuels on a national scale will be of assistance in the implementation of the National Climate Change Strategy (DOE 1997). Under the Strategy, taxation measures are to be implemented on a phased incremental basis on the basis of the carbon equivalent content of fuel inputs in the case of energy production, and also on electricity consumption. The material flow accounts can assist in the prioritisation of areas for taxation, as well as other measures under the Strategy - such as negotiated agreements.

Regional Water Flow Accounts

Application of the methodology to the material flow accounts of water in a chosen region is of assistance in the establishment of River Basin Management Plans for all Irish river basin districts under the water framework Directive (European Parliament, 2000). For each river basin district, member states must compile specified characteristics, review environmental impact of human activity and carry out an economic analysis of water use by the end of 2004, as laid out in Annexes II and III to the Directive. Member States must collect and maintain information on the type and magnitude of the significant anthropogenic pressures to which the surface water and ground water bodies in each river basin district are liable to be subject, including estimation of:

- point and diffuse sources of pollution
- significant surface or ground water abstraction for urban, industrial, agricultural and other uses
- water distribution system loss
- flow regulation, including water transfer and diversion
- artificial groundwater recharge

– determination of potential deficiencies in water supply.

The establishment of flow accounts for the chosen region can be used as a prototype for other river basin districts in Ireland.

Material flow analyses have been devised for regions, e.g. within Sweden, although there is a contrary view that the data requirements are inadequately satisfied in some cases. Often such studies are prompted by concerns for assessment of waste management options. Such work in Ireland is illustrated by waste flow estimates for electrical and electronic equipment, and for common recyclable materials. Using such data, policy decisions can be taken to promote the prevention of waste and design appropriate waste management systems. In the absence of a life cycle approach, decisions are taken based on unsubstantiated principles or “rules of thumb”, which may neglect the environmental consequences of additional transport or treatment operations.

2 REVIEW OF EXISTING MATERIAL FLOW ACCOUNTING METHODOLOGIES

A review of selected existing European MFA (Material Flow Accounting) methodologies is presented. This review is broken into two sections, the first dealing with general MFA methodologies used in other European countries and the second with MFA software in use.

2.1 Review of European MFA methodologies

This section provides an overview of the current approaches to MFA within some of the European countries involved in work in this area.

2.1.1 MFA methodology - European Level

Since the original proposal for this project was prepared, Eurostat has produced a methodological guide for economy wide material flow accounts. The Eurostat guide aims to harmonise economy-wide MFA methodologies across Europe. This study aims to tailor the methodology in the Eurostat guide to suit the Irish situation. This study has also demonstrated the use of the Eurostat methodology to prepare fossil fuel accounts and to make a first attempt at total material accounts for Ireland. Therefore much of the Eurostat guide has been used in developing an MFA methodology for Ireland. However, individual country level MFA methodologies have been reviewed for:

- additional guidance and implementation experiences
- assistance in the identification of the key parameters
- information on experiences with regional rather than economy-wide material flows

A distinction is drawn between material flow *accounts*, and material *balances*. The difference being accounts are lists of inputs and outputs but do not have to balance. There are three different categories:

- economy wide material flow accounts
- economy wide material balances
- PIOTs (Physical Input Output Tables)

PIOTs are more detailed than economy wide material balances in that they also cover flows within the economy between sectors.

2.1.2 EU TMR (Total Material Requirement) Study

The European Environment Agency has carried out an estimation of TMR (Total Material Requirement) for the EU as a whole, as well as an estimate of DMI (Direct Material Input) and DMC (Domestic Material Consumption) for each Member State where it had not already been calculated.

DMI for Ireland has been estimated as 35 tonne per capita for 1997 (for the 15 EU Member States it is estimated as 20 tonne per capita). Member States were ranked based on comparison of DMI with GDP. Ireland had achieved a significantly higher GDP with a rather constant DMI. However other Member States managed to combine economic growth with reduced DMI. There were also other Member States whose DMI rose in conjunction with GDP.

From 1980 to 1997 DMC in Ireland increased by 121%, with an estimated DMC of 40 tonne per capita in 1997.

A lot of the MFA data for the EEA study was based on data from MFA studies already carried out in individual countries which was scaled up for the rest of the EU (e.g. weighted averages, known areas of non-harvested pasture, etc.) or was based on EU level data (e.g. Eurostat energy statistics).

2.1.3 MFA Methodology - Germany

Germany was one of the first countries to develop MFA [along with the Netherlands, Austria, Japan, and the US in a World Resources Institute project (WRI 1997)]. MFA has been introduced into the official reporting of the German Federal Statistical Office since 1995 and is reported on annually. A time series for the former federal Republic was carried out from 1975 to 1990, then a revised time series for the reunited country was set up for 1991 onwards (www.destatis.de/).

The split of materials on the input side in the economy-wide balance is: biotic goods and abiotic goods (further split into energy sources, ores and products thereof, non-metallic minerals and products thereof, chemical products, machinery and equipment, and other goods). On the output side dissipative losses included are fertiliser, landspread sewage sludge, and pesticides. Water balances are also carried out separately.

PIOTs have been drawn up for Germany for direct energy consumption, water withdrawal from nature, and water discharge into nature, broken down per NACE sector (www.destatis.de/).

A notable difference between Irish and German data sources is that official waste statistics are maintained by the Federal Statistics Office Germany, whereas in Ireland the EPA performs this function.

Indicators calculated by Germany include TMR, DMI, DPO (Domestic Processed Output) on a per capita basis and per unit of GDP basis. The changes in these indicators are graphically illustrated over time. In addition some specific material flows used by Germany as indicators expressed on a per GDP unit basis (using 1991 as the base year - set at 100) are: primary energy consumption, total waste, total greenhouse gas emissions, all water discharged into nature (including losses in distribution, evaporation), water withdrawal from nature, and wastewater discharged into nature.

The change in specific material output streams are also graphically represented (setting 1975 as equal to 100).

Net additions to stocks has been calculated by difference, using DMI minus DPO and minus exports.

2.1.4 MFA Methodology - Austria

As one of the countries involved in the WRI material flows project (WRI 1997), Austria first conducted national material balances in 1995, retrospectively going back to 1970 for water, fossil fuels, mineral and bulk raw materials, and biotic substances.

Austrian material balances differ from the Eurostat Guide in that they include a balance on water (which accounts for 87% of the entire flow of material), but water is not included in the calculation of indicators (www.statistik.at).

The balances include: imports, primary extraction, processing, final use, emissions, wastes, deposition, stocks, and exports.

These balances conform to the level of detail in Physical Input Output Tables (PIOTs) since they look at the sectoral level. The fossil fuel balance differentiates between fuel used in coke-ovens, blast furnaces, and electricity/heat supply. There is no sectoral breakdown on inputs and outputs for the final consumption stage (industry, agriculture, etc.).

In addition to tonnage, Austria represents its MFAs on energy in terms of petajoules, as well as percentage contribution to final useful energy per sector.

Indicators calculated by Austria include TMR, DMI, DPO on a per capita basis and per unit of GDP basis. Austria graphically illustrates changes in these indicators over time.

Another indicator derived from the balances is emission intensity of a sector (% of total emissions, for example CO_2 emissions) plotted against percentage of monetary NPV (Net Production Value). This shows for example, that while CO_2 emissions from power generation are a significant contribution to total CO_2 emissions, the sector has one of the bigger shares of NPV. Conversely, steel manufacture also has a significant contribution of total CO_2 emissions but has a lower share of NPV. Emission intensities are calculated for solid waste, waste water, SO_2, etc. Raw material productivities are also similarly calculated.

Austria also represents its MFAs in terms of Sankey diagrams (graphical representation of material inputs and outputs where the width of each input and output arrow is proportional to the material quantity or flux – invented by the Irish engineer Sankey (1853-1921).

2.1.5 MFA Methodology - The Netherlands

As one of the countries involved in the WRI material flows project (WRI 1997), Statistics Netherlands started work on material and energy flows in 1995 and produced PIOTs for iron/steel and energy (www.cbs.nl). The Dutch material and energy flow system is connected directly to economic data.

Indicators produced by the Netherlands include TMR, DMI, DPO on a per capita basis and per unit of GDP basis.

A group of Dutch Institutes has developed the MATTER model which looks at how changes in material flows can significantly influence GHG (Greenhouse Gas) emissions (Kram 2001). In-depth studies of key groups of materials were carried out (metals, organic chemicals and building materials) and product groups (packaging, buildings, road vehicles).

2.1.6 MFA Methodology - UK

Using a portion of landfill tax credits, Biffaward have funded a series of research projects examining resource flows in the UK. Some of these projects are looking at mass balances of resource flows in specific sectors or geographical regions (for example, “A Mass Balance of the UK Newspaper Industry”; “The Environmental Footprint for the Public Sector” and “City Limits - A resource flow and ecological footprint analysis of Greater London”).

The UK study, carried out by the Wuppertal Institute, was published in June 2002 (Bringesu 2001). The main goal of the study was to establish a balanced material flow account and associated indicators for the UK economy as a whole, differentiated by economic sectors and main resource groups.

Indicators generated include TMR, DMI, TDO (Total Domestic Output), DPO, on a per capita and on a per GDP basis. These indicators were also calculated on a sectoral basis for the following sectors: crude petroleum and natural gas extraction, coal mining, energy supply, basic metals manufacture, metal ores mining, other mining and quarrying, construction, agriculture, transport, households, and other industries.

In the Eurostat guide, soil erosion from agricultural land is omitted from the main material flows contributing to TMR and classified as a ‘memory item’ - for which a country may decide to include it in TMR or not. In the UK’s case, it was decided to leave soil erosion out of the TMR calculation.

The categories of domestic extraction/input considered are: agriculture (harvest, grazing), forestry and fishing, fossil energy (hard coal, lignite crude oil, natural gas, peat), ores (iron, copper, zinc, lead, tin, silver, tungsten, gold), minerals (barite, clays, diatomite, feldspar, fluorspar, gypsum/anhydrite, potash, salt, sand and gravel, crushed stone, dimension stone, strontium minerals, talc, sulfur), excavation and dredging.

The categories of imports and exports considered are: raw materials (fossil energy carriers, minerals, metals, animals, agricultural, forestry), agricultural products (animal, plant), semi-manufactured products (fossils, minerals, metals, forestry), finished products (minerals, metals, forestry, animals).

The categories of outputs to the environment considered are: CO_2 emissions, other emissions to air, waste landfilled, unused biomass, unused extraction of minerals, unused extraction of fossil fuels, manure spread on fields, other dissipative uses on fields, emissions to water soil erosion, and excavation and dredging.

Soil erosion was also calculated separately. Additionally, net additions to stock were estimated.

The complete data of the MFA is maintained in a hierarchically structured series (up to seven levels) of Excel workbooks and their worksheets with supporting Word documents. The major split is between inputs and outputs. Each worksheet contains information for a particular sector for the complete time series in question.

Some problems, encountered during the UK study, are:

- There was a lack of consistent data on hidden flows associated with precious stones (a high hidden flow associated with such stones). Therefore, these hidden flows have been omitted from the UK TMR and constitute a significant data gap in pre-1996 MFAs.
- Soil erosion associated with imported biomass has not been estimated.
- Comprehensive figures could only be generated for 1997 and 1998 as a result of data availability.
- Missing data on waste water emissions and waste landfilled.

There are several follow-up projects now underway, including “Scottish Resource Flow and Ecological Footprint” (started September 2002 and is to finish December 2003) and “Northern Ireland Mass Balance and Ecological Footprint” (started July 2002 and is to finish January 2004). One aspect of the latter project involves a mass balance of resource flows (materials and energy) through the Northern Ireland economy.

A related UK project finalised in August 2002 is a study conducted by the Stockholm Environment Institute which estimates the total material requirement of the City of York and establishes the ecological footprint associated with the consumption of such materials (SEI 2002).

2.1.7 MFA Methodology - Sweden

Sweden has developed physical environmental accounts since 1993 and publishes Environmental Economic Accounts as a sub-set of the National Accounts (Branvall 1999a).

Sweden has calculated Direct Material Input (DMI) and Direct Material Consumption (DMC) for all major materials as far back as 1987 (Isacsson 2000). Material categories used are as per the Eurostat guide.

Sweden represents its material flow accounts in tabular format, showing yearly trends of DMI and DMC in thousands of tonnes, and also per capita.

Sweden uses DMC as one of its Sustainable Development indicators (SCB 2001). The first set of these indicators has been drawn up in 2001 by Statistics Sweden, in conjunction with the Swedish EPA. DMC is plotted over time, split into the major categories of construction materials, fossil fuels, forestry, ore and industrial minerals and food.

2.1.8 MFA Methodology - Finland

Finland started the calculation of TMR in 1998 and has a time series that goes back to 1970 (Juutinen 1999).

An Excel workbook has been developed to show the time series results TMRFIN (Total Material Requirement of Finland). Each group of natural resources has its own set of worksheets, with a summary of the series of that group presented on the top of the page. The workbook has been compiled in such a way that:

- TMR can be reviewed hierarchically at different detailed levels of material

categorisation,
- the time series is easy to update,
- calculation methods can be checked directly from the workbook (transparency).

Hidden flows are derived either directly from statistics or, with the help of parameters, from the use of direct inputs or other available information.

For the hidden flows of imports, the results of the Wuppertal Institute have been used by taking into account the differences in imports between Finland and Germany. The hidden flow coefficients have been calculated in accordance with the year 1995, and these fixed coefficients are then applied to the whole time series.

The workbook contains altogether 420 product groups of direct inputs - the domestic and imported products being calculated separately.

2.1.9 Other Countries

The Basque country has conducted a Total Material Requirement (TMR) study which was published in August 2002 (IHOBE 2002). The Wuppertal Institute has conducted a TMR study for Poland (Schütz 2000). Other countries that have generated material flow accounts and calculated TMR include Denmark, China, and Italy. This project undertook to look in detail at the work of a selection of countries, in particular those which have been at the forefront of research this area. Hence these other studies were not reviewed in detail.

2.1.10 Conclusions from Review

The review of work in other countries has shown that, for tracking resource flows at the national level, it is best to use the Eurostat methodology. This will allow comparison with other countries. The majority of national level studies that have been carried out since the publication of the Eurostat methodology utilise this method. For studies on a regional level, or for specific materials, there is more flexibility in the methods that can be used. Useful illustrative tools were also identified from the review such as Sankey diagrams. Countries are using MFA indicators in their sustainable development stategies, for example, Sweden.

2.2 Review of MFA Software

From the review of MFA software it was found that calculation/illustration software packages are less suitable to national and regional flow accounts and more suitable to company level material flows. They go into a level of calculation and detail that is not necessary/applicable for national or regional material flow accounting. Illustration only packages like S.draw or Metaflows could be useful to illustrate the results of material flow accounting while the actual MFA data is stored in a package such as Microsoft Excel. This has been borne out by the fact MFAs for a number of other countries are compiled in Excel. The appendix provides more detail on the MFA software review.

3 DRAFT IRISH METHODOLOGY FOR THE GENERATION OF MATERIAL FLOW ACCOUNTS

The following is an outline of the draft methodology recommended to be employed for conducting material flow accounts and balances for Ireland ***for all materials***. This methodology will be demonstrated in the fossil fuels case study (Section 4). A preliminary estimate of material flow accounts for Ireland for all materials is also attempted using the methodology (Section 6). The methodology is based on the Eurostat guidelines. For the River basin case study (Section 5), a modification of the method is used, since several elements of the methodology, such as the Eurostat indicators, do not apply on a local level (i.e. non national level).

3.1 Some Definitions

System Boundary

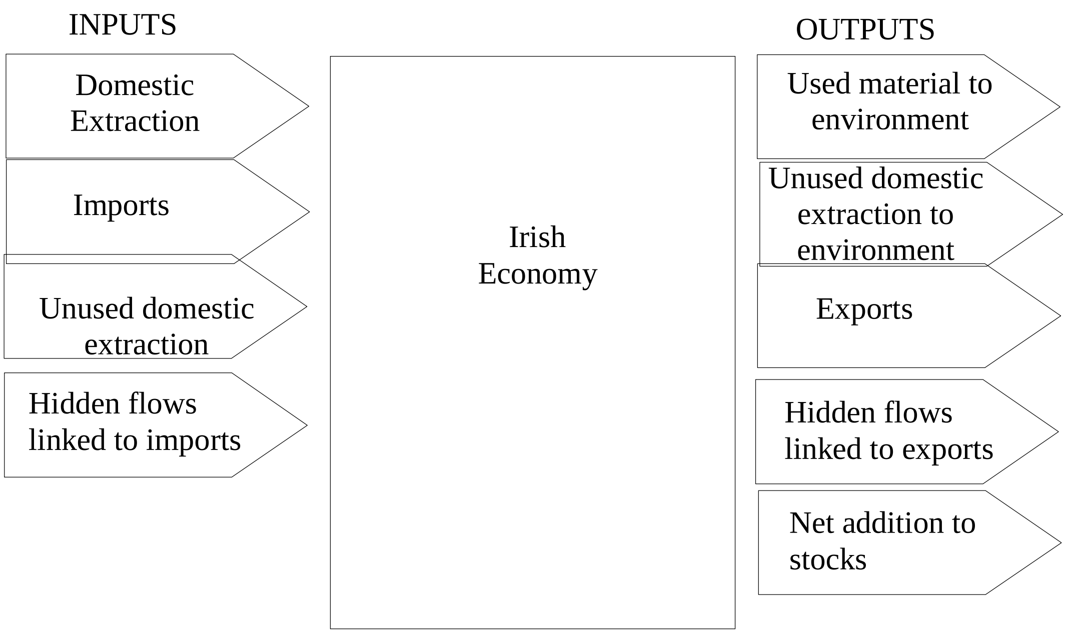
The system should be the Irish economy and the system boundary should be the national border, and the extraction/release of materials to and from the environment.

Residence versus Territory

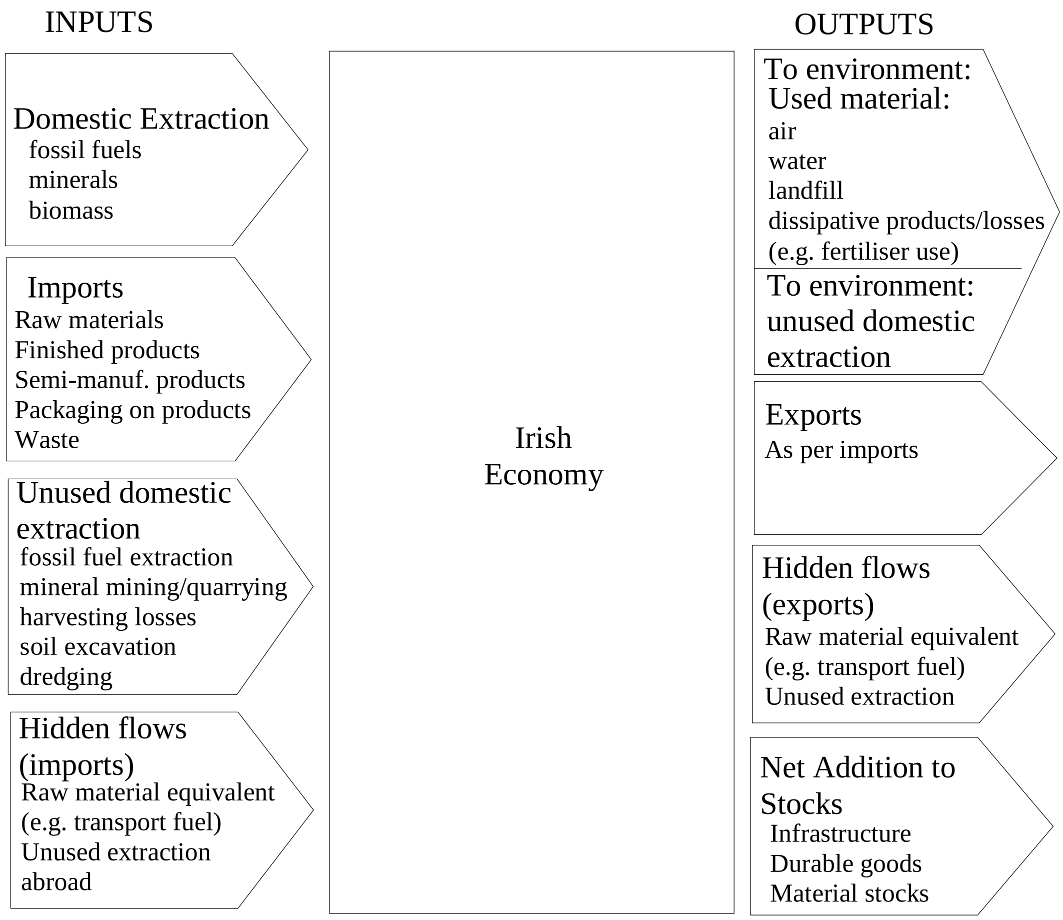
National monetary accounts are based on the consumers/producers resident in the country rather than on territory. Therefore Irish consumers' fiscal activities abroad are included in the economic figures, whereas non-residents in Ireland are not (e.g. tourists). However MFA focuses on actvities within the country and so would include the contribution to flows from non-residents within Ireland. This has to be considered in any comparisons with monetary indicators.

3.2 MFA Inputs and Outputs

The following inputs and outputs should be used in a national MFA:



More detail on each of the inputs and outputs that should be considered as part of the methodology is as follows:



3.2.1 Domestic Extraction

Domestic extraction should consider the extraction of all materials, e.g. natural gas, peat, sand and gravel, all agricultural produce, forestry products, etc.

These materials should be split into the categories of fossil fuels, minerals and biomass.

3.2.2 Imports and Exports

All imports and exports should be split into the categories of raw materials, semi-manufactured products, finished products, other products, packaging on products and waste. A more detailed classification of these categories is given in Annex 4 to the Eurostat guide. Each of these categories should also be further divided into fossil fuels, minerals and biomass.

Imports should be split by country of origin, where possible.

Imports should be classified based on the EU CN system (Combined Nomenclature) which is consistent with the HS system (Harmonised commodity description and coding System) or the HS-derived SITC (Standard International Trade Classification)

Exports should be classified based on the EU CN system (Combined Nomenclature) which is consistent with the HS system (Harmonised commodity description and coding System) or the CPA system (Classification of Products by Activities).

3.2.3 Unused Domestic Extraction

Unused domestic extraction is that material which is extracted from the environment but which does not go on for further processing.

Unused domestic extraction consists of wastes from mining and quarrying, wastes from agricultural and forestry harvesting, excavation materials, and dredging materials. Soil erosion can be optionally included as an additional material flow (the majority of countries apart from the UK have included soil erosion; in the UK's case domestic soil erosion does not make any significant difference to overall TMR unlike some other countries).
Unused domestic extraction is counted as both an input and an output to the environment.

3.2.4 Hidden Flows

Hidden flows consist of two components:

- RME (Raw Material Equivalent) - the extra weight of material required to make and bring the product/material to the country border (shipping fuel, etc.).
- unused extraction – the unused extraction associated with the material at the location of extraction (abroad for imports, in Ireland for exports).

An example of hidden flows determined from Irish data:

In 2000, just over 2 thousand tonnes of bituminous coal (a type of hard coal) was imported from Estonia, while almost 142 thousand tonnes of bituminous coal was imported from Australia:

- Raw material equivalent: The raw material equivalent of the Australian coal would have to take into account the additional fuel involved in shipping the coal from Australia, as opposed to from Estonia.
- Unused extraction: Coefficients for the hidden flows associated with imported hard coal from Australia is 10.64 and for Russia and the former Soviet Union 5.13 (taken from Wuppertal Institute data). These coefficients mean that for every tonne of imported coal from Australia there is an associated 10.64 tonnes of unused extraction back in Australia. Similarly there is 5.13 tonnes of unused extraction in Estonia for every tonne of imported Estonian coal.

In general, unused extraction is usually more significant than raw material equivalent, and in many cases raw material equivalent can be ignored**.**

Hidden flows have been estimated for some countries but mainly for raw materials and hardly any for finished products. In any case, a lot of MFA studies in other countries have omitted hidden flows associated with finished goods when calculating TMR. Therefore this is also recommended as the approach for Ireland and is the approach used in the preliminary estimate of total material flows in Ireland (Section 6).

3.2.5 Release to Environment

This consists of the release of materials which have been used (as opposed to unused extraction) to all environmental media. It includes emissions to waters and to air, as well as wastes landfilled and waste composted. MFA work in other countries has shown emissions to water to be negligible in terms of the total mass of all materials.

Also included are products which are released to the environment in an uncontrolled way (e.g. spread of pesticides) and also losses of products/materials to the environment (e.g. natural gas distribution leakages). In the majority of MFA studies in other countries the major dissipative product use is landspreading of manure.

Controlled landfills and commercial forests could also be considered to be within the system boundary, but this is considered to be a less suitable method for Ireland.

It is recommended that waste be split by waste type where data allows.

3.2.6 Net Addition to Stocks

This is the material that is added to man-made infrastructure (e.g. buildings, roads, etc.) and durable goods less any losses/removals.

It is recommended to calculate the net addition to stocks independently rather than by difference between the inputs and outputs, since uncertainties in input and output data could lead to inaccuracies. A rough method of estimating stock additions is to use the difference between Domestic Material Consumption and Domestic Processed Output to the environment. Other countries have used this method and it can be useful as a first estimate.

The net addition to stocks can be calculated by either estimating total stocks, or by estimating additions and removals only. The latter method is the one that has been used the most and is the more suitable to Ireland.

The major component of stock additions/removals is buildings/infrastructure.

3.3 Units

For material flow accounts, the mass of actual material reported is used. For material balances, there must be consistency in the units used for inputs and outputs, for example for fossil fuels, either the equivalent amount of oxygen needed on the input side and corresponding water vapour on the output side is added, or else the fuel input and carbon dioxide emissions are expressed in terms of mass of carbon. The former is the most commonly used method and is recommended for Ireland.

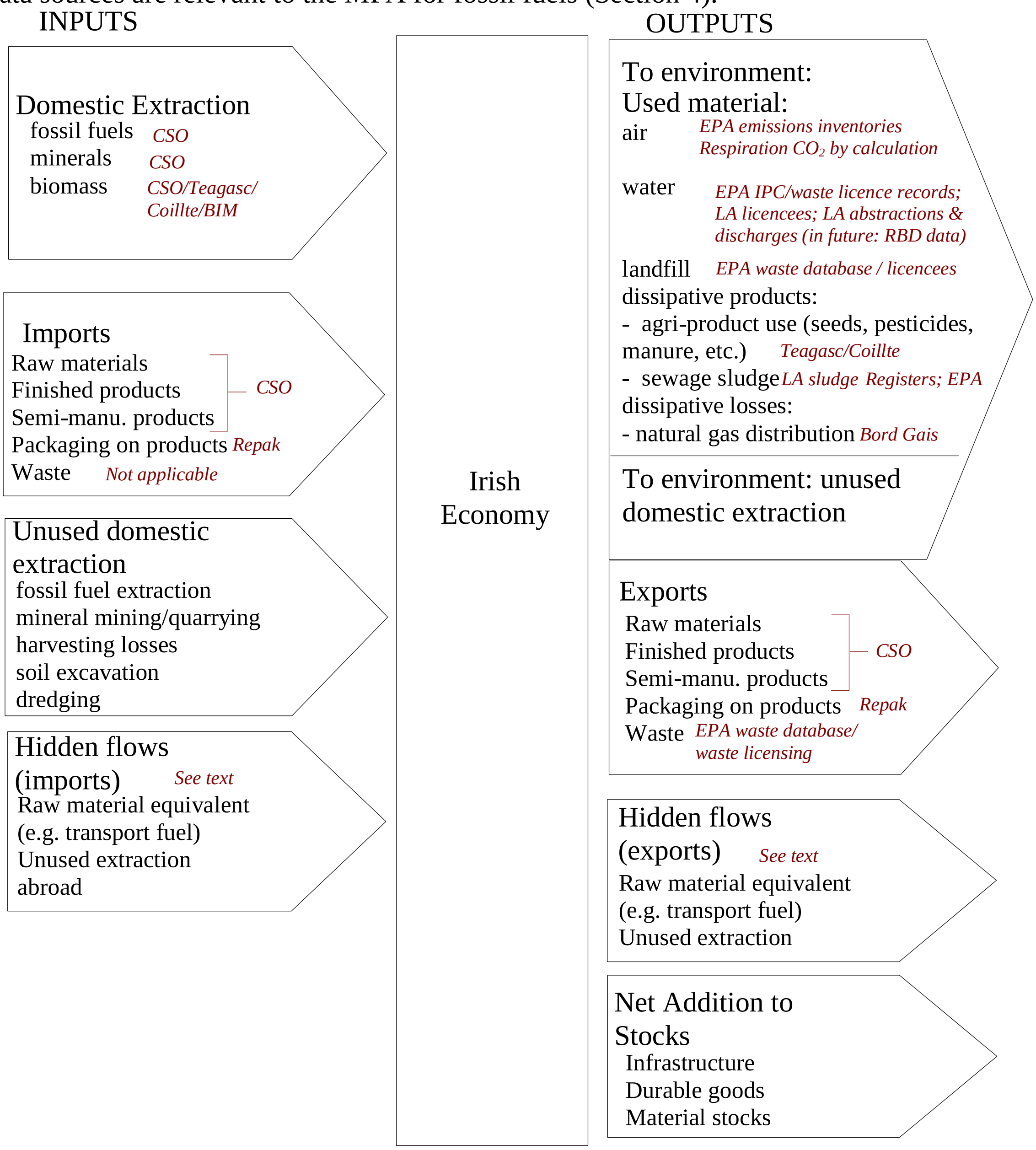
3.4 MFA Format and Illustration

An MFA for Ireland should consist of a series of Microsoft Excel files, divided into inputs per sector and outputs per sector. A guidance document and overall diagram showing the structure of the files should accompany the set of spreadsheets.

The use of Sankey diagrams for the representation of MFA is considered to be particularly illustrative and is recommended for inclusion in the Irish methodology.

3.5 Data Sources for Irish MFA

The following data sources should be used in obtaining information for total material flows in Ireland. Where usable data is available from such sources it has been included in the preliminary estimate of total material flows in Ireland (Section 6). Only some of these data sources are relevant to the MFA for fossil fuels (Section 4).



3.5.1 Hidden Flows (Imports and Exports)

Information on hidden flows associated with imports can be obtained for a lot of raw materials from the Wuppertal Institute (http://www.wupperinst.org/Projekte/mipsonline/download/download.html) as well as the Technical Part to the EEA Report "Total Material Requirement of the European Union".

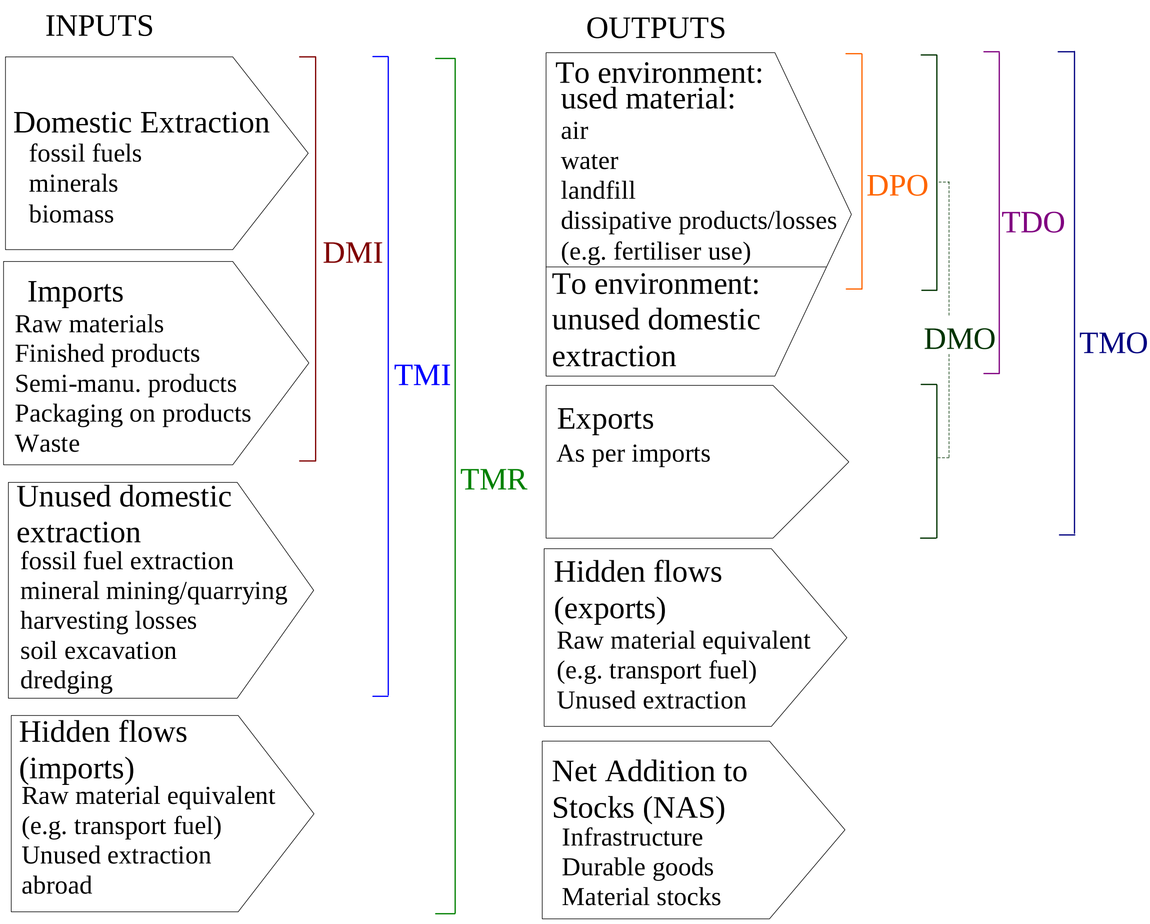
Information on hidden flows associated with exports will be the same as unused domestic extraction plus raw material equivalent associated with manufacture, etc. (RME associated with transport within Ireland will be negligible).

3.6 Identification of Indicators

MFA indicators are divided into three different categories, namely input, output and consumption indicators. As well as tonnes, these indicators are often expressed on a kg per capita basis.

3.6.1 Input and Output Indicators: relationship in overall scheme

MFA input & output indicators and the basis of their calculation:



3.6.1.1 Input Indicators - Definitions

DMI (Direct Material Input) = domestic extraction + imports
TMI (Total Material Input) = DMI + unused domestic extraction
TMR (Total Material Requirement) = TMI + hidden flows (imports)

DMI is an illustration of the weight of actual material that goes into the Irish economy. It includes material that will be consumed within Ireland, as well as other materials that will go into products and ultimately be exported. TMR is also a measure of the amount of material that goes into the Irish economy, but it includes not just the actual material itself, but the amount of unused material associated with its extraction or production, both in the State and abroad. For all three of these indicators, reducing their value (in tonnes or in tonne/capita), while maintaining or increasing fiscal activity, is to move in the direction of sustainability.

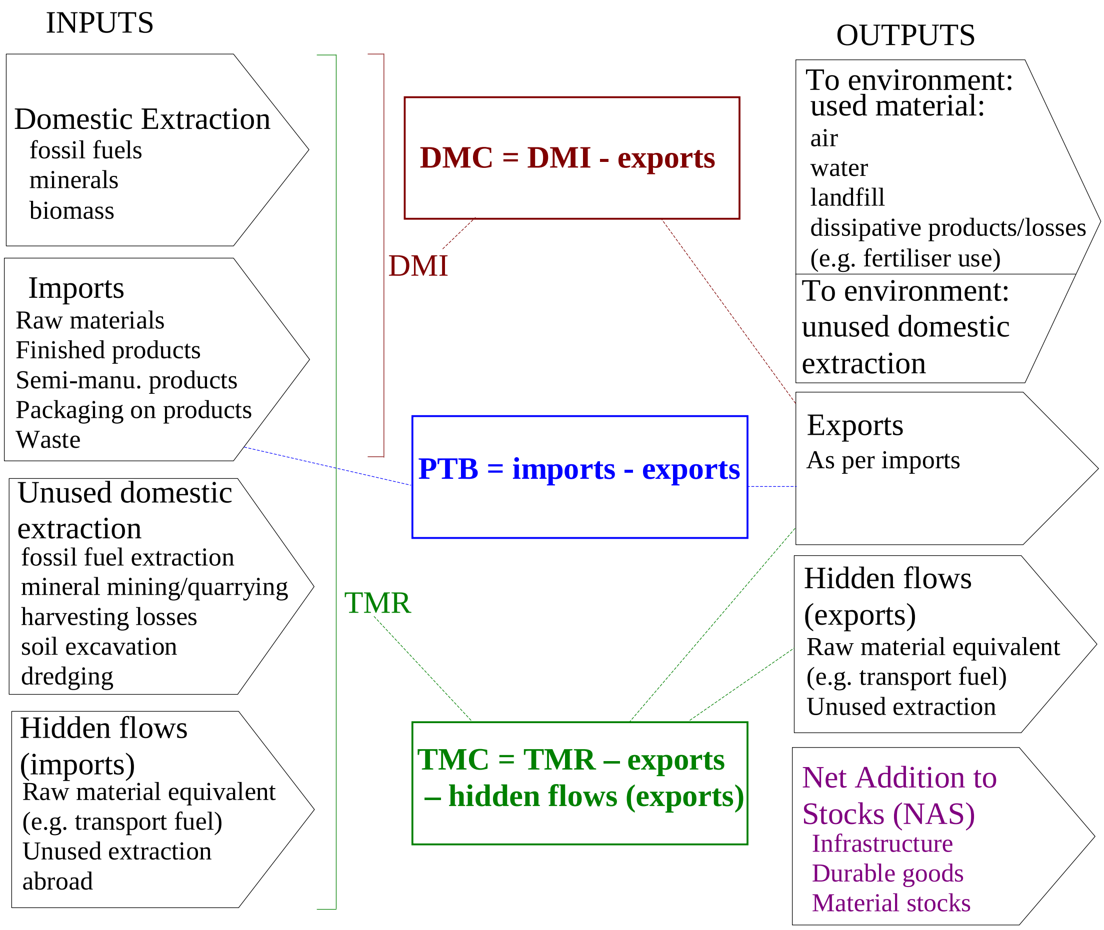
3.6.1.2 Output Indicators - Definitions

DPO (Domestic Processed Output) = used material emitted to the environment
TDO (Total Domestic Output) = DPO + unused extraction
DMO (Direct Material Output) = DPO + exports
TMO (Total Material Output) = TDO + exports

DPO illustrates the quantity of material that is discharged into the Irish environment after it has been used in the Irish economy (e,g, carbon dioxide emissions from the burning of fuel). TDO also takes into account material that is extracted in Ireland but is never actally used in an economic sense (e.g. natural gas losses during drilling). For all four of these indicators, reducing their value (in tonnes or in tonne/capita), while maintaining or increasing fiscal activity, is to move in the direction of sustainability.

3.6.2 Consumption Indicators: Relationship in Overall Scheme

MFA consumption indicators and the basis of their calculation are as follows:



3.6.2.1 Consumption Indicators - Definitions

DMC (Domestic Material Consumption) = DMI - exports
TMC (Total Material Consumption) = TMR - exports - hidden flows (exports)
PTB (Physical Trade Balance) = imports – exports
NAS (Net Additions to Stock).

DMC is an illustration of the weight of actual material that is consumed within Ireland. TMC is also a measure of the amount of consumption of material within Ireland, but it includes not just the actual material itself, but the amount of unused material associated with its extraction or production, both in the State and abroad. Reducing the value of the indicators DMC and TMC (in tonnes or in tonne/capita), while maintaining or increasing the level of fiscal activity, is to move in the direction of sustainability.

A positive value for PTB shows that an economy is dependent on imports, whereas a negative value shows a net exporting economy in terms of weight of materials. NAS shows the amount of materials that has been incorporated into infrastructure (such as roads and buildings) and durable goods (for example electrical appliances) in the country.

4 DEMONSTRATION OF METHODOLOGY: CASE STUDY – NATIONAL FOSSIL FUEL FLOW ACCOUNTS

4.1 Introduction

The case study involved the generation of material flow accounts and associated indicators for fossil fuels used in Ireland.

The outcome of this task is a set of physical accounts for fossil fuels used in Ireland for the years 2000, 1996, and 1990. It covers fossil fuel inputs, uses in various sectors, and associated emissions. Input, output and consumption indicators have also been calculated.

Section 4.2 sets out the results of the MFA for fossil fuels in Ireland for each of the years 2000, 1996 and 1990. Section 4.3 illustrates the input, output and consumption indicators for 2000, 1996 and 1990. Section 4.4 compares these Irish fossil fuel MFAs and indicators with those of other countries and the EU as a whole. Section 4.5 describes the structure of the fossil fuel MFA spreadsheets and the sources of data used in the MFA.

The fossil fuel MFA is illustrated both in tabular form, and by Sankey Diagram.

The Fossil Fuel MFA has been compiled for the years 2000, 1996 and 1990. A single Excel file is dedicated to each year – MFA2000.xls, MFA1996.xls, and MFA1990.xls. Each of the files has the following worksheets:

- Indicators
- Overall
- Inputs Outputs
- Domestic Hidden Flows
- Foreign Hidden Flows
- Throughput
- Waste
- Emissions
- Conversion Factors

The worksheets are further described in section 4.5. The worksheets form the basis of the Sankey diagrams, which were generated using the selected software. Sankey diagrams allow easy pictorial visualisation of flows. The thickness of each arrow in a Sankey Diagram is proportional to the magnitude of the flow.

4.2 MFA for Fossil Fuels in Ireland for 2000, 1996 and 1990

Tables 4.1 to 4.3 show the results of the material flow accounts for fossil fuels in Ireland for each of the years 2000, 1996, and 1990. These tables are taken from the spreadsheets referenced in section 4.5.

Overall Fossil Fuel MFA - 2000 Data in '000 tonnes						
Input			**Output**			
Domestic Extraction		**5,385**	**To Environment (Used Material)**			**42,154**
Peat	4,455		To Air	CO_2	41,239	
Natural Gas	930			N_2O	5	
Imports		**13,967**		CH_4	5	
Hard Coal	2,929			SO_2	131	
Lignite	33			NO_x	122	
Peat	0			NH_3/VOC	45	
Liquid fossil fuels	8,598			CO	275	
Natural Gas	2,406		To land	ash	331	
Unused Domestic Extraction		**1,237**	To water	N, P	0	
Peat	1,114		**To Environment (Unused Extraction)**			**1,237**
Natural Gas	124		Peat		1,114	
Hidden Flows (Imports)		**8,715**	Natural Gas		124	
Hard Coal	7,595		**Exports**			**1,193**
Lignite	283		Hard Coal		9	
Peat	0		Lignite		0	
Liquid fossil fuels	558		Peat		18	
Natural Gas	280		Liquid fossil fuels		1,166	
Oxygen (for balancing)		**29,992**	Natural Gas		0	
			Hidden Flows (Exports)			**211**
			Hard Coal		8	
			Lignite		0	
			Peat		5	
			Liquid fossil fuels		198	
			Natural Gas		0	
			Net Additions to stocks			**65**

Figure 4.1: Overall Fossil Fuel MFA, 2000

Overall Fossil Fuel MFA - 1996 Data in '000 tonnes						
Input			**Output**			
Domestic Extraction		**7,629**	**To Environment (Used Material)**			**34,624**
Peat	5,525		To Air	CO_2	33,626	
Natural Gas	2,105			N_2O	4	
Imports		**10,841**		CH_4	5	
Hard Coal	3,033			SO_2	147	
Lignite	34			NO_x	118	
Peat	0			NH_3/VOC	71	
Liquid fossil fuels	7,305			CO	303	
Natural Gas	469		To land	ash	351	
Unused Domestic Extraction		**1,661**	To water	N, P	0	
Peat	1,381		**To Environment (Unused Extraction)**			**1,661**
Natural Gas	280		Peat		1,381	
Hidden Flows (Imports)		**9,991**	Natural Gas		280	
Hard Coal	9,467		**Exports**			**906**
Lignite	284		Hard Coal		26	
Peat	0		Lignite		0	
Liquid fossil fuels	185		Peat		14	
Natural Gas	54		Liquid fossil fuels		866	
Oxygen (for balancing)		**24,455**	Natural Gas		0	
			Hidden Flows (Exports)			**173**
			Hard Coal		23	
			Lignite		0	
			Peat		3	
			Liquid fossil fuels		147	
			Natural Gas		0	
			Net Additions to stocks			**-25**

Figure 4.2: Overall Fossil Fuel MFA, 1996

Overall Fossil Fuel MFA - 1990 **Data in '000 tonnes**						
Input			**Output**			
Domestic Extraction		**8,324**	**To Environment (Used Material)**			**30,771**
Peat	6,480		To Air	CO_2	29,577	
Natural Gas	1,819			N_2O	3	
Coal	26			CH_4	7	
Imports		**9,025**		SO_2	183	
Hard Coal	3,100			NO_x	109	
Lignite	35			NH_3/VOC	73	
Peat	0			CO	397	
Liquid fossil fuels	5,889		To land	ash	421	
Natural Gas	0		To water	N, P	0	
Unused Domestic Extraction		**1,885**	**To Environment (Unused Extraction)**			**1,963**
Hard Coal	23		Hard Coal		101	
Peat	1,620		Peat		1,620	
Natural Gas	242		Natural Gas		242	
Hidden Flows (Imports)		**10,138**	**Exports**			**607**
Hard Coal	9,676		Hard Coal		29	
Lignite	291		Lignite		0	
Peat	0		Peat		9	
Liquid fossil fuels	171		Liquid fossil fuels		569	
Natural Gas	0		Natural Gas		0	
Oxygen (for balancing)		**21,511**	**Hidden Flows (Exports)**			**124**
			Hard Coal		25	
			Lignite		0	
			Peat		2	
			Liquid fossil fuels		97	
			Natural Gas		0	
			Net Additions to Stocks			**-515**

Figure 4.3: Overall Fossil Fuel MFA, 1990

Diagrams 4.1 to 4.3 illustrate the fossil fuel MFAs for each of the years 2000, 1996 and 1990 respectively. The size of the arrow is proportional to the magnitude of each of the flows. These diagrams have been generated using S.Draw.

Data Anomalies

One of the main sources of difference in the MFA for all of the years is between the total input to the economy (domestic extraction and imports) and the sum of the input to each of the sectors. The reason for the difference is because two different data sources were chosen as outlined earlier. Domestic extraction and imports were based on Department of Communications, Marine, and Natural Resources (DCMNR) figures and, after discussion, these data were considered more reliable than CSO data. A more detailed sectoral breakdown is available from the EPA data in accordance with the sectoral reporting under the Inter-governmental Panel on Climate Change (IPCC). This is also the data that is used to generate Ireland's greenhouse gas emissions. Hence the EPA data was used for illustrating the sectoral throughput and the associated emissions.

Data Gaps

All in all, data is generally readily available on an aggregated national level for fossil fuels. Domestic hidden flow data associated with Irish fossil fuel extraction is not available, and factors from other countries have been used instead.

Earlier data is only available from the CSO on micro-fiche.

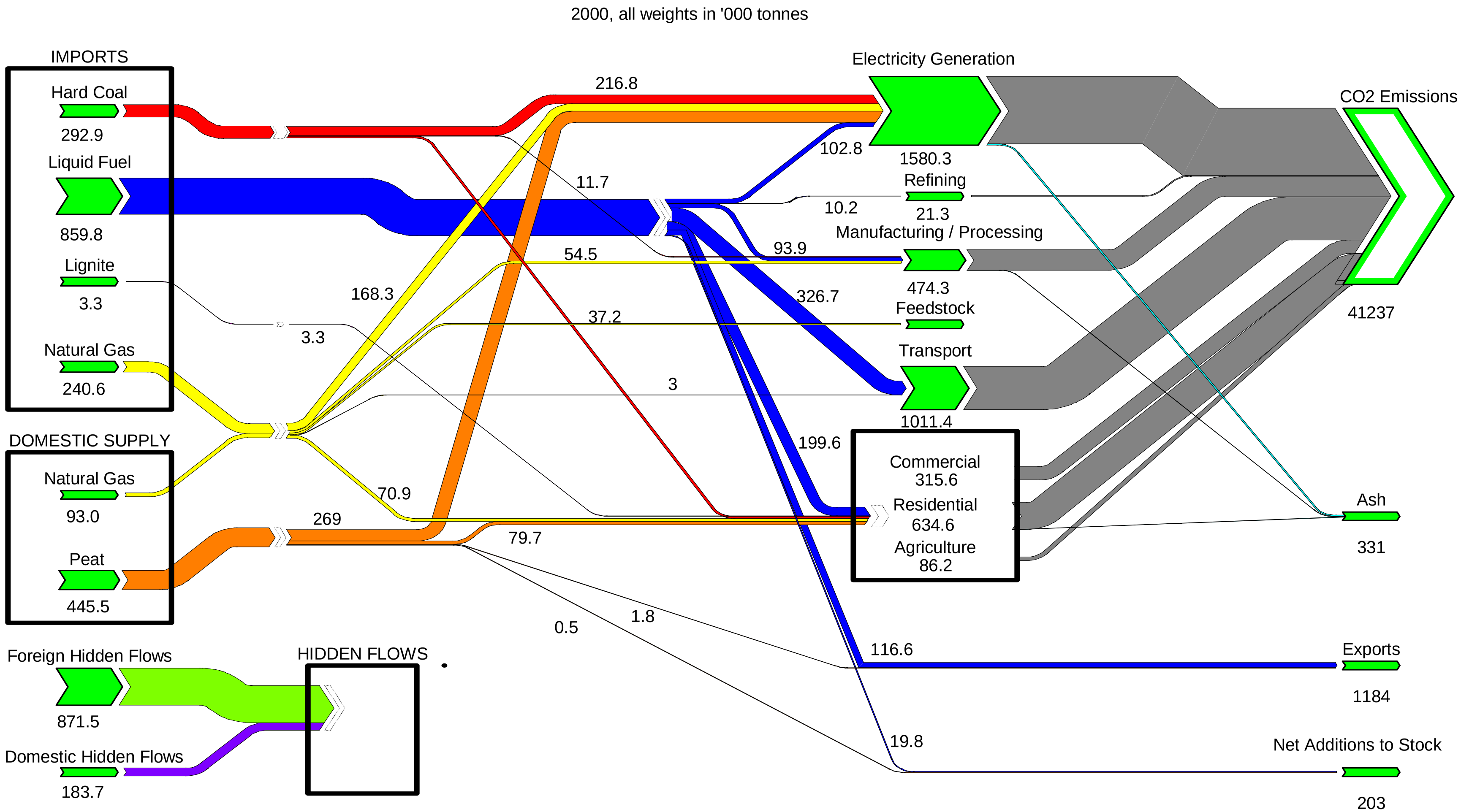

2000, all weights in '000 tonnes
IMPORTS
Hard Coal
292.9
Liquid Fuel
859.8
Lignite
3.3
Natural Gas
240.6
DOMESTIC SUPPLY
Natural Gas
93.0
Peat
445.5
Foreign Hidden Flows
871.5
Domestic Hidden Flows
183.7
HIDDEN FLOWS
216.8
11.7
168.3
54.5
37.2
3.3
3
70.9
269
79.7
0.5
1.8
102.8
10.2
93.9
326.7
199.6
116.6
19.8
Electricity Generation
1580.3
Refining
21.3
Manufacturing / Processing
474.3
Feedstock
Transport
1011.4
Commercial
315.6
Residential
634.6
Agriculture
86.2
CO2 Emissions
41237
Ash
331
Exports
1184
Net Additions to Stock
203

Figure 4.1

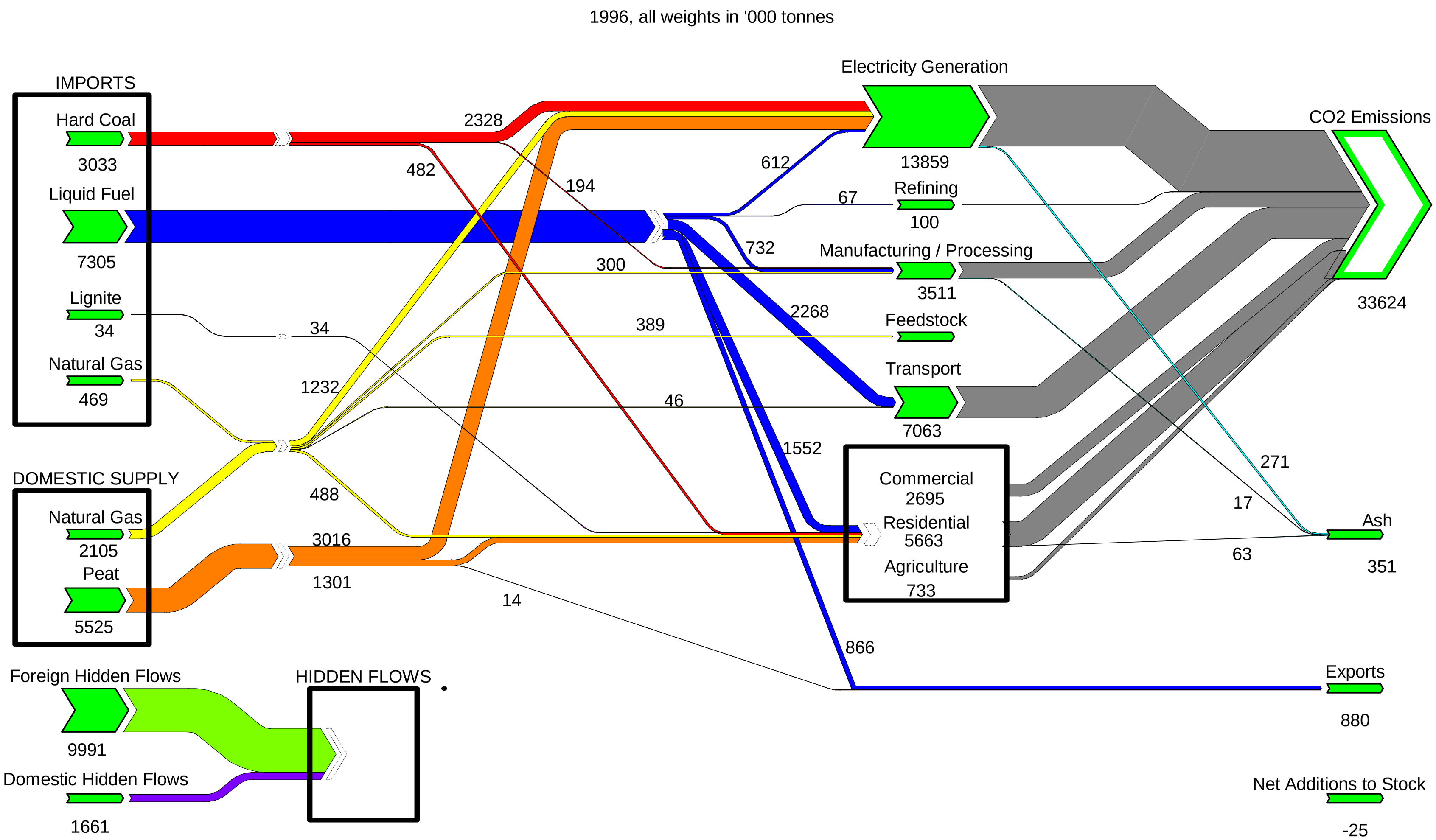

1996, all weights in '000 tonnes
IMPORTS
Hard Coal
3033
Liquid Fuel
7305
Lignite
34
Natural Gas
469
DOMESTIC SUPPLY
Natural Gas
2105
Peat
5525
Foreign Hidden Flows
9991
Domestic Hidden Flows
1661
HIDDEN FLOWS
2328
482
194
34
1232
488
3016
1301
14
300
389
46
612
67
732
2268
1552
866
Electricity Generation
13859
Refining
100
Manufacturing / Processing
3511
Feedstock
Transport
7063
Commercial
2695
Residential
5663
Agriculture
733
CO2 Emissions
33624
271
17
63
Ash
351
Exports
880
Net Additions to Stock
-25

Figure 4.2

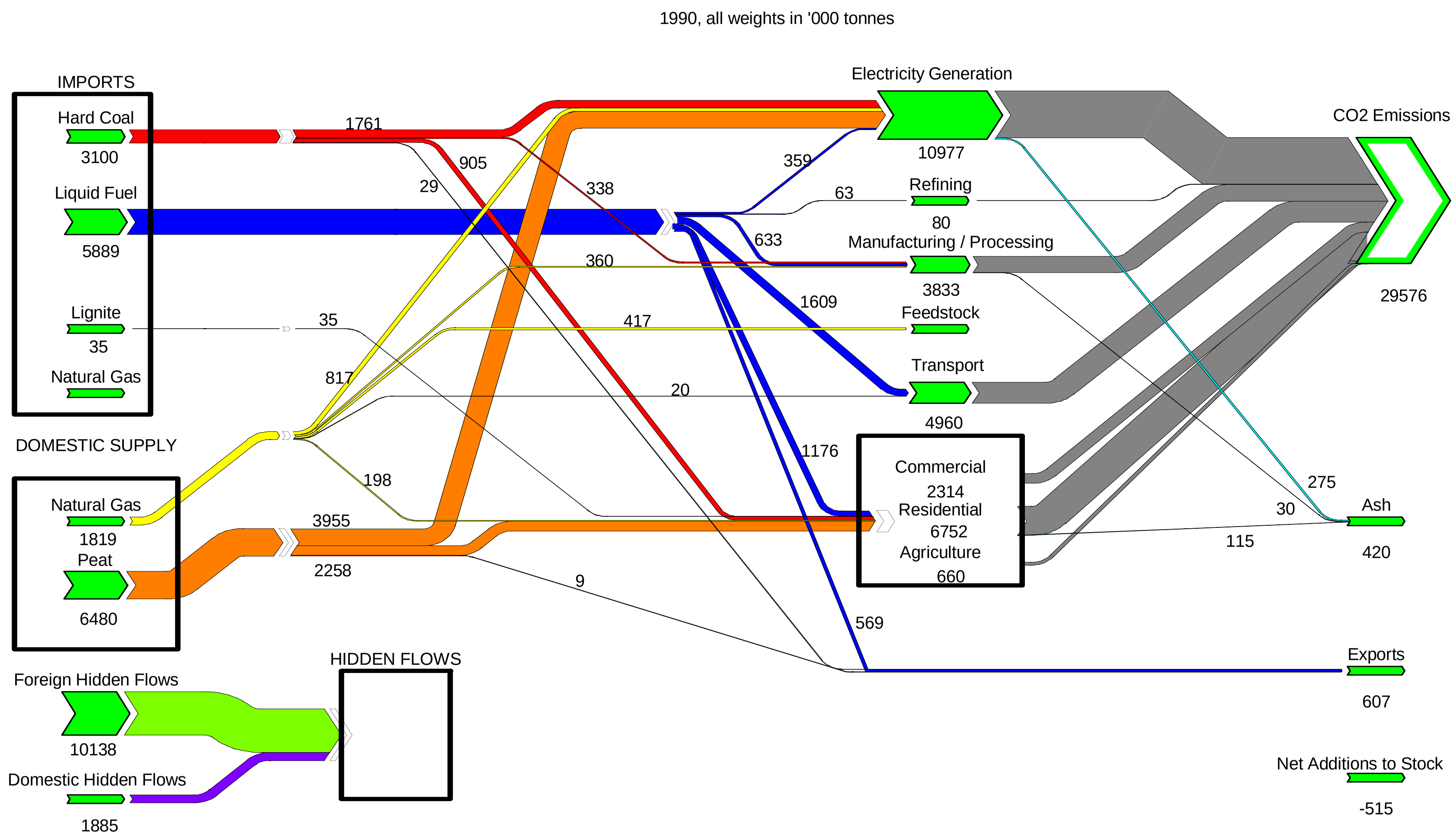

1990, all weights in '000 tonnes
IMPORTS
Hard Coal
3100
Liquid Fuel
5889
Lignite
35
Natural Gas
DOMESTIC SUPPLY
Natural Gas
1819
Peat
6480
Foreign Hidden Flows
10138
Domestic Hidden Flows
1885
HIDDEN FLOWS
1761
905
29
338
360
35
417
817
20
198
3955
2258
9
359
63
633
1609
1176
569
Electricity Generation
10977
Refining
80
Manufacturing / Processing
3833
Feedstock
Transport
4960
Commercial
2314
Residential
6752
Agriculture
660
CO2 Emissions
29576
275
30
115
Ash
420
Exports
607
Net Additions to Stock
-515

Figure 4.3

4.3 Input, Output and Consumption Indicators for Fossil Fuels in Ireland for 2000, 1996 and 1990

4.3.1 Input Indicators

Table 4.4 shows input indicators for each of the years 2000, 1996, and 1990 in terms of thousands of tonnes, and in tonnes per capita.

Figure 4.4 overleaf illustrates the input and output indicators for fossil fuels in Ireland (this diagram is useful in illustrating the meaning of each indicator).

Input Indicators for Fossil Fuels						
	Data in '000 tonnes			**Data in tonnes/capita**		
	2000	*1996*	*1990*	*2000*	*1996*	*1990*
DMI- fossil fuel	19,352	18,471	17,349	5.1	5.1	4.9
TMI - fossil fuel	20,589	20,132	19,233	5.4	5.6	5.4
TMR - fossil fuel	29,304	30,123	29,371	7.7	8.3	8.3

Table 4.4

DMI is a measure of the direct input of fossil fuels into the economy, being the sum of used domestically extracted and imported fossil fuels. On a per capita basis it has increased slighty between 1990 and 2000.

As well as direct inputs, TMI also adds in the waste associated with fossil fuel extraction here in Ireland. It has remained more or less consistent on a per capita basis since between 1990 and 2000.

TMR goes one step further than TMI in that it also adds in the waste associated with fossil fuel extraction abroad that is imported and used here in Ireland. TMR has decreased between 1990 and 2000. This is likely due to the increased usage of imported natural gas and oil over coal in this time period.

In order to move to a sustainable economy, these indicators should remain stable or decrease with time while fiscal indicators remain stable or increase.

MFA Indicators - Input & Output

2000, 1996, 1990 ('000 tonnes)

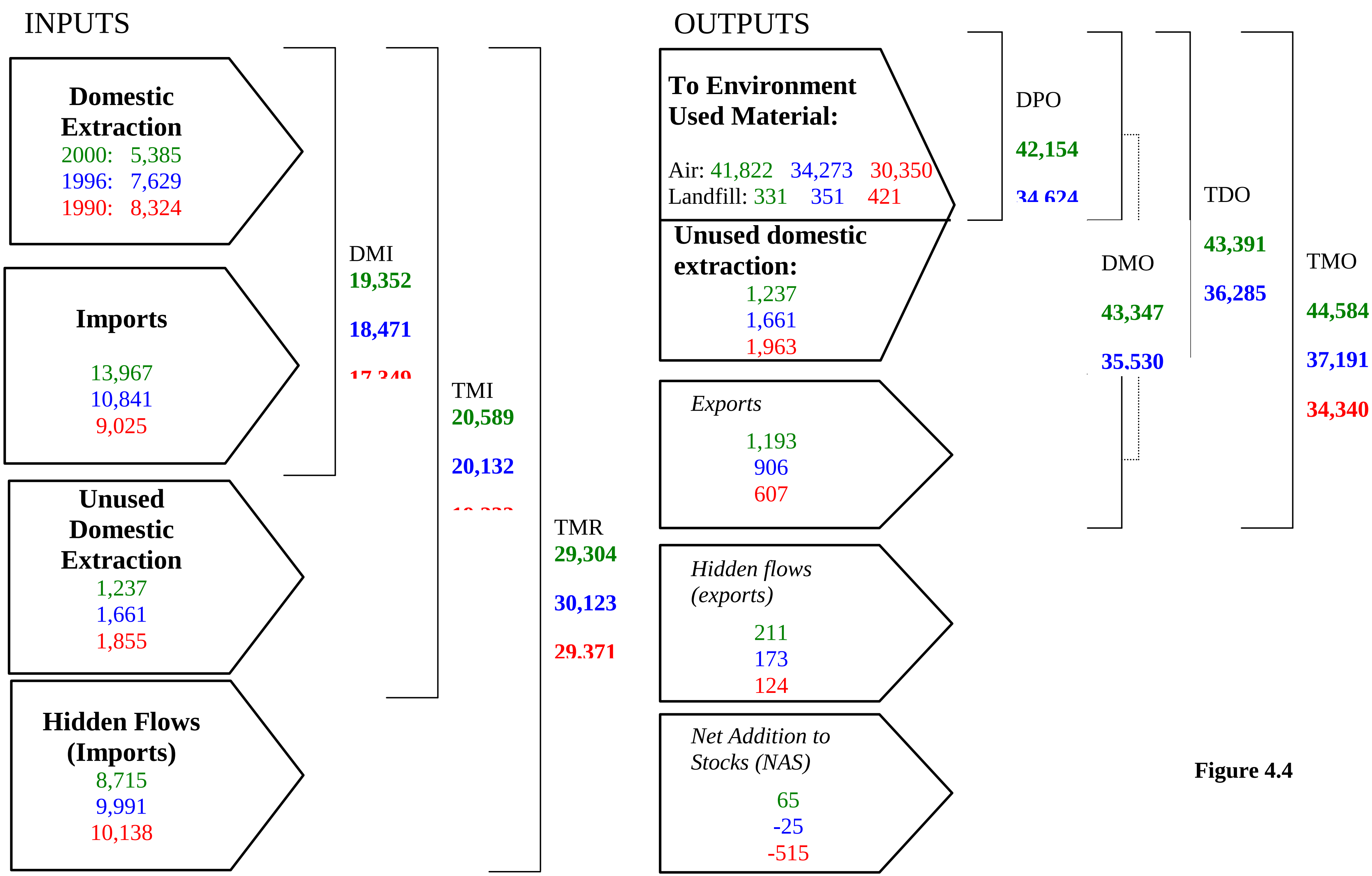


Figure 4.4

4.3.2 Output Indicators

Figure 4.4 illustrates the output indicators for fossil fuels in Ireland.

Table 4.5 shows output indicators for each of the years 2000, 1996, and 1990 in terms of thousands of tonnes, and in tonnes per capita.

Output Indicators for Fossil Fuels						
	Data in '000 tonnes			**Data in tonnes/capita**		
	2000	*1996*	*1990*	*2000*	*1996*	*1990*
DPO - fossil fuel	42,154	34,624	30,771	11.0	9.5	8.7
DMO - fossil fuel	43,347	35,530	31,377	11.3	9.8	8.9
TDO - fossil fuel	43,391	36,285	32,733	11.4	10.0	9.3
TMO - fossil fuel	44,584	37,191	33,340	11.7	10.3	9.4

Table 4.5

DPO is a measure of the direct output to all environmental media from the combustion of fossil fuels across all sectors. On a per capita basis such emissions have increased between 1990 and 2000.

As well as emissions to the environment, DMO takes exports into account. This has similarly increased between 1990 and 2000.

TDO is a measure of all releases to the environment, those which results from the combustion of fossil fuels, and those associated with the extraction of fossil fuels in Ireland - direct output to all environmental media from the combustion of fossil fuels across all sectors. On a per capita basis such emissions have increased between 1990 and 2000.

TMO is all outputs from the Irish economy – releases to the environment (both direct and indirect) as well as exports. This has similarly increased between 1990 and 2000.

Each of these output indicators for fossil fuels for Ireland show an increasing trend over the time period 1990 to 2000. However, in order to move to a sustainable economy, these indicators should remain stable or decrease with time while corresponding fiscal indicators remain stable or increase.

4.3.3 Consumption Indicators

Table 4.6 shows consumption indicators for each of the years 2000, 1996, and 1990 in terms of thousands of tonnes, and in tonnes per capita.

Figure 4.5 illustrates the consumption indicators for fossil fuels in Ireland

Consumption Indicators for Fossil Fuels						
	Data in '000 tonnes			Data in tonnes/capita		
	2000	*1996*	*1990*	*2000*	*1996*	*1990*
DMC - fossil fuel	18,159	17,565	16,742	4.8	4.8	4.7
TMC - fossil fuel	27,901	29,044	28,640	7.3	8.0	8.1
PTB - fossil fuel	12,774	9,936	8,418	3.3	2.7	2.4

Table 4.6

DMC is a measure of the consumption of fossil fuels by the economy, being the sum of used domestically extracted and imported fossil fuels, and subtracting that exported. On a per capita basis it has remained more or less constant between 1990 and 2000.

TMC is a measure of the total material consumption, both that used in the economy and that associated with domestic and foreign unused extraction, and taking away outputs via exports and hidden flows associated with such exports. It has decreased between 1990 and 2000. Similar to TMR, this is likely due to the increased usage of imported natural gas and oil over coal in this time period.

In order to move to a sustainable economy, the indicators DMC and TMC should remain stable or decrease with time while corresponding fiscal indicators remain stable or increase. Hence the trend for TMC is in a sustainable direction, however as can be seen later in section 4.4.2, Ireland's values for TMC in absolute terms are relatively high compared to other countries.

PTB is the physical trade balance between imports and exports. It has increased between 1990 and 2000. This reflects an increase in fossil fuel imports and a decrease in domestic extraction.

4.3.4 Materials Productivity

Table 4.7 shows materials productivity for fossil fuels for each of the years 2000, 1996, and 1990. Materials productivity is GDP per tonne of DMI (Direct Material Input) and per tonne of DMC (Domestic Material Consumption).

Materials Productivity for Fossil Fuels			
	Data in € per tonne		
	2000	*1996*	*1990*
GDP/DMI – fossil fuels	€ 5,318	€ 2,894	€ 2,147
GDP/DMC – fossil fuels	€ 5,667	€ 3,044	€ 2,225

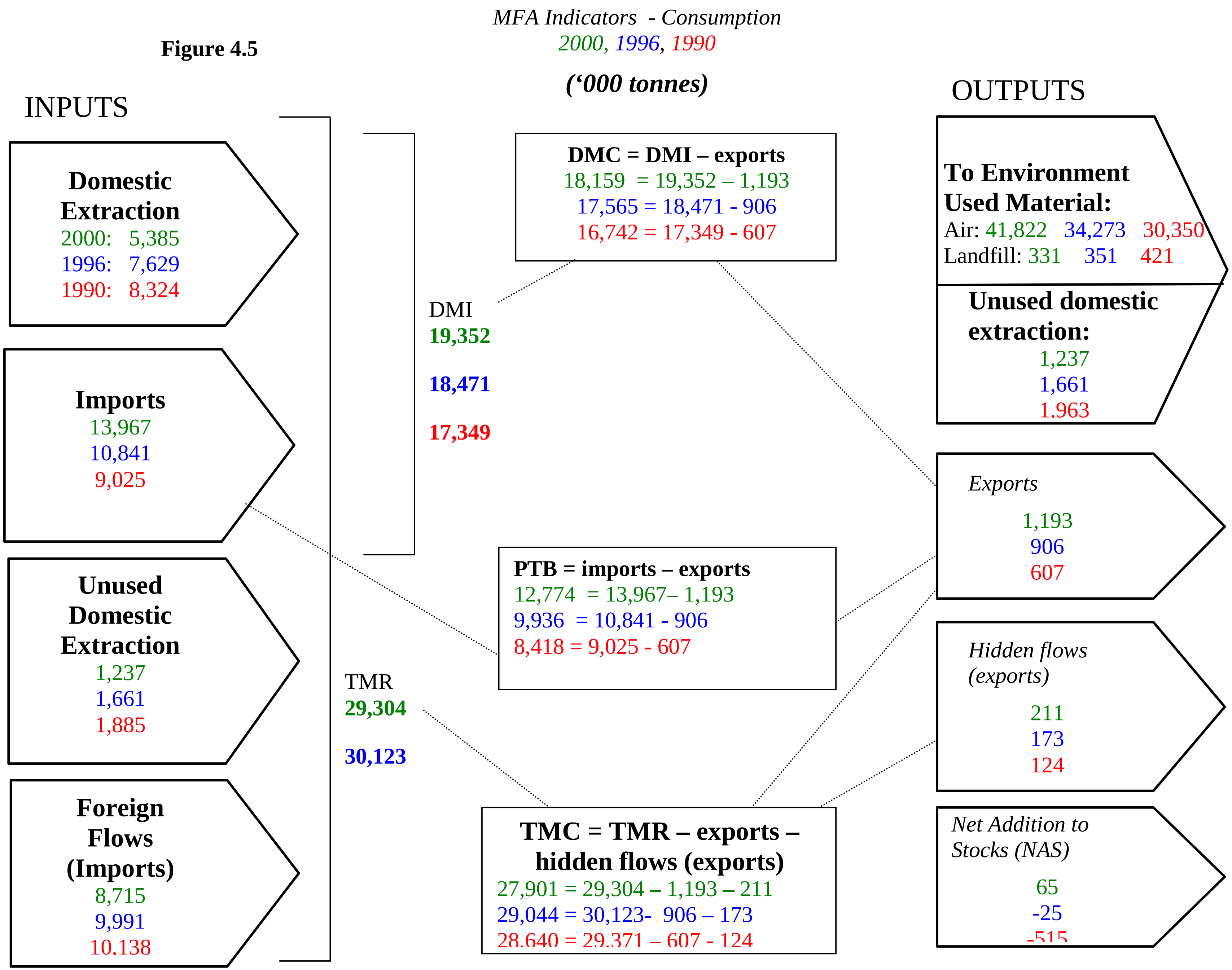
Table 4.7

It can be seen that productivity per tonne of fossil fuels has significantly increased between 1990 and 2000. This is likely as a result of the increasingly knowledged-based rather than manufacturing-based economy.

In order to move to a sustainable economy, the materials productivity indicators should increase with time. Hence the trends for the materials productivity indicators are in a sustainable direction.

It should be noted the above are in relation to fossil fuels only and not all physical materials.

Figure 4.5


MFA Indicators - Consumption
2000, 1996, 1990
('000 tonnes)
INPUTS
Domestic Extraction
2000: 5,385
1996: 7,629
1990: 8,324
Imports
13,967
10,841
9,025
Unused Domestic Extraction
1,237
1,661
1,885
Foreign Flows (Imports)
8,715
9,991
10.138
DMI
19,352
18,471
17,349
TMR
29,304
30,123
DMC = DMI – exports
18,159 = 19,352 – 1,193
17,565 = 18,471 - 906
16,742 = 17,349 - 607
PTB = imports – exports
12,774 = 13,967– 1,193
9,936 = 10,841 - 906
8,418 = 9,025 - 607
TMC = TMR – exports – hidden flows (exports)
27,901 = 29,304 – 1,193 – 211
29,044 = 30,123- 906 – 173
28.640 = 29.371 – 607 - 124
OUTPUTS
To Environment Used Material:
Air: 41,822 34,273 30,350
Landfill: 331 351 421
Unused domestic extraction:
1,237
1,661
1.963
Exports
1,193
906
607
Hidden flows (exports)
211
173
124
Net Addition to Stocks (NAS)
65
-25
-515

4.4 Comparison of Irish Fossil Fuel MFA and Indicators with other Countries

It is instructive to compare the MFA and indicators for fossil fuel use in Ireland with those calculated by ETC-WMF for Ireland, as well as those calculated for other countries and for the EU as a whole.

4.4.1 Irish DMI and DMC

A revised estimate of TMR has recently been compiled (Jan 2003) for the EU[2]. This also calculates DMI and DMC for each of the Member States. It has been generated by the European Topic Centre on Waste and Material Flows (ETC-WMF) and has been input into the Kiev report (a report on the assessment of Europe's environment published by the EEA in 2003 as a contribution to the inter-ministerial conference in Kiev). Apart from DMI and DMC, this report does not calculate any other indicators individually for each country.

For those countries which had not yet calculated MFA indicators on a national level, of which Ireland is one, this report used European and international statistics. In the case of fossil fuels, such data was obtained from the International Energy Agency (IEA) energy balances, Eurostat, and the OECD.

The estimates for Ireland are shown in Table 4.8 along with the corresponding values calculated in this report:

	As calculated in this project			ETC-WMF calculation		
	2000	*1996*	*1990*	*2000*	*1996*	*1990*
Irish Fossil Fuel extraction (‘000 t)	5,385	7,629	8,324	6,107	7,230	8,456
Irish Fossil Fuel imports (‘000 t)	13,967	10,841	9,025	12,478	9,639	8,595
Irish Fossil Fuel DMI (‘000 t)	19,352	18,471	17,349	18,585	16,869	17,051
Irish Fossil Fuel DMI (tonnes per capita)	5.1	5.1	4.9	4.9	4.6	4.9
Irish Fossil Fuel DMC (‘000 t)	18,159	17,565	16,742	16,734	15,275	15,863
Irish Fossil Fuel DMC (tonnes per capita)	4.8	4.8	4.7	4.4	4.2	4.5

Table 4.8

As can be seen the figures are similar in order of magnitude, but there are differences in the detail.

The DCMNR energy balance figures were used for imports and exports rather than CSO data because of data reliability. Eurostat data has been used in the ETC-WMF figures,

[2] Moll 2003 Datasheet for the Kiev Report http://waste.eionet.eu.int/mf/4

which would be based on the CSO data. As outlined in section 4.2, the CSO data underestimates imports - hence the lower ETC-WMF figures. The generation of Irish energy balance figures differs slightly to those published internationally. This is because slightly different conversion factors were utilised by DCMNR for the raw data. Also, petroleum coke was included in ‘coal’, whereas most international publications classify it as oil. Finally, non-energy products were excluded from the energy balance figures, while they are mostly included by international publications in their calculations.

In addition to this, the CSO data on the breakdown of countries of origin was used in calculating hidden flows in this study. In the ETC-WMF calculation, the standard hidden flow values were used.

4.4.2 Comparison with Other Countries

Table 4.9 shows some of the indicators calculated for Ireland in this report along with the corresponding EU-15 values according to the ETC-WMF.

	Ireland As calculated in this project (tonnes per capita)			EU-15 ETC-WMF calculation (tonnes per capita)		
	2000	*1996*	*1990*	*2000*	*1996*	*1990*
Fossil Fuel DMI	5.1	5.1	4.9	-	4.1	4.3
Fossil Fuel TMI	5.4	5.6	5.4	-	11.6	15.8
Fossil Fuel TMR	7.7	8.3	8.3	-	14.8	18.7

Table 4.9

As can be seen, Ireland is above the EU average for DMI. This means the per capita input of fossil fuels from imports and domestic extraction into Ireland's economy is somewhat higher than the EU average. The differences outlined in section 4.4.1 between the figures generated in this report and those of the ETC-WMF will have an effect on the ability to compare results internationally. However, the differences between the Irish figures generated in this report and the ETC-WMF's Irish figures are small overall in comparison to the differences between the ETC-WMF figures for Ireland and other countries. Hence the effect on comparisons should not be significant.

Ireland is well below the EU average for TMI and TMR for fossil fuels. This means that, taking the unused extraction associated with domestic and imported fossil fuels into account, as well as the fossil fuel input into the economy, Ireland is well below the EU average. This implies that the unused extraction associated with Ireland's domestic extraction and imports is low in comparison with other Member States. While a detailed breakdown on the sources of the EU figures is not available, one reason for this significant difference is likely to be the limited amount of domestic extraction of fossil fuels which occurs in Ireland, which is virtually all used in the Irish economy. Conversely, some EU Member States would have significant fossil fuel domestic extraction, which would increase both the TMI and TMR figures, because these indicators do not subtract exports, or hidden flows associated with exports.

Figure 4.6 shows Ireland's position relative to other EU countries in terms of DMI, Direct Material Input (domestic extraction plus imports).

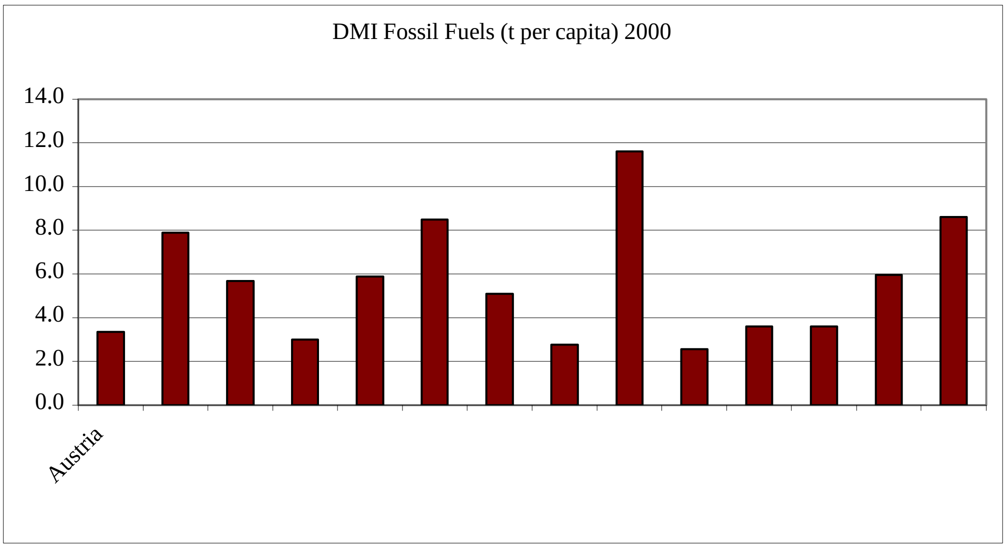
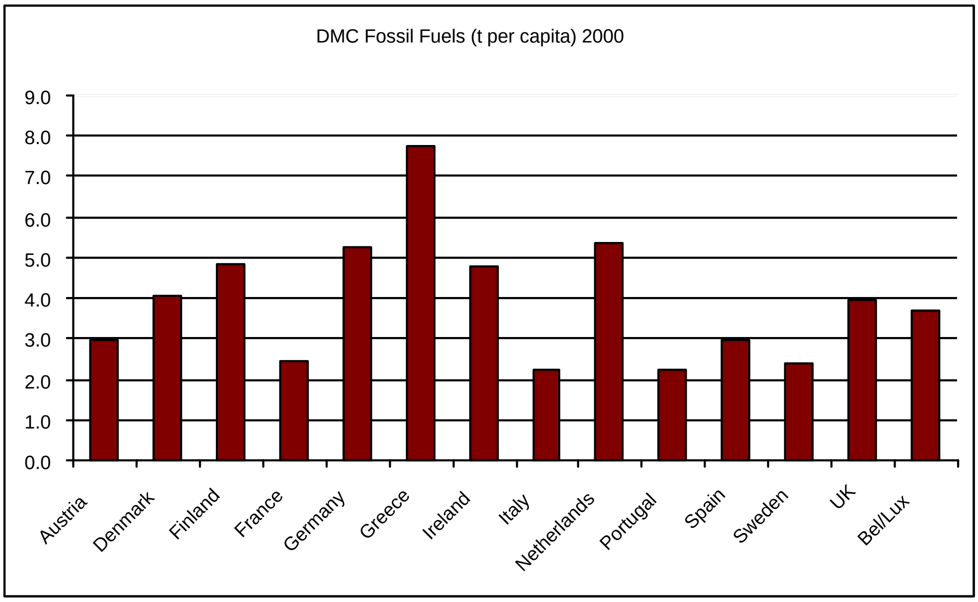


Figure 4.7 shows Ireland's position relative to other EU countries in terms of DMC, Domestic Material Consumption (domestic extraction plus imports minus exports).



As can be seen, Ireland is joint fifth highest out of all EU countries in terms of DMC. This means Ireland has the fifth highest fossil fuel consumption per capita in theEU**.**

4.5 Structure of the Fossil Fuel MFA Spreadsheets & Data Sources Used

The Fossil Fuel MFA has been compiled for the years 2000, 1996 and 1990. A single Excel file is dedicated to each year – MFA2000.xls, MFA1996.xls, and MFA1990.xls. Each of the files has the following worksheets:

- Indicators
- Overall
- Inputs Outputs
- Domestic HFs
- Foreign HFs
- Throughput
- Waste
- Emissions
- Conversion Factors

'Indicators' Worksheet

The 'Indicators' worksheet calculates the input, output, and consumption indicators for fossil fuels in Ireland based on the information in the rest of the spreadsheet.

'Overall' Worksheet

The 'Overall' worksheet calculates the overall MFA for fossil fuels in Ireland based on the information in the rest of the spreadsheet.

'Inputs Outputs' Worksheet

The 'Inputs Outputs' worksheet details the imports, exports (including those to marine bunkers), domestic extraction, and net additions to stocks for fossil fuels in Ireland.

There are two tables in each of the 'Input Output' worksheets. The first one gives all values in tonnes of oil equivalent (TOE), the second in tonnes. A TOE is an international standard measure of energy and is equivalent to 0.041868 TJ or 10^7 kilocalories.

All data assembled in the 'Input Output' worksheets compiled for 2000, 1996 and 1990 are taken from information supplied by the Department of Communications, Marine, and Natural Resources (DCMNR), consisting of energy balances for Ireland for the years in question. The data correlates with the EPA figures reported to the Inter-governmental Panel on Climate Change (IPCC) under the United Nations Framework Convention on Climate Change (EPA 2002a). It has been recommended through contact with the CSO, that the figures used in the DCMNR energy balances are more reliable as a result of industry contacts and should be used in place of the CSO data.

Out of current annual consumption of peat for energy purposes, about 60% is used in power stations (that primarily fire milled peat), 15% is briquetted and 25% consists of sod peat, used predominantly as a residential fuel. Peat briquettes are also almost all used as household fuel. Therefore, the conversion from TOE to tonnes for peat production assumed 75% milled peat and 25% sod peat. The figures in this report include commercial and private peat extraction.

The import data taken from the DCMNR energy balances was further differentiated into bituminous coal and lignite. The breakdown was estimated based on the percentage of each fuel type in the CSO import statistics.

‘Domestic HFs’ Worksheet

This worksheet calculates Domestic Hidden Flows. These are only associated with peat and natural gas.

The extraction data contained in the Domestic Hidden Flow sheets was supplied by DCMNR and correlated with those contained in the EPA data. The hidden flow factor used for peat extraction, 0.25t unused extraction per tonne of used extraction, was taken from a Conaccount workshop paper (Douglas 1997). This value has been used in several other European country MFAs. In the case of domestic extraction of natural gas, the values used are those of the UK for offshore gas extraction (a combined factor of 0.133 t unused extraction per tonne of used extraction, taking into account both drilling wastes and gas flared and re-injected). Some other European countries report different coefficients (as low as 0.001 for the Netherlands and up to 0.862 for Denmark).

‘Foreign HFs’ Worksheet

This worksheet calculates Foreign Hidden Flows associated with all imported fossil fuels.

It has been recommended through contact with the CSO, that the figures used in the DCMNR energy balances are more reliable as a result of industry contacts and should be used in place of the CSO data. An example of this can be illustrated by the import data for hard coal for the year 2000. The CSO figure is 2.1 million tonnes while the DCMNR figure is 3.3 million tonnes. Similarly, the energy balances state that peat imports are zero, while the CSO data has peat imports of ~ 8,000 t (this could be peat which is not for fuel use and has been wrongly classified).

While the CSO import data is broken down by country of origin, the DCMNR is not. Therefore, as a best estimate, the DCMNR tonnage has been split between countries of origin based on the CSO data. Caution was also exerted in the use of the CSO countries of origin, as it could be seen in many cases that rather than being the country of origin, it was the country of import - for example, significant hard coal imports through Northern Ireland.

The data supplied by the Central Statistics Office was analysed and broken into percentage values. These percentage values were then applied to the data supplied by DCMNR to calculate the hidden flows associated with the established import figures.

The hidden flow values used in worksheet ‘Foreign HFs’ were taken from the Wuppertal database. There are hidden flow coefficients for hard coal from UK, France, Germany, Spain, Australia, Russia & the former Soviet Union, USA, South Africa, and Colombia. Ireland has imports of hard coal from all of these countries. There is also a standard hidden flow coefficient which is usually used for all other countries of 0.89. This is used for the imports from all other countries (which accounts for almost 70% of imports).

‘Throughput’ Worksheet

This worksheet calculates the split of each of the fossil fuels used by the various sectors within Ireland.

This data is taken from that reported by the EPA to the Inter-governmental Panel on Climate Change (IPCC) under the United Nations Framework Convention on Climate Change (EPA 2002a).

‘Waste’ Worksheet

The ‘Waste’ worksheet details the solid wastes that are generated as a result of fossil fuel use. These consist of ash from power stations and other large combustion plants as well as ash generated by residential burning of coal and peat, and to a small extent industrial coal burning.

The figure for the ash from power stations was obtained from the EPA’s 2001 national waste database. This figure was used for the 2000 MFA. For 1990 and 1996, this figure was scaled - according to peat, coal, and oil usage for the years in question in power generation. While earlier national waste databases exist for 1995 and 1998, this method of calculation was assumed to be more accurate.

The ash associated with the residential burning of coal and peat, and the small amount of coal burned in industry, was calculated using the amount of such fossil fuels consumed in these applications and the typical ash content of coal and peat of 9% and 1.5% respectively (personal communication with the Electricity Supply Board).

‘Emissions’ Worksheet

The ‘Emissions’ worksheet sets out the emissions to air from each of the sectors as a result of fossil fuel use. It covers CO_2, N_2O, CH_4, SO_2, NO_X, NH_3/VOC, and CO.

The data in the ‘Emissions’ worksheets for CO_2, N_2O, and CH_4 were compiled from the EPA data mentioned above. The data for SO_2, NO_X, NH_3/VOC, and CO were taken from other EPA spreadsheets.

‘Conversion Factors’ Worksheet

The ‘Conversion Factors’ worksheet sets out the factors to convert from tonnes of oil equivalent to tonnes, as well as population and GDP data for the years in question.

The conversion factors used were those supplied by DCMNR (as the Irish conversation factors are slightly different to those used internationally for the reasons outlined in the Energy Balances for Ireland). These conversion factors are as follows.

Crude oil	1 tonne= 1.0226 TOE
Gasoline	1 tonne= 1.065 TOE
Kerosine	1 tonne= 1.0556 TOE
Jet fuel	1 tonne= 1.0533 TOE

Gas/diesel oil	1 tonne= 1.0344 TOE
Residual fuel oil	1 tonne= 0.9849 TOE
Milled peat	1 tonne= 0.186 TOE
Sod peat	1 tonne= 0.313 TOE
Briquettes	1 tonne= 0.443 TOE
Coal	1 tonne= 0.665 TOE
LPG	1 tonne= 1.1263 TOE
Natural Gas	1 tonne= 1.032 TOE

Conversion factors from TOE to tonnes were not provided for refinery gas or naphta. The factor for LPG was used for refinery gas since a review of other data sources showed LPG and refinery gases have similar TOE/t values (IPCC 2001). Similarly the factor for gasoline was used for naphta.

The population and GDP data were obtained from the CSO (personal communication).

5 DEMONSTRATION OF METHODOLOGY: CASE STUDY – REGIONAL WATER FLOW ACCOUNTS

5.1 Introduction

The second case study involved the demonstration of the material flow accounting methodology for water flow accounts for a particular region. The region chosen was the South Eastern River Basin District (SERBD).

5.1.1 The South Eastern River Basin District (SERBD)

Ireland has been divided into five river basin districts for the implementation of the Water Framework Directive. The SERBD is the region that is furthermost along in implementation of the Directive since it was the first SERBD project launched. Hence this is the river basin district chosen for demonstration of water flow accounts.

The SERBD covers the combined river basins of the rivers Slaney, Barrow, Nore and Suir, as well as a number of other smaller rivers near the coast. Counties Carlow, Kilkenny, Laois, Tipperary South, and Wexford are included in this river basin district (RBD) as well as parts of Kildare, Offaly, Tipperary North, Waterford, and Wicklow and a very small part of Limerick. RBDs also include coastal waters. Hence, places such as Rosslare Harbour, Wexford Harbour, Waterford Harbour and Dungarvan Harbour are relevant. The SERBD covers a land area of 12,780 km^2 - about one-fifth of the country - and has a population of 516,117 persons. A map of the SERBD is shown in Figure 5.1 (SERBD border in red, numbers refer to catchment areas).

Figure 5.1: The South Eastern River Basin District (SERBD)

5.2 Water Flow Accounts – Description of Flows

All water flows into and out of the RBD must be taken into account in drawing up the water flow accounts. This will include both natural and anthropological flows of water. The boundary for the water flow accounts consists of the geographical area of the RBD as well as flows into and out of water bodies within the RBD itself. A schematic of the RBD is shown in Figure 5.2.

Figure 5.2: Flows into and out of the SERBD

A list of the water flows in the schematic is given below.

- **Natural water flows into the SERBD**
  - Rainfall
  - Groundwater flows into the RBD
- **Natural water flows out of the SERBD**
  - evapotranspiration
  - surface water flows out of the RBD
  - Groundwater flows out of the RBD
- **Anthropogenic water flows out of the SERBD**
  - Point abstractions:
  - Public water supply abstractions (demand plus system losses)
  - group water scheme abstractions
  - private household water supply
  - private abstractions by industry - surface water
  - private abstractions by industry - groundwater
  - Water consumed by agriculture
  - Water supply to other RBDs

- **Anthropogenic water flows into the SERBD**
  - waste water discharges from industry:
    - IPC licensees - direct to waters
    - Waste Management Licencees - direct to waters
    - Water Pollution Licencees - direct to waters
    - Others (not recorded)
  - urban waste water treatment plant (UWWTP) discharges:
    - domestic/commercial discharges
    - IPC licensees - via sewer
    - Water Pollution Licencees - via sewer
    - Landfill leachate tankered to UWWTPs
    - Surface water run-off
  - Water discharges from agriculture (mostly indirect via landspreading):
    - silage effluent
    - dirty dairy water
    - water content of agricultural organic waste
    - water content of landspread/injected UWWTP sludge
    - water content of landspread/injected organic waste from agri-industry WWTPs.
  - Water supply from other RBDs
- ***"Stock" of water in the SERBD***
  - total groundwaters available in the RBD
  - total body of surface waters available in the RBD
  - water contained in soils.

Note: tidal flows have been ignored in terms of flows due to cyclical nature and because seawater is not abstracted for any uses within the SERBD.

5.3 Water Flow Accounts for the SERBD

A summary of the water flow accounts for the SERBD is shown in Table 5.1.

Water Flow Accounts - 2000 South Eastern River Basin District (SERBD) Data in '000 m3			
Natural Flows into the RBD		**Natural Flows out of the RBD**	
	Data in '000 m3		**Data in '000 m3**
annual rainfall	12,780,000	annual evapotranspiration	6,134,400
Groundwater flows into the RBD	NE	Groundwater flows out of the RBD	NE
		surface water flows out of the RBD	4,187,665
Anthropogenic Flows into the RBD		**Anthropogenic Flows out of the RBD**	
	Data in '000 m3		**Data in '000 m3**
urban waste water treatment plant discharges	**96,855**	**Point abstractions**	**124,607**
IPC licencees - via sewer	*2,488*	total domestic water consumption	25,580
Water Pollution Licencees - via sewer	*1,121*	*domestic water consumption (public water schemes > 5000 pop.)*	*11,386*
Landfill leachate tankered to UWWTPs	*30*	*domestic consump. (public < 5000 pop., group schemes, private)*	*14,194*
dicharges from septic tanks	NE	Public supply (> 5000 pop.) commercial, agri., indust. & munic.	14392
leachate to groundwaters/surface waters from landfills	107	Public water supply (> 5000 pop.) unaccounted for water	23,396
waste water discharges from industry	**42,880**	private abstractions by industry (IPC) - surface water	56,534
IPC licencees - direct to waters	37,245	private abstractions by industry (IPC) - groundwater	4,705
Waste Management Licencees - direct to waters	NE	private abstractions by industry (non-IPC)	NE
Water Pollution Licencees - direct to waters	5,635	**Water consumed by agriculture:**	**36,819**
Water discharges from agriculture	**48,765**	potato crop irrigation	816
Silage Effluent	563	horticulture irrigation	NE
Dairy Dirty Water	4,749	dairy herd	8,673
Water content of Agricultural Organic Waste:	21,628	Beef & other cattle	21,975
dairy herd	*4,262*	Sheep	4,037
Beef & other cattle	*14,273*	Pigs	751
Sheep	*2,341*	Poultry	198
Pigs	*570*	Horses, ponies, deer, mules	368
Poultry	*20*		
Horses, ponies, deer, mules	*162*		
Water content of Landspread/Injected UWWTP Sludge	11		
Water content Landspread Organic Waste - Agri-industry	65		
potato crop irrigation losses	122		
horticulture irrigation losses	NE	Note: NE = Not Estimated	

Table 5.1

5.4 Natural Water Flows Into the SERBD

5.4.1 Rainfall

Mean annual rainfall data for the region together with the total land area gives an annual rainfall of 12,780,000 (‘000 m^3) in the SERBD.

5.4.2 Groundwater Flows into the RBD

Following consultation with GSI and the SERBD project team, at present there is no data available on groundwater flows into or out of the SERBD.

5.5 Natural Water Flows Out of the SERBD

5.5.1 Evapotranspiration

Evapotranspiration is the evaporation of water from the surface and the exchange of water vapour that occurs at the leaves of plants (transpiration). Using the average evapotranspiration rate (Mills 2000) for south eastern region of 48% of rainfall gives an annual evapotranspiration of 6,134,000 (‘000 m^3) for the SERBD for 2000.

5.5.2 Surface Water Flows out of the RBD

Surface water flows out of the RBD have been calculated based on the EPA’s long term hydrometric data (MacCárthaigh 2003) for each of the major rivers in the RBD. Data from the furthermost downstream non-tidal gauges has been used. Values are given in Table 5.2.

Table 5.2: Hydrometric data for the SERBD

Hydrometric area & station	Location	River	Flow (m^3/s)	Flow in 2000 ('000 m3)
HY 12 12001	Scarawalsh	Slaney	11.97	377,486
HA 13 13001	Goff's Br.	Corock (East)	1.35	42,574
HA 13 13002	Foulk's Mill	Corock (West)	1.34	42,258
HA 13 13003	Mullinderry	Owenduff	2.43	76,632
HA 14 14029	Graiguenamanagh	Barrow	34.6	1,091,146
HA 15 15006	Brownsbarn	Nore	31.59	996,222
HA 16 16010	Anner	Anner	5.83	183,855
HA 16 16011	Clonmel	Suir	36.01	1,135,611
HA 16 16020	Kilmacthomas	Clodiagh	3.89	122,675
HA 17 17001	Kilmacthomas	Mahon	2.28	71,902
HA 17 17002	Fox's Castle	Tay	1.5	47,304
			Total flow	**4,187,665**

5.5.3 Groundwater Flows out of the RBD

There is no data available on groundwater flows into or out of the SERBD.

5.6 Anthropogenic Water Flows out of the SERBD

5.6.1 Water Supply Abstractions

The national water study (DOELG 2000) has estimated the following per capita consumption rates for the counties within the SERBD:

Table 5.3: Per Capita Water Consumption Rates

County	**Per Capita Consumption Rates (litres per head per day)**	
	1997	**2018 (predicted)**
Carlow	132.5	148.1
Kilkenny	131.9	148.7
Laois	131.3	148
Wexford	133	150.1
Kildare	131.9	148.7
Offaly	131.3	148
Tipperary North	133.7	151.1
Tipperary South	134.3	151.7
Waterford	132.9	149.9
Waterford city	134.8	152.2
Wicklow	132	149.2
Average for the SERBD	**132.7**	**149.6**

An average of the per capita consumption rates was taken, together with the SERBD population, and an interpolation of the 1997 and 2018 figures, to estimate a total domestic water consumption rate of 25,580 (‘000 m^3) for the SERBD for 2000. This value covers all supply types – public water supplies, group water schemes and private abstractions.

The national water study has also provided information on daily volumetric demand, split into domestic, commercial, agricultural, industrial and municipal use as well as “unaccounted for water” for schemes supplying more than 5000 consumers for 1997 and estimated for 2018. There are 21 such schemes within the SERBD. Based on these figures, and using the populations of the schemes involved, these schemes supply 11,386 (‘000 m^3) of the domestic water consumption for the SERBD for 2000. These schemes also account for a supply to commercial, agricultural, industrial and municipal uses of 14,392 (‘000 m^3) in 2000. Distribution water losses from schemes supplying more than 5000 consumers in the SERBD account for 23,396 (‘000 m^3).

5.6.2 Water Usage by Industry

There are 54 IPC licensees in the SERBD that have process water emissions. A review of public files in the EPA’s Headquarters for these licensees was carried out to obtain information on water consumption. The information was sourced from Annual Environmental Reports for 33 of the companies, and was based on licensed emission values for 21 of the companies, where AERs were unobtainable. The total amount of water consumption was noted, together with the source of supply (municipal, private groundwater abstraction, or private surface water abstraction).

Section 5.6.1 of this report (water supply abstractions) details a total for water consumption by industry from public water supplies in the SERBD that serve populations more than 5000. The methodology used in the national water study to estimate industrial water consumption for each water supply was based on information from the rates departments of each of the sanitary authorities on metered consumption or fixed charges. Some IPC industry will obviously be included within such supplies.

In addition to the above there will also be consumption by non-IPC licensed industry from public water supplies that serve populations less than 5000 and from private industry abstractions. In the absence of data it is unknown if these are significant or not.

5.6.3 Water Consumed by Agriculture

Water consumption in agriculture consists of two main areas:

- *Livestock*
- *Crop Irrigation*

5.6.3.1 Livestock Water Consumption

Water consumption associated with livestock is drinking of water by the livestock and, where relevant, water used for cleaning (e.g. of milking equipment, livestock housing, etc.). The following are published water consumption rates associated with different livestock:

Table 5.4: Typical livestock water consumption rates

Livestock	**Water consumption rates**	
	m^3/animal/year (Brånvall 1999b)	**m^3/unit of production** (Capenhurst 2001)
Dairy cow	30 m^3	0.003 m^3 water per litre of milk produced (drinking & cleaning)
Beef	16 m^3 (sucker cows, heifers, calves)	6.2 m^3 per animal (drinking water, 520 kg animal; up to 1.5 years slaughter age)
Sheep	2.5 m^3	0.46 m^3 per lamb (for a 38.5 kg lamb; including ewes)
Pig	13 m^3 (boars, sows) 0.875 m^3 (fattening pigs) 0.05 m^3 (piglets)	0.48 m^3 per pig (drinking & cleaning; for a 73 kg 'pork' pig)
Poultry (slaughter)	0.04 m^3	0.005 m^3 per bird (drinking & cleaning; for a 2.3 kg meat bird (broiler))
Poultry (Laying hens)	0.1 m^3	0.004 m^3 per dozen eggs (drinking & cleaning)
Horses	16 m^3	-

The 2000 Census of Agriculture (CSO 2003) details the number of animals in each county in Ireland for the following categories of animal: dairy cattle, beef and other cattle, sheep, pigs (boars, sows, fattening pigs, and pigs under 20 kg), poultry (table birds, breeding birds, laying hens, and other poultry), horses and ponies, deer, mules, jennets and asses. Since only parts of certain counties are in the SERBD, the percentage of land area in the RBD versus the total county area was used to estimate the numbers of animals in the RBD. This data was used together with the above water usage rates to give a total for water consumption by livestock in the SERBD.

In order to get a total for numbers of table birds (broilers), which have a lifespan of less than one year, it will be assumed that the number of broilers recorded in the census represents the number of bird places. It takes approximately 35 to 49 days to fatten a broiler - so each place is filled 5.5. times per year. Therefore the total number of broilers in a given year is 5.5 times the census values.

So total water consumption for livestock in the SERBD is 35.4 million m^3 per year.

A summary of water consumption by livestock in the SERBD is shown in Figure 5.3.

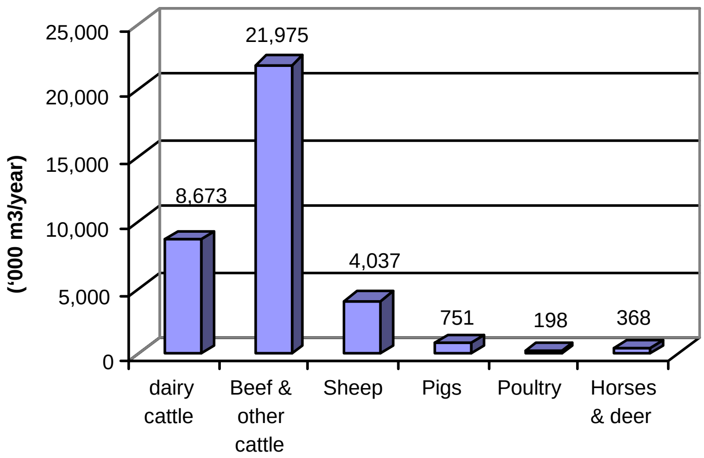


Figure 5.3: Water consumption by livestock in the SERBD

5.6.3.2 Crop Irrigation

While Ireland has plentiful rainfall - even the eastern half of the country has between 750 and 1,000 millimetres of rainfall in the year - irrigation in agriculture is still used in a number of specific applications in Ireland. In terms of commercial field-scale crops, irrigation is only carried out in Ireland for the potato crop. Irrigation is also carried out in horticulture.

(a) Potato Crop

Irrigation is used in the growth of potatoes in Ireland. Potato irrigation has increased in recent years. The main reason for irrigation is to prevent common scab during crop tuber initiation (irrigation for this purpose occurs in June), and a secondary reason is to increase the yield of the potato crop (irrigation for this purpose occurs in July and August). Irrigation is mainly carried out by larger farms only and it is especially carried out in the counties of Louth, Meath, and Dublin (none of these relevant to the SERBD). Irrigation rates differ greatly from year to year, depending on the amount of rainfall, and when it occurs during the season. For example, there was virtually no irrigation carried out in 2002 due to the wet summer. Irrigation rates also vary depending on location factors such soil type, run-off, etc.. However, approximate irrigation figures, which would be applicable for 2000 are as follows (personal communication with Teagasc):

- to prevent common scab : 50.8 mm (equivalent to 2 inches)
- to increase yield : 25.4 mm (equivalent to 1 inch)
- total: 76.2 mm (equivalent to 3 inches)

The main reason for carrying out irrigation, to prevent common scab, is as a result of pressure from the major supermarket chains. The formation of scab is reduced when the soil around the tubers is kept moist as the tubers are forming. While common scab is completely harmless, supermarket chains sell washed potatoes and do not accept potatoes with common scab due to its visual appearance.

According to the 2000 Census of Agriculture, there were approximately 2,500 hectares of potatoes grown in the SERBD on a total of about 900 farms. On a national level, 57% of the land area under potatoes is on large farms (those of 100 hectares or more). It will be assumed that only such larger farms utilise irrigation. Therefore estimated water consumption due to potato crop irrigation in the SERBD is 816 (‘000 m^3).

(b) Horticulture

The 2000 Census of Agriculture (CSO 2003) data was used to estimate the number of hectares within the SERBD under vegetables, fruit, nurseries and other horticultural usage. This was based on the number of hectares within each county under such use and the percentage land area of each county within the SERBD. Estimates are as follows:

	Area in 2000 under:		
	Vegetables for sale	**Fruit (other than apples)**	**Nurseries, horticulture, etc.**
Land area in SERBD	870 hectares	330 hectares	225 hectares

5.7 Anthropogenic Water Flows into the SERBD

5.7.1 Waste Water Discharges from Industry

Waste water discharges from industry include those from IPC licensed companies, companies which operate under water pollution control licences, and waste management licensed companies, as well as from smaller industries which are not licensed. Emissions are either direct to waters or to sewer.

5.7.1.1 IPC Licencees

There are 54 IPC licensees in the SERBD that have process water emissions. There are an additional 42 IPC licensees in the river basin district that do not have any process water emissions. Almost half of the latter are piggeries (20), and while they do not have water emissions, they do landspread their organic waste. This waste will be considered separately under organic waste from agriculture.

Of the 54 IPC licensees with process water emissions, 3 of these companies closed in 2001, 1 in 2002, and 2 were to close during 2003 (three of these are in the textiles sector). Since the water flow accounts are for 2000, these companies will be included. A sectoral breakdown of the 54 IPC licensees is shown in Figure 5.4.

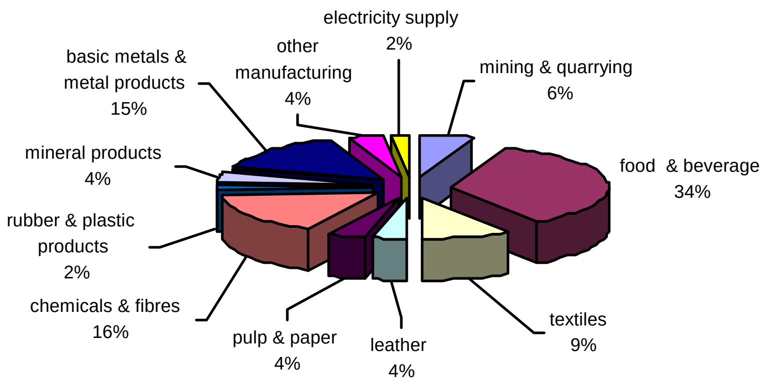


Fig 5.4: Sectoral distribution of IPC licencees with water emissions in the SERBD (based on number of companies)

The distribution of each of the sectors in terms of volume of emissions is shown in figure 5.5. The emissions data for this figure was obtained from a review of public files in the EPA's Wexford office for all of the licensees involved. The information was sourced from Annual Environmental Reports for 33 of the companies, and was based on licensed emission values for 21 of the companies where AERs were unobtainable.

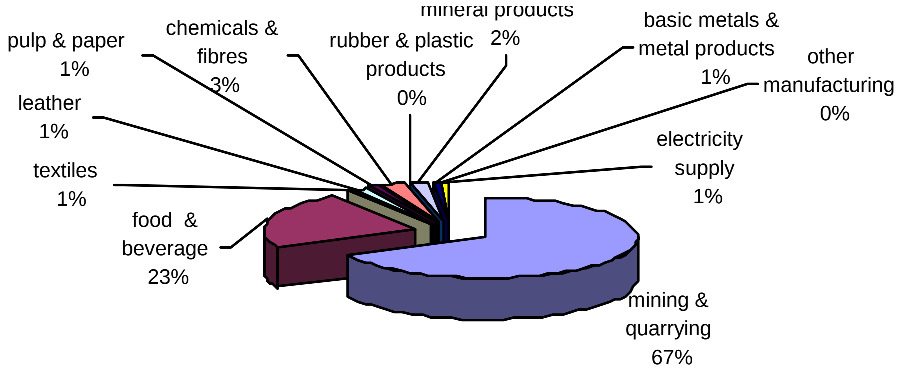


Fig 5.5: Sectoral distribution of IPC licencees with water emissions in the SERBD (based on volume of water emissions [‘000 m^3])

Of the 54 companies, 23 companies emit to sewer while 31 companies emit directly to waters. However, in terms of volume, emissions to waters are far greater than emissions to sewer.

5.7.1.2 Waste Management Licencees

There are three waste management licensees other than landfills (for landfills see later), within the SERBD. All three are waste transfer stations and are licensed for emissions to water. A review of public files in the EPA’s Wexford office for these licensees was carried out. However, no data was available on volumes of water emitted (one licensee commenced records in November 2002, another keeps quality records only, while there is no data for the third). Hence no estimate of emissions from these facilities was made for the study. Since these are waste transfer stations it can be assumed that emissions to water are not significant.

5.7.1.3 Water Pollution Licencees

There are 128 water pollution licences granted within the SERBD for discharges direct to waters (section 4 licences), and 129 water pollution licences for discharges to sewer (section 16 licences). There have been other licences issued in addition to these, but they have been superseded by IPC licences. An estimate of water emissions for the existing water pollution licensees has been made using licenced discharge volumes from a SERBD database. Such information is available for 88 of the section 4 licences and for 89 of the section 16 licences. Emissions to waters from section 4 licensees in the SERBD has been estimated as 5,634 (‘000 m^3). Emissions to sewer from section 16 licensees in the SERBD has been estimated as 1,121 (‘000 m^3).

Sectoral breakdowns of water pollution licensees emitting to waters, and of water pollution licensees emitting to sewer, are shown are shown in Figures 5.6 and 5.7.

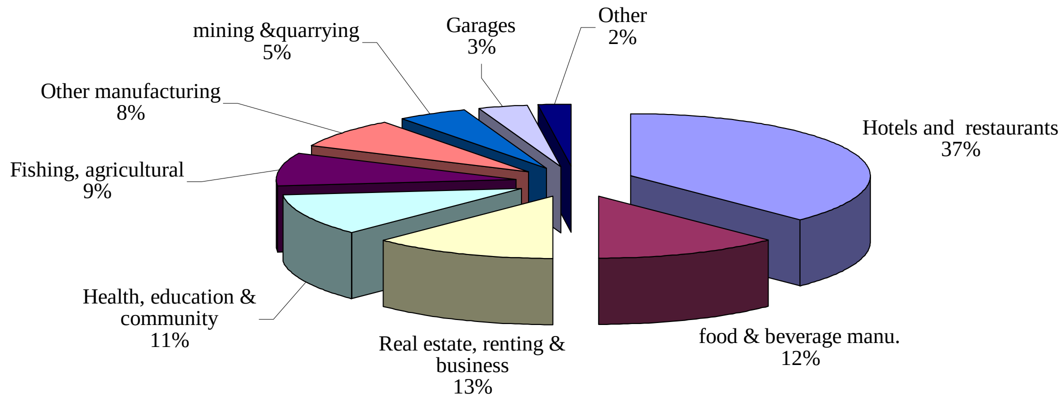


Fig 5.6: Sectoral distribution of section 4 Water Pollution licencees (direct to waters) in the SERBD (based on number of companies)

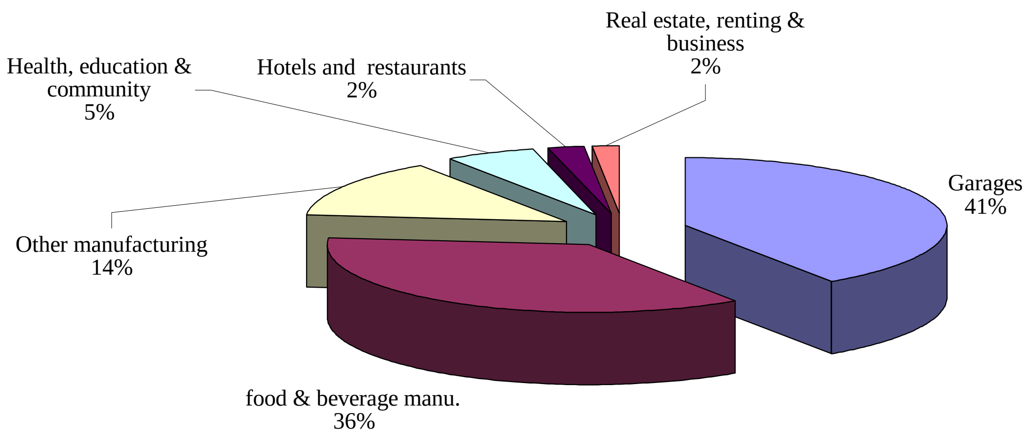


Fig 5.7: Sectoral distribution of section 16 Water Pollution licencees (to sewer) in the SERBD (based on number of companies)

Figure 5.8 shows the sectoral distribution in terms of volumetric flows for all water pollution licensees, while Figure 5.9 shows the volumetric spilt in terms of licences for emissions to waters and licences for emissions to sewers.

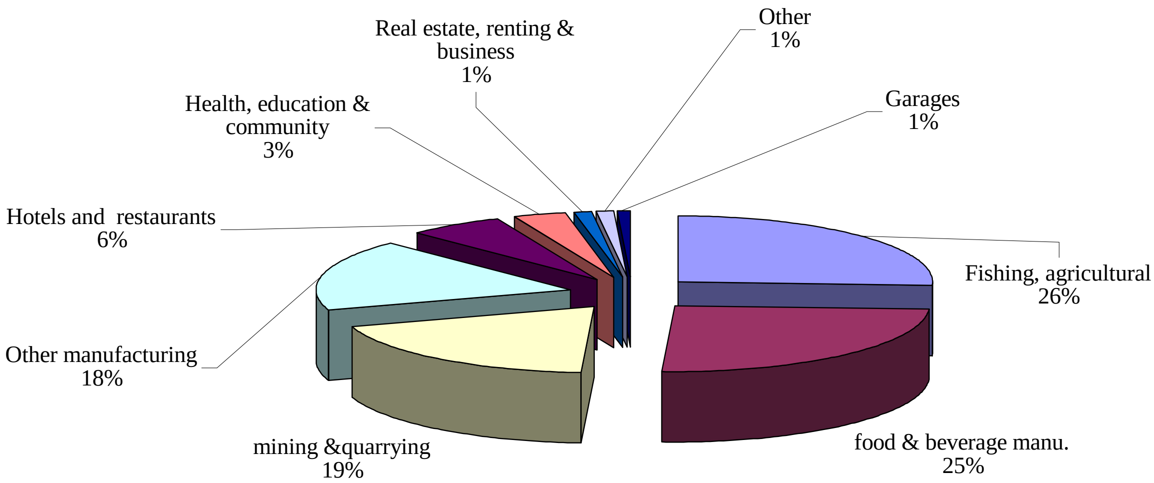


Fig 5.8: Sectoral distribution of Water Pollution licencees in the SERBD (based on volume of water emissions [‘000 m^3])

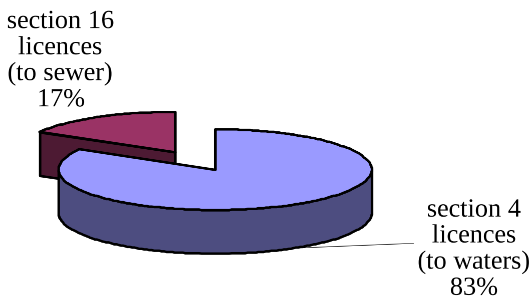


Fig 5.9: Split between section 4 licences (to waters) and section 16 licences (to sewer) in the SERBD (based on volume of water emissions [‘000 m^3])

5.7.2 Urban Waste Water Treatment Plant (UWWTP) Discharges

Urban waste water treatment plant (UWWTP) discharges have been calculated for the SERBD using a SERBD database of emissions from such plants. The database ranges from septic tanks to plants for large agglomerations, and from pumping stations only to plants with primary, secondary and tertiary treatment. The database covers 256 discharges with sizes ranging from 12 to 130,000 population equivalents. However, there are data gaps, with data on design population equivalents available for only 214 of the plants, and on operating population equivalents for only 83 of the plants. A conversion from operating/ design population equivalent to volumes of water was made using a published typical per capita wastewater flowrate (Metcalf & Eddy 1991)[3]. This has resulted in an estimated flow of water from urban waste water treatment plant (UWWTP) discharges of 96,855 ('000 m^3). A breakdown of the flows based on destination is shown in Figure 5.10.

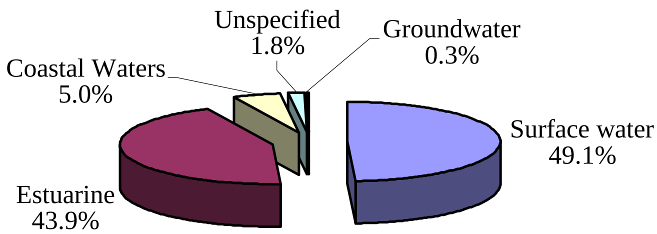


Fig 5.10: Discharges from urban waste water treatment plants (UWWTPs) in the SERBD (based on volume of water emissions ['000 m^3])

Some of the components of discharges to UWWTPs are further detailed in other sections of this report (IPC licensee discharges via sewer and Water Pollution licensee discharges via sewer). The following section details landfill leachate tankered to UWWTPs.

5.7.2.1 Landfill Leachate Tankered to UWWTPs

There were 10 landfills operational within the SERBD in 2000. A review of the public files in the EPA's Wexford office was carried out for these licensees, as well as for landfill licences that have since been granted in the SERBD. The information was sourced from Annual Environmental Reports. Information on leachate produced, on leachate destination (treated on-site or tankered off-site), and on indirect emissions to groundwater was available for 7 of the 10 landfills. In 2000, 30 ('000 m^3) of landfill leachate was tankered to UWWTPs while a further 107 ('000 m^3) was discharged to groundwaters/surface waters from landfills.

5.7.3 Water Discharges from Agriculture

Water discharges in agriculture include the following:

- silage effluent
- dirty water from dairy farming

[3] The suitability of this value may require more investigation.

- water content of landspread/injected agricultural organic waste
- water content of landspread/injected UWWTP sludge
- water content of landspread/injected organic waste from agri-industry WWTPs
- *run-off from crop irrigation*

In many of the above cases involving spreading/injecting on land, discharges are not direct to any surface waters or groundwaters. Hence not all such water will find its way to surface/ground waters, due to soil absorption, evapotranspiration, etc.

5.7.3.1 Silage Effluent

Based on the 2000 Census of Agriculture, the SERBD contains 21% of the total land area under silage. It is estimated on a national level approximately 20.65 million tonnes of fresh grass is harvested per annum and put into silage pit. This produces 130 litres of silage effluent per tonne. Therefore, estimated water generated as silage effluent in the SERBD is 563 ('000 m^3). Silage effluent is usually landspread.

5.7.3.2 Dairy Dirty Water

It is estimated that 45 litres of dirty water from the cleaning of dairies, etc. is produced per cow per day (EPA 2001). Based on the 2000 Census of Agriculture, the SERBD contains approximately 289,000 head of dairy cattle. Therefore, estimated dairy dirty water generated in the SERBD is 4,749 ('000 m^3). Dairy dirty water is usually collected and landspread.

5.7.3.3 Water Content of Agricultural Organic Waste

Organic waste produced by livestock is either deposited directly on land by livestock or is managed and subsequently landspread/injected for housed livestock. The following table shows values of organic waste produced per animal per week together with the solids content of such wastes.

	Organic waste produced (Litres/head/week)	**Solids content (%)**
Dairy cows	315	10%
Other cows & bulls	280	10%
Dairy heifers, other heifers, & cattle 1 yr & over	250	10%
Cattle under 1 year	140	10%
Sheep (hill and lowland)	17 - 28	25%
Horses	193	30%
Poultry – laying hens	0.8 – 0.89	30%
Poultry – breeding stock	0.45 – 0.85	60%
Poultry – broilers	0.45 per bird place	30%
Pigs	m^3 for all pigs per yr = 15 m^3 x no. of sows	6%

Table 5.5 Organic waste produced by animals on a weekly basis (EPA 2001)

These values used together with the numbers of animals in the SERBD from the 2000 Census of Agriculture gives the following amounts for the water content of agricultural organic waste as shown in figure 5.11.

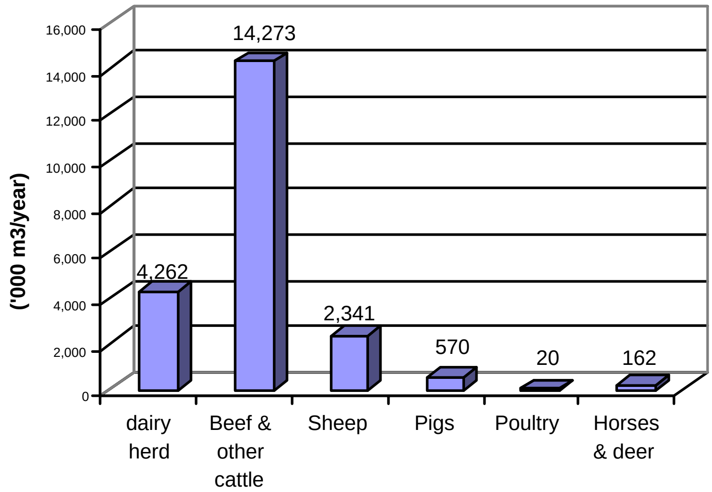


Fig 5.11: water content of agricultural waste from livestock in the SERBD

5.7.3.4 Water Content of Landspread/Injected UWWTP Sludge

It is estimated that in 2000, 40% of urban waste water treatment plant (UWWTP) sludge is landspread or injected in agricultural applications with the remaining being landfilled (EPA 2003). Data for 2000 on the quantities of UWWTP sludge reported by local authorities was used. Since only parts of some counties are in the SERBD, the percentage of land area in the RBD versus the total county area was used to estimate the total UWWTP sludge generated. The local authority values are in tonnes of dry solids. UWWTP that is landspread typically contains 80% water. Based on this data, the estimated water contained in UWWTP sludge landspread or injected in the SERBD is 11 ('000 m^3).

5.7.3.5 Water Content of Landspread/Injected Organic Waste from Agri-industry WWTPs

It is estimated that 90% of agri-industry waste water treatment plant sludge is landspread or injected in agricultural applications with the remaining being landfilled. The total agri-industry sludge generated on a national level is 605,306 tonnes (wet) for 1998 (it will be assumed that 2000 values are similar). Agri-industry water content varies, but a typical value of 90% water will be used. For the SERBD, the amount of agri-industry generated will be estimated based on population. The estimated water content of agri-industry sludge landspread or injected in the SERBD is 65 ('000 m^3).

5.7.3.6 Run-off from Crop Irrigation

As outlined earlier, irrigation is carried out in potato farming and in horticultural applications. Not all irrigation water will be absorbed by the crop, with some lost to run-off, or lost to evaporation.

(a) Potato Crop

In the case of irrigation to increase yield approximately 15% of the irrigated water is lost during application. Factors such as inaccurate scheduling, too low a pressure, incorrect nozzle sizes, and increased application amounts will increase the run-off value. It will be assumed that a similar percentage of the irrigation water used to prevent common scab is lost during application (although it is likely to be higher since the crop is younger). Therefore estimated water loss from potato crop irrigation in the SERBD is 122 ('000 m^3). The losses will include water lost as run-off and water evaporated.

(b) Horticulture

No information.

Figures 5.12 and 5.13 represent the total and anthropogenic flows through the SERBD respectively, in the form of Sankey Diagrams.

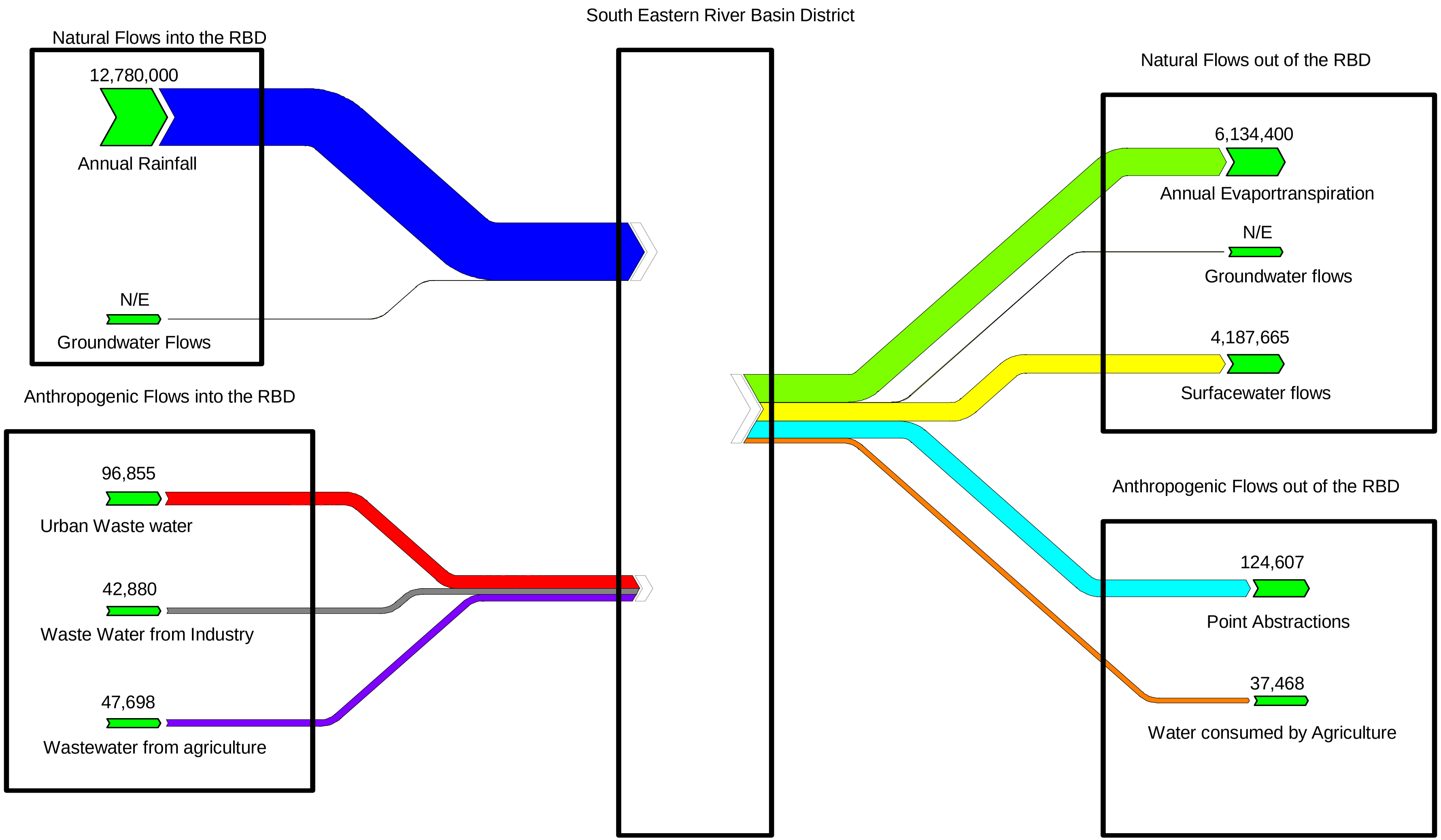


Figure 5.12: Total Flows

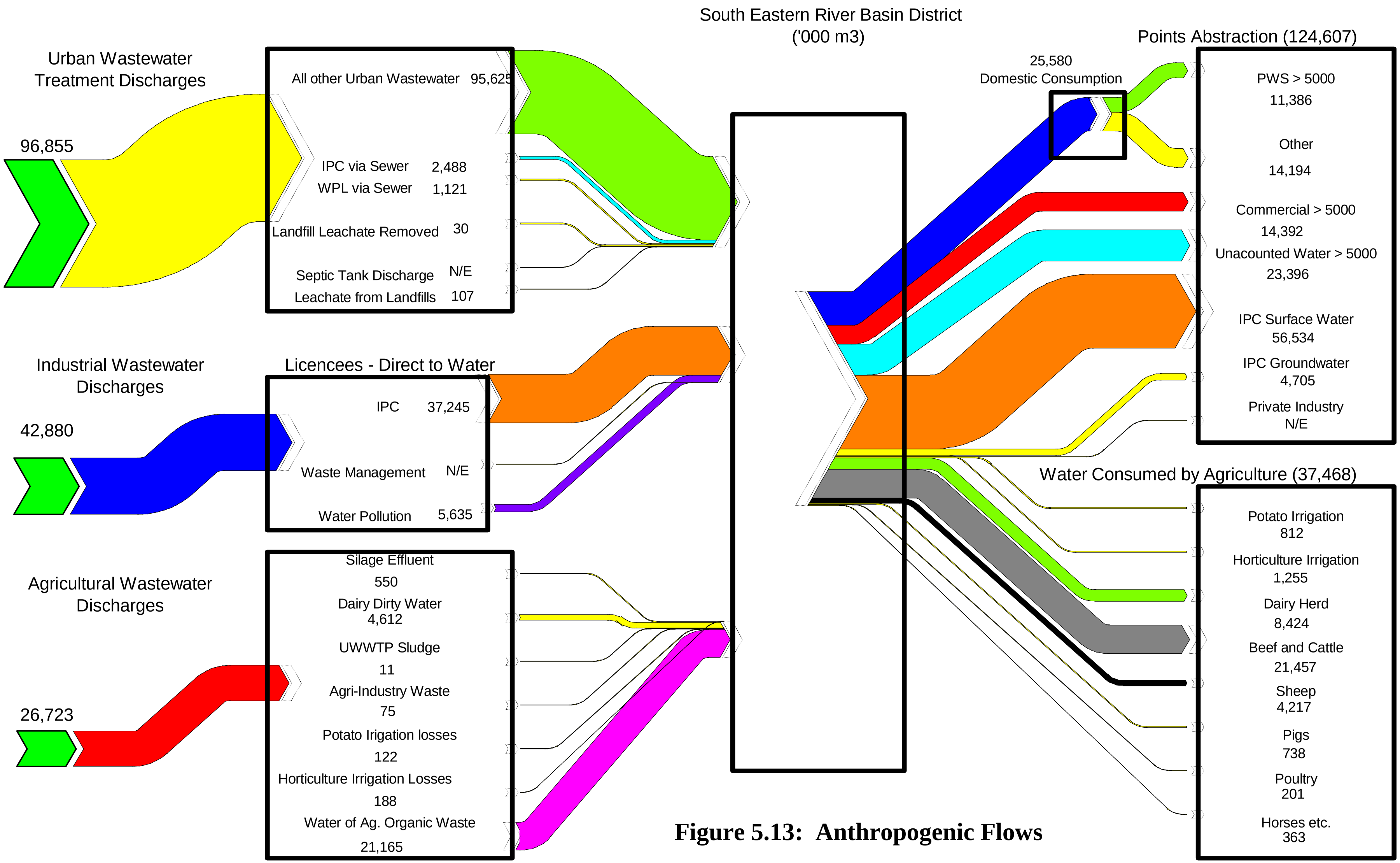


Figure 5.13: Anthropogenic Flows

5.8 An Example of Sectoral Flows within the SERBD - Brewing

The previous sections detailed all anthropogenic water flows into and out of the SERBD. An example of using MFA for water flows to and from a particular sector within the SERBD, the brewing industry, is as follows:

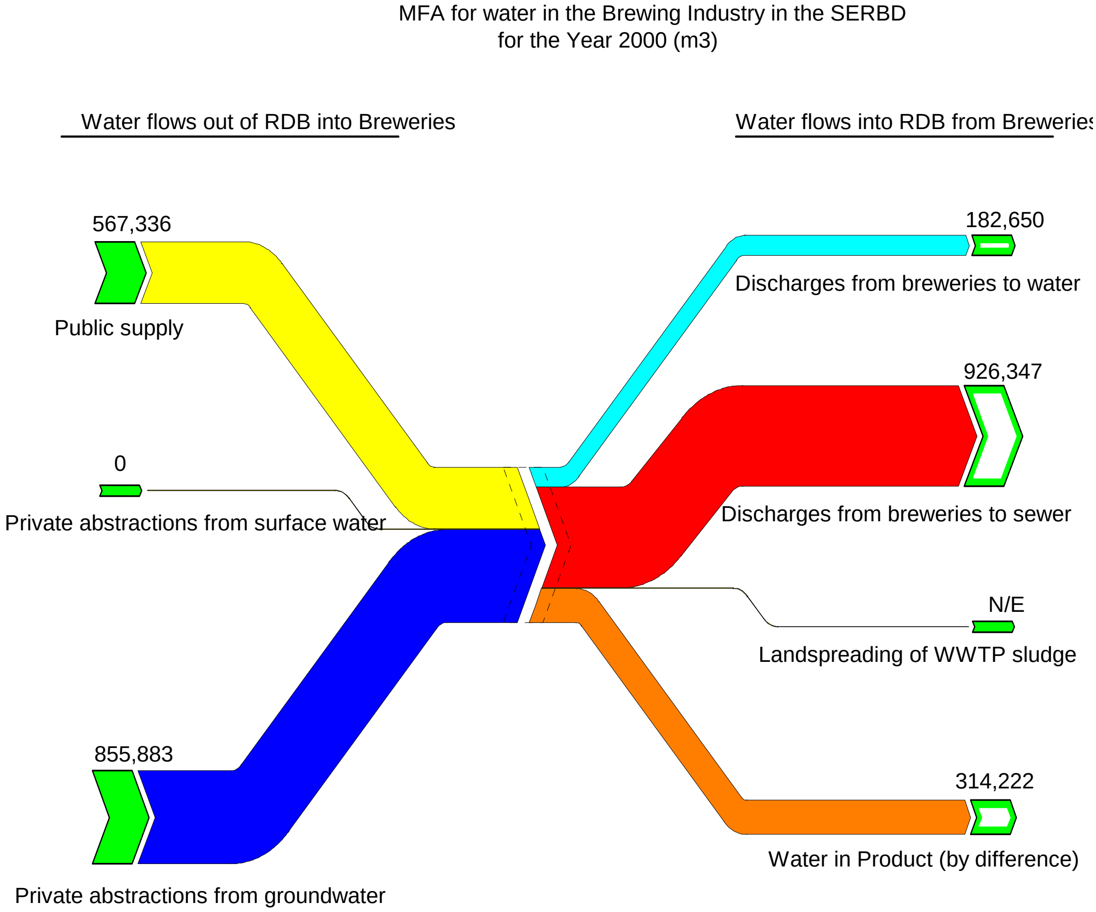


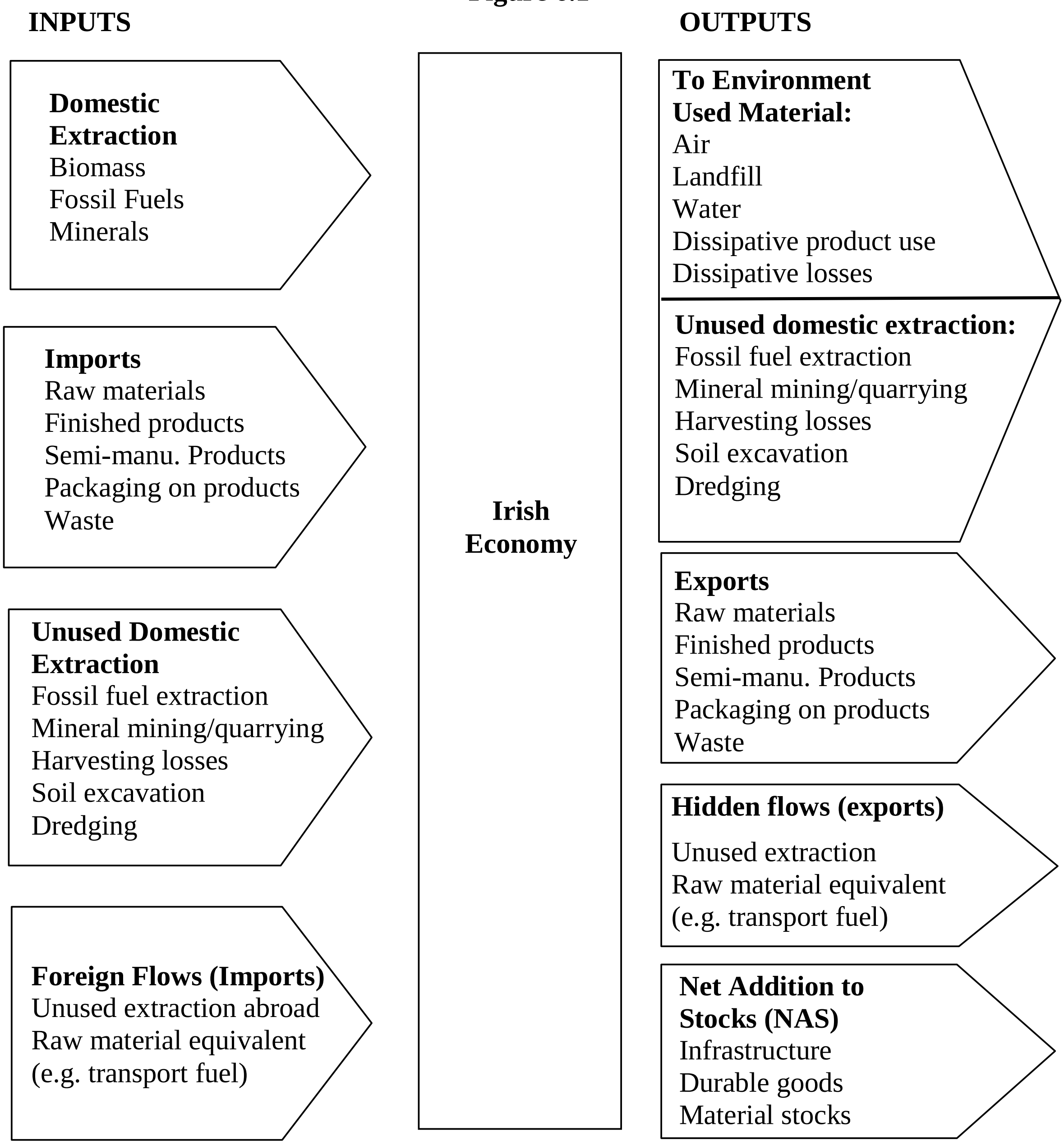
Figure 5.14: SERBD Sectoral Flow (Brewing)

This diagram is based on IPC data from the individual breweries within the SERBD. As can be seen the diagram effectively carries out a water balance for the sector, illustrating the difference between the amount of water that ends up in saleable product and that which is discharged back into the SERBD as waste water.

6 TOTAL MATERIAL FLOWS IN IRELAND

This chapter assesses the data sources available for calculating flows of all materials in Ireland and makes an initial estimate of such flows where data availability permits. The overall schematic of the MFA is illustrated in Figure 6.1.

Figure 6.1



Each of the headings in Figure 6.1 is detailed in terms of data sources, data availability and data reliability.

In addition to data gaps and data reliability, comments are made in relation to any differences between national sources of data and data that has been used in Eurostat estimates of material flows and indicators for Ireland, for example, data from FAO (Food and Agricultural Organisation of the UN).

6.1 Domestic Extraction

In accordance with the Eurostat guide, domestic extraction is split into the categories of fossil fuels, minerals and biomass.

6.1.1 Data Sources for Domestic Extraction – Agricultural Biomass

Agricultural biomass input consists of harvested crops as well as biomass grazed by livestock.

The Census of Agriculture 2000 was used to generate information on the total number of hectares under particular forms of agriculture which do not result in a direct input into the economy, i.e. land used for grazing of livestock, land under silage, animal fodder, etc.

Data on the tonnage of crops produced was obtained from two different sources; the annual CSO survey of the area, yield and production of crops, and the databases maintained by the UN's Food and Agricultural Organisation (http://apps.fao.org/). Each source details for Ireland the tonnage of each particular crop produced in a given year. The yield figures are given on a "green" (as harvested) basis which is in keeping with the Eurostat methodology. Where available from the CSO published data, the figures for a particular crop were used. However, there is detail provided in the FAO database for an additional number of other, lesser crops (in terms of quantities produced). This data was included where not available from the CSO published data. It should be noted that the CSO does maintain databases of such information, as it is the CSO who provides such data to FAO in the first instance. However, this level of detail is not available from the published summary data and was not further pursued as part of this study since FAO data was used instead. Hence, this additional information should be obtained from CSO and used in the event of a total MFA being generated for Ireland.

Information on crop production gathered by CSO now also details (since 1994) the amount of forage plants produced in Ireland. Silage and hay are the main items in this category of forage plants. It also includes fodder beet, fodder rape, fodder kale, and use of cereals within farms.

The only other category of agricultural biomass production for Ireland is grass consumed by livestock. This is a significant agricultural biomass input for Ireland with over four fifths of utilised agricultural land area under grass. Data on the total number of hectares under pasture and rough grazing has been obtained from the 2000 Census of Agriculture. This information is also available for other years in the annual CSO surveys of Land Utilisation & Livestock Numbers. In order to generate estimates of the amounts of biomass consumed by livestock, average grass yields per hectare have been obtained in terms of kg of dry matter. In accordance with the Eurostat MFA methodology, a standardised water content of 15% rather than dry mass should be utilised for grass. According to Teagasc (Teagasc 2003), average grass contains 20% dry matter and 80%

water. Therefore the values have been appropriately converted. Over 95% of forage grass seed sold in Ireland are perennial ryegrasses, which have a high yield and long season compared to indigenous grasses, and can produce up to and above 20,000 kg of grass dry matter per hectare per year (kg DM/ha/yr) under ideal conditions in Ireland. Such swards have typical yields of 10,000 - 14,000 kg DM/ha/yr. A sward without artificial nitrogen or clover would typically grow approximately 5,000 kg DM/ha/yr. However, most Irish grassland is old pasture and only about 3% of agricultural land is reseeded annually, primarily for winter-feed production. As a result, animals tend to graze old pasture for most of the season. Old pasture generally contains high proportions of inferior grasses which have lower yields.

The variability of yield depends on location in the country, weather, drainage, soil fertility, fertiliser usage, herbage varieties and grassland management. In addition to yield, the percentage utilisation of the grass is also brought into consideration, which is typically 75%. The percentage that is not utilised could be considered a hidden flow.

6.1.2 Data Gaps & Data Reliability for Domestic Extraction - Agricultural Biomass

Initial estimates on average grass yield per hectare is based on Teagasc literature. When compiling total material flows for Ireland in future, these should be confirmed with Teagasc personnel, since biomass input for Ireland from this source is significant.

Information on crop production gathered by CSO details the amount of forage plants produced in Ireland. Silage and hay are the main items in this category of forage plants. As outlined above, it also includes fodder beet, fodder rape, fodder kale, and use of cereals within farms. The published CSO summary data reviewed for this report only provides tonnage information for fodder beet. Information on other forage plants are reported in monetary terms. Hence, this initial estimate for domestic extraction from agricultural biomass has determined the contribution from grass silage and maize silage based on the number of hectares - according to the 2000 Census of Agriculture, and an average yield per hectare taken from Teagasc publications. It does not include an estimate for hay (as no information on yields could be obtained), or estimates for fodder rape, fodder kale, and use of cereals within farms (as no information on hectares or yields could be obtained). This additional information should be obtained from CSO, as should official estimates for grass silage and maize silage, if a total estimate of MFA is to be generated for Ireland.

Other than such forage plants, there are no other significant crops that have been omitted from this initial estimate.

Tonnage data is generated by the CSO, based on areas under particular crops and average yields per hectare. Where present for a particular crop type, the CSO and FAO data were identical.

6.1.3 Data Sources for Domestic Extraction –Biomass from Fishing

Statistics on biomass input to the economy from fishing are obtained from the CSO annual statistics on fishing. Quantities reported in terms of tonnes of live mass were used rather than landed mass since this is consistent with the Eurostat MFA methodology. The types of fishing included are sea fish landings, aquaculture production and inland fish catches. The CSO sea fish landings statistics are collected by the Department of the Marine and Natural Resources. Landings of clams, oysters and salmon have been excluded by the CSO from the sea fish landings figures supplied by the Department. Therefore, marine landings data reported by the Department of the Marine and Natural Resources were used instead of the CSO figures in order to include this data. Landings by foreign boats into Irish ports are not included in the sea fish landings figures for either CSO or FAO data.

In terms of aquaculture production, the CSO data is obtained from Bord Iascaigh Mhara's annual surveys of finfish and shellfish farms.

The CSO data on inland fish catches is based on information from the Fisheries Research Centre.

6.1.4 Data Gaps & Data Reliability for Domestic Extraction - Biomass from Fishing

The FAO data on total fish catch for Ireland from all fishery areas yields a different value from either the CSO or the DCMNR figures. Some of the reasons for this are outlined in the previous section. Any other reasons for these differences as well as the most appropriate figures to be used would need to be determined as part of a total MFA.

For Ireland, the harvesting of seaweed is another source of biomass input to the economy which is not specifically mentioned in the Eurostat methodological guide. Seaweed input as a raw material should be included in domestic extraction figures. Seaweed input in terms of fertiliser application should be included in outputs to the environment, dissipative use of products. Data on the total amount of seaweed harvested is detailed in the FAO database. These figures would have to be further investigated to determine the quantity used as a raw material and that used as a fertiliser.

6.1.5 Data Sources for Domestic Extraction – Biomass from Forestry

There are several sources of information on biomass from forestry including CSO's Prodcom[4], Coillte Annual Reports, EPA activity data in relation to emissions of greenhouse gases, and the FAO database. All data is reported in terms of m^3. Information on each source is as follows

- EPA activity data in relation to emissions of greenhouse gases
- Prodcom provides timber production in Ireland under the categories of pinewood, sprucewood and also provides information on some primary timber products such as impregnated rough softwood poles, sawn wood, sawdust etc.. Some statistics are reported in m^3, while others are reported in kg.
- Coillte Annual Reports detail the total sales of sawlog and pulpwood.

[4] PRODCOM stands for PRODucts of the European COMmunity Inquiry. It is an EU-wide survey of manufactured products and is carried out by each national statistical body.

- The FAO database details total roundwood production.

The values reported are shown in Table 6.1.

Data Source	Data description	Quantity (m^3)
EPA GHG activity data	Total stemwood overbark removed in commercial forestry	3,008,451
Prodcom	Various primary wood products (CN codes 4407 and 4403)	847,811
Coillte	Timber sold (sawlog and pulpwood)	2,730,000
FAO database	Total roundwood production	2,600,100

Table 6.1

The most appropriate source of data for *domestic extraction* is deemed to be the Coillte annual report data. This is because it gives the amount of timber that is sold. Other products made from wood are detailed in Prodcom (for example, wood frames, boards, etc.), and from the data provided it is not possible to determine the amount of wood consumed in the manufacture of such products - or indeed if the wood for the manufacture of such products was harvested in Ireland. The FAO database value is slightly lower than the Coillte data; hence, as a worst case, the Coillte data has been taken.

The most appropriate source of data for *unused domestic extraction* is deemed to be the EPA activity data in relation to emissions of greenhouse gases, minus the commercially sold timber as detailed in Coillte annual report. The EPA value details total biomass generated as a result of commercial harvest - not just timber production or sales values.

Data from all sources is reported in m^3 of wood. To convert from m^3 to tonnes, a conversion factor must be used. The literature provides conversion factors which range from 0.11 to 1.33 tonnes of wood per m^3. UK timber statistics utilise 0.909 t/ m^3 to convert to green tonnes of softwood. This value was used in the UK MFA. This will be used instead of the EPA conversion factor which is in terms of dry matter. It will be presumed that all roundwood production in Ireland is from softwood.

6.1.6 Data Gaps & Data Reliability for Domestic Extraction - Biomass from Forestry

The values for forestry data, in terms of $m^{3,}$ differ depending on the source, as outlined in the previous section. The most appropriate source was chosen.

The figures are for biomass removed in commercial harvest only. There is no information available on biomass consumed as fuelwood. It is expected that these values will be small in any case compared to commercial harvest.

6.1.7 Data Sources for Domestic Extraction – Fossil Fuels

Data sources for domestic extraction of fossil fuels are detailed in section 4 of this report.

6.1.8 Data Gaps & Data Reliability for Domestic Extraction - Fossil Fuels

Comments on data sources for domestic extraction of fossil fuels are detailed in section 4 of this report. It should be noted that data for electricity production in Prodcom, the information was deemed confidential**.**

6.1.9 Data Sources for Domestic Extraction – Minerals

Data for the extraction of minerals was taken from CSO's Prodcom, which details production data for several categories within construction mineral production, industrial mineral production, and metal ore production. A comparison was also made with the US Geological Survey Yearbook (one of the sources used in the Eurostat estimate of material flows for individual Member States), which details mineral production for individual countries. Published data from the DCMNR were used for certain minerals. Available annual reports were for 2001 and 2002 data. Gypsum production at Kingscourt open cast gypsum mine for 2002 was utilised. Total lead and zinc ore production (2002, and 2001 values) were used for the two mines concerned. Data was assumed to be similar to 2000 data.

A number of sources within Prodcom are classed as confidential. These include gypsum, lead ore, and magnesia (from seawater and/or magnesium carbonate) as well as some other minerals. Estimates of the quantities involved for other minerals, including magnesia, were made - based on the monetary values for confidential materials, and quantity and monetary values for known quantities of materials within the same 4-digit CN code. Prodcom sales of gypsum were classed as confidential. Hence this method of calculation could not be used. DCMNR data were used instead. Estimates for lead ore were from DCMNR data on lead and zinc ore mining.

The US Geological Survey Yearbook contained data for silver ore production (minor levels). There was no detail in Prodcom on silver ore production. DCMNR industry information did not detail anything on silver ore production - apart from several prospecting licences for silver. Hence, silver ore has been ignored for the time being.

6.1.10 Data Gaps & Data Reliability for Domestic Extraction - Minerals

The CSO Prodcom provides data on several categories within construction mineral production, industrial mineral production, and metal ore production. However, there are a number of sources which are classed as confidential - such as gypsum, magnesia, and lead ore. These will all be significant in terms of domestic extraction mass flows for Ireland. For magnesia and lead ore, estimates have been made as detailed in the previous section.

Published data from the DCMNR were used for certain minerals. Those annual reports available were for 2001 and 2002 data. Gypsum production at Kingscourt, Co. Cavan open cast gypsum mine for 2002 was utilised. Total lead and zinc ore production (2002 and 2001 values) were used for the individual mines concerned. Data was assumed to be similar to 2000 data. Examination of IPC licensing documentation, or direct contact with the limited number of companies concerned for gypsum, magnesia, and zinc and lead ore should provide more accurate estimates.

Estimates of the quantities involved were made, based on the monetary values for confidential materials, and quantity and monetary values for known quantities of materials within the same 4-digit CN code.

The basis for a number of sources within Prodcom should be further analysed, to ensure that mineral inputs to the economy are not being excluded - for example minerals that go into the production of ‘precoated aggregrate’ may not be included in the figures. This may also be true for other products.

It is also unclear from Prodcom if limestone aggregate, used in the production of cement, is included or excluded from the data. Again, examination of IPC licensing documentation, or direct contact with the limited number of cement and lime companies concerned, should determine quantities involved and provide more accurate estimates.

The sources of the data should also be investigated - to determine if small quarries and pits have been included in the estimate for sand and gravel. Definitions used need to be assessed, in order to determine what is included within the scope of a particular item. This is in order to ensure that double accounting of flows is not carried out, or conversely that particular flows are not omitted.

Prodcom does not detail any production in relation to silver or silver ores. However, the US Geological Survey Yearbook has a small amount of silver production detailed for the year 2000 (most likely as an associated product of lead and zinc mining).

When compared to the US Geological Survey Yearbook figures for Ireland, the CSO Prodcom estimate for mineral production is over twice the value of the US estimate. Particular, reasons that could be attributable to this include the fact that the Prodcom data for zinc is for zinc ore, while the US data is for pure zinc product. The Eurostat MFA guide recommends the inclusion of the total amount of material extracted when calculating mineral inputs. Hence the Prodcom figures are appropriate. The sources of data for the Prodcom figures should be further investigated to ensure that total ore is being detailed in all cases. It may be necessary to include additional factors to account for total material extracted.

While Prodcom could continue to keep financial information confidential it may be possible that a total tonnage of material for all confidential products to the level of 2 digit CN codes, or even a total figure of tonnage for all confidential products, could be reported.

6.2 Data Sources for Imports and Exports - All Materials bar Fossil Fuels

Data on all material imports and exports were obtained from CSO data broken down according to Combined Nomenclature **(**CN) codes.

In general, for external trade, tonnage (i.e. net mass) is usually required to be reported by traders - except where it is not of any additional benefit, for example in the case of valuable commodities of small mass (e.g. integrated circuits, musical instruments, disposable cameras). The use of supplementary units is also employed for certain categories of goods. These supplementary units are most often ‘number of items’, but also includes units such as m^3, litres, etc. The use of supplementary units is mandatory for certain codes and optional in others. There is a list of CN subheadings for which the specification of net mass is optional in relation to the reporting of trading of goods between Member States (the Combined Nomenclature system or CN system is the EU’s system for the classification of goods). Additional information was obtained from the CSO on data for particular CN codes which are also reported in supplementary units, and for which net mass reporting is optional. In some of these cases, for example beers, wines and non-alcoholic beverages there the data was only reported in litres. This is one of the CN codes for which net mass reporting is optional. The other area was that of clothes and shoes. Using masses of sample items (direct measurement), estimates of total tonnage was obtained. Therefore in such cases the data in supplementary units have been converted into tonnes. This accounts for an additional quantity of imports of almost 470,000 tonnes, and an additional quantity of exports of almost 460,000 tonnes.

Estimates of imports and exports of waste were taken from the EPA waste database 2001. A large, once-off, shipment that occurred in 2001 of contaminated soil from the development of the Dublin docklands was ignored (this accounts for 24% of all waste exports). Apart from this it was assumed that imports and exports for 2000 were the same as 2001.

6.2.1 Data Gaps & Data Reliability for Imports and Exports

In general, data availability in terms of mass of materials is very good for external trade. Additional information was obtained from CSO for certain CN codes to the four digit level where supplementary units are in use. A cross check between tonnage data and supplementary unit data for a small number of high volume items showed good correlation between the two sets of figures. For those codes where net mass reporting is optional, estimates were made for using these supplementary units and estimates of unit mass.

However, there are some additional CN codes for which net mass reporting is optional which were not sought for this study, but should be obtained in future. In the main, they consist of small-mass, high-value items - such as precious and semi-precious stones, silver, gold, etc. Where these flows become significant is in relation to calculating hidden flows. There are one or two other areas, involving larger mass materials such as floor coverings of textiles, certain pleasure craft, and a small number of electrical equipment categories.

Based on experience it is anticipated the contribution of all these materials will be very small in relation to the overall mass of imports and exports.

It should be noted that MFAs carried out for other countries have usually excluded items for which tonnage data is not reported. This is an area that has been reported as requiring additional investigation. Also, hidden flows for such items, and for finished goods in general, is a largely undeveloped area.

At present, the import and export data which has been gathered has only been broken down into the categories of fossil fuels, waste, and all other materials/products. In order to be consistent with the Eurostat Methodological Guide, as part of any future MFA work, the import and export data should be broken down according to the following categories:

- raw materials
- semi manufactured products
- finished products
- other products
- packaging material with products

Each of these categories should them be further broken down according to the main or predominant constituent, as follows:

- fossil fuels
- minerals
- biomass
- secondary raw materials
- other products of an abiotic or biotic kind

This will be straightforward for some CN codes. In other cases it would probably require going to at least a six digit, or eight digit CN code. It is envisaged that there may be some difficulty in assigning the data to the categories for semi manufactured products, finished products, other products. This will require a degree of interpretation. Assigning the data to the categories of fossil fuels, minerals, biomass, etc., will also require a degree of interpretation.

Packaging material with products imported and exported will not be available from external trade statistics. While information is available on packaging waste arising in Ireland through the waste database, the split between that manufactured in Ireland, and that imported for use, or imported on products is unknown. Packaging on exported products is also currently an unknown quantity. An attempt could be made to estimate quantities arising by carrying out a packaging material balance. Prodcom details a variety of different types of packaging manufactured in Ireland (although there is some confidential data within the CN codes covering packaging). External trade data also details the import and export of packaging (currently this data has only been obtained in an aggregated format - so the specific CN codes covering packaging cannot be isolated). Time lag factors would have to be taken into account.

Similarly material balances could be carried out for other priority waste streams, e.g. construction and demolition waste.

Fossil Fuels

Data sources for imports of fossil fuels are detailed in Chapter 4.

6.3 Unused Domestic Extraction

6.3.1 Data Sources for Unused Domestic Extraction – Harvesting Losses

In terms of biomass, the following materials have to be taken into account for harvesting losses in Ireland:

- wood harvesting losses,
- discarded by-catch in fishing,
- agricultural harvest losses including leaves from sugar beet and fodder beet, and straw associated with cereals that is not used for economic purposes.

For grassland grazing, Teagasc reports that a certain percentage of loss occurs due to trampling and faecal contamination, even with well managed grazing. The Eurostat MFA guide, or the MFAs compiled for other countries that have been reviewed in detail, have not taken into account ‘harvest’ losses associated with grazed grassland. However, since grassland grazing is a significant material input for Ireland, an estimate of associated losses has been included in unused domestic extraction. An average of 25% losses (from Teagasc literature) has been taken.

For wood harvesting losses, the most appropriate source of data for *unused domestic extraction* is deemed to be the EPA activity data in relation to emissions of greenhouse gases, minus the commercially sold timber as detailed in Coillte annual report. The EPA value details total biomass generated as a result of commercial harvest, not just timber production or sales values.

For sugar beet, fodder beet, and straw, factors for unused extraction used in other MFAs were utilised as a first estimate. The total production of sugar beet is equal to the mass of washed and crowned beet delivered to Irish Sugar plc. plus the Irish Sugar plc. estimate of what was not delivered to them. The yield of fodder beet refers to fodder beet roots only. Hence, in both cases, leaves need to be taken into account for indirect flows. In both cases a value of 35% for leaves as a percentage of total biomass was used (as per UK MFA). This factor was also used for turnips. In the case of straw, a factor of 0.46 tonnes of straw that is not economically used per tonne of cereal was used (based on German data).

For discarded by-catch associated with fishing, a factor of 25%, as used in other MFAs, was utilised as a first estimate. This was confined to marine landings only. Aquaculture and inland fishing were ignored.

6.3.2 Data Gaps & Data Reliability for Unused Domestic Extraction – Harvesting Losses

The applicability of the factors used to estimate unused extraction to the Irish situation should be determined by consultation with Teagasc, and for sugar beet, with the sugar industry. In particular for grassland, the figures used for losses should be confirmed in discussion with Teagasc, since biomass input for Ireland from this source is significant.

Losses associated with grassland are not specifically mentioned in the Eurostat Methodological guide or have not been included in the MFAs reviewed. However, since the growth of such ungrazed grass requires input in terms of fertiliser, land area, etc., it should be proposed as a possible consideration in unused domestic extraction in MFAs.

Harvest losses associated with crops other than those mentioned have not been included in MFAs compiled for other countries. Hence they will be ignored for this first estimate. In any case, production of such crops is much lower, with the exception of potatoes - which is of a magnitude just slightly higher than fodder beet. Discussion with Teagasc may yield a factor for unused domestic extraction associated with the potato crop.

6.3.3 Data Sources for Unused Domestic Extraction - Fossil Fuels

Data sources for unused domestic extraction of fossil fuels are detailed in Chapter 4.

6.3.4 Data Gaps & Data Reliability for Unused Domestic Extraction – Fossil Fuels

Data gaps & data reliability, in relation to unused domestic extraction of fossil fuels, are detailed in Chapter 4.

6.3.5 Data Sources for Unused Domestic Extraction - Minerals

Since the Eurostat methodological guide utilises total ores extracted as domestic extraction input into the economy, then unused domestic extraction associated with the mining of mineral ores consists of overburden that has to be removed to access the metallic ore. There is no data available at present. Information from individual companies would have to be obtained in the event of compiling a total MFA for Ireland.

6.3.6 Data Gaps & Data Reliability for Unused Domestic Extraction – Minerals

Inspection of individual IPPC licensing data or discussion with the operators of metallic and mineral mining operations may yield more applicable information on the factors to be used to estimate hidden flows.

6.4 Material Outputs to the Environment

6.4.1 Data Sources for Used Material Outputs to the Environment - Landfill

Data on waste landfilled was taken from the EPA’s National Waste database 2001.

6.4.2 Data Gaps & Data Reliability for Used Material Outputs to the Environment – Landfill

The 2001 database values were assumed to be representative of 2000.

6.4.3 Data Sources for Used Material Outputs to the Environment - Air

Data on emissions of greenhouse gases in Ireland is compiled by the EPA for reporting under the UN Framework Convention on Climate Change (UNFCCC). This includes emissions of:

- carbon dioxide,
- methane,
- nitrous oxide,
- NMVOCs,
- the industrial gases
  - PFCs,
  - HFCs,
  - SF_6.
  - carbon dioxide (CO2),
  - methane (CH4),
  - nitrous oxide (N2O),
  - perfluorocarbons (PFCs),
  - hydrofluorocarbons (HFCs)
  - sulphur hexafluoride (SF6).

Also, information on emissions of carbon monoxide (CO), nitrogen oxides (NOx) and non-methane volatile organic compounds (NMVOCs)is provided under the UNFCCC.

Data on SO_2, NO_x, NMVOC, CO and NH_3 and PM_{10} emissions in Ireland is also compiled by the EPA for reporting purposes under the Long Range Transboundary Air Pollution Convention. Emissions data is available according to different sectors as defined under the convention.

6.4.4 Data Gaps & Data Reliability for Used Material Outputs to the Environment – Air

The Eurostat guide classifies VOC emissions to air as a dissipative use, rather than under air emissions. However, the guide acknowledges that, in practice, data availability may require the classification to be adapted, and for solvent emissions to be included in air emissions. In the case of Ireland, VOC emissions to air arise from dissipative uses such as, for example, paint use by the general public - as well as from point sources such as, for example, discharges from printing companies. Data on emissions is available -

categorized by emissions sources. Therefore, it is possible to split the data on VOC emissions accordingly. However, for the purposes of this initial estimate, NMVOC emissions have been included under air. Similarly the UK MFA study has retained NMVOC emissions under Air - rather than dissipative use.

6.4.5 Data Sources for Used Material Outputs to the Environment - Water

Disposal of sewage sludge to sea ceased during the period 1998 – 1999, with no sea disposal in 2000.

EPA published data on urban waste water treatment emissions does not detail total emissions to waters in terms of tonnes of BOD, COD, nitrogen and phosphorus, and suspended solids. However, the raw data submitted to the EPA will have information from each urban waste water treatment plant discharge. This data could be assessed and figures generated in the event of compilation of an MFA for Ireland.

6.4.6 Data Gaps & Data Reliability for Used Material Outputs to the Environment – Water

No initial estimate has been made for emissions to water. Data at a more detailed level, in terms of the raw figures on urban waste water treatment submitted by local authorities to the EPA, could be used to generate an estimate of loads of nitrogen, phosphorus, BOD and COD.

In terms of industry, information on emissions to waters could be taken from AER data for IPC licensed industry that discharge directly to waters rather than to sewer. Gaps would still remain for discharges direct to waters from non-IPC industry.

In terms of run-off from landspreading of organic material, it is unclear in the Eurostat guide if it should be considered in terms of emissions to waters. However, from a mass balance point of view, if landspread manure and sewage sludge are already included as outputs to the environment under dissipative uses, then the inclusion of the nitrogen and phosphorus in runoff from the landspreading of such wastes as emissions to waters would be double accounting. For information purposes, discharges to waters of nitrogen and phosphorus should still be included. However, when calculating indicators, only nitrogen and phosphorus from direct discharges should be included. Information on nitrogen and phosphorus run-off is available in the EPA’s phosphorous balance (EPA 2001).

It should be noted that the 2000 Census of Agriculture has been published since the EPA carried out the phosphorus balance. Therefore revised estimates of the quantities of organic farm waste produced could be made based on the livestock figures of the 2000 census.

6.4.7 Data Sources for Used Material Outputs to the Environment - Dissipative Use of Products

There is FAO data available on the consumption, production, import and export of fertilisers in Ireland in terms of tonnes. This is split according to fertiliser types. The FAO data for pesticides consumption for Ireland is given by pesticide type.

The use of sewage sludge in agriculture in terms of dry solids is reported in an EPA publication on urban waste water (EPA 2002b). This report is also referenced in the EPA waste database 2001. Hence it is used as the most appropriate source of data. The corresponding average solids content of sewage sludge was taken from the EPA waste database 2001.

Estimates for the total quantity of agricultural wastes (manure, silage effluent, dirty dairy water) landspread nationally, in terms of fresh mass, has been taken from the EPA phosphorous balance.

Estimates of landspread agri-industry and other industrial sludge was taken from the EPA waste database 2001.

6.5 Areas excluded in the Preliminary Estimate of Total Material Flows in Ireland

The original aim of this part of the project was to assess data gaps and data availability for total material flows. This part of the project has been taken one step further by generating initial estimates for a number of the flows into and out of Ireland.

The following areas have been identified from this initial data sourcing exercise as those where no information currently exists for Ireland:

- Net addition to stocks - infrastructure, durable goods and material stocks. No information has been obtained for this area, other than material stocks for fossil fuels.
- Hidden Flows (exports) – unused domestic extraction. No information has been obtained for this area, other than for fossil fuels. In most national MFAs, international factors have been used.
- Foreign Hidden Flows (imports) – unused extraction abroad. No information has been obtained for this area, other than for fossil fuels. In most national MFAs, international factors have been used.
- Unused domestic extraction – soil excavation and dredging.

Each of these areas are likely to be significant. Any future MFA for total material flows in Ireland should attempt estimates for these flows. The suitability of the use of international factors for Ireland should also be investigated.

6.6 Preliminary Estimates of Total Material Flows in Ireland

Table 6.2 illustrates the total flows of materials into and out of the Irish economy in the year 2000.

2000					
Inputs			**Outputs**		
	000 tonnes	**000 tonnes**		**000 tonnes**	**000 tonnes**
Domestic extraction		**107,419**	**To Environment - Used Material**		**119,494**
biomass	64,293		Air	47,059	
Fossil Fuels	5,385		Landfill	8,278	
Minerals	37,741		Water	-	
Imports		**44,487**	Dissipative product use	64,158	
Fossil Fuels	13,967		Dissipative losses	NE	
All other materials/products	30,452		**To env.- unused domestic extraction**		**11,699**
waste	68		Fossil fuel extraction	1,237	
Unused Domestic extraction		**11,699**	Mineral mining/quarrying	NE	
Fossil fuel extraction	1,237		Harvesting losses	10,462	
Mineral mining/quarrying	NE		Soil excavation	NE	
Harvesting losses	10,462		Dredging	NE	
Soil excavation	NE		**Exports**		**13,686**
Dredging	NE		All other materials/products	11,986	
Hidden Flows (Imports)		**NE**	Fossil Fuels	1,193	
biomass	NE		waste	508	
Fossil Fuels	8,715		**Hidden flows (exports)**		**NE**
Minerals	NE		biomass	NE	
Items for Balancing		**29,992**	Fossil Fuels	211	
Oxygen for combustion	29,992		Minerals	NE	
			Net Addition to Stocks (NAS)		**NE**
			Infrastructure	NE	
			Durable goods	NE	
			Material stocks	65	

Table 6.2: Total material flows into and out of the Irish economy, 2000

Based on the data that has been gathered, it is possible to generate estimates for some of the material flow indicators for Ireland for the year 2000. These are shown in Table 6.3.

			'000 tonne	**tonne / capita**
	Indicators		**2000**	**2000**
DMI	(Direct Material Input)	Domestic extraction + imports	151,906	39.0
DMC	(Domestic Material Consumption)	DMI - exports	138,220	35.5
PTB	(Physical Trade Balance)	Imports - exports	30,800	7.9
DPO	(Domestic Processed Output)	Used material flows to the Environment	119,494	30.7
DMO	(Direct Material Output)	Used material flows to the Environment + Exports	133,181	34.2

Table 6.3 Summary of MFA Indicators for Ireland

DMI – a measure of how much material is input into the Irish economy.

DMC – a measure of how much material is consumed in Ireland.

PTB – a measure of whether an economy is a net importer or a net exporter of materials.

6.7 Comparison of Irish Indicators with Eurostat Values for Ireland and with Other Countries

Input and consumption indicators have been calculated in a Eurostat project for each Member State. Output indicators were not included.

6.7.1 DMI - Direct Material Input

Table 6.4 shows values of DMI per capita for EU Member States, as calculated by a Wuppertal project (Moll 2003) for the European Topic Centre. The value of DMI in the table for Ireland is that calculated in this EPA study. The ETC estimate of DMI for Ireland was over half this value - standing at 26.6 tonnes per capita.

	DMI tonnes/capita
Norway	60.2
Finland	42.3
Ireland	**39.0**
Belgium/Luxembourg	34.7
Denmark	30.8
Sweden	28.3
Netherlands	26.3
Austria	22.8
Germany	21.1
Spain	19.2
France	18.7
Greece	18.1
EU15	16.8
Portugal	16.0
United Kingdom	14.9
Italy	14.6

Table 6.4: DMI for EU Member States

The Irish value of DMI is at the upper end. This shows Ireland has a stronger connection between material resource use and economic activity than other EU countries. However not all of the estimates for the other countries include the same extent of products as have been included in the Irish figure in this study (see discussion in Section 6.7.3). DMI is an illustration of the weight of actual material that goes into the Irish economy. It includes material that will be consumed within Ireland, as well as other materials that will go into products and ultimately be exported. Reducing the value of DMI while maintaining or increasing fiscal activity, is to move in the direction of sustainability.

6.7.2 DMC - Domestic Material Consumption

Table 6.5 shows values of DMC per capita for EU Member States, again as calculated by the Wuppertal project. The value of DMC in the table for Ireland is that calculated in this EPA study. The ETC estimate of DMC for Ireland was somewhat lower, standing at 23.5 tonnes per capita.

	DMC tonnes/capita
Ireland	**35.5**
Finland	35.5
Denmark	22.7
Sweden	21.3
Austria	18.1
Germany	17.8
Spain	16.8
Belgium/Luxembourg	16.6
Greece	15.9
EU15	15.6
France	15.3
Portugal	14.5
Netherlands	12.9
Italy	12.6
United Kingdom	11.6
Norway	11.5

Table 6.5: DMC for EU Member States

DMC is an illustration of the weight of actual material that is consumed within Ireland. The Irish value of DMC is joint highest within the EU for 2000. This means that, in 2000, Irish people consumed the highest amount of material resources per person within the EU. However not all of the estimates for the other countries include the same extent of products as have been included in the Irish figure in this study (see discussion in Section 6.7.3). Reducing the value of DMC while maintaining or increasing fiscal activity, is to move in the direction of sustainability.

6.7.3 Comparison of Irish Indicators calculated by this study with Eurostat Values

The values for both DMI and DMC calculated for Ireland by this study are approximately 50% higher than those calculated by the Wuppertal project. The same methodology was used by both studies. However, other products were also included in this study in terms of imports and exports, whereas the Wuppertal figure for Ireland focussed on the major flows of biomass, minerals and fossil fuels only.

In addition to this, different data sources were used in certain instances:

- The category with the largest difference between the two studies was domestic extraction of biomass. The major constituents of the biomass figure are grassland and silage. The area under grass is recorded by the CSO and assumptions were made in this study on yields per hectare. The Wuppertal figure for grass from grazing is also an estimate using the same method, but the exact detail of this estimate was not available in the literature for comparison. Both figures are corrected to a standardised water content of 15%.
- For minerals, there were some additional minerals that were included in this study that were not in the CSO statistics for confidentiality reasons. Sources other than Prodcom were used for such minerals as detailed in Section 6.1.9.
- Fossil fuel data from the Department of Communications, Marine, and Natural Resources (DCMNR) was utilised in this study, whereas the Wuppertal study is based on CSO statistics submitted to Eurostat. After discussion, DCMNR data were considered more reliable than CSO data.

7 EVALUATION AND RECOMMENDATIONS

This chapter details overall conclusions and recommendations in relation to material flow accounting in Ireland, including recommendations for future work.

7.1 Applicability of MFA in Ireland

The whole concept of Material Flow Accounts is embedded in the principles of measurement and reporting. A concerted effort should be made to improve the quality of data, and to enhance its transparency. The continuing evaluation and improvement of data must work in conjunction with performance improvement measures (prevention, recycling, etc.). All countries recognise the need for sets of indicators and tools for data gathering and evaluation, in order to improve environmental performance. In order to have any hope of achieving sustainable development, economic growth must be decoupled from other factors, such as resource consumption and waste generation (the so-called Factor 10+ approach). MFA provides a mechanism for the measurement and reporting of such resource and waste flows. In order for Ireland to effectively compete in terms of environmental performance, it must develop comprehensive sets of material flow accounts. These allow priority areas for action to be identified – just as national fiscal accounts facilitate the prioritisation of economic measures.

MFA provides a basis for policy decisions, and for the framing of environmental improvement programmes. As a simple - if obvious - example, MFAs might show an overdependence in Ireland in the use of fossil fuels. This might then lead to increased measures for the promotion of renewable energy. Many individual company environmental audits have identified areas of resource use or waste production which are far greater than had been thought or anticipated. These audit allowed specific areas to be targetted for reduction. The same is true for all areas of anthropogenic activity. Until a comprehensive set of national and material specific accounts is generated, it is not possible to know, with any certainty, where best to apply resources, and to prioritise action policies. Economic policies are set with regard to economic indicators (GDP, GNP, etc.). The monetary flow through society has been much analysed. In a similar manner, the environmental policies of the future must be based on evaluation of the material and energy flows.

It is essential to decouple economic and material intensity. To do this requires an ongoing and accurate evaluation of material and energy flows. It should be a long term aim to produce economic flows in conjunction with material flows. This will facilitate the decoupling process.

It is recommended that any future MFA accounts for Ireland on a national level follow the Eurostat methodology. There are certain areas as outlined in Section 6 where the preliminary figures for total material flows within this report should be refined and the estimation methods improved.

7.1.1 Conclusions Regarding MFA Applicability in Ireland

The following conclusions can be drawn in relation to the applicability of material flow accounting in Ireland:

- National total material flows are is a key input into international and, in particular, European reporting protocols (for example the Kiev Report). Many countries have been engaged in such accounting for several years. Ireland needs to develop a well defined set of MFAs to meet reporting requirements.
- In addition to national total material flows for Ireland there are a number of areas, where the methodology could be applied, including
    - Specific stream accounts (packaging, wastes, plastics, WEEE, etc,). This should be based on prioritisation of important streams).
    - Sector specific MFAs – preferably by NACE sector. (this should be accompanied by prioritisation of important sectors)
    - Regional MFAs. In particular, some pilot studies should be carried out to determine the typical ‘ecological footprint; of different types of region (urban – small and large), rural, semi-rural.
    - Waste management facilities
    - Industrial sites (voluntary exemplars could be used for a base-line study – wherein material and energy balances, normally presented under IPPC licensing reporting requirements could be evaluated in a different way)

The examples above would form part of a comprehensive set of accounts, which can form the basis for decision making. A parallel can be drawn with the production of the National Waste Database (NWD) by the Environmental Protection Agency. The data in the NWD are used to determine the prioritisation of appropriate actions. There is, however, a constant need to improve the methodology of data collection, and the reliability of data (hence the undertaking of waste characterisation studies). MFAs represent an additional tool, which can provide additional and alternative data and information. MFAs need to be piloted, methodologies developed, and comprehensively applied. The information so gathered can aid with the development of programmes and activities to reduce the environmental footprint of Ireland.

The overall aim (in a medium term – 5-10 year scenario) should be to present a hierarchy of data. This would feed from

- Overall national accounts for specific streams
- Regional accounts
- Sector specific accounts
- Site-specific accounts
- Waste and energy management

All of the above could feed into the various reporting requirements (international protocols, European requirements, national reporting requirements, such as the State of the Environment Report, the National Waste Database, etc.)

7.2 Recommendations for Future Data Sourcing and Further MFA Generation

7.2.1 Data Sourcing

The following is a list of recommendations in relation to future data sourcing for total material flows for the Irish economy:

- There are a number of data gaps in relation to material flows in Ireland, in particular some of the domestic extraction data. Some of the initial estimates in Chapter 6 should be refined through contact with the industries involved. It should be noted that other countries have also experienced similar problems in obtaining data.
- In relation to hidden flows, national MFAs carried out elsewhere in the main tend to use international factors. It may be more appropriate to generate specific factors for the Irish situation for some of the major flows.
- The concept of confidential information constitutes a barrier to information gathering. Whilst it is recognised that financial confidentiality has a role to play in a competitive market, it should be possible for government and state organisation to provide information which will simultaneously provide statistical information and protect economic interest.

7.2.2 Future MFA Generation

It is recommended that MFAs are produced on an ongoing basis. This might best fit under the auspices of the National Waste Prevention Programme, since the production of MFAs can assist with prioritisation of prevention and reduction initiatives and programmes.

As outlined in Section 7.1.1, MFAs should be produced at several levels. These are as follows:

- ***National Level***: accounts for specific waste streams would allow better compliance with EU Directives and international protocols. Examples include:
  - Solvent accounts (Solvents Directive)
  - WEEE accounts (WEEE Directive)
  - Greenhouse gas and climate change gas accounts (these are already reported under a different format, but an MFA approach may be informative)
  - Packaging accounts (national targets)
- ***Sector Level:*** Sector-Specific Accounts can facilitate sectoral reduction measures. Examples might be

  - Agriculture
  - Food
  - Hospitality
  - Various industrial sectors

- ***Site Level:*** site specific accounts should be encouraged. This merely represents a sophistication in the type of data presented under AERs, PERs, etc.

The various MFAs could be produced on an ongoing basis under the auspices of the EPA. This would be similar to current EPA data production work – such as the National Waste Database, SNAP Sector 6 reporting, etc. In the past the EPA has carried out some of this work itself, and has sub-contracted some of it. A similar scenario can be envisaged with MFAs. As stated above, the work might fit neatly into the programmes of the National Waste Prevention programme.

It is recommended that any future MFA accounts for Ireland on a national level follow the Eurostat methodology. There is more flexibility in the methods and approaches that can be used for accounts at levels other than the national level.

7.3 Implications for Irish Policies

Ireland is fully committed to the principles of Sustainable Development, and to the various international protocols on reporting, emissions reductions, etc. In order to effectively comply with our obligations, policy makers require the most comprehensive and comprehensible information possible. It is hard to imagine the formulation of economic policy without any economic information. In a like manner, the formulation of the best, most relevant, and most effective environmental policies, requires high quality information and data. MFAs represent a mechanism towards achieveing this.

Furthermore development of an MFA methodology could be such that economic and other flows are also incorporated. In this way, it should be clearer where policy improvements could best be applied – to allow economic growth at the lowest environmental and social cost. These are the basic tenets of Sustainable Development.

Some implications for Irish policies include the following:

- the use of the Sankey illustration tool could be applicable for presenting a wide range of environmental data. Whilst it may appear that Sankey – being only a method of representing results – has no direct policy relevance, the clarity of the information presented makes it much easier to envisage problem areas, etc. Thus, there is an indirect benefit for the identification of priority areas for policy implementation.
- policy decisions and planning can be based on an accurate representation of environmental flows (see above for the link between GDP and MFA, etc.)
- the formulation of future research programmes can be linked to information provision. It is possible to envisage a national development programme, which evaluates economic, environmental, and social parameters in a similar manner, and which uses the results of all three to produce cogent policies and programmes

consistent with the three pillars of Sustainable Development. MFA is an important tool in this regard. It is not sufficient to set development targets based on economic indicators alone, environmental targets based on environmental indicators alone, or social targets based on social indicators alone. All three must be integrated in order to ensure a National Sustainable Development Programme. The MFA methodology represents a possibility to gather and present economic, environmental, and social information in the same format. This could greatly facilitate the development of holistic policies.

MFAs could be used to provide information, which would allow better implementation of specific policies. Some examples include:

- Tracking of organic solvents to facilitate implementation of the Solvents Directive. This might involve import, use, discharge, losses, etc. of solvents in sectors such as dry-cleaning, vehicle refinishing, etc.
- Tracking of priority waste streams, such as tyres, WEEE, etc.
- Specific packaging streams for compliance with declared policies.

APPENDIX – MFA SOFTWARE REVIEW

The types of software packages that have been reviewed can be broken down into two main categories:

- Those that perform calculations ***and*** illustrate results.
- Those illustrate results only.

The following calculation/illustration software packages have been reviewed:

- GaBi 3 and GaBi 4
- Umberto
- Simbox
- AUDIT
- ORWARE
- PFAST

The following illustration only software packages have been reviewed:

- S.draw
- Metaflows
- Sankey Helper

Demostration versions of the software have been obtained where available and reviewed.

A brief synopsis of the software packages follows.

A.1 GaBi Software

GaBi 3 Software provides software packages for a number of varying environmental procedures. Initial steps in the GaBi system require a detailed knowledge of the material stream network. In the **GaBi 3** software system, visualisation is provided of the subdivision of the examined system into further sub-systems (e.g. processes) and the flows of energy and materials that connect them, using Sankey diagrams.

GaBi4 professional is intended for consulting and research facilities and commercial projects with the industry.

GaBi4 professional academy is intended for use in thesis, seminar paper, dissertation and is provided with a 50% discount.

A.2 UMBERTO

Umberto mainly addresses company level flows, but can also be used for material flow analysis, input/output balances, and for life cycle assessments of products.

There are three different versions of the Umberto software package:

- Umberto consult
- Umberto business
- Umberto educ

Umberto consult is designed to be used by consultancies.

Umberto business is the version for in-house company use.

Umberto educ has been designed for universities and business schools for teaching fundamental principles of material and energy flow analyses.

A.3 SIMBOX

This software package is part of a material flow analysis system devised by S+E, of the Swiss Federal Institute of Technology in Zurich. The software is available in German only, and is therefore unsuitable for use.

A.4 AUDIT

AUDIT software has been mainly applied to companies though setting of the boundaries is user dependant. In summary, there are two areas of application for the AUDIT software:

- Visualising current company data in the form of mass flow and cost flow diagrams as well as evaluating in the form of spreadsheets, diagrams and indices.
- Calculating unknown mass flows in the production as well as simulating specific company conditions and planning material, cost, or plant changes in the production process.

A.5 ORWARE

ORWARE (ORganic WAste REsearch) is a tool for environmental systems analysis of waste management. It is a computer-based model for calculation of substance flows, environmental impacts, and costs of waste management. ORWARE consists of a number of separate submodels, which may be combined to model/design a waste management system for e.g. a city, a municipality or a company. This package is not appropriate for national MFAs or for regional material flow accounting, since only waste outputs are considered, which are just a subset of overall MFA inputs and outputs.

A.6 PFAST

PFAST (Production Flow Analysis and Simplification Toolkit) has been used predominantly by companies with regard to Production Flow Analysis (PFA). For national MFAs, and for regional material flow accounting, this software is not appropriate.

A.7 S.Draw

S.Draw generates Sankey diagrams which can be used to display energy flows, mass flows and monetary flows. Flows in any units and conversion values between different units can be used. Quantitative or qualitative data can be used. It is possible to import data sheets. Any data stored in S.Draw diagrams is easily exported to Microsoft Excel, Microsoft Access, Microsoft SQL Server™, Microsoft Word, and other reporting and data-analysis tools. It is an Austrian product.

A.8 Metaflows

Another package which generates Sankey diagrams for material, energy and water flows ,it is produced by a US company called Propolis.

A.9 Sankey Helper

This is a free macro for use in Microsoft Excel. Data from worksheets is converted into fairly simplistic Sankey diagrams. It is awkward to use, and the output is poor.

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Material Flow Accounts (MFA) – Demonstration for Ireland
2001-EEO/DS-(1/1)

FINAL REPORT

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GLOSSARY OF TERMS

For precise definitions of the mass balance terms in this report please refer to Section 3.6 (Identification of indicators).

DMC	Domestic Material Consumption
DMI	Direct Material Input
DMO	Direct Material Output
DPO	Domestic Processed Output
GDP	Gross Domestic Product
GHG	Greenhouse Gas
MFA	Material Flow Accounts / Accounting
NAS	Net Addition to Stocks
NPV	Net Production Value
PIOT	Physical Input Output Table
PTB	Physical Trade Balance
RME	Raw Material Equivalent
SNA	System of National Accounts
TDO	Total Domestic Output
TMC	Total Material Consumption
TMI	Total Material Input
TMO	Total Material Output
TMR	Total Material Requirement
WRI	World Resources Institute

EXECUTIVE SUMMARY

INTRODUCTION AND BACKGROUND

Currently, countries measure their economic growth and performance through the System of National Accounts (SNA). These financial accounts measure the total economic transactions in an economy. Indicators such as Gross Domestic Product (GDP) provide information on whether national income is growing or declining. There is no equivalent system for measuring the physical "transactions" in an economy. Policy and other decision makers have very little idea of the material requirements of modern economies and few indicators of where, or when, physical constraints are likely to be reached.

One set of tools that can be used is material flow accounting (MFA) - accounting for the physical flow of materials through our economy and society.

Material flow accounts (MFAs) are:

> **accounts in physical units** (usually in tonnes),
> **of the extraction, import, production, export, consumption, recycling and disposal of specific materials** (e.g. water, fossil fuel, minerals, products, etc,)
> **within a defined area** (e.g. a country or region).

It has been recommended by the World Resources Institute that Governments set up a set of national accounts in physical terms using material flow accounting that run parallel to the Sytem of National Accounts.

Many countries have produced material flow accounts for different substances and regions, and use them as indicators for policy making. To date, Ireland has not produced such national or regional accounts. This project represents a first attempt at generating material flow accounts for Ireland.

Ireland has undertaken a commitment to sustainable development. Appropriate monitoring tools are necessary in order to:
- Measure progress towards sustainable development.
- Make/review policies and decisions toward sustainability.

Material flow accounting is a suitable monitoring tool that can be utilised.

OBJECTIVES OF THE STUDY

The long term aim should be to develop national physical accounts for all major material flows in Ireland. This desk study serves as a first step in identifying available methodologies, demonstrating material flow accounts in an Irish situation, establishing the capability to produce flow accounts within Ireland, and identifying major data gaps for the future production of such accounts.

The main objectives of the study are:
- Review existing methodologies for material flow accounts (MFA) and select/tailor the methodology for Ireland
- Demonstrate the methodology for two pilot cases:

  - national fossil fuel flow accounts, together with derived indicators, and
  - water flow accounts for a region
- Identify data gaps for a complete set of national material flow accounts
- Evaluate the applicability of MFA in Ireland and any policy implications.

Although not part of the original specification, this report also attempts a first quantification of Total Material Flows in Ireland. This can be regarded as an extension of the data gap analysis.

REVIEW OF EXISTING MATERIAL FLOW ACCOUNTING METHODOLOGIES

The review was carried out in two parts, viz.

(i) Examination of selected European MFA methodologies

(ii) Examination of existing MFA software

European Methodologies

In total, eight methodologies were reviewed. These were on a European level and also at country specific levels. At the European level the following were examined:

- the Eurostat methodological guide for economy wide material flows
- the EU Total Material Requirement Study carried out by the European Environment Agency.

The methodologies used by the following countries were examined:

- Germany
- Austria
- the Netherlands
- United Kingdom
- Sweden
- Finland.

For national accounts of any physical flows in Ireland, a methodology based on the Eurostat methodological guide should be used. This will allow for comparability on a European level. For accounts other than those on a national level, e.g. regional or company level accounts, there is more flexibility in the type of methodology that can be used. Some of the graphical tools utilised by other countries, such as Sankey diagrams, can be useful for illustration and interpretation of the accounts.

Software Review

Nine suites of software were identified and examined. Where demonstration versions were available, these were obtained and tested.

The types of software packages that have been reviewed can be broken down into two main categories:

- Those that perform calculations ***and*** illustrate results.
- Those that illustrate results only.

The calculation/illustration software packages are less suitable for national and regional flow accounts and more suitable to company level material flows. They go into a level of calculation and detail that is not necessary/applicable for national or regional material flow accounting.

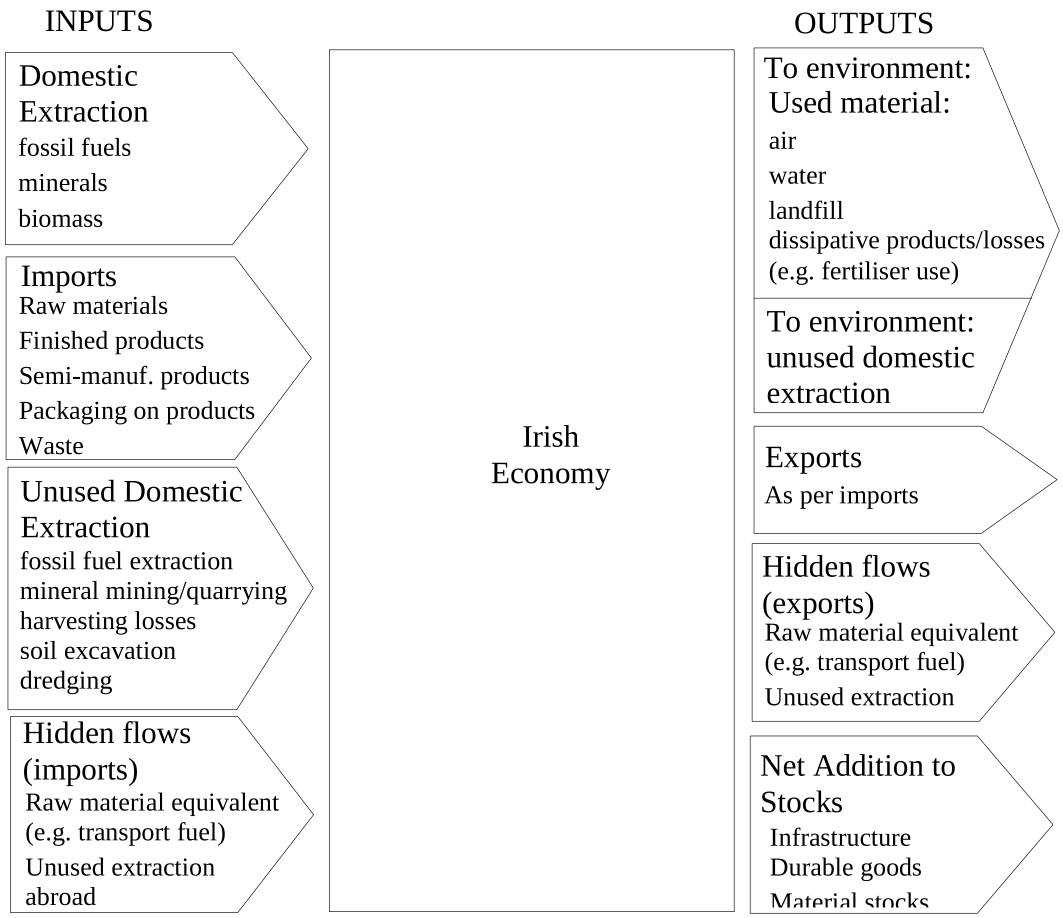
Illustration only packages can be useful to illustrate the results of material flow accounting while the actual MFA data is stored in a package such as Microsoft Excel. This has been borne out by the fact MFAs for a number of other countries are compiled in Excel. One such package was chosen for the illustration of the Irish methodology.

DRAFT IRISH METHODOLOGY FOR THE GENERATION OF MATERIAL FLOW ACCOUNTS

A draft methodology has been developed and recommended to be employed for conducting material flow accounts and balances for Ireland ***for all materials***. This methodology is later demonstrated in the fossil fuels case study (section 4). The methodology is based on the Eurostat guidelines. For the river basin case study (section 5), a modification of the method is used, since several terms and aspects of the methodology do not apply on a local (i.e. non national) level.

The main aspects of the recommended methodology are:

MFA Inputs and Outputs. These are divided into the following components, which are subsequently sun-divided, as follows:



Each of the terms is described and explained.

Data Sources for Irish MFA. These are presented in diagrammatic form.

Identification of Indicators. A list of indicators and their relationships is presented. The main indicators are:

- Input Indicators
  - DMI (Direct Material Input) = domestic extraction + imports
  - TMI (Total Material Input) = DMI + unused domestic extraction
  - TMR (Total Material Requirement) = TMI + hidden flows (imports)
- Output Indicators
  - DPO (Domestic Processed Output) = used material emitted to the environment
  - TDO (Total Domestic Output) = DPO + unused extraction
  - DMO (Direct Material Output) = DPO + exports
  - TMO (Total Material Output) = TDO + exports
- Consumption Indicators
  - DMC (Domestic Material Consumption) = DMI - exports
  - TMC (Total Material Consumption) = TMR - exports - hidden flows (exports)
  - PTB (Physical Trade Balance) = imports – exports
  - NAS (Net Additions to Stock).

DEMONSTRATION OF METHODOLOGY: CASE STUDY – NATIONAL FOSSIL FUEL FLOW ACCOUNTS

The first of two case studies involved the demonstration of the material flow accounting methodology and generation of material flow accounts and associated indicators for fossil fuels used in Ireland.

The outcome of this task is a set of physical accounts for fossil fuels used in Ireland for the years 2000, 1996, and 1990. It covers fossil fuel inputs, uses in various sectors, and associated emissions. Input, output and consumption indicators have also been calculated. The results have been sumarised in a set of Excel files. The Irish Indicators have been compared with those of other countries. These comparisons are summarized as follows.

Irish DMI and DMC - Country Comparison

The following table illustrates the results of the fossil fuel case study and compares it with certain indicators recently compiled for each of the Member States based on European and international statistics (Jan 2003).

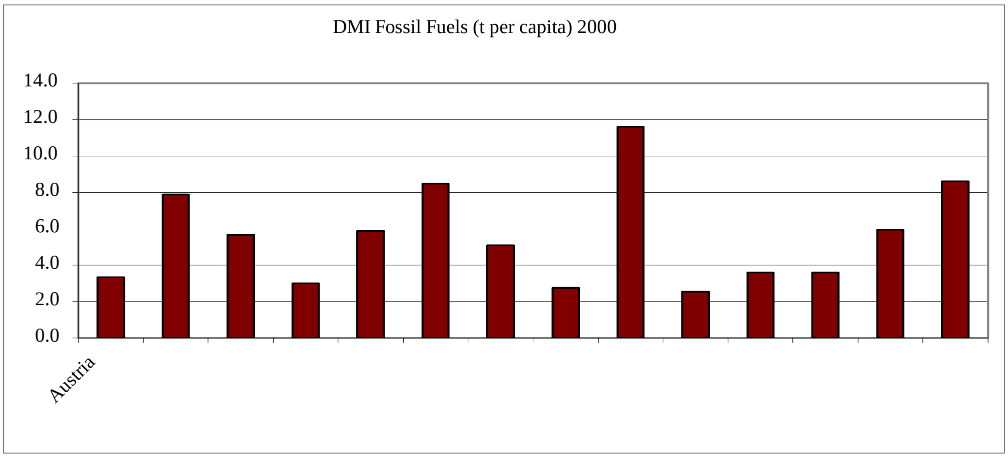
	As calculated in this project			ETC-WMF calculation[1]		
	2000	*1996*	*1990*	*2000*	*1996*	*1990*
Irish Fossil Fuel extraction (‘000 t)	5,385	7,629	8,324	6,107	7,230	8,456
Irish Fossil Fuel imports (‘000 t)	13,967	10,841	9,025	12,478	9,639	8,595
Irish Fossil Fuel DMI (‘000 t)	19,352	18,471	17,349	18,585	16,869	17,051
Irish Fossil Fuel DMI (tonnes per capita)	5.1	5.1	4.9	4.9	4.6	4.9
Irish Fossil Fuel DMC (‘000 t)	18,159	17,565	16,742	16,734	15,275	15,863
Irish Fossil Fuel DMC (tonnes per capita)	4.8	4.8	4.7	4.4	4.2	4.5

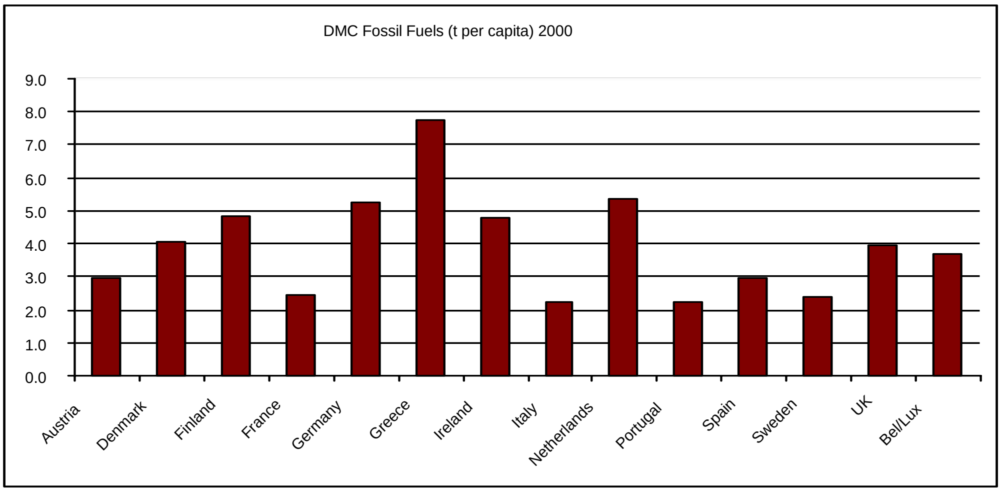
Ireland is above the EU average for DMI. This means the per capita input of fossil fuels from imports and domestic extraction into Ireland’s economy is somewhat higher than the EU average.

Ireland is well below the EU average for TMI and TMR for fossil fuels. This means that, taking the unused extraction associated with domestic and imported fossil fuels into account, as well as the fossil fuel input into the economy, Ireland is well below the EU average. This implies that the unused extraction associated with Ireland’s domestic extraction and imports is low in comparison with other Member States. While a detailed breakdown on the sources of the EU figures is not available, one reason for this significant difference is likely to be the limited amount of domestic extraction of fossil fuels which occurs in Ireland, which is virtually all used in the Irish economy. Conversely, some EU Member States would have significant fossil fuel domestic extraction, which would increase both the TMI and TMR figures, because these indicators do not subtract exports, or hidden flows associated with exports.

Ireland’s position relative to other EU countries in terms of DMI, Direct Material Input (domestic extraction plus imports) and DMC, Domestic Material Consumption (domestic extraction plus imports minus exports) is illustrated below.

[1] Input from the European Topic Centre on Waste and Material Flows (ETC-WMF) into the Kiev report - Moll 2003 Datasheet http://waste.eionet.eu.int/mf/4.





As can be seen, Ireland is joint fifth highest out of all EU countries in terms of DMC. This means Ireland has the fifth highest fossil fuel consumption per capita in the EU**.**

DEMONSTRATION OF METHODOLOGY: CASE STUDY – REGIONAL WATER FLOW ACCOUNTS

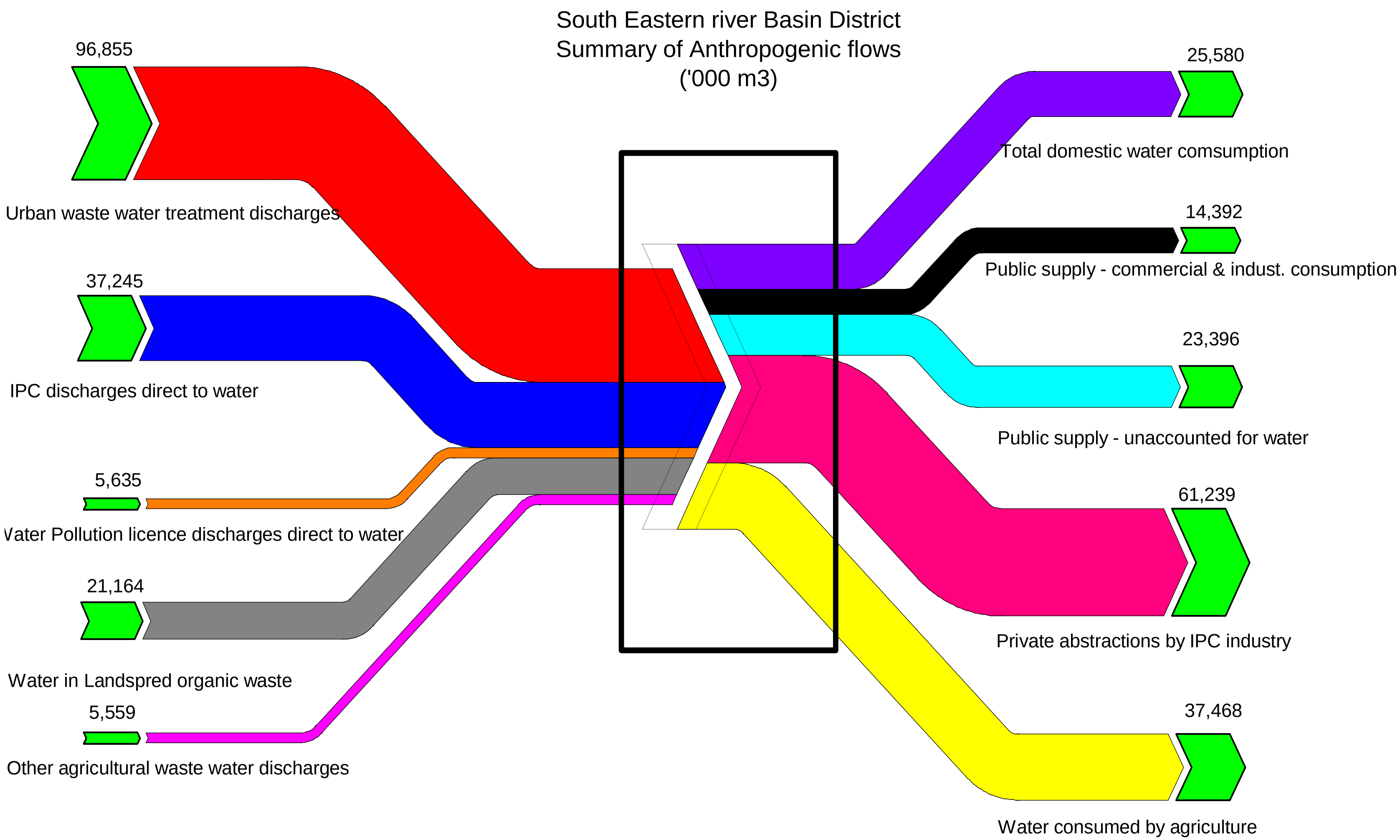
The second of two case studies involved the demonstration of the material flow accounting methodology and generation of water flow accounts for a particular region within Ireland.

Ireland has been divided into five river basin districts for the implementation of the Water Framework Directive. The South Eastern River Basin District (SERBD) is the region that is furthermost along in implementation of the Directive since it was the first SERBD project launched. Hence this is the river basin district chosen for demonstration of water flow accounts.

The South Eastern River Basin District covers the combined river basins of the rivers Slaney, Barrow, Nore and Suir, as well as a number of other smaller rivers near the coast. Counties Carlow, Kilkenny, Laois, Tipperary South, and Wexford are included in this river basin district (RBD) as well as parts of Kildare, Offaly, Tipperary North, Waterford, Wicklow and a very small part of Limerick.

All water flows into and out of the river basin district are taken into account in drawing up the water flow accounts. This includes both natural and anthropological flows of water. The boundary for the water flow accounts consists of the geographical area of the river basin district (RBD) as well as flows into and out of water bodies within the RBD itself. A schematic of the RBD and associated flows is shown below:

Where data was available, each of these flows was determined and the overall MFA presented in the form of a Sankey diagrams. A summary Sankey diagram is shown overleaf. A more detailed Sankey diagram can be seen in section 5.


South Eastern river Basin District
Summary of Anthropogenic flows
('000 m3)
96,855
Urban waste water treatment discharges
37,245
IPC discharges direct to water
5,635
Vater Pollution licence discharges direct to water
21,164
Water in Landspred organic waste
5,559
Other agricultural waste water discharges
25,580
Total domestic water comsumption
14,392
Public supply - commercial & indust. consumption
23,396
Public supply - unaccounted for water
61,239
Private abstractions by IPC industry
37,468
Water consumed by agriculture

TOTAL MATERIAL FLOWS IN IRELAND

The data sources available for calculating flows of all materials in Ireland have been assessed and an initial estimate of such flows made - where data availability permits.

In addition to data gaps and data reliability, comments are made in relation to any differences between national sources of data and data that has been used in Eurostat estimates of material flows and indicators for Ireland, for example, data from FAO (Food and Agricultural Organisation of the UN).

Data sources, data gaps & data reliability have been examined for the following areas of the Irish material flow scenario:

- Domestic Extraction
    - Agricultural biomass
    - Biomass from fishing
    - Biomass from forestry
    - Fossil fuels
    - Minerals
- Imports and Exports (bar fossil fuels which are covered in section 4)
- Unused Domestic Extraction
    - Harvesting losses
    - Fossil fuels
    - Minerals
- Material Outputs to the Environment
    - Landfill
    - Air
    - Water
    - Dissipative Use of Products

A preliminary estimate of Total Material Flows in Ireland for the year 2000 is as follows:

2000					
Inputs			**Outputs**		
	000 tonnes	**000 tonnes**		**000 tonnes**	**000 tonnes**
Domestic extraction		**107,419**	**To Environment - Used Material**		**119,494**
biomass	64,293		Air	47,059	
Fossil Fuels	5,385		Landfill	8,278	
Minerals	37,741		Water	-	
Imports		**44,487**	Dissipative product use	64,158	
Fossil Fuels	13,967		Dissipative losses	NE	
All other materials/products	30,452		**To env.- unused domestic extraction**		**11,699**
waste	68		Fossil fuel extraction	1,237	
Unused Domestic extraction		**11,699**	Mineral mining/quarrying	NE	
Fossil fuel extraction	1,237		Harvesting losses	10,462	
Mineral mining/quarrying	NE		Soil excavation	NE	
Harvesting losses	10,462		Dredging	NE	
Soil excavation	NE		**Exports**		**13,686**
Dredging	NE		All other materials/products	11,986	
Hidden Flows (Imports)		**NE**	Fossil Fuels	1,193	
biomass	NE		waste	508	
Fossil Fuels	8,715		**Hidden flows (exports)**		**NE**
Minerals	NE		biomass	NE	
Items for Balancing		**29,992**	Fossil Fuels	211	
Oxygen for combustion	29,992		Minerals	NE	
			Net Addition to Stocks (NAS)		**NE**
			Infrastructure	NE	
			Durable goods	NE	
			Material stocks	65	

Based on these flows, preliminary estimates of certain indicators for the same year have been made. These are shown below:

Indicators			**10^6 tonne 2000**	**tonne / capita 2000**
DMI	(Direct Material Input)	Domestic extraction + imports	151,906	39.0
DMC	(Domestic Material Consumption)	DMI - exports	138,220	35.5
PTB	(Physical Trade Balance)	Imports - exports	30,800	7.9
DPO	(Domestic Processed Output)	Used material flows to the Environment	119,494	30.7
DMO	(Direct Material Output)	Used material flows to the Environment + Exports	133,181	34.2

When compared to other countries, the Irish estimates of DMI and DMC are at the upper end. This shows Ireland has a stronger connection between material resource use and economic activity than other EU countries. However not all of the estimates for the other countries include the same extent of products as have been included in the Irish figure in this study (see discussion in Section 6.7.3). DMI is an illustration of the weight of actual material that goes into the Irish economy. It includes material that will be consumed within Ireland, as well as other materials that will go into products and ultimately be exported. Whereas DMC is an illustration of the weight of actual material that is consumed within Ireland. Reducing the values of DMI ad DMC while maintaining or increasing fiscal activity, is to move in the direction of sustainability.

EVALUATION AND RECOMMENDATIONS

The whole concept of Material Flow Accounts is embedded in the principles of measurement and reporting. A concerted effort should be made to improve the quality of data, and to enhance its transparency. The continuing evaluation and improvement of data must work in conjunction with performance improvement measures (prevention, recycling, etc.).

MFA provides a basis for policy decisions, and for the framing of environmental improvement programmes. Economic policies are set with regard to economic indicators (GDP, GNP, etc.). The monetary flow through society has been much analysed. In a similar manner, the economic policies of the future must be based on evaluation of the material and energy flows.

It is essential to decouple economic and material intensity. To do this requires an ongoing and accurate evaluation of material and energy flows.

Conclusions Regarding MFA Applicability in Ireland

The following conclusions can be drawn in relation to the applicability of material flow accounting in Ireland:

- national total material flows are a key input into international and, in particular, European reporting protocols (for example the Kiev Report). Many countries have been engaged in such accounting for several years. Ireland needs to develop a well defined set of MFAs to meet reporting requirements.
- in addition to national total material flows for Ireland there are a number of areas, where the methodology could be applied, including
    - Specific stream accounts (packaging, wastes, plastics, WEEE, etc,). This should be based on prioritisation of important streams.
    - Sector specific MFAs – preferably by NACE sector. This should be accompanied by prioritisation of important sectors.
    - Regional MFAs. In particular, some pilot studies should be carried out to determine the typical ‘ecological footprint’ of different types of region (urban – small and large, rural, semi-rural).
    - Waste management facilities.
    - Industrial sites (voluntary exemplars could be used for a base-line study – wherein material and energy balances, normally presented under IPPC licensing reporting requirements could be evaluated in a different way).

The overall aim (in a medium – 5-10 year scenario) should be to present a hierarchy of data. This would feed from

- Overall national accounts for specific streams
- Regional accounts
- Sector specific accounts

- Site-specific accounts
- Waste and energy management

All of the above could feed into the various reporting requirements (international protocols, European requirements, national reporting requirements, such as the State of the Environment Report, the National Waste Database, etc.)

Recommendations for Future Data Sourcing

The following is a list of recommendations in relation to future data sourcing for total material flows for the Irish economy:

- There are a number of data gaps in relation to material flows in Ireland, in particular some of the domestic extraction data. Some of the initial estimates in chapter 6 should be refined through contact with the industries involved. It should be noted that other countries have also experienced similar problems in obtaining data.
- In relation to hidden flows, national MFAs carried out elsewhere in the main tend to use international factors. It may be more appropriate to generate specific factors for the Irish situation for some of the major flows.
- The concept of ***confidential information*** constitutes a barrier to information gathering. Whilst it is recognised that financial confidentiality has a role to play in a competitive market, it should be possible for government and state organizations to provide information which will simultaneously give statistical data and protect economic interest.

Implications for Irish Policies

Implications for Irish policies include the following:

- the use of the Sankey illustration tool could be applicable for presenting a wide range of environmental data.
- policy decisions and planning can be based on an accurate representation of environmental flows (see above for the link between GDP and MFA, etc.).
- the formulation of future research programmes can be linked to information provision. It is possible to envisage a national development programme, which evaluates economic, environmental, and social parameters in a similar manner, and which uses the results of all three to produce cogent policies and programmes consistent with the three pillars of Sustainable Development. MFA is an important tool in this regard.

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1 INTRODUCTION

1.1 Introduction and Definition

Material flow accounts (MFAs) are:

accounts in physical units (usually in tonnes),
of the extraction, import, production, export, consumption, recycling, and disposal of specific materials (e.g. water, fossil fuel, minerals, products, etc,)
within a defined area (e.g. a country or region).

Currently, countries measure their economic growth and performance through the System of National Accounts (SNA). These financial accounts measure the total economic transactions in an economy. Indicators such as Gross Domestic Product (GDP) provide information on whether national income is growing or declining. There is no equivalent system for measuring the physical "transactions" in an economy.

Policy and other decision makers have very little idea of the material requirements of modern economies and few indicators of where, or when, physical constraints are likely to be reached.

A study covering Austria, Germany, Japan, the Netherlands, and the United States found that physical accounts are urgently needed, because our knowledge of resource use and waste outputs is surprisingly limited (WRI 2000). It has been recommended by the World Resources Institute that Governments set up a parallel set of national accounts in physical terms using material flow accounting.

Ireland has undertaken a commitment to sustainable development. Appropriate monitoring tools are necessary in order to:

- Measure progress towards sustainable development.
- Make/review policies and decisions toward sustainability.

One such set of monitoring tools is material flow accounting (MFA) - accounting for the physical flow of materials through our economy and society.

Current planning does not generally take account of regional material flows – at least to any great extent. For development to be sustainable, however, this is paramount.

In order to take safe steps toward sustainability, economic and societal actors need simple and practical navigation instruments that measure the ecological impact potential of human activities, products and services. This need extends from the macro-level (nations) through the meso-level (industrial sectors, regions) to the micro-level (processes, products, individual enterprise). Such an approach reflects the adages: "what you cannot measure, you cannot manage" and "what gets measured, gets managed".

There is a clear need for impact measurement, with the support of a model that identifies the origins of the activities that produce the impacts, and allows the *a priori* determination of the effects of changes in the system. Material Flow Accounts allow assessment of the flows into and out of an economy, or part of an economy. These include resource flows (imports, exports, generation and consumption). Since the efficient consumption of resources is required for the decoupling of economic growth and material and energy requirements, there is an obvious consequence in terms of sustainable development. MFAs can also include specific environmental factors, such as emissions of greenhouse gases, discharge to waters, etc.

Material flow accounts can be used to provide sufficient information in order to monitor the existing situation and trends, plan and control improvement measures, facilitate comparison of alternatives, and highlight/discover certain flows that may be of specific relevance in the future.

Not every EU country has developed material flow accounts to date. However, Ireland is somewhat behind other developed countries, especially considering the United States and the Soviet Union published such accounts in the 1970s.

1.2 Objectives

The main objectives of the study are:

- Review existing methodologies for material flow accounts (MFA) and select/tailor the methodology for Ireland
- Demonstrate the methodology for two pilot cases:
  - national fossil fuel flow accounts, together with derived indicators, and
  - water flow accounts for a region
- Identify data gaps for a complete set of national material flow accounts
- Evaluate the applicability of MFA in Ireland and any policy implications.

Although not part of the original specification, this report also attempts a first quantification of Total Material Flows in Ireland. This can be regarded as an extension of the gap analysis.

1.3 Expected Benefits

The benefits of MFAs are based on the principle that ‘what is not measured cannot be controlled’. We would never dream of trying to run an economy without a comprehensive set of economic indicators and accounts. Similarly, we cannot hope to reduce the environmental footprint of our activities without clear indications of our impacts, in terms of material and energy flows.

The specific benefits of a Material Flow Accounts pilot project are to test a methodology and to produce a first set of early accounts. The long term aim should be to develop comprehensive accounts for a range of flows. These can be used to assess current environmental impacts, and, based on these, to make decisions for improvement. Specific examples of potential future use are as follows:

National Physical Accounts

The long term aim should be to develop national physical accounts for all major material flows in Ireland. This desk study serves as a first step in identifying available methodologies, demonstrating material flow accounts in an Irish situation, establishing the capability to produce flow accounts within Ireland, and identifying major data gaps for the future production of such accounts.

MFA Methodology

As well as being used for establishing a basis for national physical accounts, the MFA methodology researched as part of the study can be utilised in other situations:

- in diverse applications such as fertiliser use and eutrophication, waste management, packaging, specific products such as steel or cement, and agricultural or forestry production.
- on different scales:
  - municipal regions
  - government departments
  - manufacturing companies

National Fossil Fuel Flow Accounts

Demonstration of the methodology to the flow of fossil fuels on a national scale will be of assistance in the implementation of the National Climate Change Strategy (DOE 1997). Under the Strategy, taxation measures are to be implemented on a phased incremental basis on the basis of the carbon equivalent content of fuel inputs in the case of energy production, and also on electricity consumption. The material flow accounts can assist in the prioritisation of areas for taxation, as well as other measures under the Strategy - such as negotiated agreements.

Regional Water Flow Accounts

Application of the methodology to the material flow accounts of water in a chosen region is of assistance in the establishment of River Basin Management Plans for all Irish river basin districts under the water framework Directive (European Parliament, 2000). For each river basin district, member states must compile specified characteristics, review environmental impact of human activity and carry out an economic analysis of water use by the end of 2004, as laid out in Annexes II and III to the Directive. Member States must collect and maintain information on the type and magnitude of the significant anthropogenic pressures to which the surface water and ground water bodies in each river basin district are liable to be subject, including estimation of:

- point and diffuse sources of pollution
- significant surface or ground water abstraction for urban, industrial, agricultural and other uses
- water distribution system loss
- flow regulation, including water transfer and diversion
- artificial groundwater recharge

– determination of potential deficiencies in water supply.

The establishment of flow accounts for the chosen region can be used as a prototype for other river basin districts in Ireland.

Material flow analyses have been devised for regions, e.g. within Sweden, although there is a contrary view that the data requirements are inadequately satisfied in some cases. Often such studies are prompted by concerns for assessment of waste management options. Such work in Ireland is illustrated by waste flow estimates for electrical and electronic equipment, and for common recyclable materials. Using such data, policy decisions can be taken to promote the prevention of waste and design appropriate waste management systems. In the absence of a life cycle approach, decisions are taken based on unsubstantiated principles or “rules of thumb”, which may neglect the environmental consequences of additional transport or treatment operations.

2 REVIEW OF EXISTING MATERIAL FLOW ACCOUNTING METHODOLOGIES

A review of selected existing European MFA (Material Flow Accounting) methodologies is presented. This review is broken into two sections, the first dealing with general MFA methodologies used in other European countries and the second with MFA software in use.

2.1 Review of European MFA methodologies

This section provides an overview of the current approaches to MFA within some of the European countries involved in work in this area.

2.1.1 MFA methodology - European Level

Since the original proposal for this project was prepared, Eurostat has produced a methodological guide for economy wide material flow accounts. The Eurostat guide aims to harmonise economy-wide MFA methodologies across Europe. This study aims to tailor the methodology in the Eurostat guide to suit the Irish situation. This study has also demonstrated the use of the Eurostat methodology to prepare fossil fuel accounts and to make a first attempt at total material accounts for Ireland. Therefore much of the Eurostat guide has been used in developing an MFA methodology for Ireland. However, individual country level MFA methodologies have been reviewed for:

- additional guidance and implementation experiences
- assistance in the identification of the key parameters
- information on experiences with regional rather than economy-wide material flows

A distinction is drawn between material flow *accounts*, and material *balances*. The difference being accounts are lists of inputs and outputs but do not have to balance. There are three different categories:

- economy wide material flow accounts
- economy wide material balances
- PIOTs (Physical Input Output Tables)

PIOTs are more detailed than economy wide material balances in that they also cover flows within the economy between sectors.

2.1.2 EU TMR (Total Material Requirement) Study

The European Environment Agency has carried out an estimation of TMR (Total Material Requirement) for the EU as a whole, as well as an estimate of DMI (Direct Material Input) and DMC (Domestic Material Consumption) for each Member State where it had not already been calculated.

DMI for Ireland has been estimated as 35 tonne per capita for 1997 (for the 15 EU Member States it is estimated as 20 tonne per capita). Member States were ranked based on comparison of DMI with GDP. Ireland had achieved a significantly higher GDP with a rather constant DMI. However other Member States managed to combine economic growth with reduced DMI. There were also other Member States whose DMI rose in conjunction with GDP.

From 1980 to 1997 DMC in Ireland increased by 121%, with an estimated DMC of 40 tonne per capita in 1997.

A lot of the MFA data for the EEA study was based on data from MFA studies already carried out in individual countries which was scaled up for the rest of the EU (e.g. weighted averages, known areas of non-harvested pasture, etc.) or was based on EU level data (e.g. Eurostat energy statistics).

2.1.3 MFA Methodology - Germany

Germany was one of the first countries to develop MFA [along with the Netherlands, Austria, Japan, and the US in a World Resources Institute project (WRI 1997)]. MFA has been introduced into the official reporting of the German Federal Statistical Office since 1995 and is reported on annually. A time series for the former federal Republic was carried out from 1975 to 1990, then a revised time series for the reunited country was set up for 1991 onwards (www.destatis.de/).

The split of materials on the input side in the economy-wide balance is: biotic goods and abiotic goods (further split into energy sources, ores and products thereof, non-metallic minerals and products thereof, chemical products, machinery and equipment, and other goods). On the output side dissipative losses included are fertiliser, landspread sewage sludge, and pesticides. Water balances are also carried out separately.

PIOTs have been drawn up for Germany for direct energy consumption, water withdrawal from nature, and water discharge into nature, broken down per NACE sector (www.destatis.de/).

A notable difference between Irish and German data sources is that official waste statistics are maintained by the Federal Statistics Office Germany, whereas in Ireland the EPA performs this function.

Indicators calculated by Germany include TMR, DMI, DPO (Domestic Processed Output) on a per capita basis and per unit of GDP basis. The changes in these indicators are graphically illustrated over time. In addition some specific material flows used by Germany as indicators expressed on a per GDP unit basis (using 1991 as the base year - set at 100) are: primary energy consumption, total waste, total greenhouse gas emissions, all water discharged into nature (including losses in distribution, evaporation), water withdrawal from nature, and wastewater discharged into nature.

The change in specific material output streams are also graphically represented (setting 1975 as equal to 100).

Net additions to stocks has been calculated by difference, using DMI minus DPO and minus exports.

2.1.4 MFA Methodology - Austria

As one of the countries involved in the WRI material flows project (WRI 1997), Austria first conducted national material balances in 1995, retrospectively going back to 1970 for water, fossil fuels, mineral and bulk raw materials, and biotic substances.

Austrian material balances differ from the Eurostat Guide in that they include a balance on water (which accounts for 87% of the entire flow of material), but water is not included in the calculation of indicators (www.statistik.at).

The balances include: imports, primary extraction, processing, final use, emissions, wastes, deposition, stocks, and exports.

These balances conform to the level of detail in Physical Input Output Tables (PIOTs) since they look at the sectoral level. The fossil fuel balance differentiates between fuel used in coke-ovens, blast furnaces, and electricity/heat supply. There is no sectoral breakdown on inputs and outputs for the final consumption stage (industry, agriculture, etc.).

In addition to tonnage, Austria represents its MFAs on energy in terms of petajoules, as well as percentage contribution to final useful energy per sector.

Indicators calculated by Austria include TMR, DMI, DPO on a per capita basis and per unit of GDP basis. Austria graphically illustrates changes in these indicators over time.

Another indicator derived from the balances is emission intensity of a sector (% of total emissions, for example CO_2 emissions) plotted against percentage of monetary NPV (Net Production Value). This shows for example, that while CO_2 emissions from power generation are a significant contribution to total CO_2 emissions, the sector has one of the bigger shares of NPV. Conversely, steel manufacture also has a significant contribution of total CO_2 emissions but has a lower share of NPV. Emission intensities are calculated for solid waste, waste water, SO_2, etc. Raw material productivities are also similarly calculated.

Austria also represents its MFAs in terms of Sankey diagrams (graphical representation of material inputs and outputs where the width of each input and output arrow is proportional to the material quantity or flux – invented by the Irish engineer Sankey (1853-1921).

2.1.5 MFA Methodology - The Netherlands

As one of the countries involved in the WRI material flows project (WRI 1997), Statistics Netherlands started work on material and energy flows in 1995 and produced PIOTs for iron/steel and energy (www.cbs.nl). The Dutch material and energy flow system is connected directly to economic data.

Indicators produced by the Netherlands include TMR, DMI, DPO on a per capita basis and per unit of GDP basis.

A group of Dutch Institutes has developed the MATTER model which looks at how changes in material flows can significantly influence GHG (Greenhouse Gas) emissions (Kram 2001). In-depth studies of key groups of materials were carried out (metals, organic chemicals and building materials) and product groups (packaging, buildings, road vehicles).

2.1.6 MFA Methodology - UK

Using a portion of landfill tax credits, Biffaward have funded a series of research projects examining resource flows in the UK. Some of these projects are looking at mass balances of resource flows in specific sectors or geographical regions (for example, “A Mass Balance of the UK Newspaper Industry”; “The Environmental Footprint for the Public Sector” and “City Limits - A resource flow and ecological footprint analysis of Greater London”).

The UK study, carried out by the Wuppertal Institute, was published in June 2002 (Bringesu 2001). The main goal of the study was to establish a balanced material flow account and associated indicators for the UK economy as a whole, differentiated by economic sectors and main resource groups.

Indicators generated include TMR, DMI, TDO (Total Domestic Output), DPO, on a per capita and on a per GDP basis. These indicators were also calculated on a sectoral basis for the following sectors: crude petroleum and natural gas extraction, coal mining, energy supply, basic metals manufacture, metal ores mining, other mining and quarrying, construction, agriculture, transport, households, and other industries.

In the Eurostat guide, soil erosion from agricultural land is omitted from the main material flows contributing to TMR and classified as a ‘memory item’ - for which a country may decide to include it in TMR or not. In the UK’s case, it was decided to leave soil erosion out of the TMR calculation.

The categories of domestic extraction/input considered are: agriculture (harvest, grazing), forestry and fishing, fossil energy (hard coal, lignite crude oil, natural gas, peat), ores (iron, copper, zinc, lead, tin, silver, tungsten, gold), minerals (barite, clays, diatomite, feldspar, fluorspar, gypsum/anhydrite, potash, salt, sand and gravel, crushed stone, dimension stone, strontium minerals, talc, sulfur), excavation and dredging.

The categories of imports and exports considered are: raw materials (fossil energy carriers, minerals, metals, animals, agricultural, forestry), agricultural products (animal, plant), semi-manufactured products (fossils, minerals, metals, forestry), finished products (minerals, metals, forestry, animals).

The categories of outputs to the environment considered are: CO_2 emissions, other emissions to air, waste landfilled, unused biomass, unused extraction of minerals, unused extraction of fossil fuels, manure spread on fields, other dissipative uses on fields, emissions to water soil erosion, and excavation and dredging.

Soil erosion was also calculated separately. Additionally, net additions to stock were estimated.

The complete data of the MFA is maintained in a hierarchically structured series (up to seven levels) of Excel workbooks and their worksheets with supporting Word documents. The major split is between inputs and outputs. Each worksheet contains information for a particular sector for the complete time series in question.

Some problems, encountered during the UK study, are:

- There was a lack of consistent data on hidden flows associated with precious stones (a high hidden flow associated with such stones). Therefore, these hidden flows have been omitted from the UK TMR and constitute a significant data gap in pre-1996 MFAs.
- Soil erosion associated with imported biomass has not been estimated.
- Comprehensive figures could only be generated for 1997 and 1998 as a result of data availability.
- Missing data on waste water emissions and waste landfilled.

There are several follow-up projects now underway, including “Scottish Resource Flow and Ecological Footprint” (started September 2002 and is to finish December 2003) and “Northern Ireland Mass Balance and Ecological Footprint” (started July 2002 and is to finish January 2004). One aspect of the latter project involves a mass balance of resource flows (materials and energy) through the Northern Ireland economy.

A related UK project finalised in August 2002 is a study conducted by the Stockholm Environment Institute which estimates the total material requirement of the City of York and establishes the ecological footprint associated with the consumption of such materials (SEI 2002).

2.1.7 MFA Methodology - Sweden

Sweden has developed physical environmental accounts since 1993 and publishes Environmental Economic Accounts as a sub-set of the National Accounts (Branvall 1999a).

Sweden has calculated Direct Material Input (DMI) and Direct Material Consumption (DMC) for all major materials as far back as 1987 (Isacsson 2000). Material categories used are as per the Eurostat guide.

Sweden represents its material flow accounts in tabular format, showing yearly trends of DMI and DMC in thousands of tonnes, and also per capita.

Sweden uses DMC as one of its Sustainable Development indicators (SCB 2001). The first set of these indicators has been drawn up in 2001 by Statistics Sweden, in conjunction with the Swedish EPA. DMC is plotted over time, split into the major categories of construction materials, fossil fuels, forestry, ore and industrial minerals and food.

2.1.8 MFA Methodology - Finland

Finland started the calculation of TMR in 1998 and has a time series that goes back to 1970 (Juutinen 1999).

An Excel workbook has been developed to show the time series results TMRFIN (Total Material Requirement of Finland). Each group of natural resources has its own set of worksheets, with a summary of the series of that group presented on the top of the page. The workbook has been compiled in such a way that:

- TMR can be reviewed hierarchically at different detailed levels of material categorisation,

- the time series is easy to update,
- calculation methods can be checked directly from the workbook (transparency).

Hidden flows are derived either directly from statistics or, with the help of parameters, from the use of direct inputs or other available information.

For the hidden flows of imports, the results of the Wuppertal Institute have been used by taking into account the differences in imports between Finland and Germany. The hidden flow coefficients have been calculated in accordance with the year 1995, and these fixed coefficients are then applied to the whole time series.

The workbook contains altogether 420 product groups of direct inputs - the domestic and imported products being calculated separately.

2.1.9 Other Countries

The Basque country has conducted a Total Material Requirement (TMR) study which was published in August 2002 (IHOBE 2002). The Wuppertal Institute has conducted a TMR study for Poland (Schütz 2000). Other countries that have generated material flow accounts and calculated TMR include Denmark, China, and Italy. This project undertook to look in detail at the work of a selection of countries, in particular those which have been at the forefront of research this area. Hence these other studies were not reviewed in detail.

2.1.10 Conclusions from Review

The review of work in other countries has shown that, for tracking resource flows at the national level, it is best to use the Eurostat methodology. This will allow comparison with other countries. The majority of national level studies that have been carried out since the publication of the Eurostat methodology utilise this method. For studies on a regional level, or for specific materials, there is more flexibility in the methods that can be used. Useful illustrative tools were also identified from the review such as Sankey diagrams. Countries are using MFA indicators in their sustainable development stategies, for example, Sweden.

2.2 Review of MFA Software

From the review of MFA software it was found that calculation/illustration software packages are less suitable to national and regional flow accounts and more suitable to company level material flows. They go into a level of calculation and detail that is not necessary/applicable for national or regional material flow accounting. Illustration only packages like S.draw or Metaflows could be useful to illustrate the results of material flow accounting while the actual MFA data is stored in a package such as Microsoft Excel. This has been borne out by the fact MFAs for a number of other countries are compiled in Excel. The appendix provides more detail on the MFA software review.

3 DRAFT IRISH METHODOLOGY FOR THE GENERATION OF MATERIAL FLOW ACCOUNTS

The following is an outline of the draft methodology recommended to be employed for conducting material flow accounts and balances for Ireland ***for all materials***. This methodology will be demonstrated in the fossil fuels case study (Section 4). A preliminary estimate of material flow accounts for Ireland for all materials is also attempted using the methodology (Section 6). The methodology is based on the Eurostat guidelines. For the River basin case study (Section 5), a modification of the method is used, since several elements of the methodology, such as the Eurostat indicators, do not apply on a local level (i.e. non national level).

3.1 Some Definitions

System Boundary

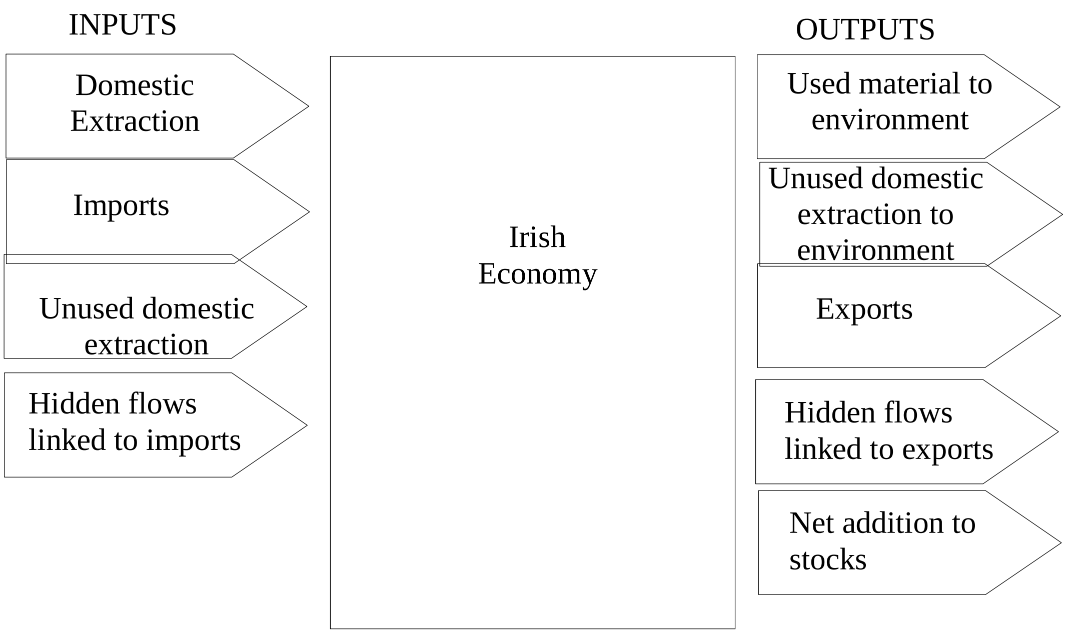
The system should be the Irish economy and the system boundary should be the national border, and the extraction/release of materials to and from the environment.

Residence versus Territory

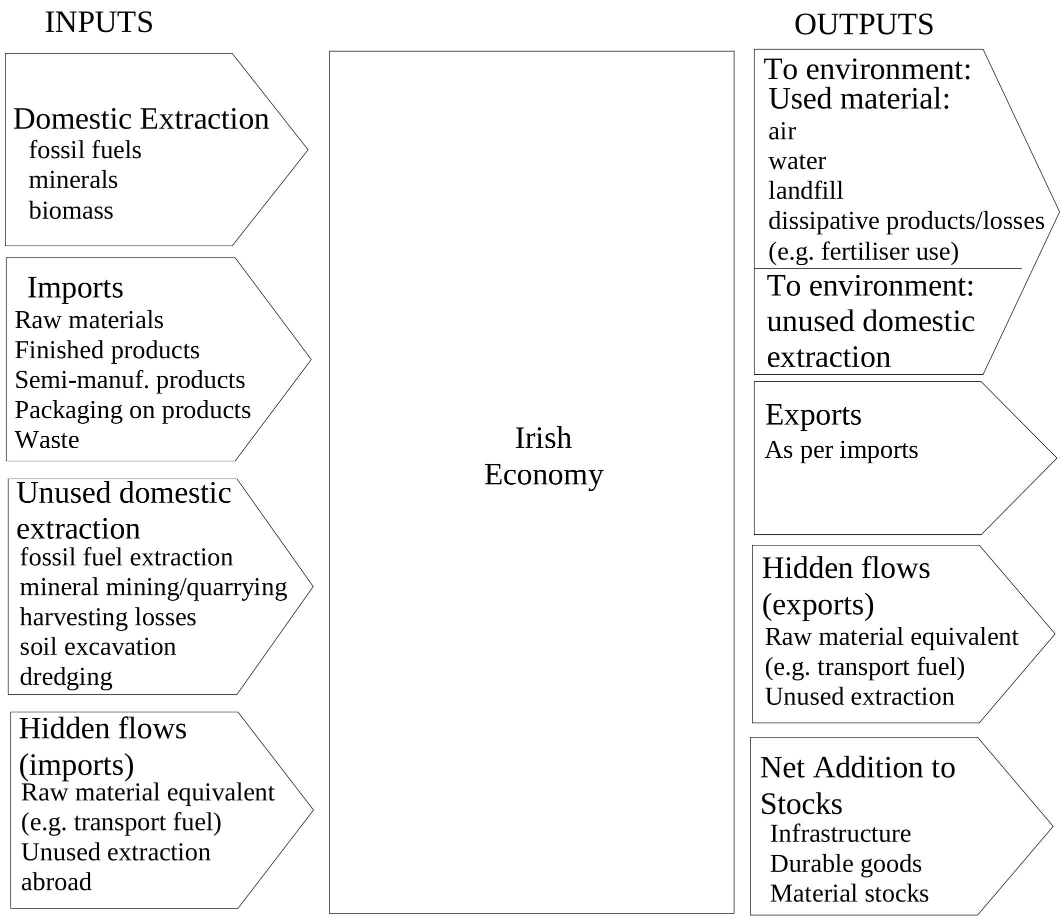
National monetary accounts are based on the consumers/producers resident in the country rather than on territory. Therefore Irish consumers' fiscal activities abroad are included in the economic figures, whereas non-residents in Ireland are not (e.g. tourists). However MFA focuses on actvities within the country and so would include the contribution to flows from non-residents within Ireland. This has to be considered in any comparisons with monetary indicators.

3.2 MFA Inputs and Outputs

The following inputs and outputs should be used in a national MFA:



More detail on each of the inputs and outputs that should be considered as part of the methodology is as follows:



3.2.1 Domestic Extraction

Domestic extraction should consider the extraction of all materials, e.g. natural gas, peat, sand and gravel, all agricultural produce, forestry products, etc.

These materials should be split into the categories of fossil fuels, minerals and biomass.

3.2.2 Imports and Exports

All imports and exports should be split into the categories of raw materials, semi-manufactured products, finished products, other products, packaging on products and waste. A more detailed classification of these categories is given in Annex 4 to the Eurostat guide. Each of these categories should also be further divided into fossil fuels, minerals and biomass.

Imports should be split by country of origin, where possible.

Imports should be classified based on the EU CN system (Combined Nomenclature) which is consistent with the HS system (Harmonised commodity description and coding System) or the HS-derived SITC (Standard International Trade Classification)

Exports should be classified based on the EU CN system (Combined Nomenclature) which is consistent with the HS system (Harmonised commodity description and coding System) or the CPA system (Classification of Products by Activities).

3.2.3 Unused Domestic Extraction

Unused domestic extraction is that material which is extracted from the environment but which does not go on for further processing.

Unused domestic extraction consists of wastes from mining and quarrying, wastes from agricultural and forestry harvesting, excavation materials, and dredging materials. Soil erosion can be optionally included as an additional material flow (the majority of countries apart from the UK have included soil erosion; in the UK's case domestic soil erosion does not make any significant difference to overall TMR unlike some other countries).
Unused domestic extraction is counted as both an input and an output to the environment.

3.2.4 Hidden Flows

Hidden flows consist of two components:

- RME (Raw Material Equivalent) - the extra weight of material required to make and bring the product/material to the country border (shipping fuel, etc.).
- unused extraction – the unused extraction associated with the material at the location of extraction (abroad for imports, in Ireland for exports).

An example of hidden flows determined from Irish data:

In 2000, just over 2 thousand tonnes of bituminous coal (a type of hard coal) was imported from Estonia, while almost 142 thousand tonnes of bituminous coal was imported from Australia:

- Raw material equivalent: The raw material equivalent of the Australian coal would have to take into account the additional fuel involved in shipping the coal from Australia, as opposed to from Estonia.
- Unused extraction: Coefficients for the hidden flows associated with imported hard coal from Australia is 10.64 and for Russia and the former Soviet Union 5.13 (taken from Wuppertal Institute data). These coefficients mean that for every tonne of imported coal from Australia there is an associated 10.64 tonnes of unused extraction back in Australia. Similarly there is 5.13 tonnes of unused extraction in Estonia for every tonne of imported Estonian coal.

In general, unused extraction is usually more significant than raw material equivalent, and in many cases raw material equivalent can be ignored**.**

Hidden flows have been estimated for some countries but mainly for raw materials and hardly any for finished products. In any case, a lot of MFA studies in other countries have omitted hidden flows associated with finished goods when calculating TMR. Therefore this is also recommended as the approach for Ireland and is the approach used in the preliminary estimate of total material flows in Ireland (Section 6).

3.2.5 Release to Environment

This consists of the release of materials which have been used (as opposed to unused extraction) to all environmental media. It includes emissions to waters and to air, as well as wastes landfilled and waste composted. MFA work in other countries has shown emissions to water to be negligible in terms of the total mass of all materials.

Also included are products which are released to the environment in an uncontrolled way (e.g. spread of pesticides) and also losses of products/materials to the environment (e.g. natural gas distribution leakages). In the majority of MFA studies in other countries the major dissipative product use is landspreading of manure.

Controlled landfills and commercial forests could also be considered to be within the system boundary, but this is considered to be a less suitable method for Ireland.

It is recommended that waste be split by waste type where data allows.

3.2.6 Net Addition to Stocks

This is the material that is added to man-made infrastructure (e.g. buildings, roads, etc.) and durable goods less any losses/removals.

It is recommended to calculate the net addition to stocks independently rather than by difference between the inputs and outputs, since uncertainties in input and output data could lead to inaccuracies. A rough method of estimating stock additions is to use the difference between Domestic Material Consumption and Domestic Processed Output to the environment. Other countries have used this method and it can be useful as a first estimate.

The net addition to stocks can be calculated by either estimating total stocks, or by estimating additions and removals only. The latter method is the one that has been used the most and is the more suitable to Ireland.

The major component of stock additions/removals is buildings/infrastructure.

3.3 Units

For material flow accounts, the mass of actual material reported is used. For material balances, there must be consistency in the units used for inputs and outputs, for example for fossil fuels, either the equivalent amount of oxygen needed on the input side and corresponding water vapour on the output side is added, or else the fuel input and carbon dioxide emissions are expressed in terms of mass of carbon. The former is the most commonly used method and is recommended for Ireland.

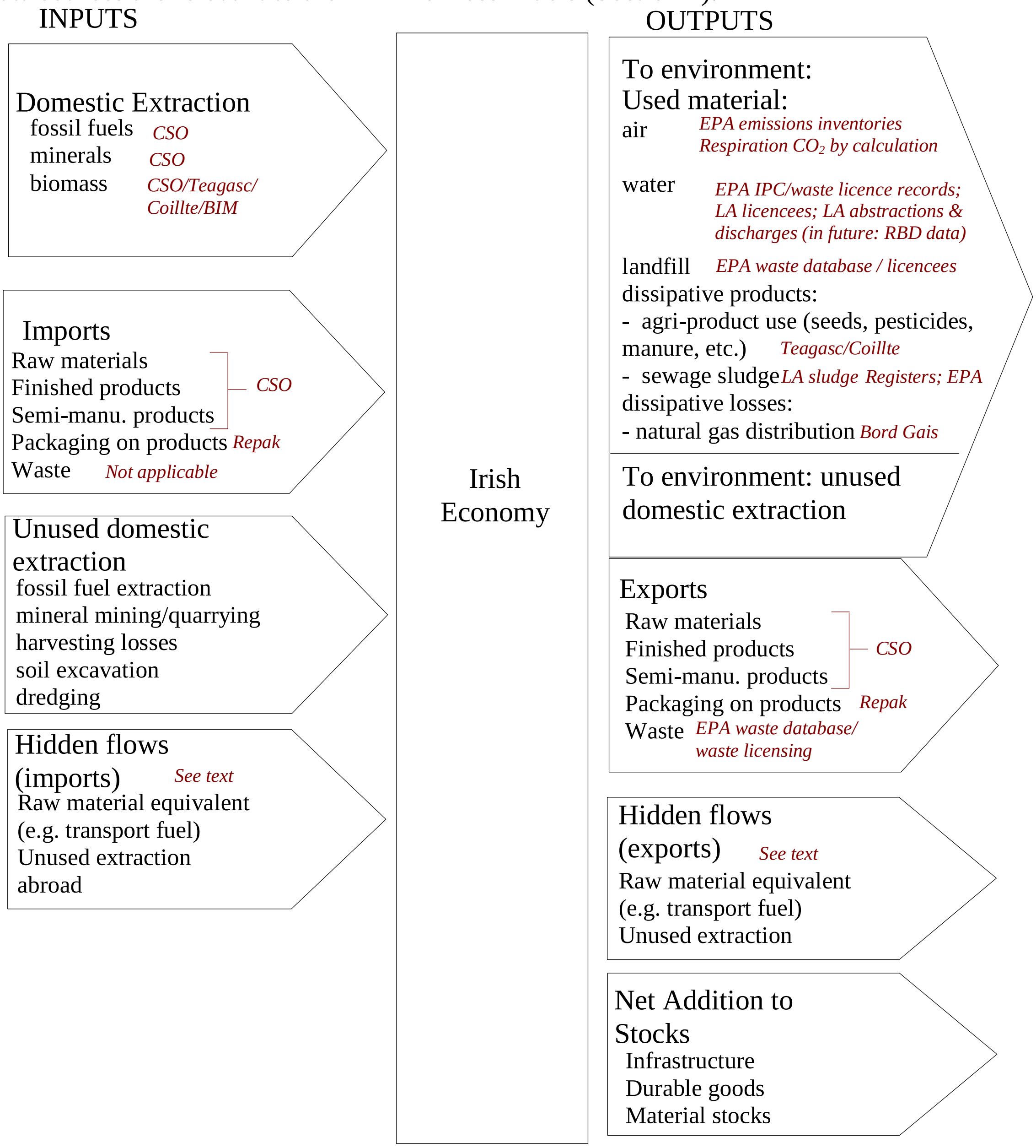
3.4 MFA Format and Illustration

An MFA for Ireland should consist of a series of Microsoft Excel files, divided into inputs per sector and outputs per sector. A guidance document and overall diagram showing the structure of the files should accompany the set of spreadsheets.

The use of Sankey diagrams for the representation of MFA is considered to be particularly illustrative and is recommended for inclusion in the Irish methodology.

3.5 Data Sources for Irish MFA

The following data sources should be used in obtaining information for total material flows in Ireland. Where usable data is available from such sources it has been included in the preliminary estimate of total material flows in Ireland (Section 6). Only some of these data sources are relevant to the MFA for fossil fuels (Section 4).



3.5.1 Hidden Flows (Imports and Exports)

Information on hidden flows associated with imports can be obtained for a lot of raw materials from the Wuppertal Institute (http://www.wupperinst.org/Projekte/mipsonline/download/download.html) as well as the Technical Part to the EEA Report "Total Material Requirement of the European Union".

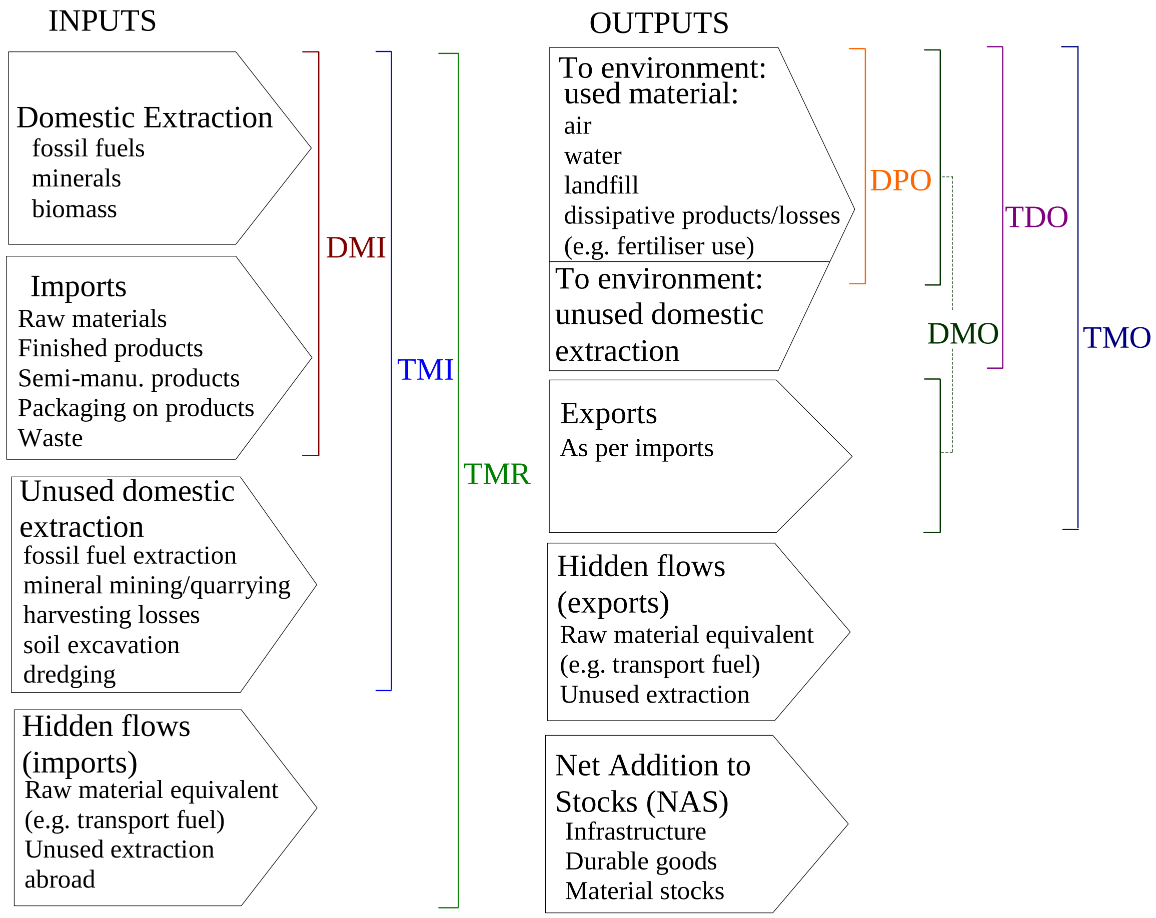
Information on hidden flows associated with exports will be the same as unused domestic extraction plus raw material equivalent associated with manufacture, etc. (RME associated with transport within Ireland will be negligible).

3.6 Identification of Indicators

MFA indicators are divided into three different categories, namely input, output and consumption indicators. As well as tonnes, these indicators are often expressed on a kg per capita basis.

3.6.1 Input and Output Indicators: relationship in overall scheme

MFA input & output indicators and the basis of their calculation:



3.6.1.1 Input Indicators - Definitions

DMI (Direct Material Input) = domestic extraction + imports

TMI (Total Material Input) = DMI + unused domestic extraction

TMR (Total Material Requirement) = TMI + hidden flows (imports)

DMI is an illustration of the weight of actual material that goes into the Irish economy. It includes material that will be consumed within Ireland, as well as other materials that will go into products and ultimately be exported. TMR is also a measure of the amount of material that goes into the Irish economy, but it includes not just the actual material itself, but the amount of unused material associated with its extraction or production, both in the State and abroad. For all three of these indicators, reducing their value (in tonnes or in tonne/capita), while maintaining or increasing fiscal activity, is to move in the direction of sustainability.

3.6.1.2 Output Indicators - Definitions

DPO (Domestic Processed Output) = used material emitted to the environment

TDO (Total Domestic Output) = DPO + unused extraction

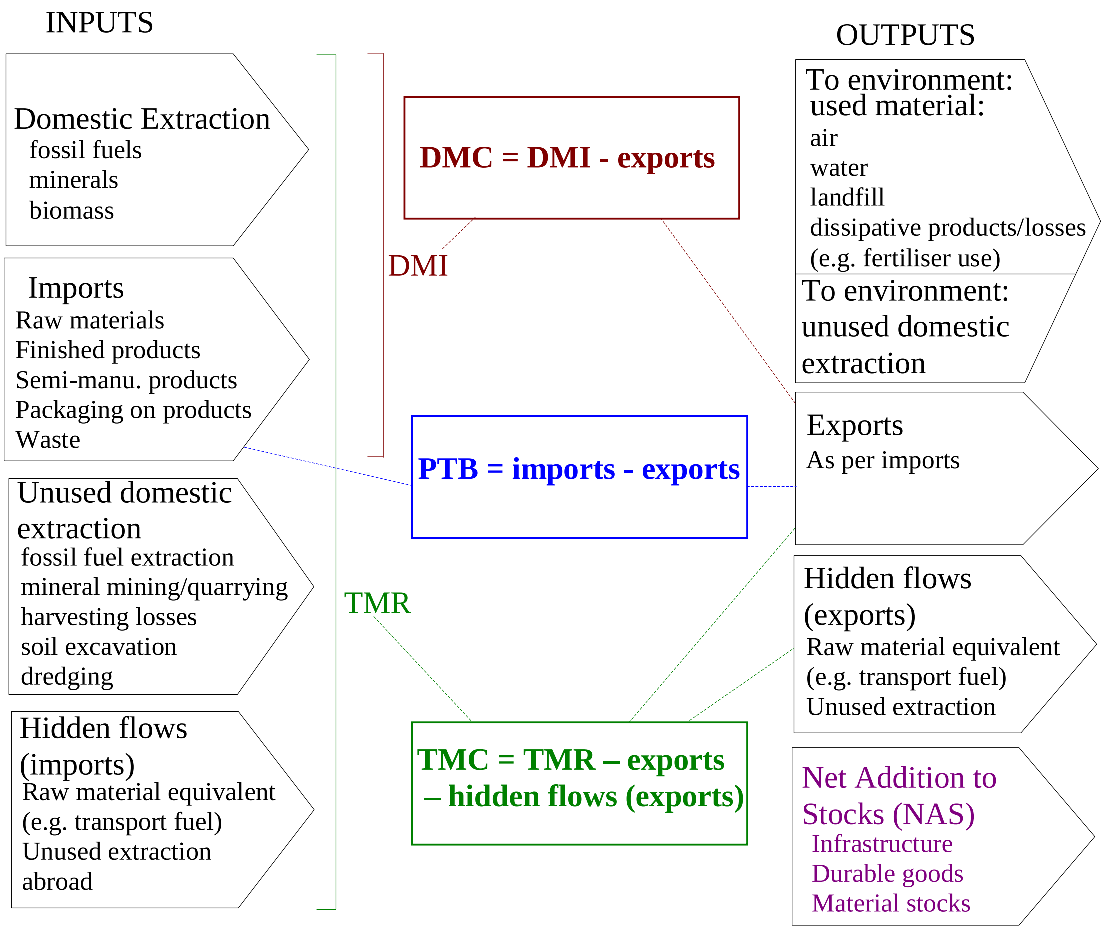
DMO (Direct Material Output) = DPO + exports

TMO (Total Material Output) = TDO + exports

DPO illustrates the quantity of material that is discharged into the Irish environment after it has been used in the Irish economy (e,g, carbon dioxide emissions from the burning of fuel). TDO also takes into account material that is extracted in Ireland but is never actally used in an economic sense (e.g. natural gas losses during drilling). For all four of these indicators, reducing their value (in tonnes or in tonne/capita), while maintaining or increasing fiscal activity, is to move in the direction of sustainability.

3.6.2 Consumption Indicators: Relationship in Overall Scheme

MFA consumption indicators and the basis of their calculation are as follows:



3.6.2.1 Consumption Indicators - Definitions

DMC (Domestic Material Consumption) = DMI - exports
TMC (Total Material Consumption) = TMR - exports - hidden flows (exports)
PTB (Physical Trade Balance) = imports – exports
NAS (Net Additions to Stock).

DMC is an illustration of the weight of actual material that is consumed within Ireland. TMC is also a measure of the amount of consumption of material within Ireland, but it includes not just the actual material itself, but the amount of unused material associated with its extraction or production, both in the State and abroad. Reducing the value of the indicators DMC and TMC (in tonnes or in tonne/capita), while maintaining or increasing the level of fiscal activity, is to move in the direction of sustainability.

A positive value for PTB shows that an economy is dependent on imports, whereas a negative value shows a net exporting economy in terms of weight of materials. NAS shows the amount of materials that has been incorporated into infrastructure (such as roads and buildings) and durable goods (for example electrical appliances) in the country.

4 DEMONSTRATION OF METHODOLOGY: CASE STUDY – NATIONAL FOSSIL FUEL FLOW ACCOUNTS

4.1 Introduction

The case study involved the generation of material flow accounts and associated indicators for fossil fuels used in Ireland.

The outcome of this task is a set of physical accounts for fossil fuels used in Ireland for the years 2000, 1996, and 1990. It covers fossil fuel inputs, uses in various sectors, and associated emissions. Input, output and consumption indicators have also been calculated.

Section 4.2 sets out the results of the MFA for fossil fuels in Ireland for each of the years 2000, 1996 and 1990. Section 4.3 illustrates the input, output and consumption indicators for 2000, 1996 and 1990. Section 4.4 compares these Irish fossil fuel MFAs and indicators with those of other countries and the EU as a whole. Section 4.5 describes the structure of the fossil fuel MFA spreadsheets and the sources of data used in the MFA.

The fossil fuel MFA is illustrated both in tabular form, and by Sankey Diagram.

The Fossil Fuel MFA has been compiled for the years 2000, 1996 and 1990. A single Excel file is dedicated to each year – MFA2000.xls, MFA1996.xls, and MFA1990.xls. Each of the files has the following worksheets:

- Indicators
- Overall
- Inputs Outputs
- Domestic Hidden Flows
- Foreign Hidden Flows
- Throughput
- Waste
- Emissions
- Conversion Factors

The worksheets are further described in section 4.5. The worksheets form the basis of the Sankey diagrams, which were generated using the selected software. Sankey diagrams allow easy pictorial visualisation of flows. The thickness of each arrow in a Sankey Diagram is proportional to the magnitude of the flow.

4.2 MFA for Fossil Fuels in Ireland for 2000, 1996 and 1990

Tables 4.1 to 4.3 show the results of the material flow accounts for fossil fuels in Ireland for each of the years 2000, 1996, and 1990. These tables are taken from the spreadsheets referenced in section 4.5.

Overall Fossil Fuel MFA - 2000 Data in '000 tonnes						
Input			**Output**			
Domestic Extraction		**5,385**	**To Environment (Used Material)**			**42,154**
Peat	4,455		To Air	CO_2	41,239	
Natural Gas	930			N_2O	5	
Imports		**13,967**		CH_4	5	
Hard Coal	2,929			SO_2	131	
Lignite	33			NO_x	122	
Peat	0			NH_3/VOC	45	
Liquid fossil fuels	8,598			CO	275	
Natural Gas	2,406		To land	ash	331	
Unused Domestic Extraction		**1,237**	To water	N, P	0	
Peat	1,114		**To Environment (Unused Extraction)**			**1,237**
Natural Gas	124		Peat		1,114	
Hidden Flows (Imports)		**8,715**	Natural Gas		124	
Hard Coal	7,595		**Exports**			**1,193**
Lignite	283		Hard Coal		9	
Peat	0		Lignite		0	
Liquid fossil fuels	558		Peat		18	
Natural Gas	280		Liquid fossil fuels		1,166	
Oxygen (for balancing)		**29,992**	Natural Gas		0	
			Hidden Flows (Exports)			**211**
			Hard Coal		8	
			Lignite		0	
			Peat		5	
			Liquid fossil fuels		198	
			Natural Gas		0	
			Net Additions to stocks			**65**

Figure 4.1: Overall Fossil Fuel MFA, 2000

Overall Fossil Fuel MFA - 1996 **Data in '000 tonnes**						
Input			**Output**			
Domestic Extraction		**7,629**	**To Environment (Used Material)**			**34,624**
Peat	5,525		To Air	CO_2	33,626	
Natural Gas	2,105			N_2O	4	
Imports		**10,841**		CH_4	5	
Hard Coal	3,033			SO_2	147	
Lignite	34			NO_x	118	
Peat	0			NH_3/VOC	71	
Liquid fossil fuels	7,305			CO	303	
Natural Gas	469		To land	ash	351	
Unused Domestic Extraction		**1,661**	To water	N, P	0	
Peat	1,381		**To Environment (Unused Extraction)**			**1,661**
Natural Gas	280		Peat		1,381	
Hidden Flows (Imports)		**9,991**	Natural Gas		280	
Hard Coal	9,467		**Exports**			**906**
Lignite	284		Hard Coal		26	
Peat	0		Lignite		0	
Liquid fossil fuels	185		Peat		14	
Natural Gas	54		Liquid fossil fuels		866	
Oxygen (for balancing)		**24,455**	Natural Gas		0	
			Hidden Flows (Exports)			**173**
			Hard Coal		23	
			Lignite		0	
			Peat		3	
			Liquid fossil fuels		147	
			Natural Gas		0	
			Net Additions to stocks			**-25**

Figure 4.2: Overall Fossil Fuel MFA, 1996

Overall Fossil Fuel MFA - 1990 Data in '000 tonnes						
Input			**Output**			
Domestic Extraction		**8,324**	**To Environment (Used Material)**			**30,771**
Peat	6,480		To Air	CO_2	29,577	
Natural Gas	1,819			N_2O	3	
Coal	26			CH_4	7	
Imports		**9,025**		SO_2	183	
Hard Coal	3,100			NO_x	109	
Lignite	35			NH_3/VOC	73	
Peat	0			CO	397	
Liquid fossil fuels	5,889		To land	ash	421	
Natural Gas	0		To water	N, P	0	
Unused Domestic Extraction		**1,885**	**To Environment (Unused Extraction)**			**1,963**
Hard Coal	23		Hard Coal		101	
Peat	1,620		Peat		1,620	
Natural Gas	242		Natural Gas		242	
Hidden Flows (Imports)		**10,138**	**Exports**			**607**
Hard Coal	9,676		Hard Coal		29	
Lignite	291		Lignite		0	
Peat	0		Peat		9	
Liquid fossil fuels	171		Liquid fossil fuels		569	
Natural Gas	0		Natural Gas		0	
Oxygen (for balancing)		**21,511**	**Hidden Flows (Exports)**			**124**
			Hard Coal		25	
			Lignite		0	
			Peat		2	
			Liquid fossil fuels		97	
			Natural Gas		0	
			Net Additions to Stocks			**-515**

Figure 4.3: Overall Fossil Fuel MFA, 1990

Diagrams 4.1 to 4.3 illustrate the fossil fuel MFAs for each of the years 2000, 1996 and 1990 respectively. The size of the arrow is proportional to the magnitude of each of the flows. These diagrams have been generated using S.Draw.

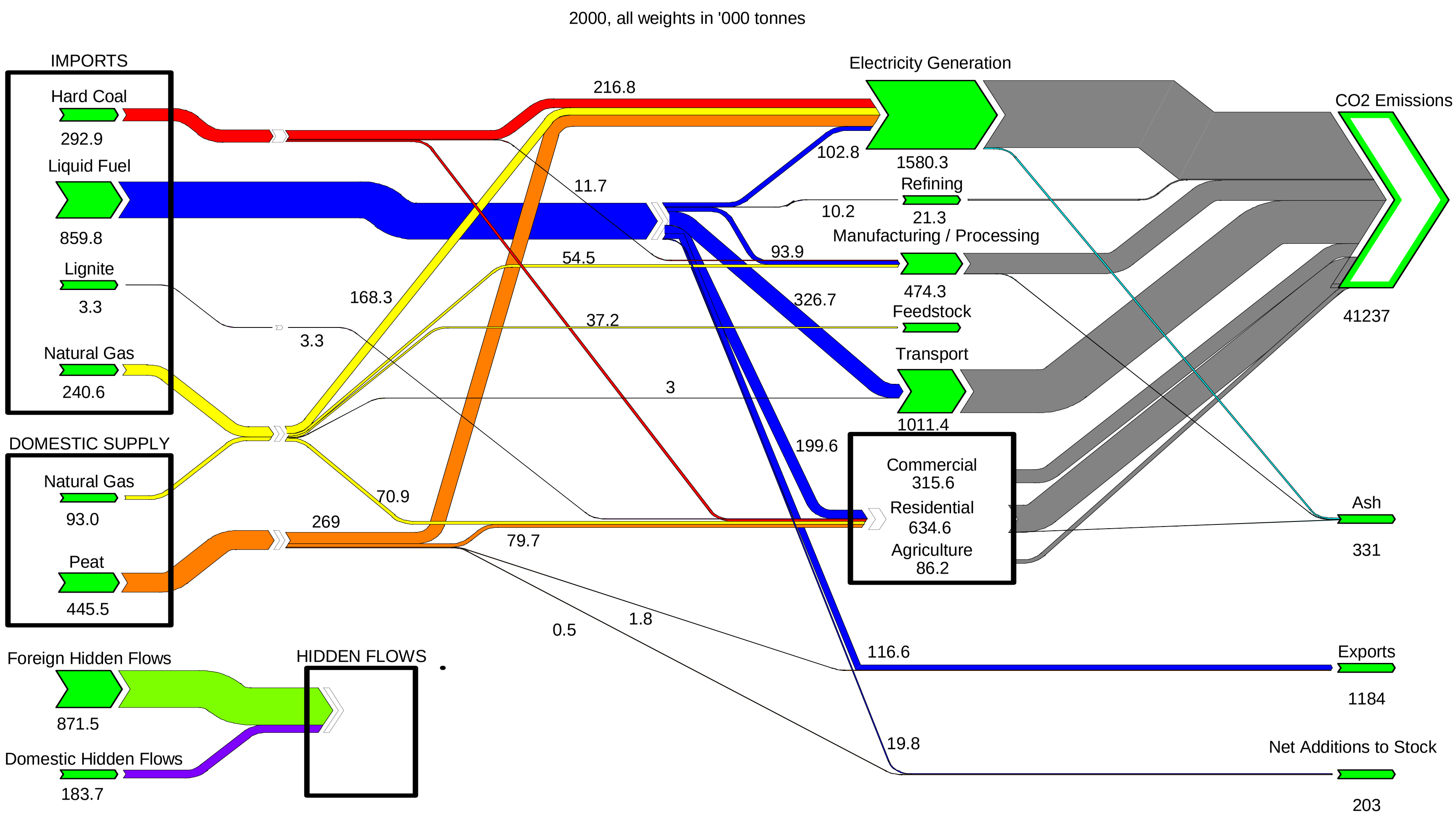
Data Anomalies

One of the main sources of difference in the MFA for all of the years is between the total input to the economy (domestic extraction and imports) and the sum of the input to each of the sectors. The reason for the difference is because two different data sources were chosen as outlined earlier. Domestic extraction and imports were based on Department of Communications, Marine, and Natural Resources (DCMNR) figures and, after discussion, these data were considered more reliable than CSO data. A more detailed sectoral breakdown is available from the EPA data in accordance with the sectoral reporting under the Inter-governmental Panel on Climate Change (IPCC). This is also the data that is used to generate Ireland's greenhouse gas emissions. Hence the EPA data was used for illustrating the sectoral throughput and the associated emissions.

Data Gaps

All in all, data is generally readily available on an aggregated national level for fossil fuels. Domestic hidden flow data associated with Irish fossil fuel extraction is not available, and factors from other countries have been used instead.

Earlier data is only available from the CSO on micro-fiche.



2000, all weights in '000 tonnes
IMPORTS
Hard Coal
292.9
Liquid Fuel
859.8
Lignite
3.3
Natural Gas
240.6
DOMESTIC SUPPLY
Natural Gas
93.0
Peat
445.5
Foreign Hidden Flows
871.5
Domestic Hidden Flows
183.7
HIDDEN FLOWS
216.8
11.7
168.3
54.5
3.3
37.2
3
70.9
269
79.7
0.5
1.8
102.8
10.2
93.9
326.7
199.6
116.6
19.8
Electricity Generation
1580.3
Refining
21.3
Manufacturing / Processing
474.3
Feedstock
Transport
1011.4
Commercial
315.6
Residential
634.6
Agriculture
86.2
CO2 Emissions
41237
Ash
331
Exports
1184
Net Additions to Stock
203

Figure 4.1

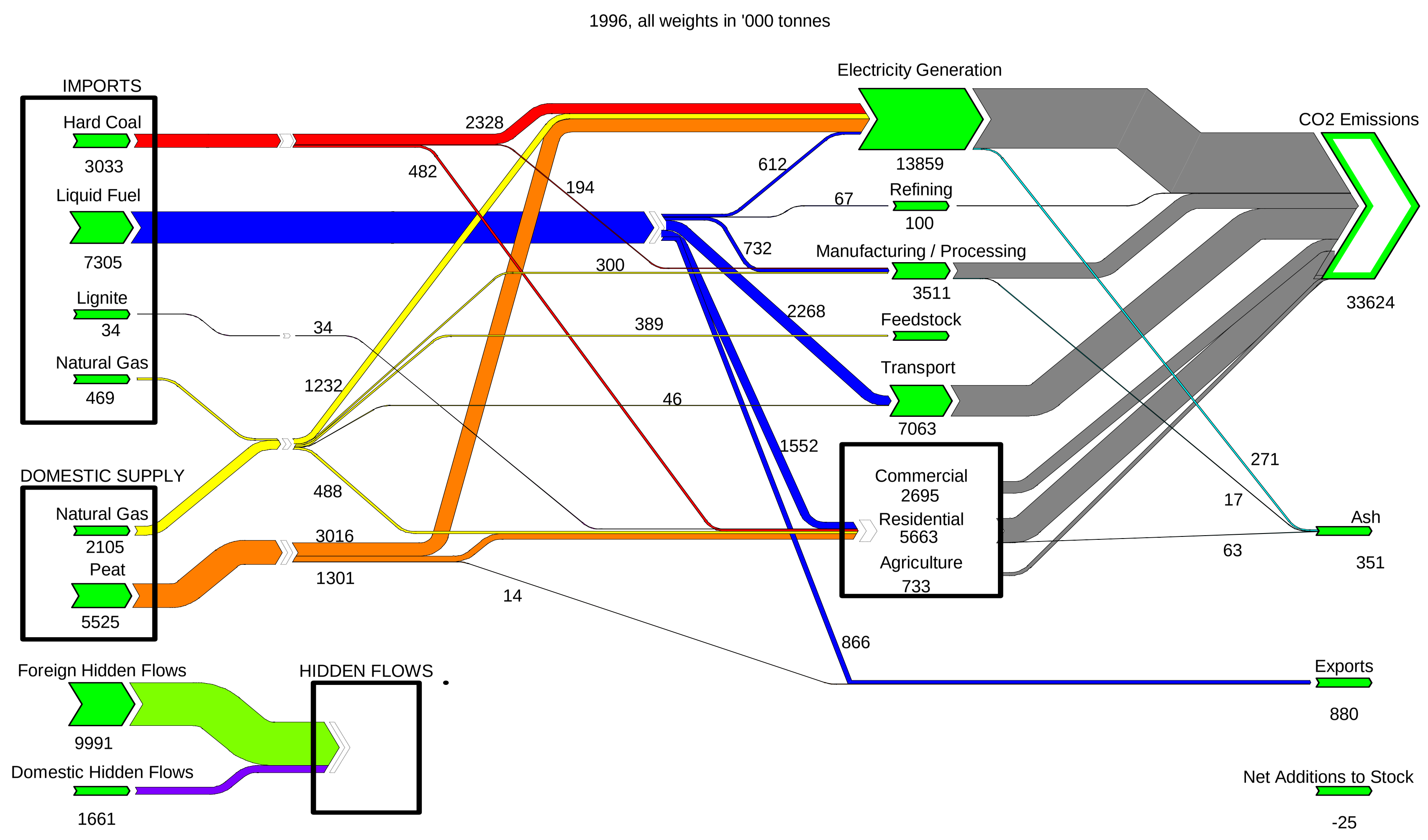

1996, all weights in '000 tonnes
IMPORTS
Hard Coal
3033
Liquid Fuel
7305
Lignite
34
Natural Gas
469
DOMESTIC SUPPLY
Natural Gas
2105
Peat
5525
Foreign Hidden Flows
9991
Domestic Hidden Flows
1661
HIDDEN FLOWS
2328
482
194
34
1232
488
3016
1301
14
300
389
46
612
67
732
2268
1552
866
Electricity Generation
13859
Refining
100
Manufacturing / Processing
3511
Feedstock
Transport
7063
Commercial
2695
Residential
5663
Agriculture
733
CO2 Emissions
33624
271
17
63
Ash
351
Exports
880
Net Additions to Stock
-25

Figure 4.2

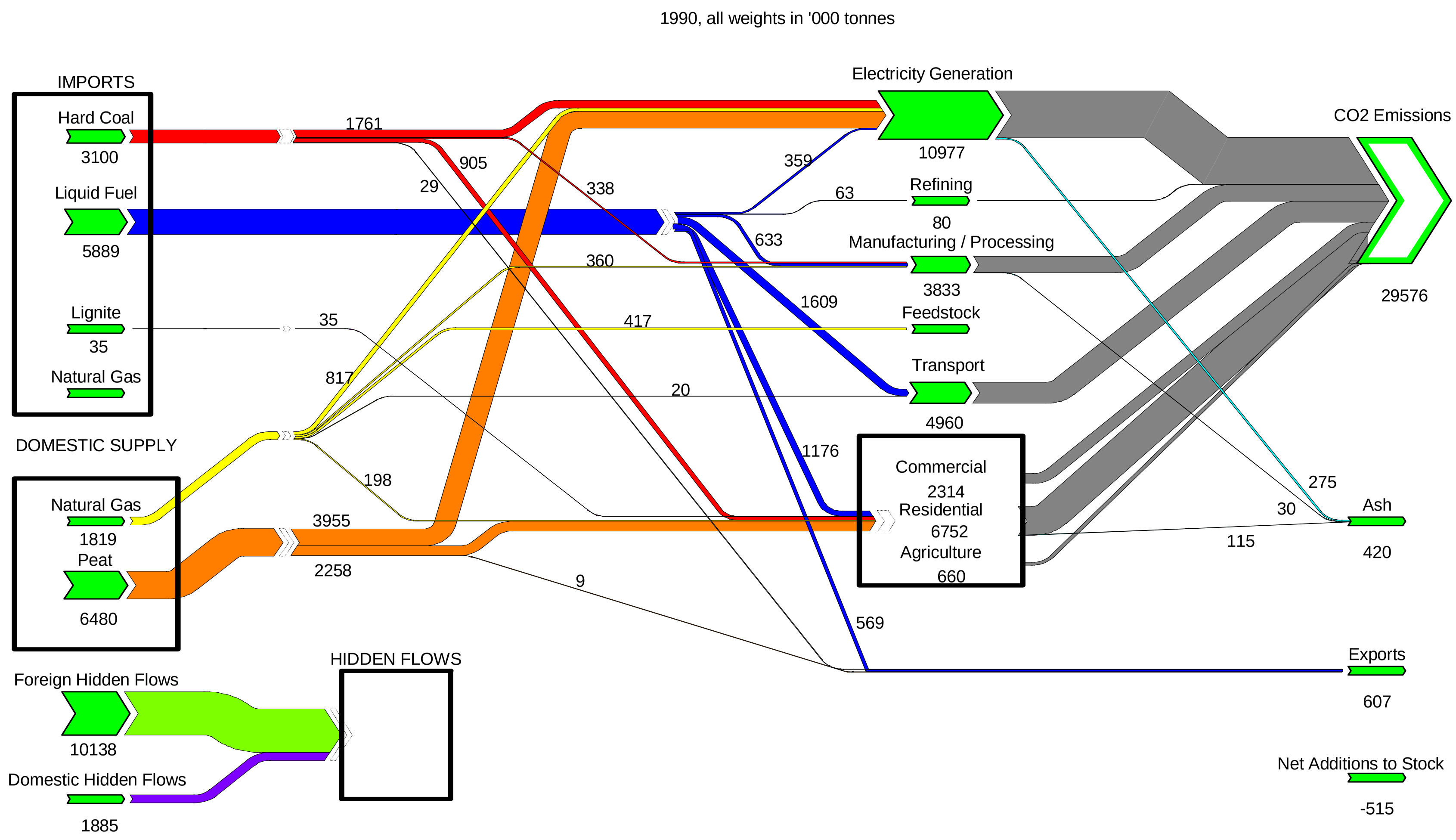

1990, all weights in '000 tonnes
IMPORTS
Hard Coal
3100
Liquid Fuel
5889
Lignite
35
Natural Gas
DOMESTIC SUPPLY
Natural Gas
1819
Peat
6480
Foreign Hidden Flows
10138
Domestic Hidden Flows
1885
HIDDEN FLOWS
1761
905
29
338
360
35
417
817
20
198
3955
2258
9
359
63
633
1609
1176
569
Electricity Generation
10977
Refining
80
Manufacturing / Processing
3833
Feedstock
Transport
4960
Commercial
2314
Residential
6752
Agriculture
660
CO2 Emissions
29576
275
30
115
Ash
420
Exports
607
Net Additions to Stock
-515

Figure 4.3

4.3 Input, Output and Consumption Indicators for Fossil Fuels in Ireland for 2000, 1996 and 1990

4.3.1 Input Indicators

Table 4.4 shows input indicators for each of the years 2000, 1996, and 1990 in terms of thousands of tonnes, and in tonnes per capita.

Figure 4.4 overleaf illustrates the input and output indicators for fossil fuels in Ireland (this diagram is useful in illustrating the meaning of each indicator).

Input Indicators for Fossil Fuels						
	Data in '000 tonnes			**Data in tonnes/capita**		
	2000	*1996*	*1990*	*2000*	*1996*	*1990*
DMI- fossil fuel	19,352	18,471	17,349	5.1	5.1	4.9
TMI - fossil fuel	20,589	20,132	19,233	5.4	5.6	5.4
TMR - fossil fuel	29,304	30,123	29,371	7.7	8.3	8.3

Table 4.4

DMI is a measure of the direct input of fossil fuels into the economy, being the sum of used domestically extracted and imported fossil fuels. On a per capita basis it has increased slighty between 1990 and 2000.

As well as direct inputs, TMI also adds in the waste associated with fossil fuel extraction here in Ireland. It has remained more or less consistent on a per capita basis since between 1990 and 2000.

TMR goes one step further than TMI in that it also adds in the waste associated with fossil fuel extraction abroad that is imported and used here in Ireland. TMR has decreased between 1990 and 2000. This is likely due to the increased usage of imported natural gas and oil over coal in this time period.

In order to move to a sustainable economy, these indicators should remain stable or decrease with time while fiscal indicators remain stable or increase.

MFA Indicators - Input & Output

2000, 1996, 1990 ('000 tonnes)

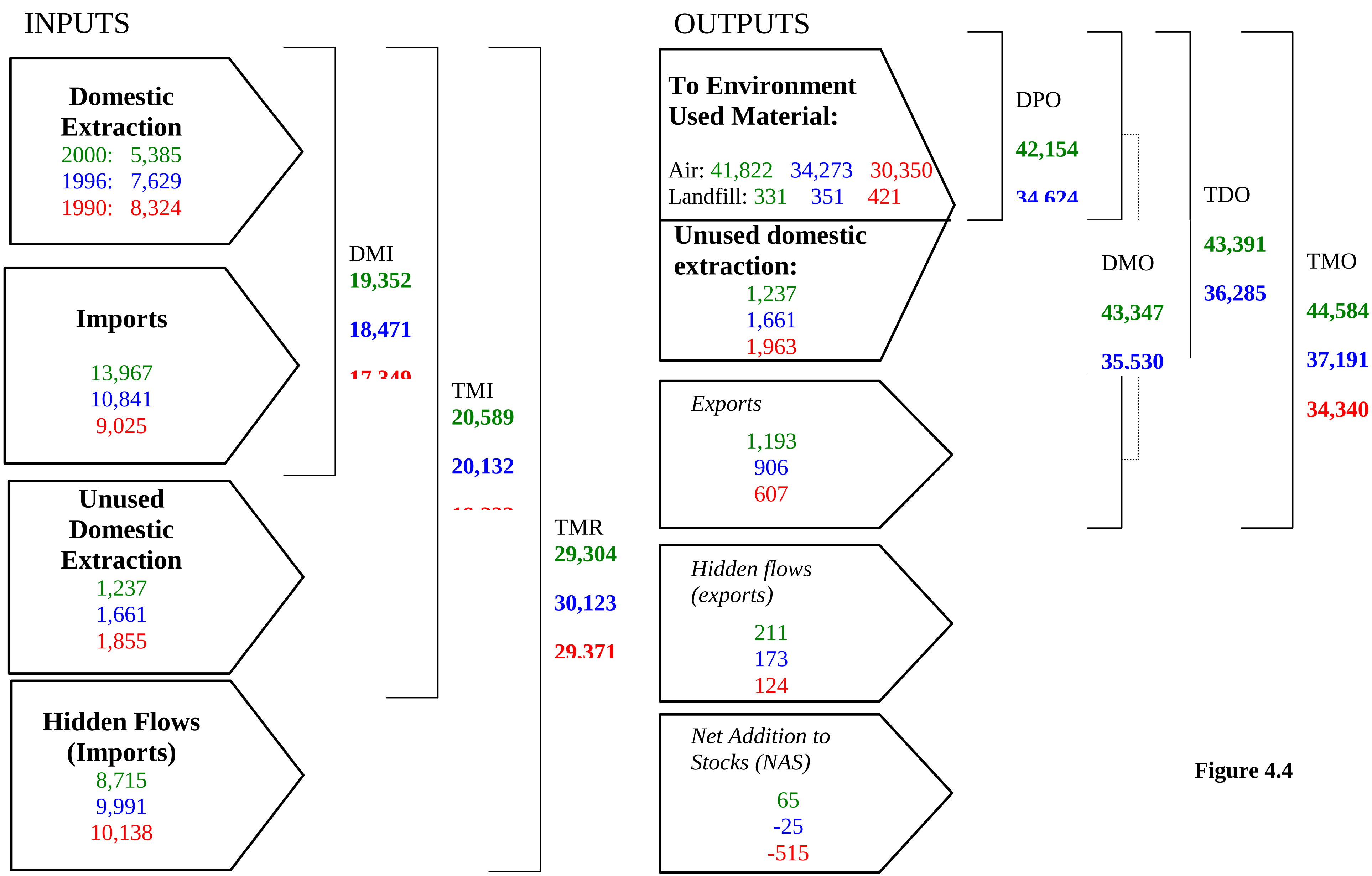


Figure 4.4

4.3.2 Output Indicators

Figure 4.4 illustrates the output indicators for fossil fuels in Ireland.

Table 4.5 shows output indicators for each of the years 2000, 1996, and 1990 in terms of thousands of tonnes, and in tonnes per capita.

Output Indicators for Fossil Fuels						
	Data in '000 tonnes			**Data in tonnes/capita**		
	2000	*1996*	*1990*	*2000*	*1996*	*1990*
DPO - fossil fuel	42,154	34,624	30,771	11.0	9.5	8.7
DMO - fossil fuel	43,347	35,530	31,377	11.3	9.8	8.9
TDO - fossil fuel	43,391	36,285	32,733	11.4	10.0	9.3
TMO - fossil fuel	44,584	37,191	33,340	11.7	10.3	9.4

Table 4.5

DPO is a measure of the direct output to all environmental media from the combustion of fossil fuels across all sectors. On a per capita basis such emissions have increased between 1990 and 2000.

As well as emissions to the environment, DMO takes exports into account. This has similarly increased between 1990 and 2000.

TDO is a measure of all releases to the environment, those which results from the combustion of fossil fuels, and those associated with the extraction of fossil fuels in Ireland - direct output to all environmental media from the combustion of fossil fuels across all sectors. On a per capita basis such emissions have increased between 1990 and 2000.

TMO is all outputs from the Irish economy – releases to the environment (both direct and indirect) as well as exports. This has similarly increased between 1990 and 2000.

Each of these output indicators for fossil fuels for Ireland show an increasing trend over the time period 1990 to 2000. However, in order to move to a sustainable economy, these indicators should remain stable or decrease with time while corresponding fiscal indicators remain stable or increase.

4.3.3 Consumption Indicators

Table 4.6 shows consumption indicators for each of the years 2000, 1996, and 1990 in terms of thousands of tonnes, and in tonnes per capita.

Figure 4.5 illustrates the consumption indicators for fossil fuels in Ireland

Consumption Indicators for Fossil Fuels						
	Data in '000 tonnes			Data in tonnes/capita		
	2000	*1996*	*1990*	*2000*	*1996*	*1990*
DMC - fossil fuel	18,159	17,565	16,742	4.8	4.8	4.7
TMC - fossil fuel	27,901	29,044	28,640	7.3	8.0	8.1
PTB - fossil fuel	12,774	9,936	8,418	3.3	2.7	2.4

Table 4.6

DMC is a measure of the consumption of fossil fuels by the economy, being the sum of used domestically extracted and imported fossil fuels, and subtracting that exported. On a per capita basis it has remained more or less constant between 1990 and 2000.

TMC is a measure of the total material consumption, both that used in the economy and that associated with domestic and foreign unused extraction, and taking away outputs via exports and hidden flows associated with such exports. It has decreased between 1990 and 2000. Similar to TMR, this is likely due to the increased usage of imported natural gas and oil over coal in this time period.

In order to move to a sustainable economy, the indicators DMC and TMC should remain stable or decrease with time while corresponding fiscal indicators remain stable or increase. Hence the trend for TMC is in a sustainable direction, however as can be seen later in section 4.4.2, Ireland’s values for TMC in absolute terms are relatively high compared to other countries.

PTB is the physical trade balance between imports and exports. It has increased between 1990 and 2000. This reflects an increase in fossil fuel imports and a decrease in domestic extraction.

4.3.4 Materials Productivity

Table 4.7 shows materials productivity for fossil fuels for each of the years 2000, 1996, and 1990. Materials productivity is GDP per tonne of DMI (Direct Material Input) and per tonne of DMC (Domestic Material Consumption).

Materials Productivity for Fossil Fuels			
	Data in € per tonne		
	2000	*1996*	*1990*
GDP/DMI – fossil fuels	€ 5,318	€ 2,894	€ 2,147
GDP/DMC – fossil fuels	€ 5,667	€ 3,044	€ 2,225

Table 4.7

It can be seen that productivity per tonne of fossil fuels has significantly increased between 1990 and 2000. This is likely as a result of the increasingly knowledged-based rather than manufacturing-based economy.

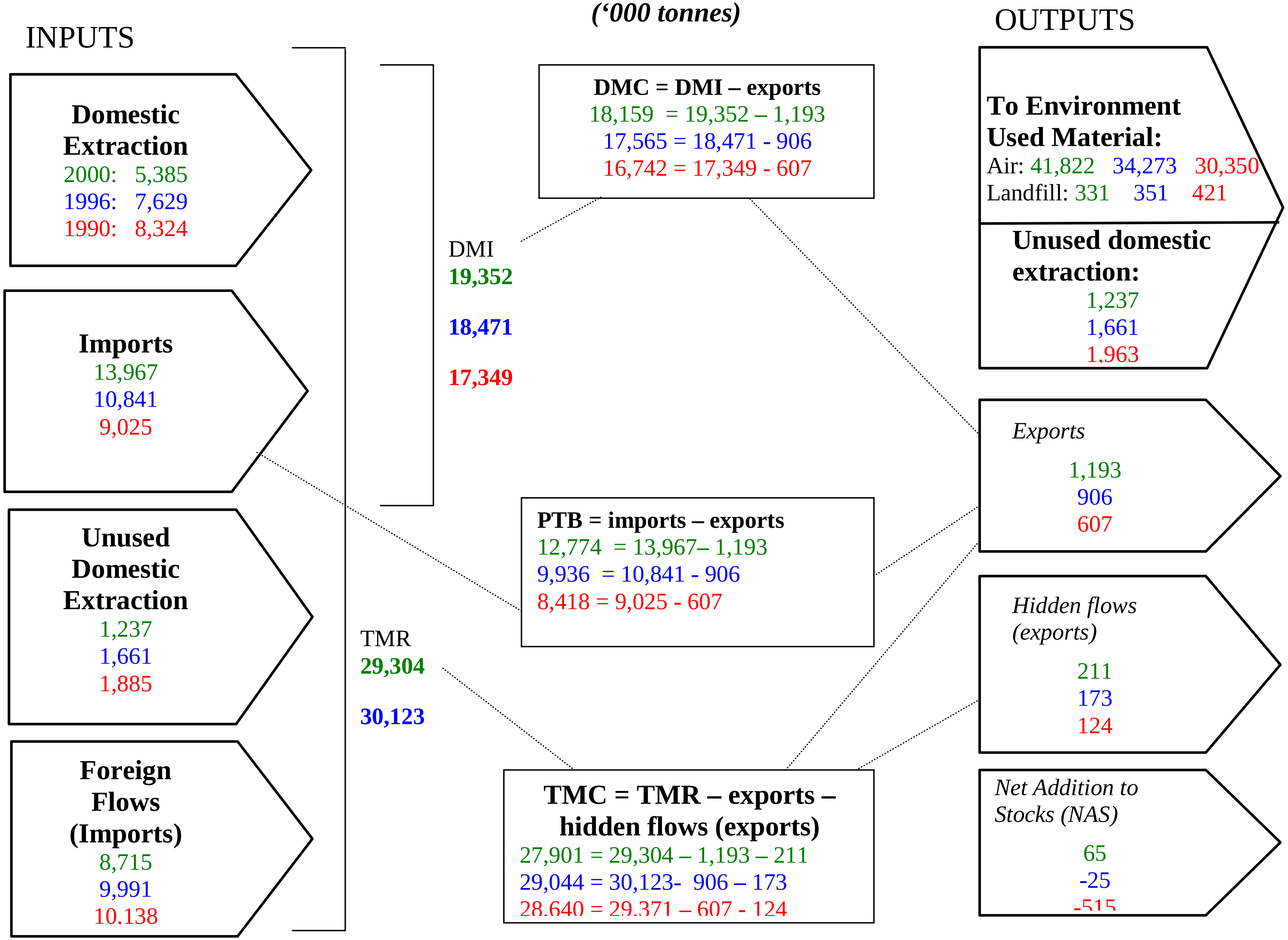
In order to move to a sustainable economy, the materials productivity indicators should increase with time. Hence the trends for the materials productivity indicators are in a sustainable direction.

It should be noted the above are in relation to fossil fuels only and not all physical materials.

Figure 4.5

MFA Indicators - Consumption
2000, 1996, 1990

('000 tonnes)



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4.4 Comparison of Irish Fossil Fuel MFA and Indicators with other Countries

It is instructive to compare the MFA and indicators for fossil fuel use in Ireland with those calculated by ETC-WMF for Ireland, as well as those calculated for other countries and for the EU as a whole.

4.4.1 Irish DMI and DMC

A revised estimate of TMR has recently been compiled (Jan 2003) for the EU[2]. This also calculates DMI and DMC for each of the Member States. It has been generated by the European Topic Centre on Waste and Material Flows (ETC-WMF) and has been input into the Kiev report (a report on the assessment of Europe's environment published by the EEA in 2003 as a contribution to the inter-ministerial conference in Kiev). Apart from DMI and DMC, this report does not calculate any other indicators individually for each country.

For those countries which had not yet calculated MFA indicators on a national level, of which Ireland is one, this report used European and international statistics. In the case of fossil fuels, such data was obtained from the International Energy Agency (IEA) energy balances, Eurostat, and the OECD.

The estimates for Ireland are shown in Table 4.8 along with the corresponding values calculated in this report:

	As calculated in this project			ETC-WMF calculation		
	2000	*1996*	*1990*	*2000*	*1996*	*1990*
Irish Fossil Fuel extraction (‘000 t)	5,385	7,629	8,324	6,107	7,230	8,456
Irish Fossil Fuel imports (‘000 t)	13,967	10,841	9,025	12,478	9,639	8,595
Irish Fossil Fuel DMI (‘000 t)	19,352	18,471	17,349	18,585	16,869	17,051
Irish Fossil Fuel DMI (tonnes per capita)	5.1	5.1	4.9	4.9	4.6	4.9
Irish Fossil Fuel DMC (‘000 t)	18,159	17,565	16,742	16,734	15,275	15,863
Irish Fossil Fuel DMC (tonnes per capita)	4.8	4.8	4.7	4.4	4.2	4.5

Table 4.8

As can be seen the figures are similar in order of magnitude, but there are differences in the detail.

The DCMNR energy balance figures were used for imports and exports rather than CSO data because of data reliability. Eurostat data has been used in the ETC-WMF figures,

[2] Moll 2003 Datasheet for the Kiev Report http://waste.eionet.eu.int/mf/4

which would be based on the CSO data. As outlined in section 4.2, the CSO data underestimates imports - hence the lower ETC-WMF figures. The generation of Irish energy balance figures differs slightly to those published internationally. This is because slightly different conversion factors were utilised by DCMNR for the raw data. Also, petroleum coke was included in ‘coal’, whereas most international publications classify it as oil. Finally, non-energy products were excluded from the energy balance figures, while they are mostly included by international publications in their calculations.

In addition to this, the CSO data on the breakdown of countries of origin was used in calculating hidden flows in this study. In the ETC-WMF calculation, the standard hidden flow values were used.

4.4.2 Comparison with Other Countries

Table 4.9 shows some of the indicators calculated for Ireland in this report along with the corresponding EU-15 values according to the ETC-WMF.

	Ireland As calculated in this project (tonnes per capita)			EU-15 ETC-WMF calculation (tonnes per capita)		
	2000	*1996*	*1990*	*2000*	*1996*	*1990*
Fossil Fuel DMI	5.1	5.1	4.9	-	4.1	4.3
Fossil Fuel TMI	5.4	5.6	5.4	-	11.6	15.8
Fossil Fuel TMR	7.7	8.3	8.3	-	14.8	18.7

Table 4.9

As can be seen, Ireland is above the EU average for DMI. This means the per capita input of fossil fuels from imports and domestic extraction into Ireland's economy is somewhat higher than the EU average. The differences outlined in section 4.4.1 between the figures generated in this report and those of the ETC-WMF will have an effect on the ability to compare results internationally. However, the differences between the Irish figures generated in this report and the ETC-WMF's Irish figures are small overall in comparison to the differences between the ETC-WMF figures for Ireland and other countries. Hence the effect on comparisons should not be significant.

Ireland is well below the EU average for TMI and TMR for fossil fuels. This means that, taking the unused extraction associated with domestic and imported fossil fuels into account, as well as the fossil fuel input into the economy, Ireland is well below the EU average. This implies that the unused extraction associated with Ireland's domestic extraction and imports is low in comparison with other Member States. While a detailed breakdown on the sources of the EU figures is not available, one reason for this significant difference is likely to be the limited amount of domestic extraction of fossil fuels which occurs in Ireland, which is virtually all used in the Irish economy. Conversely, some EU Member States would have significant fossil fuel domestic extraction, which would increase both the TMI and TMR figures, because these indicators do not subtract exports, or hidden flows associated with exports.

Figure 4.6 shows Ireland's position relative to other EU countries in terms of DMI, Direct Material Input (domestic extraction plus imports).

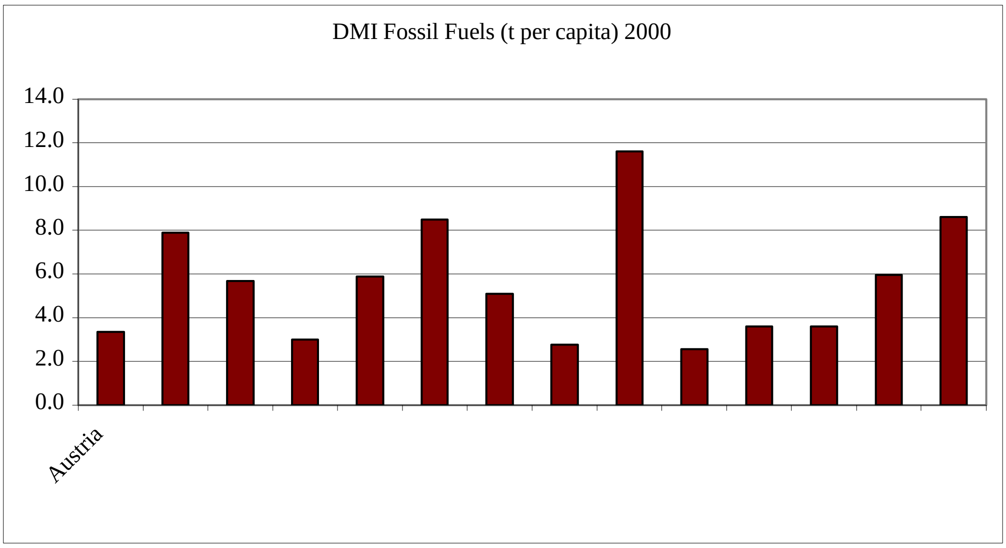
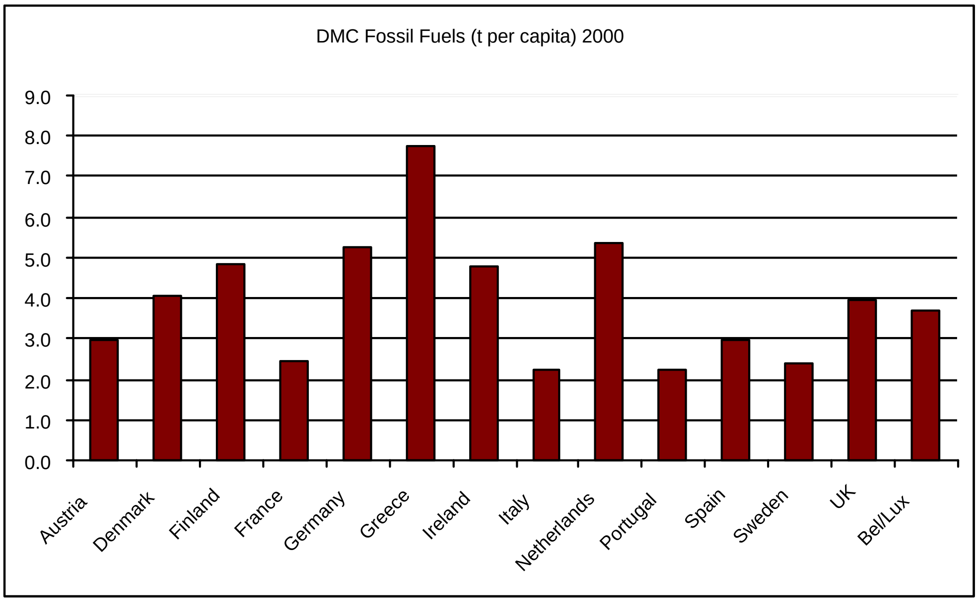


Figure 4.7 shows Ireland's position relative to other EU countries in terms of DMC, Domestic Material Consumption (domestic extraction plus imports minus exports).



As can be seen, Ireland is joint fifth highest out of all EU countries in terms of DMC. This means Ireland has the fifth highest fossil fuel consumption per capita in theEU**.**

4.5 Structure of the Fossil Fuel MFA Spreadsheets & Data Sources Used

The Fossil Fuel MFA has been compiled for the years 2000, 1996 and 1990. A single Excel file is dedicated to each year – MFA2000.xls, MFA1996.xls, and MFA1990.xls. Each of the files has the following worksheets:

- Indicators
- Overall
- Inputs Outputs
- Domestic HFs
- Foreign HFs
- Throughput
- Waste
- Emissions
- Conversion Factors

'Indicators' Worksheet

The 'Indicators' worksheet calculates the input, output, and consumption indicators for fossil fuels in Ireland based on the information in the rest of the spreadsheet.

'Overall' Worksheet

The 'Overall' worksheet calculates the overall MFA for fossil fuels in Ireland based on the information in the rest of the spreadsheet.

'Inputs Outputs' Worksheet

The 'Inputs Outputs' worksheet details the imports, exports (including those to marine bunkers), domestic extraction, and net additions to stocks for fossil fuels in Ireland.

There are two tables in each of the 'Input Output' worksheets. The first one gives all values in tonnes of oil equivalent (TOE), the second in tonnes. A TOE is an international standard measure of energy and is equivalent to 0.041868 TJ or 10^7 kilocalories.

All data assembled in the 'Input Output' worksheets compiled for 2000, 1996 and 1990 are taken from information supplied by the Department of Communications, Marine, and Natural Resources (DCMNR), consisting of energy balances for Ireland for the years in question. The data correlates with the EPA figures reported to the Inter-governmental Panel on Climate Change (IPCC) under the United Nations Framework Convention on Climate Change (EPA 2002a). It has been recommended through contact with the CSO, that the figures used in the DCMNR energy balances are more reliable as a result of industry contacts and should be used in place of the CSO data.

Out of current annual consumption of peat for energy purposes, about 60% is used in power stations (that primarily fire milled peat), 15% is briquetted and 25% consists of sod peat, used predominantly as a residential fuel. Peat briquettes are also almost all used as household fuel. Therefore, the conversion from TOE to tonnes for peat production assumed 75% milled peat and 25% sod peat. The figures in this report include commercial and private peat extraction.

The import data taken from the DCMNR energy balances was further differentiated into bituminous coal and lignite. The breakdown was estimated based on the percentage of each fuel type in the CSO import statistics.

‘Domestic HFs’ Worksheet

This worksheet calculates Domestic Hidden Flows. These are only associated with peat and natural gas.

The extraction data contained in the Domestic Hidden Flow sheets was supplied by DCMNR and correlated with those contained in the EPA data. The hidden flow factor used for peat extraction, 0.25t unused extraction per tonne of used extraction, was taken from a Conaccount workshop paper (Douglas 1997). This value has been used in several other European country MFAs. In the case of domestic extraction of natural gas, the values used are those of the UK for offshore gas extraction (a combined factor of 0.133 t unused extraction per tonne of used extraction, taking into account both drilling wastes and gas flared and re-injected). Some other European countries report different coefficients (as low as 0.001 for the Netherlands and up to 0.862 for Denmark).

‘Foreign HFs’ Worksheet

This worksheet calculates Foreign Hidden Flows associated with all imported fossil fuels.

It has been recommended through contact with the CSO, that the figures used in the DCMNR energy balances are more reliable as a result of industry contacts and should be used in place of the CSO data. An example of this can be illustrated by the import data for hard coal for the year 2000. The CSO figure is 2.1 million tonnes while the DCMNR figure is 3.3 million tonnes. Similarly, the energy balances state that peat imports are zero, while the CSO data has peat imports of ~ 8,000 t (this could be peat which is not for fuel use and has been wrongly classified).

While the CSO import data is broken down by country of origin, the DCMNR is not. Therefore, as a best estimate, the DCMNR tonnage has been split between countries of origin based on the CSO data. Caution was also exerted in the use of the CSO countries of origin, as it could be seen in many cases that rather than being the country of origin, it was the country of import - for example, significant hard coal imports through Northern Ireland.

The data supplied by the Central Statistics Office was analysed and broken into percentage values. These percentage values were then applied to the data supplied by DCMNR to calculate the hidden flows associated with the established import figures.

The hidden flow values used in worksheet ‘Foreign HFs’ were taken from the Wuppertal database. There are hidden flow coefficients for hard coal from UK, France, Germany, Spain, Australia, Russia & the former Soviet Union, USA, South Africa, and Colombia. Ireland has imports of hard coal from all of these countries. There is also a standard hidden flow coefficient which is usually used for all other countries of 0.89. This is used for the imports from all other countries (which accounts for almost 70% of imports).

‘Throughput’ Worksheet

This worksheet calculates the split of each of the fossil fuels used by the various sectors within Ireland.

This data is taken from that reported by the EPA to the Inter-governmental Panel on Climate Change (IPCC) under the United Nations Framework Convention on Climate Change (EPA 2002a).

‘Waste’ Worksheet

The ‘Waste’ worksheet details the solid wastes that are generated as a result of fossil fuel use. These consist of ash from power stations and other large combustion plants as well as ash generated by residential burning of coal and peat, and to a small extent industrial coal burning.

The figure for the ash from power stations was obtained from the EPA’s 2001 national waste database. This figure was used for the 2000 MFA. For 1990 and 1996, this figure was scaled - according to peat, coal, and oil usage for the years in question in power generation. While earlier national waste databases exist for 1995 and 1998, this method of calculation was assumed to be more accurate.

The ash associated with the residential burning of coal and peat, and the small amount of coal burned in industry, was calculated using the amount of such fossil fuels consumed in these applications and the typical ash content of coal and peat of 9% and 1.5% respectively (personal communication with the Electricity Supply Board).

‘Emissions’ Worksheet

The ‘Emissions’ worksheet sets out the emissions to air from each of the sectors as a result of fossil fuel use. It covers CO_2, N_2O, CH_4, SO_2, NO_X, NH_3/VOC, and CO.

The data in the ‘Emissions’ worksheets for CO_2, N_2O, and CH_4 were compiled from the EPA data mentioned above. The data for SO_2, NO_X, NH_3/VOC, and CO were taken from other EPA spreadsheets.

‘Conversion Factors’ Worksheet

The ‘Conversion Factors’ worksheet sets out the factors to convert from tonnes of oil equivalent to tonnes, as well as population and GDP data for the years in question.

The conversion factors used were those supplied by DCMNR (as the Irish conversation factors are slightly different to those used internationally for the reasons outlined in the Energy Balances for Ireland). These conversion factors are as follows.

Crude oil	1 tonne= 1.0226 TOE
Gasoline	1 tonne= 1.065 TOE
Kerosine	1 tonne= 1.0556 TOE
Jet fuel	1 tonne= 1.0533 TOE

Gas/diesel oil	1 tonne= 1.0344 TOE
Residual fuel oil	1 tonne= 0.9849 TOE
Milled peat	1 tonne= 0.186 TOE
Sod peat	1 tonne= 0.313 TOE
Briquettes	1 tonne= 0.443 TOE
Coal	1 tonne= 0.665 TOE
LPG	1 tonne= 1.1263 TOE
Natural Gas	1 tonne= 1.032 TOE

Conversion factors from TOE to tonnes were not provided for refinery gas or naphta. The factor for LPG was used for refinery gas since a review of other data sources showed LPG and refinery gases have similar TOE/t values (IPCC 2001). Similarly the factor for gasoline was used for naphta.

The population and GDP data were obtained from the CSO (personal communication).

5 DEMONSTRATION OF METHODOLOGY: CASE STUDY – REGIONAL WATER FLOW ACCOUNTS

5.1 Introduction

The second case study involved the demonstration of the material flow accounting methodology for water flow accounts for a particular region. The region chosen was the South Eastern River Basin District (SERBD).

5.1.1 The South Eastern River Basin District (SERBD)

Ireland has been divided into five river basin districts for the implementation of the Water Framework Directive. The SERBD is the region that is furthermost along in implementation of the Directive since it was the first SERBD project launched. Hence this is the river basin district chosen for demonstration of water flow accounts.

The SERBD covers the combined river basins of the rivers Slaney, Barrow, Nore and Suir, as well as a number of other smaller rivers near the coast. Counties Carlow, Kilkenny, Laois, Tipperary South, and Wexford are included in this river basin district (RBD) as well as parts of Kildare, Offaly, Tipperary North, Waterford, and Wicklow and a very small part of Limerick. RBDs also include coastal waters. Hence, places such as Rosslare Harbour, Wexford Harbour, Waterford Harbour and Dungarvan Harbour are relevant. The SERBD covers a land area of 12,780 km^2 - about one-fifth of the country - and has a population of 516,117 persons. A map of the SERBD is shown in Figure 5.1 (SERBD border in red, numbers refer to catchment areas).

Figure 5.1: The South Eastern River Basin District (SERBD)

5.2 Water Flow Accounts – Description of Flows

All water flows into and out of the RBD must be taken into account in drawing up the water flow accounts. This will include both natural and anthropological flows of water. The boundary for the water flow accounts consists of the geographical area of the RBD as well as flows into and out of water bodies within the RBD itself. A schematic of the RBD is shown in Figure 5.2.

Figure 5.2: Flows into and out of the SERBD

A list of the water flows in the schematic is given below.

- **Natural water flows into the SERBD**
  - Rainfall
  - Groundwater flows into the RBD
- **Natural water flows out of the SERBD**
  - evapotranspiration
  - surface water flows out of the RBD
  - Groundwater flows out of the RBD
- **Anthropogenic water flows out of the SERBD**
  - Point abstractions:
  - Public water supply abstractions (demand plus system losses)
  - group water scheme abstractions
  - private household water supply
  - private abstractions by industry - surface water
  - private abstractions by industry - groundwater
  - Water consumed by agriculture
  - Water supply to other RBDs

- **Anthropogenic water flows into the SERBD**
  - waste water discharges from industry:
    - IPC licensees - direct to waters
    - Waste Management Licencees - direct to waters
    - Water Pollution Licencees - direct to waters
    - Others (not recorded)
  - urban waste water treatment plant (UWWTP) discharges:
    - domestic/commercial discharges
    - IPC licensees - via sewer
    - Water Pollution Licencees - via sewer
    - Landfill leachate tankered to UWWTPs
    - Surface water run-off
  - Water discharges from agriculture (mostly indirect via landspreading):
    - silage effluent
    - dirty dairy water
    - water content of agricultural organic waste
    - water content of landspread/injected UWWTP sludge
    - water content of landspread/injected organic waste from agri-industry WWTPs.
  - Water supply from other RBDs
- ***"Stock" of water in the SERBD***
  - total groundwaters available in the RBD
  - total body of surface waters available in the RBD
  - water contained in soils.

Note: tidal flows have been ignored in terms of flows due to cyclical nature and because seawater is not abstracted for any uses within the SERBD.

5.3 Water Flow Accounts for the SERBD

A summary of the water flow accounts for the SERBD is shown in Table 5.1.

Water Flow Accounts - 2000
South Eastern River Basin District (SERBD)
Data in '000 m3

Natural Flows into the RBD	Data in '000 m3	Natural Flows out of the RBD	Data in '000 m3
annual rainfall	12,780,000	annual evapotranspiration	6,134,400
Groundwater flows into the RBD	NE	Groundwater flows out of the RBD	NE
		surface water flows out of the RBD	4,187,665
Anthropogenic Flows into the RBD	**Data in '000 m3**	**Anthropogenic Flows out of the RBD**	**Data in '000 m3**
urban waste water treatment plant discharges	**96,855**	**Point abstractions**	**124,607**
IPC licencees - via sewer	*2,488*	total domestic water consumption	25,580
Water Pollution Licencees - via sewer	*1,121*	*domestic water consumption (public water schemes > 5000 pop.)*	*11,386*
Landfill leachate tankered to UWWTPs	*30*	*domestic consump. (public < 5000 pop., group schemes, private)*	*14,194*
dicharges from septic tanks	NE	Public supply (> 5000 pop.) commercial, agri., indust. & munic.	14392
leachate to groundwaters/surface waters from landfills	107	Public water supply (> 5000 pop.) unaccounted for water	23,396
waste water discharges from industry	**42,880**	private abstractions by industry (IPC) - surface water	56,534
IPC licencees - direct to waters	37,245	private abstractions by industry (IPC) - groundwater	4,705
Waste Management Licencees - direct to waters	NE	private abstractions by industry (non-IPC)	NE
Water Pollution Licencees - direct to waters	5,635	**Water consumed by agriculture:**	**36,819**
Water discharges from agriculture	**48,765**	potato crop irrigation	816
Silage Effluent	563	horticulture irrigation	NE
Dairy Dirty Water	4,749	dairy herd	8,673
Water content of Agricultural Organic Waste:	21,628	Beef & other cattle	21,975
dairy herd	*4,262*	Sheep	4,037
Beef & other cattle	*14,273*	Pigs	751
Sheep	*2,341*	Poultry	198
Pigs	*570*	Horses, ponies, deer, mules	368
Poultry	*20*		
Horses, ponies, deer, mules	*162*		
Water content of Landspread/Injected UWWTP Sludge	11		
Water content Landspread Organic Waste - Agri-industry	65		
potato crop irrigation losses	122		
horticulture irrigation losses	NE	Note: NE = Not Estimated	

Table 5.1

5.4 Natural Water Flows Into the SERBD

5.4.1 Rainfall

Mean annual rainfall data for the region together with the total land area gives an annual rainfall of 12,780,000 (‘000 m^3) in the SERBD.

5.4.2 Groundwater Flows into the RBD

Following consultation with GSI and the SERBD project team, at present there is no data available on groundwater flows into or out of the SERBD.

5.5 Natural Water Flows Out of the SERBD

5.5.1 Evapotranspiration

Evapotranspiration is the evaporation of water from the surface and the exchange of water vapour that occurs at the leaves of plants (transpiration). Using the average evapotranspiration rate (Mills 2000) for south eastern region of 48% of rainfall gives an annual evapotranspiration of 6,134,000 (‘000 m^3) for the SERBD for 2000.

5.5.2 Surface Water Flows out of the RBD

Surface water flows out of the RBD have been calculated based on the EPA’s long term hydrometric data (MacCárthaigh 2003) for each of the major rivers in the RBD. Data from the furthermost downstream non-tidal gauges has been used. Values are given in Table 5.2.

Table 5.2: Hydrometric data for the SERBD

Hydrometric area & station	Location	River	Flow (m^3/s)	Flow in 2000 ('000 m3)
HY 12 12001	Scarawalsh	Slaney	11.97	377,486
HA 13 13001	Goff's Br.	Corock (East)	1.35	42,574
HA 13 13002	Foulk's Mill	Corock (West)	1.34	42,258
HA 13 13003	Mullinderry	Owenduff	2.43	76,632
HA 14 14029	Graiguenamanagh	Barrow	34.6	1,091,146
HA 15 15006	Brownsbarn	Nore	31.59	996,222
HA 16 16010	Anner	Anner	5.83	183,855
HA 16 16011	Clonmel	Suir	36.01	1,135,611
HA 16 16020	Kilmacthomas	Clodiagh	3.89	122,675
HA 17 17001	Kilmacthomas	Mahon	2.28	71,902
HA 17 17002	Fox's Castle	Tay	1.5	47,304
			Total flow	**4,187,665**

5.5.3 Groundwater Flows out of the RBD

There is no data available on groundwater flows into or out of the SERBD.

5.6 Anthropogenic Water Flows out of the SERBD

5.6.1 Water Supply Abstractions

The national water study (DOELG 2000) has estimated the following per capita consumption rates for the counties within the SERBD:

Table 5.3: Per Capita Water Consumption Rates

County	**Per Capita Consumption Rates (litres per head per day)**	
	1997	**2018 (predicted)**
Carlow	132.5	148.1
Kilkenny	131.9	148.7
Laois	131.3	148
Wexford	133	150.1
Kildare	131.9	148.7
Offaly	131.3	148
Tipperary North	133.7	151.1
Tipperary South	134.3	151.7
Waterford	132.9	149.9
Waterford city	134.8	152.2
Wicklow	132	149.2
Average for the SERBD	**132.7**	**149.6**

An average of the per capita consumption rates was taken, together with the SERBD population, and an interpolation of the 1997 and 2018 figures, to estimate a total domestic water consumption rate of 25,580 (‘000 m^3) for the SERBD for 2000. This value covers all supply types – public water supplies, group water schemes and private abstractions.

The national water study has also provided information on daily volumetric demand, split into domestic, commercial, agricultural, industrial and municipal use as well as “unaccounted for water” for schemes supplying more than 5000 consumers for 1997 and estimated for 2018. There are 21 such schemes within the SERBD. Based on these figures, and using the populations of the schemes involved, these schemes supply 11,386 (‘000 m^3) of the domestic water consumption for the SERBD for 2000. These schemes also account for a supply to commercial, agricultural, industrial and municipal uses of 14,392 (‘000 m^3) in 2000. Distribution water losses from schemes supplying more than 5000 consumers in the SERBD account for 23,396 (‘000 m^3).

5.6.2 Water Usage by Industry

There are 54 IPC licensees in the SERBD that have process water emissions. A review of public files in the EPA’s Headquarters for these licensees was carried out to obtain information on water consumption. The information was sourced from Annual Environmental Reports for 33 of the companies, and was based on licensed emission values for 21 of the companies, where AERs were unobtainable. The total amount of water consumption was noted, together with the source of supply (municipal, private groundwater abstraction, or private surface water abstraction).

Section 5.6.1 of this report (water supply abstractions) details a total for water consumption by industry from public water supplies in the SERBD that serve populations more than 5000. The methodology used in the national water study to estimate industrial water consumption for each water supply was based on information from the rates departments of each of the sanitary authorities on metered consumption or fixed charges. Some IPC industry will obviously be included within such supplies.

In addition to the above there will also be consumption by non-IPC licensed industry from public water supplies that serve populations less than 5000 and from private industry abstractions. In the absence of data it is unknown if these are significant or not.

5.6.3 Water Consumed by Agriculture

Water consumption in agriculture consists of two main areas:

- *Livestock*
- *Crop Irrigation*

5.6.3.1 Livestock Water Consumption

Water consumption associated with livestock is drinking of water by the livestock and, where relevant, water used for cleaning (e.g. of milking equipment, livestock housing, etc.). The following are published water consumption rates associated with different livestock:

Table 5.4: Typical livestock water consumption rates

Livestock	**Water consumption rates**	
	m^3/animal/year (Brånvall 1999b)	**m^3/unit of production** (Capenhurst 2001)
Dairy cow	30 m^3	0.003 m^3 water per litre of milk produced (drinking & cleaning)
Beef	16 m^3 (sucker cows, heifers, calves)	6.2 m^3 per animal (drinking water, 520 kg animal; up to 1.5 years slaughter age)
Sheep	2.5 m^3	0.46 m^3 per lamb (for a 38.5 kg lamb; including ewes)
Pig	13 m^3 (boars, sows) 0.875 m^3 (fattening pigs) 0.05 m^3 (piglets)	0.48 m^3 per pig (drinking & cleaning; for a 73 kg ‘pork’ pig)
Poultry (slaughter)	0.04 m^3	0.005 m^3 per bird (drinking & cleaning; for a 2.3 kg meat bird (broiler))
Poultry (Laying hens)	0.1 m^3	0.004 m^3 per dozen eggs (drinking & cleaning)
Horses	16 m^3	-

The 2000 Census of Agriculture (CSO 2003) details the number of animals in each county in Ireland for the following categories of animal: dairy cattle, beef and other cattle, sheep, pigs (boars, sows, fattening pigs, and pigs under 20 kg), poultry (table birds, breeding birds, laying hens, and other poultry), horses and ponies, deer, mules, jennets and asses. Since only parts of certain counties are in the SERBD, the percentage of land area in the RBD versus the total county area was used to estimate the numbers of animals in the RBD. This data was used together with the above water usage rates to give a total for water consumption by livestock in the SERBD.

In order to get a total for numbers of table birds (broilers), which have a lifespan of less than one year, it will be assumed that the number of broilers recorded in the census represents the number of bird places. It takes approximately 35 to 49 days to fatten a broiler - so each place is filled 5.5. times per year. Therefore the total number of broilers in a given year is 5.5 times the census values.

So total water consumption for livestock in the SERBD is 35.4 million m^3 per year.

A summary of water consumption by livestock in the SERBD is shown in Figure 5.3.

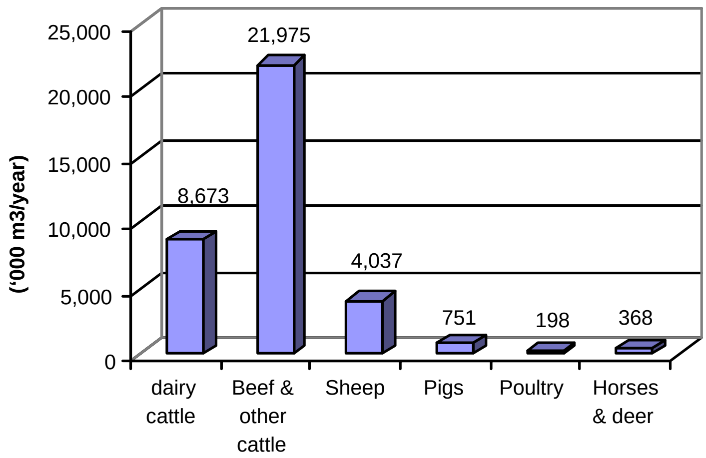


Figure 5.3: Water consumption by livestock in the SERBD

5.6.3.2 Crop Irrigation

While Ireland has plentiful rainfall - even the eastern half of the country has between 750 and 1,000 millimetres of rainfall in the year - irrigation in agriculture is still used in a number of specific applications in Ireland. In terms of commercial field-scale crops, irrigation is only carried out in Ireland for the potato crop. Irrigation is also carried out in horticulture.

(a) Potato Crop

Irrigation is used in the growth of potatoes in Ireland. Potato irrigation has increased in recent years. The main reason for irrigation is to prevent common scab during crop tuber initiation (irrigation for this purpose occurs in June), and a secondary reason is to increase the yield of the potato crop (irrigation for this purpose occurs in July and August). Irrigation is mainly carried out by larger farms only and it is especially carried out in the counties of Louth, Meath, and Dublin (none of these relevant to the SERBD). Irrigation rates differ greatly from year to year, depending on the amount of rainfall, and when it occurs during the season. For example, there was virtually no irrigation carried out in 2002 due to the wet summer. Irrigation rates also vary depending on location factors such soil type, run-off, etc.. However, approximate irrigation figures, which would be applicable for 2000 are as follows (personal communication with Teagasc):

- to prevent common scab : 50.8 mm (equivalent to 2 inches)
- to increase yield : 25.4 mm (equivalent to 1 inch)
- total: 76.2 mm (equivalent to 3 inches)

The main reason for carrying out irrigation, to prevent common scab, is as a result of pressure from the major supermarket chains. The formation of scab is reduced when the soil around the tubers is kept moist as the tubers are forming. While common scab is completely harmless, supermarket chains sell washed potatoes and do not accept potatoes with common scab due to its visual appearance.

According to the 2000 Census of Agriculture, there were approximately 2,500 hectares of potatoes grown in the SERBD on a total of about 900 farms. On a national level, 57% of the land area under potatoes is on large farms (those of 100 hectares or more). It will be assumed that only such larger farms utilise irrigation. Therefore estimated water consumption due to potato crop irrigation in the SERBD is 816 (‘000 m^3).

(b) Horticulture

The 2000 Census of Agriculture (CSO 2003) data was used to estimate the number of hectares within the SERBD under vegetables, fruit, nurseries and other horticultural usage. This was based on the number of hectares within each county under such use and the percentage land area of each county within the SERBD. Estimates are as follows:

	Area in 2000 under:		
	Vegetables for sale	**Fruit (other than apples)**	**Nurseries, horticulture, etc.**
Land area in SERBD	870 hectares	330 hectares	225 hectares

5.7 Anthropogenic Water Flows into the SERBD

5.7.1 Waste Water Discharges from Industry

Waste water discharges from industry include those from IPC licensed companies, companies which operate under water pollution control licences, and waste management licensed companies, as well as from smaller industries which are not licensed. Emissions are either direct to waters or to sewer.

5.7.1.1 IPC Licencees

There are 54 IPC licensees in the SERBD that have process water emissions. There are an additional 42 IPC licensees in the river basin district that do not have any process water emissions. Almost half of the latter are piggeries (20), and while they do not have water emissions, they do landspread their organic waste. This waste will be considered separately under organic waste from agriculture.

Of the 54 IPC licensees with process water emissions, 3 of these companies closed in 2001, 1 in 2002, and 2 were to close during 2003 (three of these are in the textiles sector). Since the water flow accounts are for 2000, these companies will be included. A sectoral breakdown of the 54 IPC licensees is shown in Figure 5.4.

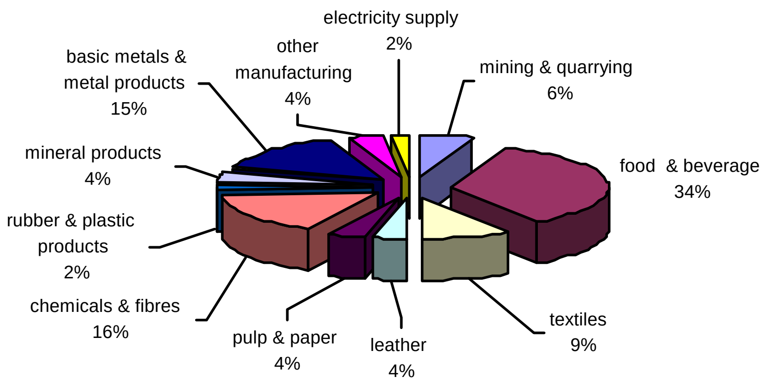


Fig 5.4: Sectoral distribution of IPC licencees with water emissions in the SERBD (based on number of companies)

The distribution of each of the sectors in terms of volume of emissions is shown in figure 5.5. The emissions data for this figure was obtained from a review of public files in the EPA's Wexford office for all of the licensees involved. The information was sourced from Annual Environmental Reports for 33 of the companies, and was based on licensed emission values for 21 of the companies where AERs were unobtainable.

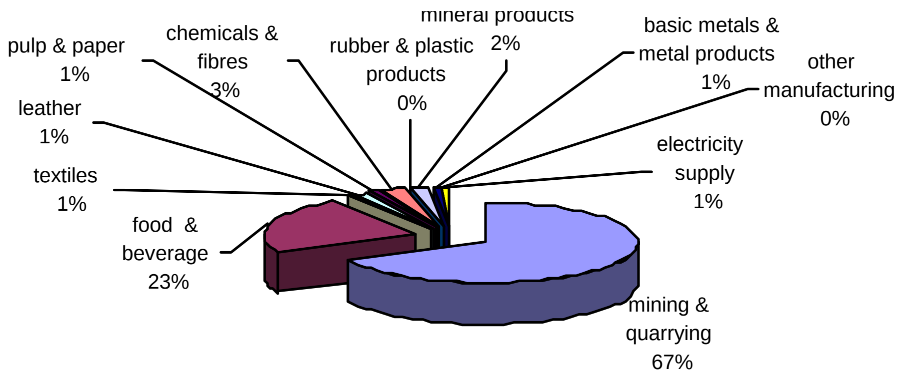


Fig 5.5: Sectoral distribution of IPC licencees with water emissions in the SERBD (based on volume of water emissions [‘000 m^3])

Of the 54 companies, 23 companies emit to sewer while 31 companies emit directly to waters. However, in terms of volume, emissions to waters are far greater than emissions to sewer.

5.7.1.2 Waste Management Licencees

There are three waste management licensees other than landfills (for landfills see later), within the SERBD. All three are waste transfer stations and are licensed for emissions to water. A review of public files in the EPA’s Wexford office for these licensees was carried out. However, no data was available on volumes of water emitted (one licensee commenced records in November 2002, another keeps quality records only, while there is no data for the third). Hence no estimate of emissions from these facilities was made for the study. Since these are waste transfer stations it can be assumed that emissions to water are not significant.

5.7.1.3 Water Pollution Licencees

There are 128 water pollution licences granted within the SERBD for discharges direct to waters (section 4 licences), and 129 water pollution licences for discharges to sewer (section 16 licences). There have been other licences issued in addition to these, but they have been superseded by IPC licences. An estimate of water emissions for the existing water pollution licensees has been made using licenced discharge volumes from a SERBD database. Such information is available for 88 of the section 4 licences and for 89 of the section 16 licences. Emissions to waters from section 4 licensees in the SERBD has been estimated as 5,634 (‘000 m^3). Emissions to sewer from section 16 licensees in the SERBD has been estimated as 1,121 (‘000 m^3).

Sectoral breakdowns of water pollution licensees emitting to waters, and of water pollution licensees emitting to sewer, are shown are shown in Figures 5.6 and 5.7.

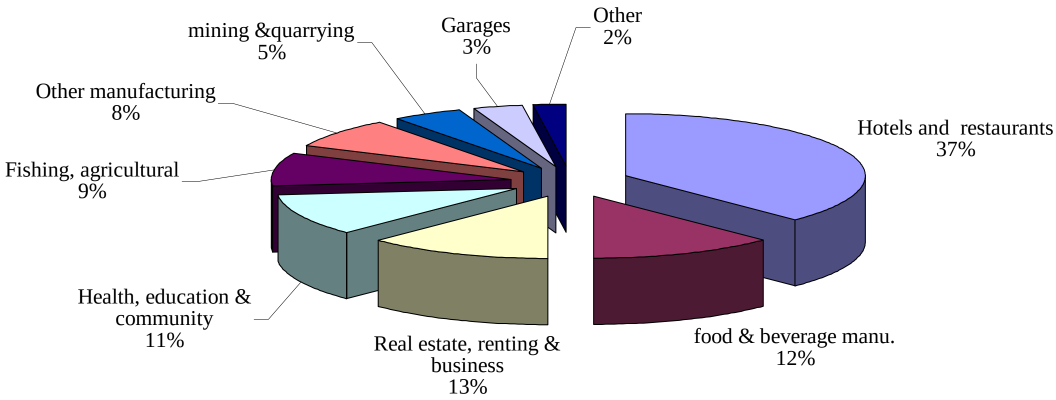


Fig 5.6: Sectoral distribution of section 4 Water Pollution licencees (direct to waters) in the SERBD (based on number of companies)

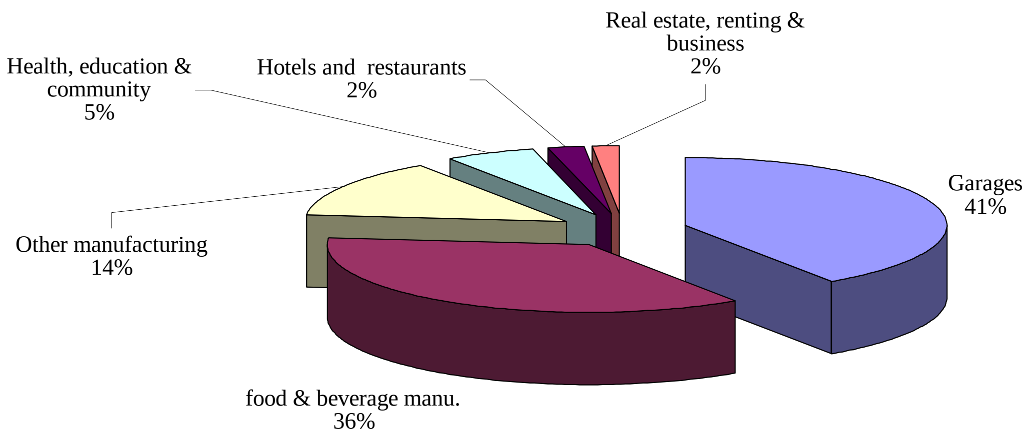


Fig 5.7: Sectoral distribution of section 16 Water Pollution licencees (to sewer) in the SERBD (based on number of companies)

Figure 5.8 shows the sectoral distribution in terms of volumetric flows for all water pollution licensees, while Figure 5.9 shows the volumetric spilt in terms of licences for emissions to waters and licences for emissions to sewers.

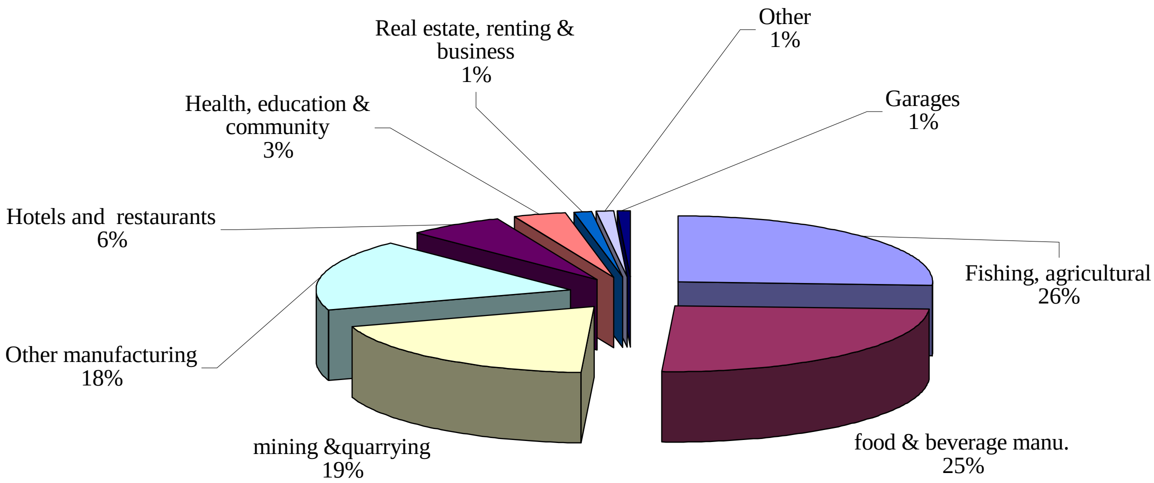


Fig 5.8: Sectoral distribution of Water Pollution licencees in the SERBD (based on volume of water emissions ['000 m^3])

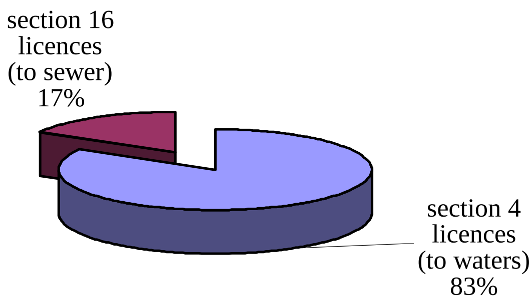


Fig 5.9: Split between section 4 licences (to waters) and section 16 licences (to sewer) in the SERBD (based on volume of water emissions ['000 m^3])

5.7.2 Urban Waste Water Treatment Plant (UWWTP) Discharges

Urban waste water treatment plant (UWWTP) discharges have been calculated for the SERBD using a SERBD database of emissions from such plants. The database ranges from septic tanks to plants for large agglomerations, and from pumping stations only to plants with primary, secondary and tertiary treatment. The database covers 256 discharges with sizes ranging from 12 to 130,000 population equivalents. However, there are data gaps, with data on design population equivalents available for only 214 of the plants, and on operating population equivalents for only 83 of the plants. A conversion from operating/ design population equivalent to volumes of water was made using a published typical per capita wastewater flowrate (Metcalf & Eddy 1991)[3]. This has resulted in an estimated flow of water from urban waste water treatment plant (UWWTP) discharges of 96,855 ('000 m^3). A breakdown of the flows based on destination is shown in Figure 5.10.

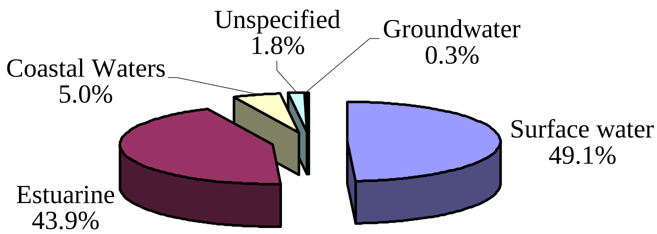


Fig 5.10: Discharges from urban waste water treatment plants (UWWTPs) in the SERBD (based on volume of water emissions ['000 m^3])

Some of the components of discharges to UWWTPs are further detailed in other sections of this report (IPC licensee discharges via sewer and Water Pollution licensee discharges via sewer). The following section details landfill leachate tankered to UWWTPs.

5.7.2.1 Landfill Leachate Tankered to UWWTPs

There were 10 landfills operational within the SERBD in 2000. A review of the public files in the EPA's Wexford office was carried out for these licensees, as well as for landfill licences that have since been granted in the SERBD. The information was sourced from Annual Environmental Reports. Information on leachate produced, on leachate destination (treated on-site or tankered off-site), and on indirect emissions to groundwater was available for 7 of the 10 landfills. In 2000, 30 ('000 m^3) of landfill leachate was tankered to UWWTPs while a further 107 ('000 m^3) was discharged to groundwaters/surface waters from landfills.

5.7.3 Water Discharges from Agriculture

Water discharges in agriculture include the following:

- silage effluent
- dirty water from dairy farming

[3] The suitability of this value may require more investigation.

- water content of landspread/injected agricultural organic waste
- water content of landspread/injected UWWTP sludge
- water content of landspread/injected organic waste from agri-industry WWTPs
- *run-off from crop irrigation*

In many of the above cases involving spreading/injecting on land, discharges are not direct to any surface waters or groundwaters. Hence not all such water will find its way to surface/ground waters, due to soil absorption, evapotranspiration, etc.

5.7.3.1 Silage Effluent

Based on the 2000 Census of Agriculture, the SERBD contains 21% of the total land area under silage. It is estimated on a national level approximately 20.65 million tonnes of fresh grass is harvested per annum and put into silage pit. This produces 130 litres of silage effluent per tonne. Therefore, estimated water generated as silage effluent in the SERBD is 563 (‘000 m^3). Silage effluent is usually landspread.

5.7.3.2 Dairy Dirty Water

It is estimated that 45 litres of dirty water from the cleaning of dairies, etc. is produced per cow per day (EPA 2001). Based on the 2000 Census of Agriculture, the SERBD contains approximately 289,000 head of dairy cattle. Therefore, estimated dairy dirty water generated in the SERBD is 4,749 (‘000 m^3). Dairy dirty water is usually collected and landspread.

5.7.3.3 Water Content of Agricultural Organic Waste

Organic waste produced by livestock is either deposited directly on land by livestock or is managed and subsequently landspread/injected for housed livestock. The following table shows values of organic waste produced per animal per week together with the solids content of such wastes.

	Organic waste produced (Litres/head/week)	**Solids content (%)**
Dairy cows	315	10%
Other cows & bulls	280	10%
Dairy heifers, other heifers, & cattle 1 yr & over	250	10%
Cattle under 1 year	140	10%
Sheep (hill and lowland)	17 - 28	25%
Horses	193	30%
Poultry – laying hens	0.8 – 0.89	30%
Poultry – breeding stock	0.45 – 0.85	60%
Poultry – broilers	0.45 per bird place	30%
Pigs	m^3 for all pigs per yr = 15 m^3 x no. of sows	6%

Table 5.5 Organic waste produced by animals on a weekly basis (EPA 2001)

These values used together with the numbers of animals in the SERBD from the 2000 Census of Agriculture gives the following amounts for the water content of agricultural organic waste as shown in figure 5.11.

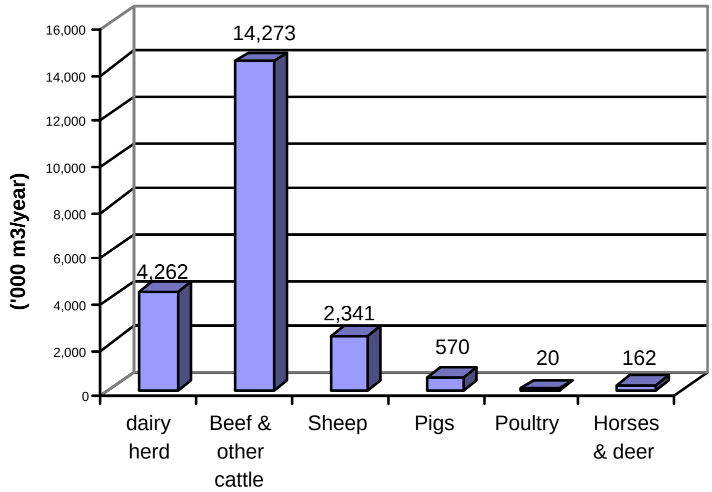


Fig 5.11: water content of agricultural waste from livestock in the SERBD

5.7.3.4 Water Content of Landspread/Injected UWWTP Sludge

It is estimated that in 2000, 40% of urban waste water treatment plant (UWWTP) sludge is landspread or injected in agricultural applications with the remaining being landfilled (EPA 2003). Data for 2000 on the quantities of UWWTP sludge reported by local authorities was used. Since only parts of some counties are in the SERBD, the percentage of land area in the RBD versus the total county area was used to estimate the total UWWTP sludge generated. The local authority values are in tonnes of dry solids. UWWTP that is landspread typically contains 80% water. Based on this data, the estimated water contained in UWWTP sludge landspread or injected in the SERBD is 11 ('000 m^3).

5.7.3.5 Water Content of Landspread/Injected Organic Waste from Agri-industry WWTPs

It is estimated that 90% of agri-industry waste water treatment plant sludge is landspread or injected in agricultural applications with the remaining being landfilled. The total agri-industry sludge generated on a national level is 605,306 tonnes (wet) for 1998 (it will be assumed that 2000 values are similar). Agri-industry water content varies, but a typical value of 90% water will be used. For the SERBD, the amount of agri-industry generated will be estimated based on population. The estimated water content of agri-industry sludge landspread or injected in the SERBD is 65 ('000 m^3).

5.7.3.6 Run-off from Crop Irrigation

As outlined earlier, irrigation is carried out in potato farming and in horticultural applications. Not all irrigation water will be absorbed by the crop, with some lost to run-off, or lost to evaporation.

(a) Potato Crop

In the case of irrigation to increase yield approximately 15% of the irrigated water is lost during application. Factors such as inaccurate scheduling, too low a pressure, incorrect nozzle sizes, and increased application amounts will increase the run-off value. It will be assumed that a similar percentage of the irrigation water used to prevent common scab is lost during application (although it is likely to be higher since the crop is younger). Therefore estimated water loss from potato crop irrigation in the SERBD is 122 (‘000 m^3). The losses will include water lost as run-off and water evaporated.

(b) Horticulture

No information.

Figures 5.12 and 5.13 represent the total and anthropogenic flows through the SERBD respectively, in the form of Sankey Diagrams.

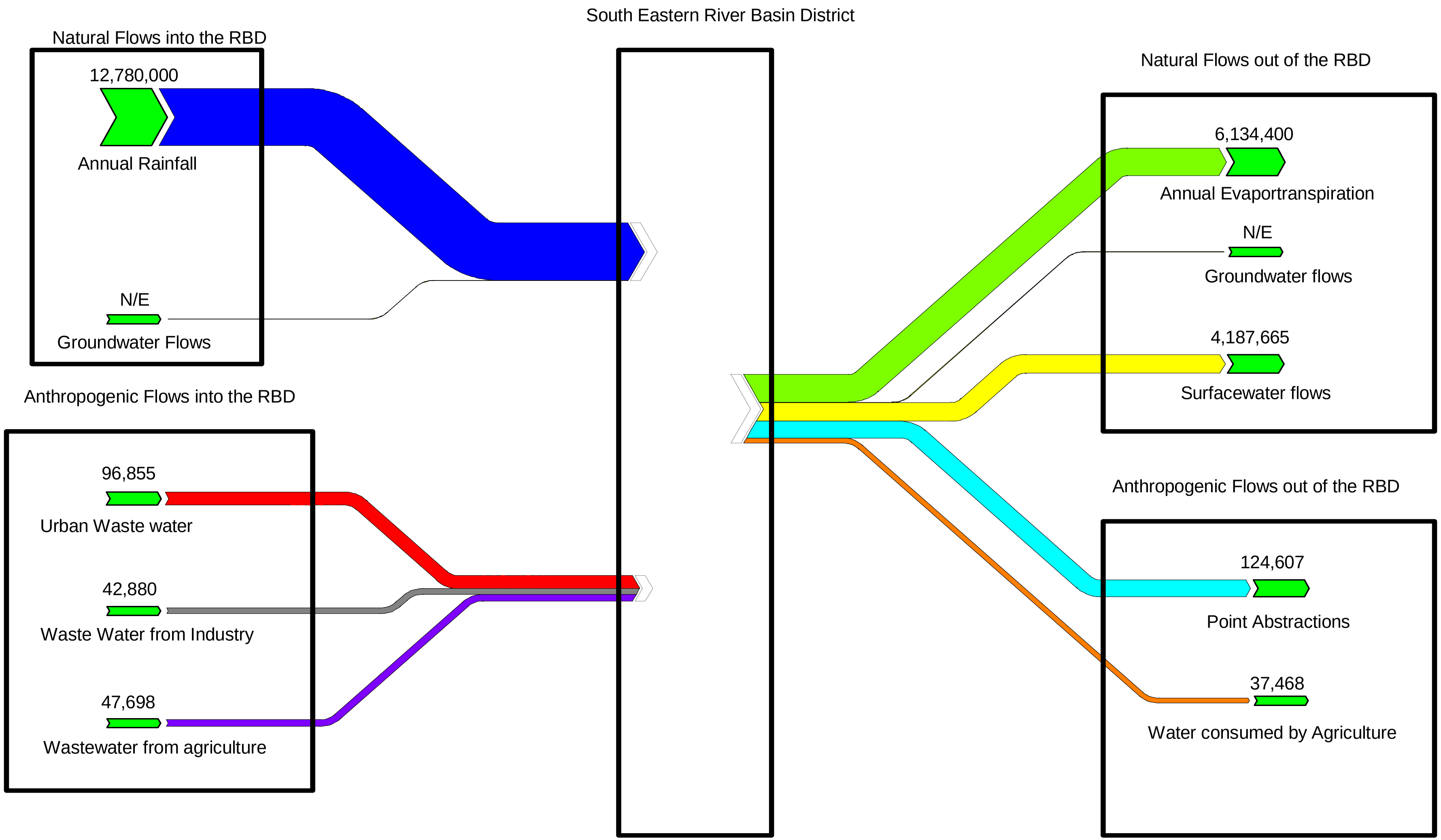


Figure 5.12: Total Flows

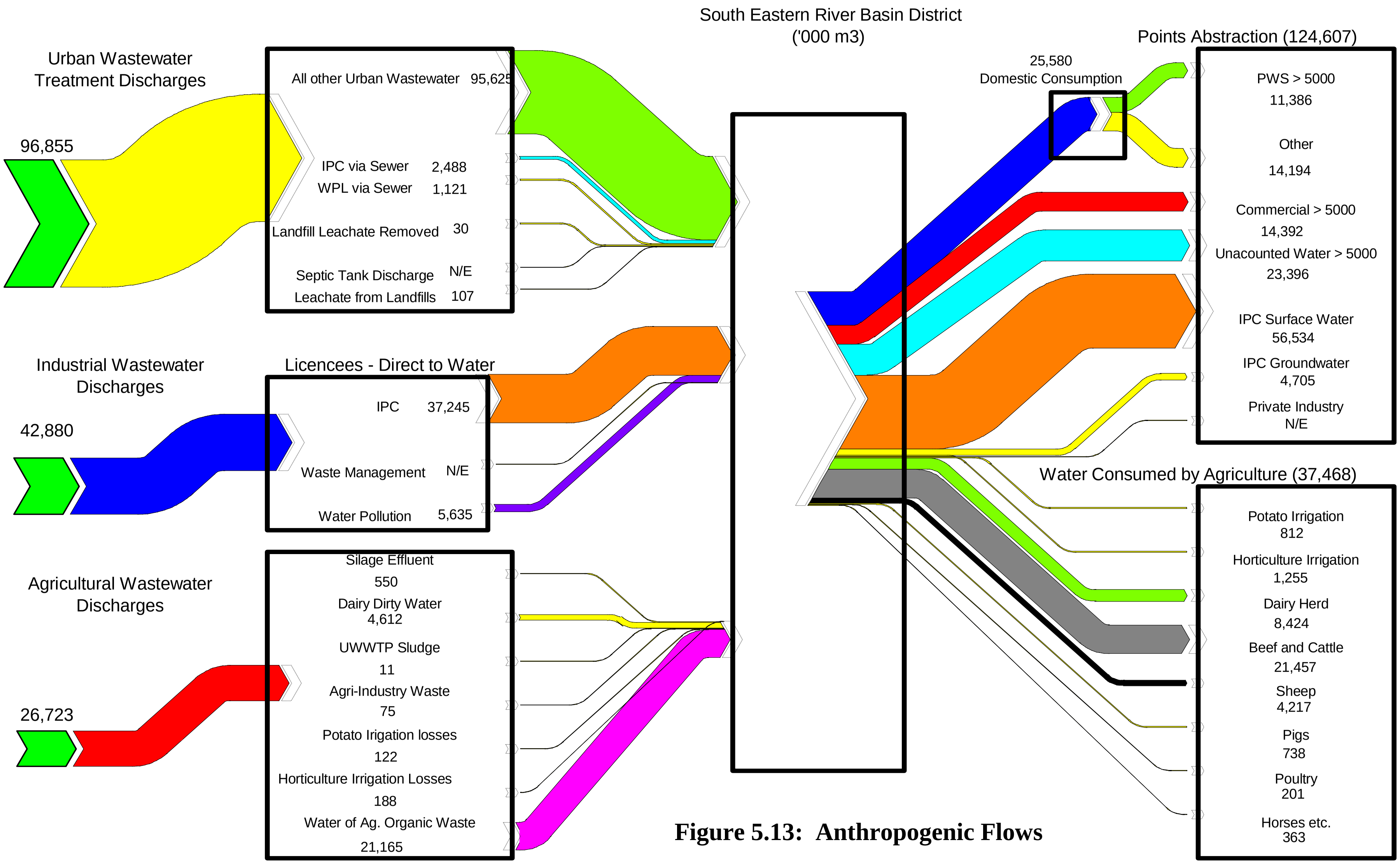


Figure 5.13: Anthropogenic Flows

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5.8 An Example of Sectoral Flows within the SERBD - Brewing

The previous sections detailed all anthropogenic water flows into and out of the SERBD. An example of using MFA for water flows to and from a particular sector within the SERBD, the brewing industry, is as follows:

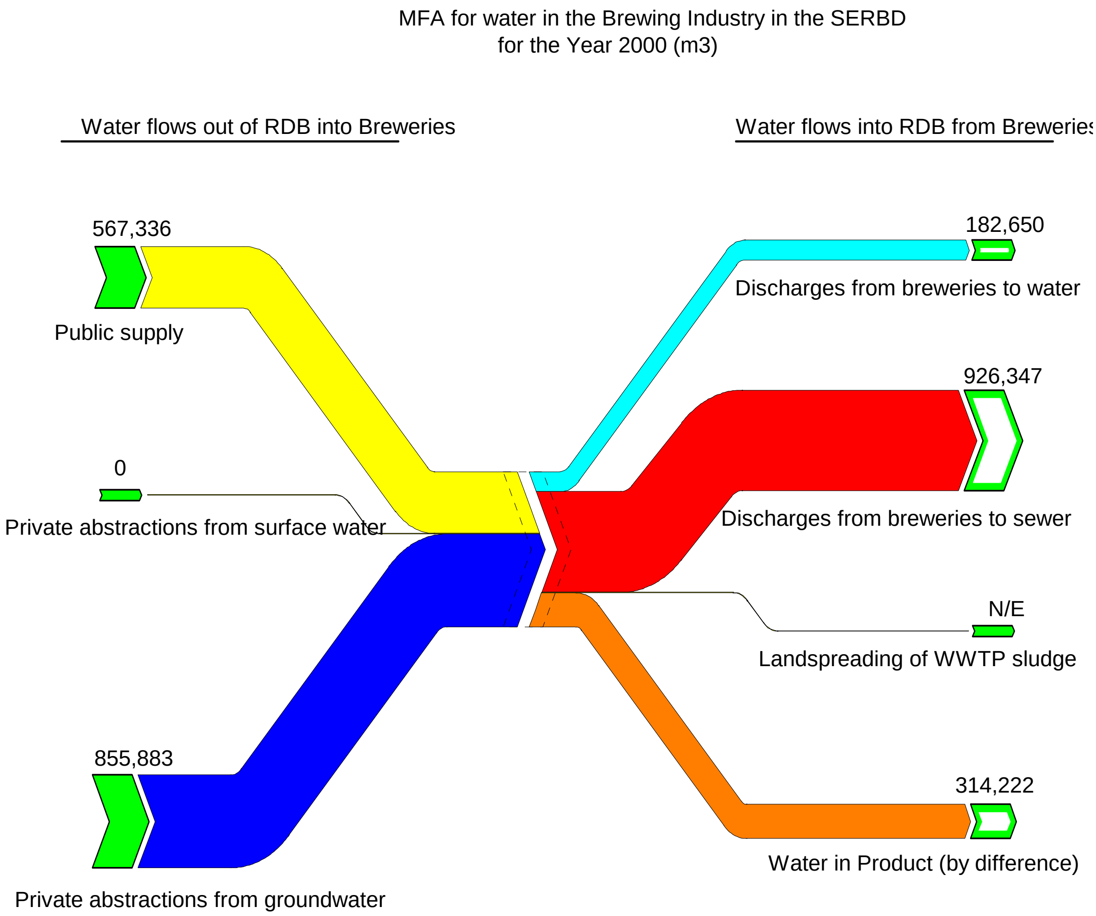


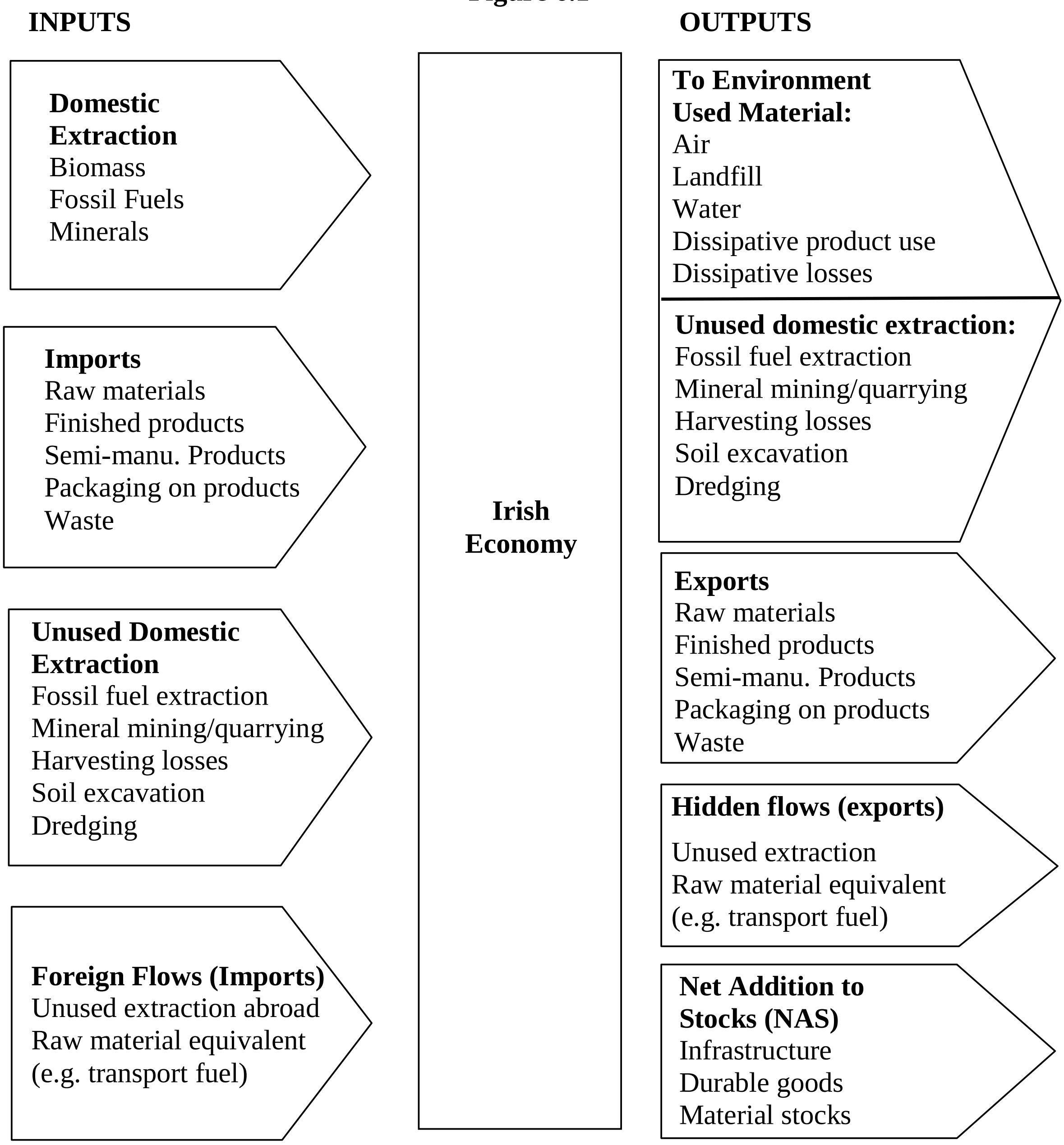
Figure 5.14: SERBD Sectoral Flow (Brewing)

This diagram is based on IPC data from the individual breweries within the SERBD. As can be seen the diagram effectively carries out a water balance for the sector, illustrating the difference between the amount of water that ends up in saleable product and that which is discharged back into the SERBD as waste water.

6 TOTAL MATERIAL FLOWS IN IRELAND

This chapter assesses the data sources available for calculating flows of all materials in Ireland and makes an initial estimate of such flows where data availability permits. The overall schematic of the MFA is illustrated in Figure 6.1.

Figure 6.1



Each of the headings in Figure 6.1 is detailed in terms of data sources, data availability and data reliability.

In addition to data gaps and data reliability, comments are made in relation to any differences between national sources of data and data that has been used in Eurostat estimates of material flows and indicators for Ireland, for example, data from FAO (Food and Agricultural Organisation of the UN).

6.1 Domestic Extraction

In accordance with the Eurostat guide, domestic extraction is split into the categories of fossil fuels, minerals and biomass.

6.1.1 Data Sources for Domestic Extraction – Agricultural Biomass

Agricultural biomass input consists of harvested crops as well as biomass grazed by livestock.

The Census of Agriculture 2000 was used to generate information on the total number of hectares under particular forms of agriculture which do not result in a direct input into the economy, i.e. land used for grazing of livestock, land under silage, animal fodder, etc.

Data on the tonnage of crops produced was obtained from two different sources; the annual CSO survey of the area, yield and production of crops, and the databases maintained by the UN's Food and Agricultural Organisation (http://apps.fao.org/). Each source details for Ireland the tonnage of each particular crop produced in a given year. The yield figures are given on a "green" (as harvested) basis which is in keeping with the Eurostat methodology. Where available from the CSO published data, the figures for a particular crop were used. However, there is detail provided in the FAO database for an additional number of other, lesser crops (in terms of quantities produced). This data was included where not available from the CSO published data. It should be noted that the CSO does maintain databases of such information, as it is the CSO who provides such data to FAO in the first instance. However, this level of detail is not available from the published summary data and was not further pursued as part of this study since FAO data was used instead. Hence, this additional information should be obtained from CSO and used in the event of a total MFA being generated for Ireland.

Information on crop production gathered by CSO now also details (since 1994) the amount of forage plants produced in Ireland. Silage and hay are the main items in this category of forage plants. It also includes fodder beet, fodder rape, fodder kale, and use of cereals within farms.

The only other category of agricultural biomass production for Ireland is grass consumed by livestock. This is a significant agricultural biomass input for Ireland with over four fifths of utilised agricultural land area under grass. Data on the total number of hectares under pasture and rough grazing has been obtained from the 2000 Census of Agriculture. This information is also available for other years in the annual CSO surveys of Land Utilisation & Livestock Numbers. In order to generate estimates of the amounts of biomass consumed by livestock, average grass yields per hectare have been obtained in terms of kg of dry matter. In accordance with the Eurostat MFA methodology, a standardised water content of 15% rather than dry mass should be utilised for grass. According to Teagasc (Teagasc 2003), average grass contains 20% dry matter and 80%

water. Therefore the values have been appropriately converted. Over 95% of forage grass seed sold in Ireland are perennial ryegrasses, which have a high yield and long season compared to indigenous grasses, and can produce up to and above 20,000 kg of grass dry matter per hectare per year (kg DM/ha/yr) under ideal conditions in Ireland. Such swards have typical yields of 10,000 - 14,000 kg DM/ha/yr. A sward without artificial nitrogen or clover would typically grow approximately 5,000 kg DM/ha/yr. However, most Irish grassland is old pasture and only about 3% of agricultural land is reseeded annually, primarily for winter-feed production. As a result, animals tend to graze old pasture for most of the season. Old pasture generally contains high proportions of inferior grasses which have lower yields.

The variability of yield depends on location in the country, weather, drainage, soil fertility, fertiliser usage, herbage varieties and grassland management. In addition to yield, the percentage utilisation of the grass is also brought into consideration, which is typically 75%. The percentage that is not utilised could be considered a hidden flow.

6.1.2 Data Gaps & Data Reliability for Domestic Extraction - Agricultural Biomass

Initial estimates on average grass yield per hectare is based on Teagasc literature. When compiling total material flows for Ireland in future, these should be confirmed with Teagasc personnel, since biomass input for Ireland from this source is significant.

Information on crop production gathered by CSO details the amount of forage plants produced in Ireland. Silage and hay are the main items in this category of forage plants. As outlined above, it also includes fodder beet, fodder rape, fodder kale, and use of cereals within farms. The published CSO summary data reviewed for this report only provides tonnage information for fodder beet. Information on other forage plants are reported in monetary terms. Hence, this initial estimate for domestic extraction from agricultural biomass has determined the contribution from grass silage and maize silage based on the number of hectares - according to the 2000 Census of Agriculture, and an average yield per hectare taken from Teagasc publications. It does not include an estimate for hay (as no information on yields could be obtained), or estimates for fodder rape, fodder kale, and use of cereals within farms (as no information on hectares or yields could be obtained). This additional information should be obtained from CSO, as should official estimates for grass silage and maize silage, if a total estimate of MFA is to be generated for Ireland.

Other than such forage plants, there are no other significant crops that have been omitted from this initial estimate.

Tonnage data is generated by the CSO, based on areas under particular crops and average yields per hectare. Where present for a particular crop type, the CSO and FAO data were identical.

6.1.3 Data Sources for Domestic Extraction –Biomass from Fishing

Statistics on biomass input to the economy from fishing are obtained from the CSO annual statistics on fishing. Quantities reported in terms of tonnes of live mass were used rather than landed mass since this is consistent with the Eurostat MFA methodology. The types of fishing included are sea fish landings, aquaculture production and inland fish catches. The CSO sea fish landings statistics are collected by the Department of the Marine and Natural Resources. Landings of clams, oysters and salmon have been excluded by the CSO from the sea fish landings figures supplied by the Department. Therefore, marine landings data reported by the Department of the Marine and Natural Resources were used instead of the CSO figures in order to include this data. Landings by foreign boats into Irish ports are not included in the sea fish landings figures for either CSO or FAO data.

In terms of aquaculture production, the CSO data is obtained from Bord Iascaigh Mhara's annual surveys of finfish and shellfish farms.

The CSO data on inland fish catches is based on information from the Fisheries Research Centre.

6.1.4 Data Gaps & Data Reliability for Domestic Extraction - Biomass from Fishing

The FAO data on total fish catch for Ireland from all fishery areas yields a different value from either the CSO or the DCMNR figures. Some of the reasons for this are outlined in the previous section. Any other reasons for these differences as well as the most appropriate figures to be used would need to be determined as part of a total MFA.

For Ireland, the harvesting of seaweed is another source of biomass input to the economy which is not specifically mentioned in the Eurostat methodological guide. Seaweed input as a raw material should be included in domestic extraction figures. Seaweed input in terms of fertiliser application should be included in outputs to the environment, dissipative use of products. Data on the total amount of seaweed harvested is detailed in the FAO database. These figures would have to be further investigated to determine the quantity used as a raw material and that used as a fertiliser.

6.1.5 Data Sources for Domestic Extraction – Biomass from Forestry

There are several sources of information on biomass from forestry including CSO's Prodcom[4], Coillte Annual Reports, EPA activity data in relation to emissions of greenhouse gases, and the FAO database. All data is reported in terms of m^3. Information on each source is as follows

- EPA activity data in relation to emissions of greenhouse gases
- Prodcom provides timber production in Ireland under the categories of pinewood, sprucewood and also provides information on some primary timber products such as impregnated rough softwood poles, sawn wood, sawdust etc.. Some statistics are reported in m^3, while others are reported in kg.
- Coillte Annual Reports detail the total sales of sawlog and pulpwood.

[4] PRODCOM stands for PRODucts of the European COMmunity Inquiry. It is an EU-wide survey of manufactured products and is carried out by each national statistical body.

- The FAO database details total roundwood production.

The values reported are shown in Table 6.1.

Data Source	**Data description**	**Quantity (m^3)**
EPA GHG activity data	Total stemwood overbark removed in commercial forestry	3,008,451
Prodcom	Various primary wood products (CN codes 4407 and 4403)	847,811
Coillte	Timber sold (sawlog and pulpwood)	2,730,000
FAO database	Total roundwood production	2,600,100

Table 6.1

The most appropriate source of data for *domestic extraction* is deemed to be the Coillte annual report data. This is because it gives the amount of timber that is sold. Other products made from wood are detailed in Prodcom (for example, wood frames, boards, etc.), and from the data provided it is not possible to determine the amount of wood consumed in the manufacture of such products - or indeed if the wood for the manufacture of such products was harvested in Ireland. The FAO database value is slightly lower than the Coillte data; hence, as a worst case, the Coillte data has been taken.

The most appropriate source of data for *unused domestic extraction* is deemed to be the EPA activity data in relation to emissions of greenhouse gases, minus the commercially sold timber as detailed in Coillte annual report. The EPA value details total biomass generated as a result of commercial harvest - not just timber production or sales values.

Data from all sources is reported in m^3 of wood. To convert from m^3 to tonnes, a conversion factor must be used. The literature provides conversion factors which range from 0.11 to 1.33 tonnes of wood per m^3. UK timber statistics utilise 0.909 t/ m^3 to convert to green tonnes of softwood. This value was used in the UK MFA. This will be used instead of the EPA conversion factor which is in terms of dry matter. It will be presumed that all roundwood production in Ireland is from softwood.

6.1.6 Data Gaps & Data Reliability for Domestic Extraction - Biomass from Forestry

The values for forestry data, in terms of $m^{3,}$ differ depending on the source, as outlined in the previous section. The most appropriate source was chosen.

The figures are for biomass removed in commercial harvest only. There is no information available on biomass consumed as fuelwood. It is expected that these values will be small in any case compared to commercial harvest.

6.1.7 Data Sources for Domestic Extraction – Fossil Fuels

Data sources for domestic extraction of fossil fuels are detailed in section 4 of this report.

6.1.8 Data Gaps & Data Reliability for Domestic Extraction - Fossil Fuels

Comments on data sources for domestic extraction of fossil fuels are detailed in section 4 of this report. It should be noted that data for electricity production in Prodcom, the information was deemed confidential**.**

6.1.9 Data Sources for Domestic Extraction – Minerals

Data for the extraction of minerals was taken from CSO's Prodcom, which details production data for several categories within construction mineral production, industrial mineral production, and metal ore production. A comparison was also made with the US Geological Survey Yearbook (one of the sources used in the Eurostat estimate of material flows for individual Member States), which details mineral production for individual countries. Published data from the DCMNR were used for certain minerals. Available annual reports were for 2001 and 2002 data. Gypsum production at Kingscourt open cast gypsum mine for 2002 was utilised. Total lead and zinc ore production (2002, and 2001 values) were used for the two mines concerned. Data was assumed to be similar to 2000 data.

A number of sources within Prodcom are classed as confidential. These include gypsum, lead ore, and magnesia (from seawater and/or magnesium carbonate) as well as some other minerals. Estimates of the quantities involved for other minerals, including magnesia, were made - based on the monetary values for confidential materials, and quantity and monetary values for known quantities of materials within the same 4-digit CN code. Prodcom sales of gypsum were classed as confidential. Hence this method of calculation could not be used. DCMNR data were used instead. Estimates for lead ore were from DCMNR data on lead and zinc ore mining.

The US Geological Survey Yearbook contained data for silver ore production (minor levels). There was no detail in Prodcom on silver ore production. DCMNR industry information did not detail anything on silver ore production - apart from several prospecting licences for silver. Hence, silver ore has been ignored for the time being.

6.1.10 Data Gaps & Data Reliability for Domestic Extraction - Minerals

The CSO Prodcom provides data on several categories within construction mineral production, industrial mineral production, and metal ore production. However, there are a number of sources which are classed as confidential - such as gypsum, magnesia, and lead ore. These will all be significant in terms of domestic extraction mass flows for Ireland. For magnesia and lead ore, estimates have been made as detailed in the previous section.

Published data from the DCMNR were used for certain minerals. Those annual reports available were for 2001 and 2002 data. Gypsum production at Kingscourt, Co. Cavan open cast gypsum mine for 2002 was utilised. Total lead and zinc ore production (2002 and 2001 values) were used for the individual mines concerned. Data was assumed to be similar to 2000 data. Examination of IPC licensing documentation, or direct contact with the limited number of companies concerned for gypsum, magnesia, and zinc and lead ore should provide more accurate estimates.

Estimates of the quantities involved were made, based on the monetary values for confidential materials, and quantity and monetary values for known quantities of materials within the same 4-digit CN code.

The basis for a number of sources within Prodcom should be further analysed, to ensure that mineral inputs to the economy are not being excluded - for example minerals that go into the production of 'precoated aggregrate' may not be included in the figures. This may also be true for other products.

It is also unclear from Prodcom if limestone aggregate, used in the production of cement, is included or excluded from the data. Again, examination of IPC licensing documentation, or direct contact with the limited number of cement and lime companies concerned, should determine quantities involved and provide more accurate estimates.

The sources of the data should also be investigated - to determine if small quarries and pits have been included in the estimate for sand and gravel. Definitions used need to be assessed, in order to determine what is included within the scope of a particular item. This is in order to ensure that double accounting of flows is not carried out, or conversely that particular flows are not omitted.

Prodcom does not detail any production in relation to silver or silver ores. However, the US Geological Survey Yearbook has a small amount of silver production detailed for the year 2000 (most likely as an associated product of lead and zinc mining).

When compared to the US Geological Survey Yearbook figures for Ireland, the CSO Prodcom estimate for mineral production is over twice the value of the US estimate. Particular, reasons that could be attributable to this include the fact that the Prodcom data for zinc is for zinc ore, while the US data is for pure zinc product. The Eurostat MFA guide recommends the inclusion of the total amount of material extracted when calculating mineral inputs. Hence the Prodcom figures are appropriate. The sources of data for the Prodcom figures should be further investigated to ensure that total ore is being detailed in all cases. It may be necessary to include additional factors to account for total material extracted.

While Prodcom could continue to keep financial information confidential it may be possible that a total tonnage of material for all confidential products to the level of 2 digit CN codes, or even a total figure of tonnage for all confidential products, could be reported.

6.2 Data Sources for Imports and Exports - All Materials bar Fossil Fuels

Data on all material imports and exports were obtained from CSO data broken down according to Combined Nomenclature **(**CN) codes.

In general, for external trade, tonnage (i.e. net mass) is usually required to be reported by traders - except where it is not of any additional benefit, for example in the case of valuable commodities of small mass (e.g. integrated circuits, musical instruments, disposable cameras). The use of supplementary units is also employed for certain categories of goods. These supplementary units are most often ‘number of items’, but also includes units such as m^3, litres, etc. The use of supplementary units is mandatory for certain codes and optional in others. There is a list of CN subheadings for which the specification of net mass is optional in relation to the reporting of trading of goods between Member States (the Combined Nomenclature system or CN system is the EU’s system for the classification of goods). Additional information was obtained from the CSO on data for particular CN codes which are also reported in supplementary units, and for which net mass reporting is optional. In some of these cases, for example beers, wines and non-alcoholic beverages there the data was only reported in litres. This is one of the CN codes for which net mass reporting is optional. The other area was that of clothes and shoes. Using masses of sample items (direct measurement), estimates of total tonnage was obtained. Therefore in such cases the data in supplementary units have been converted into tonnes. This accounts for an additional quantity of imports of almost 470,000 tonnes, and an additional quantity of exports of almost 460,000 tonnes.

Estimates of imports and exports of waste were taken from the EPA waste database 2001. A large, once-off, shipment that occurred in 2001 of contaminated soil from the development of the Dublin docklands was ignored (this accounts for 24% of all waste exports). Apart from this it was assumed that imports and exports for 2000 were the same as 2001.

6.2.1 Data Gaps & Data Reliability for Imports and Exports

In general, data availability in terms of mass of materials is very good for external trade. Additional information was obtained from CSO for certain CN codes to the four digit level where supplementary units are in use. A cross check between tonnage data and supplementary unit data for a small number of high volume items showed good correlation between the two sets of figures. For those codes where net mass reporting is optional, estimates were made for using these supplementary units and estimates of unit mass.

However, there are some additional CN codes for which net mass reporting is optional which were not sought for this study, but should be obtained in future. In the main, they consist of small-mass, high-value items - such as precious and semi-precious stones, silver, gold, etc. Where these flows become significant is in relation to calculating hidden flows. There are one or two other areas, involving larger mass materials such as floor coverings of textiles, certain pleasure craft, and a small number of electrical equipment categories.

Based on experience it is anticipated the contribution of all these materials will be very small in relation to the overall mass of imports and exports.

It should be noted that MFAs carried out for other countries have usually excluded items for which tonnage data is not reported. This is an area that has been reported as requiring additional investigation. Also, hidden flows for such items, and for finished goods in general, is a largely undeveloped area.

At present, the import and export data which has been gathered has only been broken down into the categories of fossil fuels, waste, and all other materials/products. In order to be consistent with the Eurostat Methodological Guide, as part of any future MFA work, the import and export data should be broken down according to the following categories:

- raw materials
- semi manufactured products
- finished products
- other products
- packaging material with products

Each of these categories should them be further broken down according to the main or predominant constituent, as follows:

- fossil fuels
- minerals
- biomass
- secondary raw materials
- other products of an abiotic or biotic kind

This will be straightforward for some CN codes. In other cases it would probably require going to at least a six digit, or eight digit CN code. It is envisaged that there may be some difficulty in assigning the data to the categories for semi manufactured products, finished products, other products. This will require a degree of interpretation. Assigning the data to the categories of fossil fuels, minerals, biomass, etc., will also require a degree of interpretation.

Packaging material with products imported and exported will not be available from external trade statistics. While information is available on packaging waste arising in Ireland through the waste database, the split between that manufactured in Ireland, and that imported for use, or imported on products is unknown. Packaging on exported products is also currently an unknown quantity. An attempt could be made to estimate quantities arising by carrying out a packaging material balance. Prodcom details a variety of different types of packaging manufactured in Ireland (although there is some confidential data within the CN codes covering packaging). External trade data also details the import and export of packaging (currently this data has only been obtained in an aggregated format - so the specific CN codes covering packaging cannot be isolated). Time lag factors would have to be taken into account.

Similarly material balances could be carried out for other priority waste streams, e.g. construction and demolition waste.

Fossil Fuels

Data sources for imports of fossil fuels are detailed in Chapter 4.

6.3 Unused Domestic Extraction

6.3.1 Data Sources for Unused Domestic Extraction – Harvesting Losses

In terms of biomass, the following materials have to be taken into account for harvesting losses in Ireland:

- wood harvesting losses,
- discarded by-catch in fishing,
- agricultural harvest losses including leaves from sugar beet and fodder beet, and straw associated with cereals that is not used for economic purposes.

For grassland grazing, Teagasc reports that a certain percentage of loss occurs due to trampling and faecal contamination, even with well managed grazing. The Eurostat MFA guide, or the MFAs compiled for other countries that have been reviewed in detail, have not taken into account ‘harvest’ losses associated with grazed grassland. However, since grassland grazing is a significant material input for Ireland, an estimate of associated losses has been included in unused domestic extraction. An average of 25% losses (from Teagasc literature) has been taken.

For wood harvesting losses, the most appropriate source of data for *unused domestic extraction* is deemed to be the EPA activity data in relation to emissions of greenhouse gases, minus the commercially sold timber as detailed in Coillte annual report. The EPA value details total biomass generated as a result of commercial harvest, not just timber production or sales values.

For sugar beet, fodder beet, and straw, factors for unused extraction used in other MFAs were utilised as a first estimate. The total production of sugar beet is equal to the mass of washed and crowned beet delivered to Irish Sugar plc. plus the Irish Sugar plc. estimate of what was not delivered to them. The yield of fodder beet refers to fodder beet roots only. Hence, in both cases, leaves need to be taken into account for indirect flows. In both cases a value of 35% for leaves as a percentage of total biomass was used (as per UK MFA). This factor was also used for turnips. In the case of straw, a factor of 0.46 tonnes of straw that is not economically used per tonne of cereal was used (based on German data).

For discarded by-catch associated with fishing, a factor of 25%, as used in other MFAs, was utilised as a first estimate. This was confined to marine landings only. Aquaculture and inland fishing were ignored.

6.3.2 Data Gaps & Data Reliability for Unused Domestic Extraction – Harvesting Losses

The applicability of the factors used to estimate unused extraction to the Irish situation should be determined by consultation with Teagasc, and for sugar beet, with the sugar industry. In particular for grassland, the figures used for losses should be confirmed in discussion with Teagasc, since biomass input for Ireland from this source is significant.

Losses associated with grassland are not specifically mentioned in the Eurostat Methodological guide or have not been included in the MFAs reviewed. However, since the growth of such ungrazed grass requires input in terms of fertiliser, land area, etc., it should be proposed as a possible consideration in unused domestic extraction in MFAs.

Harvest losses associated with crops other than those mentioned have not been included in MFAs compiled for other countries. Hence they will be ignored for this first estimate. In any case, production of such crops is much lower, with the exception of potatoes - which is of a magnitude just slightly higher than fodder beet. Discussion with Teagasc may yield a factor for unused domestic extraction associated with the potato crop.

6.3.3 Data Sources for Unused Domestic Extraction - Fossil Fuels

Data sources for unused domestic extraction of fossil fuels are detailed in Chapter 4.

6.3.4 Data Gaps & Data Reliability for Unused Domestic Extraction – Fossil Fuels

Data gaps & data reliability, in relation to unused domestic extraction of fossil fuels, are detailed in Chapter 4.

6.3.5 Data Sources for Unused Domestic Extraction - Minerals

Since the Eurostat methodological guide utilises total ores extracted as domestic extraction input into the economy, then unused domestic extraction associated with the mining of mineral ores consists of overburden that has to be removed to access the metallic ore. There is no data available at present. Information from individual companies would have to be obtained in the event of compiling a total MFA for Ireland.

6.3.6 Data Gaps & Data Reliability for Unused Domestic Extraction – Minerals

Inspection of individual IPPC licensing data or discussion with the operators of metallic and mineral mining operations may yield more applicable information on the factors to be used to estimate hidden flows.

6.4 Material Outputs to the Environment

6.4.1 Data Sources for Used Material Outputs to the Environment - Landfill

Data on waste landfilled was taken from the EPA's National Waste database 2001.

6.4.2 Data Gaps & Data Reliability for Used Material Outputs to the Environment – Landfill

The 2001 database values were assumed to be representative of 2000.

6.4.3 Data Sources for Used Material Outputs to the Environment - Air

Data on emissions of greenhouse gases in Ireland is compiled by the EPA for reporting under the UN Framework Convention on Climate Change (UNFCCC). This includes emissions of:

- carbon dioxide,
- methane,
- nitrous oxide,
- NMVOCs,
- the industrial gases
  - PFCs,
  - HFCs,
  - SF_6.
  - carbon dioxide (CO2),
  - methane (CH4),
  - nitrous oxide (N2O),
  - perfluorocarbons (PFCs),
  - hydrofluorocarbons (HFCs)
  - sulphur hexafluoride (SF6).

Also, information on emissions of carbon monoxide (CO), nitrogen oxides (NOx) and non-methane volatile organic compounds (NMVOCs)is provided under the UNFCCC.

Data on SO_2, NO_x, NMVOC, CO and NH_3 and PM_{10} emissions in Ireland is also compiled by the EPA for reporting purposes under the Long Range Transboundary Air Pollution Convention. Emissions data is available according to different sectors as defined under the convention.

6.4.4 Data Gaps & Data Reliability for Used Material Outputs to the Environment – Air

The Eurostat guide classifies VOC emissions to air as a dissipative use, rather than under air emissions. However, the guide acknowledges that, in practice, data availability may require the classification to be adapted, and for solvent emissions to be included in air emissions. In the case of Ireland, VOC emissions to air arise from dissipative uses such as, for example, paint use by the general public - as well as from point sources such as, for example, discharges from printing companies. Data on emissions is available -

categorized by emissions sources. Therefore, it is possible to split the data on VOC emissions accordingly. However, for the purposes of this initial estimate, NMVOC emissions have been included under air. Similarly the UK MFA study has retained NMVOC emissions under Air - rather than dissipative use.

6.4.5 Data Sources for Used Material Outputs to the Environment - Water

Disposal of sewage sludge to sea ceased during the period 1998 – 1999, with no sea disposal in 2000.

EPA published data on urban waste water treatment emissions does not detail total emissions to waters in terms of tonnes of BOD, COD, nitrogen and phosphorus, and suspended solids. However, the raw data submitted to the EPA will have information from each urban waste water treatment plant discharge. This data could be assessed and figures generated in the event of compilation of an MFA for Ireland.

6.4.6 Data Gaps & Data Reliability for Used Material Outputs to the Environment – Water

No initial estimate has been made for emissions to water. Data at a more detailed level, in terms of the raw figures on urban waste water treatment submitted by local authorities to the EPA, could be used to generate an estimate of loads of nitrogen, phosphorus, BOD and COD.

In terms of industry, information on emissions to waters could be taken from AER data for IPC licensed industry that discharge directly to waters rather than to sewer. Gaps would still remain for discharges direct to waters from non-IPC industry.

In terms of run-off from landspreading of organic material, it is unclear in the Eurostat guide if it should be considered in terms of emissions to waters. However, from a mass balance point of view, if landspread manure and sewage sludge are already included as outputs to the environment under dissipative uses, then the inclusion of the nitrogen and phosphorus in runoff from the landspreading of such wastes as emissions to waters would be double accounting. For information purposes, discharges to waters of nitrogen and phosphorus should still be included. However, when calculating indicators, only nitrogen and phosphorus from direct discharges should be included. Information on nitrogen and phosphorus run-off is available in the EPA’s phosphorous balance (EPA 2001).

It should be noted that the 2000 Census of Agriculture has been published since the EPA carried out the phosphorus balance. Therefore revised estimates of the quantities of organic farm waste produced could be made based on the livestock figures of the 2000 census.

6.4.7 Data Sources for Used Material Outputs to the Environment - Dissipative Use of Products

There is FAO data available on the consumption, production, import and export of fertilisers in Ireland in terms of tonnes. This is split according to fertiliser types. The FAO data for pesticides consumption for Ireland is given by pesticide type.

The use of sewage sludge in agriculture in terms of dry solids is reported in an EPA publication on urban waste water (EPA 2002b). This report is also referenced in the EPA waste database 2001. Hence it is used as the most appropriate source of data. The corresponding average solids content of sewage sludge was taken from the EPA waste database 2001.

Estimates for the total quantity of agricultural wastes (manure, silage effluent, dirty dairy water) landspread nationally, in terms of fresh mass, has been taken from the EPA phosphorous balance.

Estimates of landspread agri-industry and other industrial sludge was taken from the EPA waste database 2001.

6.5 Areas excluded in the Preliminary Estimate of Total Material Flows in Ireland

The original aim of this part of the project was to assess data gaps and data availability for total material flows. This part of the project has been taken one step further by generating initial estimates for a number of the flows into and out of Ireland.

The following areas have been identified from this initial data sourcing exercise as those where no information currently exists for Ireland:

- Net addition to stocks - infrastructure, durable goods and material stocks. No information has been obtained for this area, other than material stocks for fossil fuels.
- Hidden Flows (exports) – unused domestic extraction. No information has been obtained for this area, other than for fossil fuels. In most national MFAs, international factors have been used.
- Foreign Hidden Flows (imports) – unused extraction abroad. No information has been obtained for this area, other than for fossil fuels. In most national MFAs, international factors have been used.
- Unused domestic extraction – soil excavation and dredging.

Each of these areas are likely to be significant. Any future MFA for total material flows in Ireland should attempt estimates for these flows. The suitability of the use of international factors for Ireland should also be investigated.

6.6 Preliminary Estimates of Total Material Flows in Ireland

Table 6.2 illustrates the total flows of materials into and out of the Irish economy in the year 2000.

2000					
Inputs			**Outputs**		
	000 tonnes	**000 tonnes**		**000 tonnes**	**000 tonnes**
Domestic extraction		**107,419**	**To Environment - Used Material**		**119,494**
biomass	64,293		Air	47,059	
Fossil Fuels	5,385		Landfill	8,278	
Minerals	37,741		Water	-	
Imports		**44,487**	Dissipative product use	64,158	
Fossil Fuels	13,967		Dissipative losses	NE	
All other materials/products	30,452		**To env.- unused domestic extraction**		**11,699**
waste	68		Fossil fuel extraction	1,237	
Unused Domestic extraction		**11,699**	Mineral mining/quarrying	NE	
Fossil fuel extraction	1,237		Harvesting losses	10,462	
Mineral mining/quarrying	NE		Soil excavation	NE	
Harvesting losses	10,462		Dredging	NE	
Soil excavation	NE		**Exports**		**13,686**
Dredging	NE		All other materials/products	11,986	
Hidden Flows (Imports)		**NE**	Fossil Fuels	1,193	
biomass	NE		waste	508	
Fossil Fuels	8,715		**Hidden flows (exports)**		**NE**
Minerals	NE		biomass	NE	
Items for Balancing		**29,992**	Fossil Fuels	211	
Oxygen for combustion	29,992		Minerals	NE	
			Net Addition to Stocks (NAS)		**NE**
			Infrastructure	NE	
			Durable goods	NE	
			Material stocks	65	

Table 6.2: Total material flows into and out of the Irish economy, 2000

Based on the data that has been gathered, it is possible to generate estimates for some of the material flow indicators for Ireland for the year 2000. These are shown in Table 6.3.

	Indicators		**'000 tonne 2000**	**tonne / capita 2000**
DMI	(Direct Material Input)	Domestic extraction + imports	151,906	39.0
DMC	(Domestic Material Consumption)	DMI - exports	138,220	35.5
PTB	(Physical Trade Balance)	Imports - exports	30,800	7.9
DPO	(Domestic Processed Output)	Used material flows to the Environment	119,494	30.7
DMO	(Direct Material Output)	Used material flows to the Environment + Exports	133,181	34.2

Table 6.3 Summary of MFA Indicators for Ireland

DMI – a measure of how much material is input into the Irish economy.

DMC – a measure of how much material is consumed in Ireland.

PTB – a measure of whether an economy is a net importer or a net exporter of materials.

6.7 Comparison of Irish Indicators with Eurostat Values for Ireland and with Other Countries

Input and consumption indicators have been calculated in a Eurostat project for each Member State. Output indicators were not included.

6.7.1 DMI - Direct Material Input

Table 6.4 shows values of DMI per capita for EU Member States, as calculated by a Wuppertal project (Moll 2003) for the European Topic Centre. The value of DMI in the table for Ireland is that calculated in this EPA study. The ETC estimate of DMI for Ireland was over half this value - standing at 26.6 tonnes per capita.

	DMI tonnes/capita
Norway	60.2
Finland	42.3
Ireland	**39.0**
Belgium/Luxembourg	34.7
Denmark	30.8
Sweden	28.3
Netherlands	26.3
Austria	22.8
Germany	21.1
Spain	19.2
France	18.7
Greece	18.1
EU15	16.8
Portugal	16.0
United Kingdom	14.9
Italy	14.6

Table 6.4: DMI for EU Member States

The Irish value of DMI is at the upper end. This shows Ireland has a stronger connection between material resource use and economic activity than other EU countries. However not all of the estimates for the other countries include the same extent of products as have been included in the Irish figure in this study (see discussion in Section 6.7.3). DMI is an illustration of the weight of actual material that goes into the Irish economy. It includes material that will be consumed within Ireland, as well as other materials that will go into products and ultimately be exported. Reducing the value of DMI while maintaining or increasing fiscal activity, is to move in the direction of sustainability.

6.7.2 DMC - Domestic Material Consumption

Table 6.5 shows values of DMC per capita for EU Member States, again as calculated by the Wuppertal project. The value of DMC in the table for Ireland is that calculated in this EPA study. The ETC estimate of DMC for Ireland was somewhat lower, standing at 23.5 tonnes per capita.

	DMC tonnes/capita
Ireland	**35.5**
Finland	35.5
Denmark	22.7
Sweden	21.3
Austria	18.1
Germany	17.8
Spain	16.8
Belgium/Luxembourg	16.6
Greece	15.9
EU15	15.6
France	15.3
Portugal	14.5
Netherlands	12.9
Italy	12.6
United Kingdom	11.6
Norway	11.5

Table 6.5: DMC for EU Member States

DMC is an illustration of the weight of actual material that is consumed within Ireland. The Irish value of DMC is joint highest within the EU for 2000. This means that, in 2000, Irish people consumed the highest amount of material resources per person within the EU. However not all of the estimates for the other countries include the same extent of products as have been included in the Irish figure in this study (see discussion in Section 6.7.3). Reducing the value of DMC while maintaining or increasing fiscal activity, is to move in the direction of sustainability.

6.7.3 Comparison of Irish Indicators calculated by this study with Eurostat Values

The values for both DMI and DMC calculated for Ireland by this study are approximately 50% higher than those calculated by the Wuppertal project. The same methodology was used by both studies. However, other products were also included in this study in terms of imports and exports, whereas the Wuppertal figure for Ireland focussed on the major flows of biomass, minerals and fossil fuels only.

In addition to this, different data sources were used in certain instances:

- The category with the largest difference between the two studies was domestic extraction of biomass. The major constituents of the biomass figure are grassland and silage. The area under grass is recorded by the CSO and assumptions were made in this study on yields per hectare. The Wuppertal figure for grass from grazing is also an estimate using the same method, but the exact detail of this estimate was not available in the literature for comparison. Both figures are corrected to a standardised water content of 15%.
- For minerals, there were some additional minerals that were included in this study that were not in the CSO statistics for confidentiality reasons. Sources other than Prodcom were used for such minerals as detailed in Section 6.1.9.
- Fossil fuel data from the Department of Communications, Marine, and Natural Resources (DCMNR) was utilised in this study, whereas the Wuppertal study is based on CSO statistics submitted to Eurostat. After discussion, DCMNR data were considered more reliable than CSO data.

7 EVALUATION AND RECOMMENDATIONS

This chapter details overall conclusions and recommendations in relation to material flow accounting in Ireland, including recommendations for future work.

7.1 Applicability of MFA in Ireland

The whole concept of Material Flow Accounts is embedded in the principles of measurement and reporting. A concerted effort should be made to improve the quality of data, and to enhance its transparency. The continuing evaluation and improvement of data must work in conjunction with performance improvement measures (prevention, recycling, etc.). All countries recognise the need for sets of indicators and tools for data gathering and evaluation, in order to improve environmental performance. In order to have any hope of achieving sustainable development, economic growth must be decoupled from other factors, such as resource consumption and waste generation (the so-called Factor 10+ approach). MFA provides a mechanism for the measurement and reporting of such resource and waste flows. In order for Ireland to effectively compete in terms of environmental performance, it must develop comprehensive sets of material flow accounts. These allow priority areas for action to be identified – just as national fiscal accounts facilitate the prioritisation of economic measures.

MFA provides a basis for policy decisions, and for the framing of environmental improvement programmes. As a simple - if obvious - example, MFAs might show an overdependence in Ireland in the use of fossil fuels. This might then lead to increased measures for the promotion of renewable energy. Many individual company environmental audits have identified areas of resource use or waste production which are far greater than had been thought or anticipated. These audit allowed specific areas to be targetted for reduction. The same is true for all areas of anthropogenic activity. Until a comprehensive set of national and material specific accounts is generated, it is not possible to know, with any certainty, where best to apply resources, and to prioritise action policies. Economic policies are set with regard to economic indicators (GDP, GNP, etc.). The monetary flow through society has been much analysed. In a similar manner, the environmental policies of the future must be based on evaluation of the material and energy flows.

It is essential to decouple economic and material intensity. To do this requires an ongoing and accurate evaluation of material and energy flows. It should be a long term aim to produce economic flows in conjunction with material flows. This will facilitate the decoupling process.

It is recommended that any future MFA accounts for Ireland on a national level follow the Eurostat methodology. There are certain areas as outlined in Section 6 where the preliminary figures for total material flows within this report should be refined and the estimation methods improved.

7.1.1 Conclusions Regarding MFA Applicability in Ireland

The following conclusions can be drawn in relation to the applicability of material flow accounting in Ireland:

- National total material flows are is a key input into international and, in particular, European reporting protocols (for example the Kiev Report). Many countries have been engaged in such accounting for several years. Ireland needs to develop a well defined set of MFAs to meet reporting requirements.
- In addition to national total material flows for Ireland there are a number of areas, where the methodology could be applied, including
  - Specific stream accounts (packaging, wastes, plastics, WEEE, etc,). This should be based on prioritisation of important streams).
  - Sector specific MFAs – preferably by NACE sector. (this should be accompanied by prioritisation of important sectors)
  - Regional MFAs. In particular, some pilot studies should be carried out to determine the typical ‘ecological footprint; of different types of region (urban – small and large), rural, semi-rural.
  - Waste management facilities
  - Industrial sites (voluntary exemplars could be used for a base-line study – wherein material and energy balances, normally presented under IPPC licensing reporting requirements could be evaluated in a different way)

The examples above would form part of a comprehensive set of accounts, which can form the basis for decision making. A parallel can be drawn with the production of the National Waste Database (NWD) by the Environmental Protection Agency. The data in the NWD are used to determine the prioritisation of appropriate actions. There is, however, a constant need to improve the methodology of data collection, and the reliability of data (hence the undertaking of waste characterisation studies). MFAs represent an additional tool, which can provide additional and alternative data and information. MFAs need to be piloted, methodologies developed, and comprehensively applied. The information so gathered can aid with the development of programmes and activities to reduce the environmental footprint of Ireland.

The overall aim (in a medium term – 5-10 year scenario) should be to present a hierarchy of data. This would feed from

- Overall national accounts for specific streams
- Regional accounts
- Sector specific accounts
- Site-specific accounts
- Waste and energy management

All of the above could feed into the various reporting requirements (international protocols, European requirements, national reporting requirements, such as the State of the Environment Report, the National Waste Database, etc.)

7.2 Recommendations for Future Data Sourcing and Further MFA Generation

7.2.1 Data Sourcing

The following is a list of recommendations in relation to future data sourcing for total material flows for the Irish economy:

- There are a number of data gaps in relation to material flows in Ireland, in particular some of the domestic extraction data. Some of the initial estimates in Chapter 6 should be refined through contact with the industries involved. It should be noted that other countries have also experienced similar problems in obtaining data.
- In relation to hidden flows, national MFAs carried out elsewhere in the main tend to use international factors. It may be more appropriate to generate specific factors for the Irish situation for some of the major flows.
- The concept of confidential information constitutes a barrier to information gathering. Whilst it is recognised that financial confidentiality has a role to play in a competitive market, it should be possible for government and state organisation to provide information which will simultaneously provide statistical information and protect economic interest.

7.2.2 Future MFA Generation

It is recommended that MFAs are produced on an ongoing basis. This might best fit under the auspices of the National Waste Prevention Programme, since the production of MFAs can assist with prioritisation of prevention and reduction initiatives and programmes.

As outlined in Section 7.1.1, MFAs should be produced at several levels. These are as follows:

- ***National Level***: accounts for specific waste streams would allow better compliance with EU Directives and international protocols. Examples include:
  - Solvent accounts (Solvents Directive)
  - WEEE accounts (WEEE Directive)
  - Greenhouse gas and climate change gas accounts (these are already reported under a different format, but an MFA approach may be informative)
  - Packaging accounts (national targets)
- ***Sector Level:*** Sector-Specific Accounts can facilitate sectoral reduction measures. Examples might be

  - Agriculture
  - Food
  - Hospitality
  - Various industrial sectors

- ***Site Level:*** site specific accounts should be encouraged. This merely represents a sophistication in the type of data presented under AERs, PERs, etc.

The various MFAs could be produced on an ongoing basis under the auspices of the EPA. This would be similar to current EPA data production work – such as the National Waste Database, SNAP Sector 6 reporting, etc. In the past the EPA has carried out some of this work itself, and has sub-contracted some of it. A similar scenario can be envisaged with MFAs. As stated above, the work might fit neatly into the programmes of the National Waste Prevention programme.

It is recommended that any future MFA accounts for Ireland on a national level follow the Eurostat methodology. There is more flexibility in the methods and approaches that can be used for accounts at levels other than the national level.

7.3 Implications for Irish Policies

Ireland is fully committed to the principles of Sustainable Development, and to the various international protocols on reporting, emissions reductions, etc. In order to effectively comply with our obligations, policy makers require the most comprehensive and comprehensible information possible. It is hard to imagine the formulation of economic policy without any economic information. In a like manner, the formulation of the best, most relevant, and most effective environmental policies, requires high quality information and data. MFAs represent a mechanism towards achieveing this.

Furthermore development of an MFA methodology could be such that economic and other flows are also incorporated. In this way, it should be clearer where policy improvements could best be applied – to allow economic growth at the lowest environmental and social cost. These are the basic tenets of Sustainable Development.

Some implications for Irish policies include the following:

- the use of the Sankey illustration tool could be applicable for presenting a wide range of environmental data. Whilst it may appear that Sankey – being only a method of representing results – has no direct policy relevance, the clarity of the information presented makes it much easier to envisage problem areas, etc. Thus, there is an indirect benefit for the identification of priority areas for policy implementation.

- policy decisions and planning can be based on an accurate representation of environmental flows (see above for the link between GDP and MFA, etc.)

- the formulation of future research programmes can be linked to information provision. It is possible to envisage a national development programme, which evaluates economic, environmental, and social parameters in a similar manner, and which uses the results of all three to produce cogent policies and programmes

> consistent with the three pillars of Sustainable Development. MFA is an important tool in this regard. It is not sufficient to set development targets based on economic indicators alone, environmental targets based on environmental indicators alone, or social targets based on social indicators alone. All three must be integrated in order to ensure a National Sustainable Development Programme. The MFA methodology represents a possibility to gather and present economic, environmental, and social information in the same format. This could greatly facilitate the development of holistic policies.

MFAs could be used to provide information, which would allow better implementation of specific policies. Some examples include:

- Tracking of organic solvents to facilitate implementation of the Solvents Directive. This might involve import, use, discharge, losses, etc. of solvents in sectors such as dry-cleaning, vehicle refinishing, etc.
- Tracking of priority waste streams, such as tyres, WEEE, etc.
- Specific packaging streams for compliance with declared policies.

APPENDIX – MFA SOFTWARE REVIEW

The types of software packages that have been reviewed can be broken down into two main categories:

- Those that perform calculations ***and*** illustrate results.
- Those illustrate results only.

The following calculation/illustration software packages have been reviewed:

- GaBi 3 and GaBi 4
- Umberto
- Simbox
- AUDIT
- ORWARE
- PFAST

The following illustration only software packages have been reviewed:

- S.draw
- Metaflows
- Sankey Helper

Demostration versions of the software have been obtained where available and reviewed.

A brief synopsis of the software packages follows.

A.1 GaBi Software

GaBi 3 Software provides software packages for a number of varying environmental procedures. Initial steps in the GaBi system require a detailed knowledge of the material stream network. In the **GaBi 3** software system, visualisation is provided of the subdivision of the examined system into further sub-systems (e.g. processes) and the flows of energy and materials that connect them, using Sankey diagrams.

GaBi4 professional is intended for consulting and research facilities and commercial projects with the industry.

GaBi4 professional academy is intended for use in thesis, seminar paper, dissertation and is provided with a 50% discount.

A.2 UMBERTO

Umberto mainly addresses company level flows, but can also be used for material flow analysis, input/output balances, and for life cycle assessments of products.

There are three different versions of the Umberto software package:

- Umberto consult
- Umberto business
- Umberto educ

Umberto consult is designed to be used by consultancies.

Umberto business is the version for in-house company use.

Umberto educ has been designed for universities and business schools for teaching fundamental principles of material and energy flow analyses.

A.3 SIMBOX

This software package is part of a material flow analysis system devised by S+E, of the Swiss Federal Institute of Technology in Zurich. The software is available in German only, and is therefore unsuitable for use.

A.4 AUDIT

AUDIT software has been mainly applied to companies though setting of the boundaries is user dependant. In summary, there are two areas of application for the AUDIT software:

- Visualising current company data in the form of mass flow and cost flow diagrams as well as evaluating in the form of spreadsheets, diagrams and indices.
- Calculating unknown mass flows in the production as well as simulating specific company conditions and planning material, cost, or plant changes in the production process.

A.5 ORWARE

ORWARE (ORganic WAste REsearch) is a tool for environmental systems analysis of waste management. It is a computer-based model for calculation of substance flows, environmental impacts, and costs of waste management. ORWARE consists of a number of separate submodels, which may be combined to model/design a waste management system for e.g. a city, a municipality or a company. This package is not appropriate for national MFAs or for regional material flow accounting, since only waste outputs are considered, which are just a subset of overall MFA inputs and outputs.

A.6 PFAST

PFAST (Production Flow Analysis and Simplification Toolkit) has been used predominantly by companies with regard to Production Flow Analysis (PFA). For national MFAs, and for regional material flow accounting, this software is not appropriate.

A.7 S.Draw

S.Draw generates Sankey diagrams which can be used to display energy flows, mass flows and monetary flows. Flows in any units and conversion values between different units can be used. Quantitative or qualitative data can be used. It is possible to import data sheets. Any data stored in S.Draw diagrams is easily exported to Microsoft Excel, Microsoft Access, Microsoft SQL Server™, Microsoft Word, and other reporting and data-analysis tools. It is an Austrian product.

A.8 Metaflows

Another package which generates Sankey diagrams for material, energy and water flows ,it is produced by a US company called Propolis.

A.9 Sankey Helper

This is a free macro for use in Microsoft Excel. Data from worksheets is converted into fairly simplistic Sankey diagrams. It is awkward to use, and the output is poor.

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