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Abstract. This paper describes the construction of the Irish Social Accounting Matrix for the year 1998. Treatment of taxation, margins and import data is described in detail. The SAM is disaggregated to create seven separate energy industries and commodities using various data sources. Emissions data are made consistent with the SAM and are disaggregated by commodity and industry or agent.

Keywords. Social Accounting Matrix, Integrated Economic and Environmental Accounts.

JEL classification. Y1, Q4, Q5.

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1 INTRODUCTION

Wissema and Dellink (2006) constructed and applied a general equilibrium model to analyse the impact of a carbon tax on the Irish economy focusing on CO_2 emissions from the use and production of energy. The model requires a lot of data, most conveniently in the form of a Social Accounting Matrix (SAM) with particular detail with regard to energy and emissions.

This paper describes the construction of the SAM for the year 1998. This is the most recent year for which the Central Statistics Office (CSO) has produced Supply and Use Tables (GoI, 2004), the main data source for the SAM. Some of the sectors/products in the CSO Tables were aggregated in the SAM in order to reduce the dimensions of the model. The SAM is disaggregated to create separate energy industries and commodities in Section 3. Emissions are added in Section 4.

2 THE AGGREGATED SOCIAL ACCOUNTING MATRIX

Figure 1 shows a simplified SAM structure. Only three industries and commodities are shown, but the structure is the same for each industry and commodity. The index for the 26 commodities is *i*, and *j* indicates the 26 industries. Appendix A lists the acronyms with their full descriptions and shows concordance with the sector numbers used in the CSO tables.

The CSO Supply Table (CSO Table 1) provides *MAKE(j,i)*, at *basic prices*, and then adds imports, trade margins and taxes on commodities and deducts subsidies on commodities in order to arrive at the same totals for each commodity as in the Use Table, at *purchaser's prices* (CSO Table 2). In the SAM, imports are valued at *c.i.f.* prices and import duties are included with product taxes *TY(j)* in the industry columns. Because the Use Table is valued at *purchaser's prices*, and thus includes indirect taxes (net of subsidies), it cannot be used directly to create the commodity rows in the SAM, which show demand for, or use of commodities by industries (*ID(i,j)*) and final demand (*FD(i,f)*). In the SAM, the commodity rows should be valued at basic prices, *i.e.*, equal to the costs of supply, without product taxes and without deducting any product subsidies. It was decided to include the costs of trade margins, though. This is discussed in detail in Appendix B.

The CSO provided three unpublished tables. A Use Table at basic prices (Table 7), a net taxes table (Table 8) and a table with margins on all commodities paid by all industries (Table 9). With these, the commodity rows could be calculated by adding each corresponding cell in Table 7, Table 3 (imports) and Table 9[1]. Labour and capital costs *L(j)* and *K(j)* as well as taxes and subsidies on products *TID(j)* and production taxes and subsidies *TY(j)* are published as part of the CSO Use Table. The transfers between agents appearing in the section in the SAM beneath the commodity rows and in the columns for final demand are taken from the CSO tax table (Table 8); savings are calculated as residual income for each agent to balance their budgets.

[1] Totals match those of CSO Table 2 after adding the indirect (product) taxes *TID(j)* and *TFD(f)*, *i.e.*, the totals of Table 8.

		Industries			Commodities			Primary income		Final Demand				Total
		1	2	3	1	2	3	L	K	HOU	GOV	EXP	INV+STC	
Industries	1 2 3				*MAKE(j,i)*									*TotRev(j)*
Commo-dities	1 2 3	*ID(i,j)*								*FD(i,f)*				*TotDem(i)*
Factor Inputs	Labour	*L(j)*												
	Capital	*K(j)*												
House-holds	HH													
Government	product taxes (net)	*TID(j)*								*TFD(f)*				
	production taxes (net)	*TY(j)*												
Rest of World	imports				*IMP(i)*									
Savings/ investment	savings													
Total		*TotCost(j)*			*TotSup(i)*									

Figure 1. Simple SAM Structure

3 DISAGGREGATION OF ENERGY IN THE SAM

3.1 From SAM to ESAM

In order to simulate climate change policies in relation to energy-related carbon dioxide emissions, it is imperative to first adequately model the following features:

- energy flows among industries (intermediate demand);
- energy flows between industries and consumers (final demand including exports);
- tax paid on energy products;
- imports of energy products;
- the cost structure of energy producing industries.

The main energy sources and industries need to be distinguished separately in the model, and thus also in the SAM. This disaggregated SAM will henceforth be referred to as the energy-SAM (ESAM). Seven energy industries and commodities were disaggregated as follows:

1. 'Mining and quarrying' in the SAM[2] was divided into crude oil (CRUD), coal (COAL), peat (PEAT), natural gas (NGAS) and other mining and quarrying (MINE).
2. 'Other manufacturing'[3] was divided into oil products (OILS) and other manufacturing (OMAN).
3. 'Electricity and gas'[4] was divided over electricity (ELEC), renewable electricity (RNEW) and natural gas (NGAS).

The first disaggregation with regard to industries is reduced to a split between PEAT and MINE, because there is no mining of coal or extraction of crude oil in Ireland. Extraction of NGAS is also classified with mining, but the domestic production of NGAS is included with 'Electricity and Gas'. The second disaggregation is greatly hindered by the fact that there is only one firm in the oil refineries sector (NACE code 23) in Ireland. In order to keep this firm-level data confidential, the CSO was forced to conceal it by adding 'Oil production' to 'Other manufacturing'. In the third disaggregation, renewables are defined as electricity from renewable resources such as hydropower and wind. Renewable energy other than that used in the form of electricity or used in the production of electricity, is not explicitly classified anywhere in the Use Table. The commodity and industry NGAS (natural gas) in the ESAM is the aggregate of extraction and imports from 'Mining and quarrying' and production and distribution from 'Electricity and gas'.

3.2 Control Totals for Energy Data in the ESAM

In order to maintain the balance in the SAM, the relevant rows and columns were initially disaggregated proportionally, using shares. The shares are based on values, because one commodity may have a much higher price than another. Using quantity shares would lead to incorrect results. Appendix C describes the methodology applied in the disaggregation of the totals of each of the three original aggregate industries/commodities and presents the data sources used. The data manipulations described in Appendix D culminate in two tables. Table 1 shows an alternative energy balance in metric kilo tonnes of oil-equivalent (KTOE) based on the International Energy Agency's Detailed Energy Balance for Ireland 1998 (IEA, [2001]). Table 2 is similar but expressed in monetary units. The values are mostly derived from the volume data in Table 1 and prices from the Economic and Social Research Institute (ESRI). Import values in Table 2 are taken from the CSO Trade Statistics and disaggregated using Table 1.

3.3 More Detailed Disaggregation

Disaggregating each cell in a row or column using the initial aggregate shares would necessarily lead to the correct totals. However, this would not be realistic for most industries and in some cases far more data was available to refine this disaggregation. With value shares calculated from CIP data, the energy rows in intermediate demand of manufacturing industries and the utilities sector were disaggregated in considerable detail. Furthermore, the disaggregation of the electricity and gas industries were

[2] In the Supply and Use Tables this is activity 2. It covers NACE codes 10-14. NACE is the General Industrial Classification of Economic Activities in the European Community. In accordance with EU legislation, the CSO used the NACE Rev. 1 classification to classify the 1998 activities.
[3] Activity 23; NACE codes 23 and 36.
[4] Activity 25; NACE code 40.

refined using the CIP data in Table 3 below. Table 2 also provides values from which these shares can be derived, but the CIP data is more reliable because the prices used to calculate the values in Table 2 are not very detailed. The advantage of the data in Table 2 is that it covers all users, as well as energy costs of the energy sectors. Details of this further disaggregation process are contained in Appendix C.

Table 1. Adjusted Energy Balance for Ireland, 1998 (KTOE)

	CRUDE OIL	REFINED OIL	COAL	PEAT	GAS	ELECTRICITY	RENEWABLES
Production	0	3225	0	833	1406	1796	259
Imports	3220	5394	1902	23	1395	13	0
Statistical Differences and Transfers	146	-47	-75	-45	0	0	0
Intermediate Energy Use by Sector:							
Oil	3250	98	0	0	0	3	0
Coal	0	0	0	0	0	5	0
Peat	0	10	10	33	0	0	0
Electricity	0	1088	1476	566	1347	275	124
Gas	0	0	0	0	32	0	0
Agriculture	0	245	0	0	0	0	0
Mining and Quarrying	0	29	0	0	12	24	0
Food and Tobacco	0	157	27	0	151	148	4
Chemical	0	104	0	0	555	76	0
Petrochemical	0	7	0	0	35	5	0
Other Non-Metallic Minerals	0	114	53	0	47	50	0
Iron and Steel and Non-Ferrous Metals	0	250	0	0	18	54	0
Transport Equipment and Machinery	0	68	0	0	0	80	0
Wood and Wood Products	0	14	0	0	0	34	87
Textile and Leather	0	32	0	0	0	32	0
Construction	0	0	0	0	0	5	0
Non-specified (Industry)	0	52	0	0	40	101	0
Air Transport	0	465	0	0	0	0	0
Road, Rail and Water Transport	0	2904	0	0	0	2	0
Hotels, Restaurants, Bars	0	52	0	0	16	28	0
Commercial Services	0	441	0	4	139	236	0
Non-Commercial Services	0	225	0	2	71	120	0
Final Demand including Additions to Stock:							
Residential	0	791	271	394	338	524	44
Exports	0	1259	3	15	0	6	0
Additions to Stock	117	166	-14	-202	0	0	0

Source: Derived from IEA Detailed Energy Balance for Ireland 1998.

Note: Production + import + statistical differences and transfers = intermediate demand + final demand, save for rounding errors.

Table 2. Energy Use, Imports and Domestic Production, Ireland, 1998 (thousand euro)

	CRUDE OIL	REFINED OIL	COAL	PEAT	GAS	ELECTRICITY	RENEWABLES
Agriculture	-	71 143	-	-	-	-	-
Mining and Quarrying	-	5 382	-	-	2 095	14 921	-
Crude oil							
Coal industry	-	-	-	-	-	3 345	-
Peat briquetting	-	730	566	3 347	-	-	-
Food and Tobacco	-	28 708	2 236	-	25 763	91 120	-
Textile and Leather	-	5 852	-	-	-	20 019	-
Wood and Wood Products	-	2 521	-	-	-	20 921	-
Chemical	-	19 036	-	-	94 449	47 169	-
Petrochemical	-	1 215	-	-	6 029	3 011	-
Other Non-Metallic Minerals	-	20 774	4 362	-	8 033	30 904	-
Iron and Steel and Non-Ferrous Metals	-	45 705	-	-	3 064	33 559	-
Transport Equipment and Machinery	-	12 408	-	-	-	49 436	-
Non-specified (Industry)	-	9 440	-	-	6 750	62 393	-
Oil refinery	269 218	6 891	-	-	-	1 646	-
Gas extraction and distribution	-	-	-	-	3 271	-	-
Electricity generation and distribution	-	76 686	79 808	56 638	138 553	169 655	76 295
Renewables							
Construction	-	-	-	-	-	2 867	-
Trade							
Hotels, Restaurants and Bars	-	15 206	-	115	2 805	31 870	-
Road, Rail and Water Transport	-	842 341	-	-	-	2 347	-
Air Transport	-	84 939	-	-	-	-	-
Other Commercial Services	-	127 901	-	968	23 595	268 059	-
Non-Commercial	-	65 200	-	494	12 028	136 649	-
Residential	-	215 129	91 142	108 852	125 174	595 662	-
Government							
Exports (1)	-	108 563	-	38 854	2 666	635	-
Investment							
Stock							
Total demand	269 218	1 765 770	178 113	209 268	454 277	1 586 187	76 295
Imports (1)	269 218	467 103	128 323	1 571	139 544	2 286	-
Production (2)	-	1 298 667	49 790	207 698	314 732	1 583 902	76 295

Note 1. Import and export figures from CSO Trade Statistics.
Note 2. Domestic production calculated as total demand less imports.

For the imports of crude oil, the monetary data from the Trade Statistics is used.

Table 3. Inputs into Electricity, Gas and Water Sectors (million euro)

	Electricity	Gas	Share of Electricity including Renewables (%)	Share of Gas (%)
Materials Inputs	285.615	216.442	57	43
Services Inputs	46.770	47.426	50	50
Fuel and Power Inputs	393.386	1.889	100	0
Wages and Salaries	318.758	36.563	90	10
Remainder of Net Output	766.127	164.002	82	18
Gross Output	**1810.657**	**466.323**	**80**	**20**

Source: Adapted from CSO CIP Table 1

3.4 The Resulting ESAM

In the following tables the ESAM is presented.

Table 4. Intermediate Demand in the ESAM for Ireland, 1998 (100 million euro)

ID(i,j)	AGFF	MINE	PEAT	FOOD	TEXT	WOOD	CHEM	RBPL	NMIN	METL	MTPR	OMAN
AGFF	6.3			46.8	0.4	0.4	0.3	0.1				
MINE		0.4			0.0	0.0	0.9	0.0	0.4	0.6	0.0	0.0
CRUD												
COAL			0.0	0.1	0.0				0.1		0.0	
PEAT			0.0									
FOOD	9.9			4.0	0.3	0.0	1.3	0.0				
TEXT	0.2	0.0	0.0		4.7	0.0	0.4	0.2	0.0		0.3	0.5
WOOD	0.1	0.0	0.0	2.6	0.1	24.2	1.8	0.3	0.2	0.0	1.9	1.2
CHEM	4.6	0.2	0.1	1.3	0.2	1.5	22.5	1.6	0.2	0.1	1.2	
RBPL	0.1	0.0	0.0	0.8	0.0	0.3	0.9	1.1	0.0	0.0	2.6	0.1
NMIN		0.1	0.1	0.3		0.0	0.1	0.2	0.8	0.0	0.9	
METL		0.0	0.0	0.0			0.4	0.1	0.0	1.3	7.1	0.2
MTPR	1.1	0.7	0.4	1.1	0.1	3.0	6.7	1.2	2.6	0.5	135.2	0.2
OMAN							0.8					0.8
OILS	1.1	0.1	0.0	0.2	0.0	0.0	0.2	0.0	0.1	0.1	0.1	0.1
NGAS		0.0		0.3	0.0	0.0	0.4	0.0	0.0	0.0	0.1	
ELEC	0.5	0.2		0.9	0.1	0.4	1.1	0.3	0.3	0.3	0.7	0.1
RNEW												
CONS	1.1	0.1	0.0	0.5	0.0	0.3	0.7	0.0	0.0	0.0	0.2	0.0
TRAD	0.4											
LDCT	0.0	0.0	0.0	0.3	0.0	0.2	0.5	0.1	0.0	0.0	0.1	0.0
TRNS	0.1	0.3	0.1	1.8	0.1	3.6	3.0	0.2	0.5	0.2	1.0	0.1
AIRT	0.0	0.0	0.0	0.2	0.0	0.5	0.8	0.0	0.1	0.1	0.2	0.0
SVCC	0.6	0.5	0.3	26.3	0.8	17.1	51.0	1.9	1.1	1.0	23.1	0.2
SVCN	0.8	0.0	0.0	1.1	0.1	0.3	2.6	0.1	0.1	0.0	0.4	0.0
MARG	1.1	0.1	0.0	14.5	9.1	24.0	8.0	1.1	2.7	2.1	54.0	0.6

Table 4. Intermediate Demand in the ESAM for Ireland, 1998 (100 million euro) (cont.)

ID(i,j)	OILS	NGAS	ELEC	RNEW	CONS	TRAD	LDCT	TRNS	AIRT	SVCC	SVCN	MARG
AGFF		0.0	0.0	0.0		0.2	1.0	0.0		0.0		
MINE	0.1	0.0	0.1	0.0	3.4	0.1	0.1	0.0	0.2	0.3	0.5	
CRUD	2.7											
COAL			0.8									
PEAT			0.6				0.0				0.0	
FOOD						0.0	0.0			0.0	0.0	
TEXT					0.8	1.2	0.6	0.0	0.1	1.2	0.5	
WOOD				0.2	4.0	0.9	0.2	0.0	0.0	3.6	1.6	
CHEM	0.2	0.0	0.0	0.0	0.8	0.3	0.1	0.0	0.0	0.7	1.8	
RBPL	0.3	0.0	0.0	0.0	4.4	0.7	0.0	1.0	0.0	0.8	0.7	
NMIN					9.9	0.3	0.0	0.0	0.0	0.1	0.0	
METL	0.8	0.0	0.0	0.0	0.8	0.1		0.2	0.0	0.1	0.0	
MTPR	0.9	1.4	2.5	0.1	14.0	2.2	0.1	2.9	2.3	8.5	2.3	
OMAN					0.8		0.0			0.0	0.0	
OILS	0.1		0.3		0.2	0.8	0.3	1.0	0.1	1.2	1.8	
NGAS		0.0	1.4			0.9	0.1			0.1	0.1	
ELEC	0.0		0.3		0.2	0.6	1.2	0.8	0.1	1.3	1.3	
RNEW			0.9									
CONS	0.0	0.2	0.4	0.0	45.2	0.4	0.1	0.0	0.0	8.4	6.7	
TRAD					0.0	0.0	0.0	0.1	0.0	0.2	0.1	121.0
LDCT	0.0	0.1	0.1	0.0	0.1	0.8	0.1	0.0	0.3	1.1	0.2	
TRNS	0.3	0.0	0.0	0.0	1.5	3.1	0.3	2.8	0.8	3.8	0.2	
AIRT	0.0	0.0	0.0	0.0	0.2	0.5	0.2	0.0	2.0	4.3	0.1	
SVCC	0.9	1.7	2.6	0.1	12.2	19.6	7.1	3.2	4.0	65.4	9.7	
SVCN	0.1	0.1	0.2	0.0	0.8	0.4	0.3	0.0	0.1	2.8	12.4	
MARG	3.1								0.5	0.0		

Table 5. Value Added and Total Costs of each Industry in the ESAM for Ireland, 1998 (100 million euro)

VAD	AGFF	MINE	PEAT	FOOD	TEXT	WOOD	CHEM	RBPL	NMIN	METL	MTPR	OMAN
L	3.6	1.4	0.6	12.9	3.0	8.8	8.1	2.7	3.2	0.3	27.7	0.9
K	34.0	0.7	0.3	19.6	0.9	7.7	69.3	0.7	1.7	0.5	40.6	0.6
Taxes on Products	0.9	0.1	0.0	-9.1	0.0	1.0	3.0	0.1	0.1	0.1	1.1	0.0
Production Taxes	-3.5	0.1	0.0	0.8	0.2	0.1	0.1	0.0	0.1	0.0	0.2	0.0
TotCost	**62.9**	**5.0**	**2.1**	**127.3**	**20.5**	**93.6**	**184.9**	**12.0**	**14.3**	**7.1**	**298.7**	**5.7**

Table 5. (cont.)

VAD	OILS	NGAS	ELEC	RNEW	CONS	TRAD	LDCT	TRNS	AIRT	SVCC	SVCN	MARG
L	2.0	0.7	3.0	0.2	28.8	38.9	10.9	5.8	3.2	66.8	89.2	
K	1.4	0.2	3.6	0.2	25.8	26.8	9.2	5.4	1.3	106.0	11.7	
Taxes on Products	0.0	0.1	0.3	0.0	1.1	1.4	0.4	0.9	0.2	2.5	1.5	
Production Taxes	0.0	0.0	0.1	0.0	0.1	2.2	0.6	0.3	0.2	0.2	0.2	
TotCost	**13.0**	**4.7**	**17.2**	**0.9**	**155.2**	**102.4**	**33.0**	**24.4**	**15.5**	**279.5**	**142.3**	**121.0**

Table 6. The MAKE Matrix in the ESAM for Ireland, 1998 (100 million euro)

MAKE(j,i)	AGFF	MINE	CRUD	COAL	PEAT	FOOD	TEXT	WOOD	CHEM	RBPL	NMIN	METL	MTPR
AGFF	62.6												
MINE		5.0											
CRUD													
COAL													
PEAT					2.1								
FOOD						125.5	0.1		1.6	0.1			
TEXT						0.0	20.3	0.0	0.0	0.0	0.0	0.1	0.0
WOOD						0.0	0.0	92.8	0.0	0.1	0.0	0.0	0.4
CHEM		0.0				0.0	0.0	0.1	184.4	0.0	0.0	0.0	0.2
RBPL						0.3	0.0	0.2	0.0	10.8	0.0	0.0	0.4
NMIN		0.7					0.0	0.0	0.0	0.0	13.5		0.1
METL		0.1					0.0		0.0	0.1	0.0	6.6	0.3
MTPR							0.1	0.1	0.6	0.6	0.2	0.4	296.5
OMAN	2.0	0.0					0.1	0.1	0.7	0.1	0.0	0.0	0.7
OILS													
NGAS													
ELEC													0.0
RNEW													
CONS													
TRAD													
LDCT													
TRNS													
AIRT													
SVCC													
SVCN													
MARG													

Table 7. Imports and Total Supply of each Commodity in the ESAM for Ireland, 1998 (100 million euro)

IMP	AGFF	MINE	CRUD	COAL	PEAT	FOOD	TEXT	WOOD	CHEM	RBPL	NMIN	METL	MTPR
Imports	7.9	1.7	2.7	1.3	0.0	25.6	20.6	17.5	43.5	10.0	5.3	9.3	223.8
TotSup	70.5	7.5	2.7	1.3	2.1	151.5	41.3	110.9	230.9	21.8	19.0	16.4	522.4

Table 7. Imports and Total Supply of each Commodity in the ESAM for Ireland, 1998 (100 million euro) (cont.)

IMP	OMAN	OILS	NGAS	ELEC	RNEW	CONS	TRAD	LDCT	TRNS	AIRT	SVCC	SVCN	MARG
Imports	6.1	4.7	1.4	0.0			28.8	8.2	12.7	3.4	144.8	0.7	
TotSup	10.8	17.7	6.1	17.2	0.9	155.2	131.1	41.2	37.2	18.9	424.6	143.0	121.0

Table 6. The MAKE Matrix in the ESAM for Ireland, 1998 (100 million euro) (cont.)

MAKE(j,i)	OMAN	OILS	NGAS	ELEC	RNEW	CONS	TRAD	LDCT	TRNS	AIRT	SVCC	SVCN	MARG
AGFF											0.3		
MINE													
CRUD													
COAL													
PEAT													
FOOD													
TEXT	0.0												
WOOD	0.2												
CHEM	0.0												
RBPL	0.0												
NMIN	0.0												
METL	0.0												
MTPR	0.2												
OMAN	4.1												
OILS		13.0											
NGAS			4.7										
ELEC				17.2									
RNEW					0.9								
CONS						155.2							
TRAD							102.4						
LDCT								33.0					
TRNS									24.4				
AIRT										15.5			
SVCC											279.5		
SVCN												142.3	
MARG													121.0

Table 8. Transfers in the ESAM for Ireland, 1998 (100 million euro)

From / **To**	**L**	**K**	**HOU**	**GOV**	**EXP**	**INV**
HOU	322.7	368.5				
Net Taxes on Products			60.6	2.8	-1.6	14.7
Direct Taxes			86.0			
Savings		18.6	211.3	68.8	-87.6	18.606

Table 9. Final and Total Demand in the ESAM for Ireland, 1998 (100 million euro)

FD	HOU	GOV	EXP	INV	STC	TotDem
AGFF	8.4		5.3	0.2	1.1	**70.5**
MINE			0.2		0.0	**7.5**
CRUD						**2.7**
COAL	0.2				0.2	**1.3**
PEAT	0.2		1.3		0.0	**2.1**
FOOD	66.6		67.8		1.3	**151.5**
TEXT	18.7		10.6	0.6	0.7	**41.3**
WOOD	8.6		58.7	0.2	0.5	**110.9**
CHEM	12.1		177.9		3.7	**230.9**
RBPL	1.1		6.6		0.2	**21.8**
NMIN	1.4		4.7	0.0	0.1	**19.0**
METL	0.1		5.0		0.3	**16.4**
MTPR	20.4		247.3	54.2	10.7	**522.4**
OMAN	4.2		5.7	1.8	-3.4	**10.8**
OILS	4.2		1.1		4.9	**17.7**
NGAS	1.7		0.0		1.0	**6.1**
ELEC	7.6		0.0		-1.0	**17.2**
RNEW						**0.9**
CONS	1.2			89.4	0.0	**155.2**
TRAD	9.3					**131.1**
LDCT	28.6		8.6		0.0	**41.2**
TRNS	10.2		3.0		0.0	**37.2**
AIRT	3.1		6.4		0.0	**18.9**
SVCC	99.5	6.1	57.332	11.2	0.1	**424.6**
SVCN	25.9	92.9	1.543		0.0	**143.0**
MARG						**121.0**

4 EMISSIONS

Emissions data were calculated by multiplying the energy volume data of Table 1 with emission factors of Table E.2 in the appendix. Table 10 shows the results, disaggregated by fuel and user. Total emissions of CO2 for 1998 are estimated at some 39.7 million tonnes by the ESRI and 40.0 million tonnes in the National Climate Change Strategy (GoI, 2000). The ESRI estimates that CO2 emissions from the use of energy amount to 37.4 million tonnes. Total emissions in Table 10 are slightly higher, at almost 37.8 million tonnes. This is due to the fact that revised IEA data was used here.

Table 10. Emissions of CO2 in Ireland, 1998 (million tonnes)

	AGFF	MINE	PEAT	FOOD	TEXT	WOOD	CHEM	RBPL	NMIN	METL	MTPR
COAL			0.038	0.098					0.191		
PEAT											
OILS	0.748	0.09	0.032	0.48	0.098	0.042	0.318	0.02	0.347	0.764	0.207
NGAS		0.028		0.348			1.277	0.081	0.109	0.041	

Table 10. Emissions of CO2 in Ireland, 1998 (million tonnes) (cont.)

	OMAN	OILS	NGAS	ELEC	LDCT	TRNS	AIRT	SVCC	SVCN	MARG	HOU
COAL				5.292					0.971		
PEAT				2.733					1.632		
OILS	0.158	0.298		3.461	0.16	8.717	1.345	0.686	2.411	0.158	0.298
NGAS	0.091		0.073	3.099	0.038		0.319	0.163	0.777	0.091	

BIBLIOGRAPHY

Armington, P., 1969, "A theory of demand for products distinguished by place of production", *IMF Staff Papers* 16, pp. 159-178.

Central Statistics Office (CSO), 2000a, *Trade Statistics*, Central Statistics Office, pp. 8, ISSN 1393-5364.

Central Statistics Office (CSO), 2000b, *Census of Industrial Production*, Central Statistics Office, www.cso.ie.

Central Statistics Office (CSO), 2000c, *Census of Industrial Production – Breakdown of Energy Inputs*, presented by the Central Statistics Office.

ESRI, 2003, Personal communications with John Fitz Gerald.

Government of Ireland (GoI), 2004, *1998 Supply and Use and Input-Output Tables*, Stationary Office, Dublin, pp. 44, ISSN 1649-5918, ISBN 0755718569.

International Energy Agency (IEA, 2000a) *Energy Balances of OECD Countries 1997-1998*, IEA.

International Energy Agency (IEA, 2000b) *Detailed Energy Balances of Ireland 1998*, presented by the IEA for free.

International Energy Agency (IEA, 2004) *Energy Prices and Taxes, 3rd Quarter 2004*, IEA, p. 160-166.

Wissema, W. and R.B. Dellink, 2006, "AGE comparison of the impact of a uniform energy tax and a carbon energy tax on the Irish economy", *presented at the EcoMod2006 International Conference on Policy Modelling, Hong Kong, 28-30 June*, pp. 25.

APPENDIX A SECTORS AND COMMODITIES IN THE ESAM

The sectors and commodities have the same acronyms, because each commodity is produced mainly by one corresponding sector. Each industry can thus be regarded as the main producer or manufacturer of the product with the same acronym. Table B.1 therefore gives descriptions of commodities only.

Table A.1. Commodities in the ESAM and the Model

Model Acronyms	Descriptions	CSO Sector Number
AGFF	Agriculture, forestry and fishing	1
MINE	Mining and quarrying products	2
CRUD	Crude oil	2
COAL	Coal	2
PEAT	Peat	2
FOOD	Food, beverages and tobacco products	3-4
TEXT	Textiles, wearing apparel, leather and leather products	5-7
WOOD	Wood and wood products (excl furniture), pulp, paper and	8-10
CHEM	Chemical products and man-made fibres	11
RBPL	Rubber and plastics	12
NMIN	Other non-metallic mineral products (glass, concrete, stone)	13
METL	Basic metals	14
MTPR	Fabricated metal products, machinery and equipment	15-22
OMAN	Furniture and other manufactured goods n.e.c.	23
OILS	Oil products	23
NGAS	Natural gas	25
ELEC	Electricity	25
RNEW	Renewable energy (electricity from)	25
CONS	Construction work	27
TRAD	Wholesale and retail trade	28-30
LDCT	Lodging and catering (includes bars)	31
TRNS	Transport services by land and water	32-33
AIRT	Air transport services	34
SVCC	Services - Commercial	24, 35-40, 45-
SVCN	Services - Non-commercial	26, 41 - 44
MARG	Margins	n/a

APPENDIX B MARGINS IN THE SAM

The values of commodities for intermediate or final demand include a trade margin. This is related to the cost of handling and transporting commodities. In the row for the TRAD commodity of the intermediate demand matrix, *ID(TRAD,j)*, the column totals of the margins table (Table 9 of the CSO) were deducted, in order to achieve consistency with the original Use Table at purchaser's prices. The net effect is that the industry column totals are exclusive of trade margins.

The margins column in the Supply Table (column 52) distributes the margins from the trade sector over all other sectors. Apart from the negative entry of total margins for the trade sector itself, this column is identical to the sum over industries of the margins table (CSO Table 9). The values in the margins column in the Supply Table were added (after transposing) to the values on the diagonal of the *MAKE* matrix, except to *MAKE(TRAD,TRAD)*.

Thus, to arrive at the same industry totals as the *MAKE* matrix (*i.e.*, the CSO Supply Table plus trade margins but without net taxes) the margins need to be included in each industry column in the SAM as well. For this reason, an industry and commodity for trade margins, MARG, was added in the SAM. In the MAKE matrix, the total amount of margins (12099.1 million euro) was entered in *MAKE(MARG,MARG)*. In row *ID(MARG,j)* the values of the transposed commodity totals column of CSO Table 9 were entered. *ID(TRAD,MARG)* equals the total value of margins, 12099.1 million euro. This way, the MARG industry uses only TRAD to produce margins, which are used by each industry.

APPENDIX C ENERGY DATA

This appendix describes in detail how each of the three relevant industries and commodities in the SAM were disaggregated in order to separately distinguish the energy industries and commodities and thus create an energy-SAM.

C.1 Initial Disaggregation

The energy industries and commodities were initially disaggregated using shares of total supply and demand or total costs and revenue.

C.1.1 Mining and Quarrying

Since the data on demand for the CRUD, COAL and PEAT commodities as well as the import values of these commodities are more reliable than the data on cost structures of the mining and peat industries, the first step is to decide on the disaggregation of total demand (*TotDem*) for these commodities. According to the calculations reported in Table 2, total demand for CRUD is 269.2 million euro (this is total supply, equal to the import figure according to CSO Trade Statistics as this figure is more accurate than the value derived from IEA data), COAL 128.3, PEAT 209.3 and NGAS 139.5, leaving other mining and quarrying to 747.2 million euro.

The second step is to set total supply equal to total demand, disaggregate imports and calculate how much of total supply must have been produced domestically.

Crude oil is not produced in Ireland, the imports are 269.2 million euro. Coal is not produced in Ireland, the imports are 128.3 million euro. Imports of peat are 1.6 million euro as derived from the Trade Statistics. Thus, total domestic production of the commodity PEAT is 207.7 million euro. Imports of natural gas amount to 139.5 million euro. Production of NGAS is not included in this category, but with 'Electricity and gas'.

After deducting the 207.7 million euro of PEAT from the value of domestic production of mining and quarrying commodities (786.6 million euro) in the SAM, total domestic production of the new commodity MINE is found to equal 578.9 million euro. In the SAM, the MINE sector produced 695.2 million euro of MINE (*MAKE(MINE,MINE)*) the remainder being produced by NMIN and METL. The production of PEAT must be deducted from the value on the diagonal of the MAKE matrix, here 707.4, leaving 499.7 million euro in the cell *MAKE(MINE,MINE)* in the ESAM.

TotRev(PEAT) is calculated as the row total of the *MAKE* matrix for the PEAT row. This is equal to 207.7. In the ESAM, *TotRev(MINE)* is 499.7 million euro. Finally, total costs of production must equal total revenue for each industry. The industry columns can initially be divided accordingly, using the shares 29% and 71% respectively.

C.1.2 Other Manufacturing

Total demand for oil products in 1998 was worth 1765.8 million euro. This is derived from IEA data and ESRI prices as shown in Table 2. *TotSup* is set equal to *TotDem* and imports of OILS were 467.1 million euro. Domestic production of OILS therefore must have been equal to 1298.7 million euro. Domestic production of the commodity

associated with 'Other manufacturing' in the SAM was worth 1761.3 million euro. After deducting 1298.7, it follows that 462.6 million euro of other manufacturing products were fabricated in Ireland, but some of this is produced by other sectors, mostly MTPR and WOOD. The OILS are produced only by the OMAN sector, so domestic production is deducted from the *MAKE(OMAN,OMAN)* cell in the SAM. Its value is thus reduced to 411.0 million euro for the new OMAN sector in the ESAM.

Now *TotRev(OILS)* is calculated as the row total of the *MAKE* matrix for the OILS row. This is equal to 1298.7. *TotRev(OMAN)* is 568.3 million euro.

Setting *TotCost* equal to *TotRev*, the 'Other manufacturing' sector in the SAM can be split initially using the output shares, OILS 70% and OMAN 30%.

C.1.3 Electricity and Gas

As opposed to the previous approach, in the disaggregation of 'Electricity and gas' production costs are best taken as a starting point. This is because the CSO provides data on the production costs of the Electricity and Gas industries separately in the Census of Industrial Production (CIP). Table 3 presents production costs of both industries and the percentages used to disaggregate the original 'Electricity and gas' industry.

The CSO Supply and Use Tables are partly based on data from the CIP. Thus, total production (*i.e.*, *TotCost*) of 'Electricity and gas' in the SAM equals total production of Electricity and Gas in the CIP (2277 million euro). According to the CIP, the gas industry produces a total value of 466.3 million euro. Thus, the share of NGAS in 'Electricity and gas' is 20% and the share of ELEC, including RNEW, is 80%.

The renewables industry can then be separated from the electricity sector using Table 1. It can be derived from IEA data that 5% of the output of electricity is produced using hydropower, wind energy, biomass or other renewable resources. The 80% for electricity found above is thus reduced by 5%, leading to total domestic production costs (*TotCost*) in the ELEC industry of 1718.2 million euro and in the RNEW industry of 92.4 million euro.

The industry column for 'Electricity and gas' in the SAM can thus initially be divided as follows:

- NGAS 20.5%;
- ELEC 75.5%;
- RNEW 4.1%.

TotRev must equal *TotCost* for each industry. The energy industries NGAS and RNEW only produce their respective commodities. The industry ELEC produces one other commodity: 0.6 million euro worth of electrical equipment in the MTPR category. In the *MAKE* matrix, the values on the diagonal therefore become *MAKE(NGAS,NGAS)* = 466.3, *MAKE(ELEC,ELEC)* = (1718.2 - 0.6 =) 1717.6 and *MAKE(RNEW,RNEW)* = 92.4 million euro. None of these three commodities is produced by any other industry than their own corresponding industry, *i.e.*, their columns in the *MAKE* matrix have only one non-zero value each.

In order to find *TotSup* imports must be added to the domestic supply of each commodity. Imports of NGAS are 139.5 million euro, ELEC 2.3 million euro and RNEW is insignificant.

Finally, *TotDem* is set equal to *TotSup* for each of these commodities. The shares of the commodities NGAS, ELEC and RNEW in total demand for 'Electricity and gas' in the SAM are also 20.5% (466.3 million euro), 75.5% (1719.9 million euro) and 4.1% (92.4 million euro).

C.2 More Detailed Disaggregation

C.2.1 Energy Commodities

Starting with the disaggregation of energy commodities in the industries using CIP data, demand for the three original commodities is divided using percentages in such a way that demand for any one energy source as a percentage of total energy costs in the industry, *i.e.*,

$$ID(ie,j) / \Sigma_{ie} ID(ie,j)$$

resembles the corresponding percentage derived from CIP data as closely as possible. It is impossible to make the percentages match exactly. For example, even if it is assumed that the FOOD industry uses no OMAN products, still the costs of OILS are much lower than in the CIP data. The result is that the percentage of OILS in energy costs is lower (11 vs. 31%) and percentages of other energy inputs are higher (NGAS 18 vs. 12%; ELEC 65 vs. 53%).

In some cases an industry uses a small amount of an energy source according to the CIP, while this is not the case according to the IEA. Since emissions will be based on IEA quantities, the IEA stance is preferred in these instances. This rule has another advantage in that it solves the problem of the CIP category 'other'. Respondents to the CIP could enter anything under this heading and the CSO could not give any more information as to what type of sources could be included. Only in the case of electricity generation it is known to comprise of PEAT, according to IEA data. In all other industries, any use of 'other' energy commodities is relatively small and, as a rule, not included in the energy values of the ESAM.

Energy demand by industries to which the CIP does not apply, *i.e.*, AGFF, CONS, and all transport and services sectors, as well as energy demand by the institutions (final demand), are disaggregated based on Table 2 using the same methodology. In the IEA data, services are a single category. In the disaggregation process, the LDCT, SVCC and SVCC industries are made to match the IEA services percentages together. Individually, they do not match properly, but together, using differentiated percentages based on common sense, the IEA shares are made to match relatively closely. The main discrepancies between the shares of Table 2 and those in the ESAM occur in the transport sectors, TRNS and AIRT, where the IEA says 100% is OILS, but in the SAM the value of 'Electricity and gas' amounts to about 45% of total energy use in each sector.

After adjusting the disaggregation by energy user as described, the values of *TotDem(ie)* do not match those calculated in the previous section. Closing the gap requires additional adjustments. In particular, the large sectors are adjusted because changes in these have a significant impact on the total. In the construction sector it is

therefore assumed that, besides ELEC, which, according to the IEA, is the only energy commodity used in this industry, OILS is also used. This appears to be realistic judging from construction machinery activity at building sites. Considering that OMAN is also likely to be a significant input for this industry, most of the original OMAN commodity is considered to comprise of the new OMAN, with OILS making up just 20%.

The trade sector is the only industry for which there is no energy data at all. It is relatively large and therefore it is useful to assume that OILS amount to 100% of the original OMAN commodity.

In cases where totals still do not match those calculated, stock changes are calculated such that the totals become exactly equal. The magnitude can be seen in the STC column of the table for final demand in the ESAM.

The disaggregation of energy inputs into the energy industries is discussed in section 3.2.4.3.

C.2.2 Energy Industries

Mining and Quarrying

In disaggregating the inputs of the original 'Mining and quarrying' sector, first energy use is allocated to the new subsectors using shares based on Table 2 above. Of the use of OILS 88% is allocated to MINE and 12% to PEAT. Subsector MINE is assumed to use all NGAS and ELEC that is used in the original sector, because the PEAT industry does not use these energy commodities according to the IEA. Table 2 shows that the COAL industry uses ELEC, but since this industry is not active in Ireland all inputs are set to zero.

Then assumptions are made for some of the other cost items. The input MINE is assumed to be used in subsector MINE only. Labour, capital and the taxes are assumed to be related to the output level, so they are disaggregated using the same shares as the control total for production (*TotCost*), *i.e.*, MINE 71% and PEAT 29%.

Finally, all other inputs are divided using the shares of each subsector's 'other costs' in total 'other costs', where 'other costs' is calculated as *TotCost* less 'known costs'. In this case, the latter are MINE, all energy inputs, labour, capital and taxes.

Other Manufacturing

The method used to disaggregate the cost items of the 'Other Manufacturing' industry is identical to that used in 'Mining and quarrying'. Here the 'known costs' are as follows:

- Labour, capital and the taxes are again disaggregated using the same shares as the control total for production, *i.e.*, OMAN 30% and OILS 70%.
- All TEXT, WOOD and OMAN is assumed to be used only in OMAN;
- CHEM is assumed to be used only in OILS;
- CRUD is only used in OILS;

- OILS is divided over OMAN and OILS using the corresponding shares from Table 2 of 58% and 42% respectively. Table 2 shows that OILS used 6.9 million euro worth of OILS, in the ESAM this is 8.4 million euro. So even in absolute terms the figures are relatively close.

Electricity and Gas

The industry columns for ELEC and NGAS are disaggregated using CIP data, making sure the column totals remain equal to those derived above. The CIP data gives a breakdown of costs for each industry into the components materials, energy, services, labour and capital as shown in Table 3 in the main text, which is derived from Table A.4 I the following section of this appendix. The components are not as detailed as in the SAM, but the data can be used in terms of shares assuming all materials used in 'Electricity and gas' are used by ELEC, NGAS and RNEW in the same proportions. First some inputs are disaggregated based on non-CIP data:

- The input of 'Wood and wood products' in the production of 'Electricity and gas' was assumed to be used only in the RNEW industry, as biomass.
- From the IEA data it is clear that most of the energy inputs are used in ELEC, with some 2.3% of the natural gas used in the NGAS industry itself; the remainder is burnt in power plants. Thus it can be concluded that the energy used in the production of gas according to the CIP only consists of natural gas, and that all other intermediate energy is used in ELEC.
- The RNEW sector does not purchase a significant amount of energy.
- Production tax is assumed to be a fixed proportion of total costs. Therefore it is divided among the three industries using the same shares that were used to divide total costs.

Then the remaining elements of the *ID* matrix for the 'Electricity and gas' sector in the SAM are divided among NGAS, ELEC and RNEW using the following formula. First the 'other' costs, left over after the 'known' costs are deducted from TotCost, are calculated. Then the shares of these in the corresponding residual costs of the former sector are derived. These shares are then adjusted to correspond to the shares of material inputs, services, labour or capital (less production taxes) in the CIP data.

C.2.3 Energy Inputs of Energy Industries

Because the energy inputs into energy industries are important factors in the model, it is interesting to discuss in some more detail the disaggregation of the energy commodities for these sectors. In the section on the disaggregation of energy commodities above, the general methodology was described. For energy commodities used in energy industries, however, a different approach is used.

In disaggregating MINE and OMAN, the approach is to make sure that total absolute values in *ID(ie,je)* match the corresponding values in Table 2 as closely as possible. Where possible, the values in Table 2 are deducted from $ID(MINE^{SAM},je)$ and $ID(OMAN^{SAM},je)$ with the remainders entered in $ID(MINE^{ESAM},je)$ and in $ID(OMAN^{ESAM},je)$. In many cases, however, the amounts in the SAM are too low and the aggregate commodities of the SAM are divided among energy commodities only, based on shares.

In disaggregating the 'Electricity and gas' commodity in the SAM, CIP values are used. Because this commodity is entirely divided into NGAS, ELEC and RNEW, there is no room for any residual.

C.3 Data Sources

This appendix describes how the three tables in the main text were derived from the following available data sources:

1. International Energy Agency;
2. Census of Industrial Production;
3. Trade Statistics;
4. The Economic and Social Research Institute
5. Final Assumptions.

First, the sources are introduced together with their data and some adjustments to their data are described. In Section A.3.5, the final assumptions needed to arrive at the main tables are discussed.

C.3.1 The IEA

The International Energy Agency is the most comprehensive source of energy data in the world. The IEA publishes data on supply and use of energy as well as prices and tax data. Highly disaggregated Irish data for 1998 is found in the Energy Statistics of OECD countries (IEA, 2000a). This data uses source-specific units such as metric tons or kilowatt hours. The IEA also publishes Energy Balances in the common (energy content based) unit of tonnes of oil-equivalent (TOE[5]), but the number of energy sources in these is limited (IEA, 2000b). Peat, which is still an important fuel in electricity generation in Ireland, is included with coal in these tables. The Irish Energy Balance for 1998 with the energy sources broken down in as much detail as in the Energy Statistics was provided, courtesy of the IEA. These figures are all expressed in kilo tonnes of oil-equivalent (KTOE). This greatly facilitates the aggregation of the great number of fuels into the seven energy sources distinguished in the energy-CGE model.

In the Energy Balance, each column applies to one energy source. As can be seen in Table A.1, the energy circle in closed. First total primary energy supply (TPES) is calculated by adding domestic production and imports and deducting exports and energy used by international marine bunkers and additions to stock. Energy used by the transformation sector and the energy sectors is deducted to find the total amount used for final consumption (TFC). Entries in italic are subtotals of the entries directly below them.

All crude oil is imported. All of this imported crude oil is used in the only refinery in Ireland. Refined oil products are either imported or produced in the Irish refinery. Of all oil supplied, 15% is used in electricity generation or refining. Half is used in the transport sector, mainly for road transport. The residential and the industrial sector both use about 11%. The manufacturing sectors that use most oil are the metals industry, food, beverages and tobacco, and the petrochemical industry. The services sector consumes 10% of the total primary oil supply.

[5] 1 tonne of oil-equivalent = 10E07 kcal = 41.686 gigajoules.

All coal is imported and virtually all peat is produced in Ireland. One firm, Bord na Móna Ltd., produces peat and distributes both solid fuels mainly to electricity generators and households. The small amount remaining is used in the production of non-metallic minerals and food, beverages and tobacco. The insignificant amount of patent fuel is included with peat in Table C.1.

Almost half of the natural gas used in Ireland is imported. About half is used in electricity generation both for the national grid and for own use in firms ('auto production'), usually in Combined Heat and Power plants. The remainder is used mostly in industry and for space heating in the residential sector and the (commercial and public) services sector.

Electricity is produced domestically, except for an insignificant amount of import. It is used almost equally in industry, households and the (commercial and public) services sector. Renewables can be classified as biofuels or 'green electricity'. The latter is produced for the national grid using mostly hydropower plants but also wind and solar energy. Biogas and biomass are used mostly by the wood and paper industry and households, while about one fifth is converted into electricity.

Table 1 in the main text was derived from Table C.1 as follows. Starting at the top of Table C.1, a number of rows can be removed by including them with other rows. Firstly, energy used by international marine bunkers can be included with stock changes. In the model these remain fixed, so this does not affect the results.

Secondly, energy usage in the transformation sectors and the energy sectors can be summed to obtain total energy used by the energy industries as defined in the model. The distinction between the use of energy as an input in energy production, own use of energy and distribution losses is not relevant in the model. The production of patent fuel from coal and oil can be included with peat.

Thirdly, the sectors using energy as an intermediate input and final demand sectors are not identical to the sectors in the model, although 'final consumption'[6] in the IEA publications is disaggregated fairly well. Table C.2 below indicates how the sectoral breakdown in the IEA data matches that in the model.

Only the chemical and petrochemical industry and the services sector need further disaggregation. Assuming that the share of energy inputs in total costs is the same in the Chemical sector and in Rubber and Plastic (the petrochemical sector) then the energy input costs can be divided according to the output values of the two sectors. Assuming the prices these sectors pay for energy are the same as well, the output values can be used to divide the quantities of energy used. The output values of the chemical and petrochemical sectors are 94 and 6 percent of their combined output value, as can be derived from the Use Table. The same assumptions can be applied to the services sector. From the Use Table it is calculated that the sector 'Hotels, restaurants and bars' contributes 7.3 percent to the total services output value, while other commercial services contribute 61.4 percent and non-commercial services 31.3 percent.

Finally, non-energy use needs to be addressed, as it should not be included in the energy flows in the model. Oil products totalling 0.19 MTOE were used as lubricants and for other non-energy purposes. This small amount can be taken out of TPES to remove it from the balance consistently. The oil products in question were mostly imported, so the 0.19 MTOE can be deducted from imported oil products.

[6] In the IEA publications this includes both intermediate and final demand, but excludes inputs for energy production industries, *i.e.,* the transformation and energy sectors.

Table C.1. Irish Energy Balance 1998 (KTOE)

	CRUDE OIL	REFINED OIL	COAL	PEAT	GAS	ELECTRICITY	RENEWABLES	TOTAL
Production	**0**	**0**	**0**	**813**	**1406**	**0**	**259**	2479
Imports	**3220**	**5587**	**1902**	**23**	**1395**	**13**	**0**	12141
Exports	**0**	**-1259**	**-3**	**-15**	**0**	**-6**	**0**	-1283
Int. mar. bunkers	0	-160	0	0	0	0	0	-160
Stock changes	-117	-6	14	202	0	0	0	94
TPES	**3104**	**4163**	**1913**	**1024**	**2802**	**7**	**259**	13271
Statistical differ.	146	-47	-75	-45	0	0	0	-21
Transformation	*-3250*	*2126*	*-1486*	*-571*	*-1347*	*1796*	*-124*	*-2856*
Electricity gen.	0	-1088	-1476	-566	-1347	1796	-124	-2805
Petrol. Refineries	-3250	3225	0	0	0	0	0	-25
BKB plants[7]	0	0	0	-26	0	0	0	-26
Patent fuel plants	0	-10	-10	20	0	0	0	-1
Energy sector	*0*	*-98*	*0*	*-8*	*0*	*-118*	*0*	*-223*
Petrol. Refineries	0	-98	0	0	0	-3	0	-100
BKB plants	0	0	0	-8	0	-5	0	-13
Electricity plants	0	0	0	0	0	-110	0	-110
Distribution losses	*0*	*0*	*0*	*0*	*-32*	*-165*	*0*	*-197*
TFC	**0**	**6144**	**351**	**400**	**1423**	**1519**	**135**	9973
Industry sector	*0*	*828*	*80*	*0*	*859*	*609*	*92*	*2469*
Iron and steel	0	7	0	0	18	26	0	51
Chemical and petrochemical	0	111	0	0	591	81	0	783
Non-ferrous metals	0	243	0	0	0	28	0	271
Non-metallic minerals	0	114	53	0	47	50	0	264
Transport equipment	0	10	0	0	0	7	0	16
Machinery	0	58	0	0	0	73	0	132
Mining and quarrying	0	29	0	0	12	24	0	66
Food and tobacco	0	157	27	0	151	148	4	488
Paper, pulp and printing	0	10	0	0	0	14	0	23
Wood and wood products	0	4	0	0	0	20	87	112
Construction	0	0	0	0	0	5	0	5
Textile and leather	0	32	0	0	0	32	0	64
Non-specified	0	52	0	0	40	101	0	192
Transport sector	*0*	*3370*	*0*	*0*	*0*	*2*	*0*	*3372*
Int'l civil aviation	0	441	0	0	0	0	0	441
Domestic air transport	0	25	0	0	0	0	0	25
Road	0	2763	0	0	0	0	0	2763
Rail	0	105	0	0	0	2	0	107
Internal navigation	0	37	0	0	0	0	0	37
Other sectors	*0*	*1754*	*271*	*400*	*564*	*908*	*44*	*3940*
Agriculture	0	245	0	0	0	0	0	245
Commercial and public	0	718	0	6	226	384	0	1334
Residential	0	791	271	394	338	524	44	2361
Non-energy use	*0*	*193*	*0*	*0*	*0*	*0*	*0*	*193*

TPES = Total Primary Energy Supply
TFC = Total Final Consumption
Source: Adapted from IEA, 2000c

The IEA omits fuels used as a feedstock in industrial production processes from the balances, but reports them separately. In Ireland in 1998, one firm used natural gas with an energy content of 0.46 MTOE in the production of fertiliser. This factory closed since. The amount of feedstock used in 1998 was 459 KTOE and its omission reduces total final consumption of gas from 1.88 to 1.42 MTOE.

[7] In Ireland, this only refers to the production of peat briquettes for heating or cooking.

The result is that the new energy commodities OILS and NGAS only contain the energy commodities relevant for the model, whereas the non-energy products remain part of the commodities labelled OMAN and MINE. Similarly, the industries OILS and NGAS do not produce these lubricants and feedstock; they are produced in the OMAN and MINE industries.

The IEA has included electricity use on farms with residential electricity use. That would help to correctly represent farming costs, as electricity used in the home is not part of the production costs.

Table C.2. Sectoral correspondence between IEA data and the model

IEA sectors	Model sectors
Iron and Steel	METL
Chemical and Petrochemical	CHEM+RBPL
Non-Ferrous Metals	METL
Non-Metallic Minerals	NMIN
Transport Equipment	MTPR
Machinery	MTPR
Mining and Quarrying	MINE
Food and Tobacco	FOOD
Paper, Pulp and Print	WOOD
Wood and Wood Products	WOOD
Construction	CONS
Textile and Leather	TEXT
Non-specified (Industry)	OMAN
International Civil Aviation	AIRT
Domestic Air Transport	AIRT
Road	TRNS
Rail	TRNS
Pipeline Transport	TRNS
Internal Navigation	TRNS
Non-specified (Transport)	TRNS
Agriculture	AGFF
Commercial and Public Services	LDCT+SVCC+SVCN
Residential	Households[8]
Non-energy Use	Not applicable

The IEA also publishes some price and tax data. The Irish data for 1998 is displayed in Table C.3. This table does not include any taxes that are rebated. Oil products are subject to the National Oil Reserves Levy. The amounts average 0.476 euro per litre and are included in the excise column.

[8] Electricity use on farms is included with residential electricity use.

Table C.3. Energy Prices and Taxes in Ireland, 1998 (euro)

Energy Source	Unit	Basic Price	Excise tax	VAT
Light Fuel Oil for Industry	1000 litres	155.53	52.12	-
Fuel Oil for Electricity Generation	Tonne (=0.96 TOE)	67.65	13.46	-
Light Fuel Oil for Households	Tonne (=0.85 TOE)	224.03	52.12	34.52
Automotive Diesel for Commercial Use	litre	0.252	0.330	-
Automotive Diesel for Non-Commercial Use	litre	0.253	0.330	0.122 (21%)
Natural Gas for Industry	TOE GCV[9]	153.13	-	-
Natural Gas for Electricity Generation	TOE GCV	92.56	-	-
Natural Gas for Households	TOE GCV	333.56	-	41.65 (12.5%)
Steam Coal for Electricity Generation	tonne	32.45	-	-
Electricity for Industry	kilowatt hour	0.0531	-	-
Electricity for Households	kilowatt hour	0.0978	-	0.0122

Source: IEA, 2004.

C.3.2 Census of Industrial Production

The Central Statistics Office (CSO) annually carries out a census of industrial production (CIP). Both enterprises and local production units are requested to fill out questionnaires. The table with data from local units is more detailed than the one for enterprises. The only two energy sectors that are separately shown are gas and electricity. Table C.4 displays the relevant data for these two sectors. Renewable electricity production is classified under electricity. Remainder of net output includes capital costs (depreciation), profits and taxes.

Table C.4. Inputs into Electricity and, Gas Sectors (million euro)

	Electricity	Gas
Materials Inputs	285.615	216.442
Services Inputs	46.770	47.426
Fuel and Power Inputs	393.386	1.889
Wages and Salaries	318.758	36.563
Remainder of Net Output	766.127	164.002
Gross Output	**1810.657**	**466.323**

Source: Adapted from CSO CIP Table 1

The CSO kindly provided a more detailed breakdown of the fuels used by each industrial sector, as the published table merely shows a single entry for energy inputs labelled 'fuel and power'. In Table C.5 the data is shown in percentages of total energy use per industrial sector.

[9] GCV = Gross Calorific Value or 9,444 kcal/cm^3. Needs to be converted to Net Calorific Value through multiplication by 0.9, *i.e.,* the GCV price of gas needs to be divided by 0.9 to get the NCV price.

Table C.5. Industrial Energy Inputs by Source (%) with total use by industry in million euro

NACE Rev. 1	Sector	Oil Products	Coal	Gas	Electricity and Heat	Renewable energy	Other	Total
10 - 14	Mining and quarrying	43.3	0.0	10.6	46.1	0.0	0.0	**43.4**
15 - 16	Food, beverages and tobacco	30.8	3.1	11.6	52.7	0.0	1.7	**173.4**
17 - 18	Textiles and textile products	19.6	8.8	1.7	67.0	0.0	2.9	**16.0**
20 - 22	Wood, Pulp, Paper and Publishing	15.1	0.0	9.1	73.2	0.0	2.7	**47.2**
24	Chemicals and fibres	12.6	0.0	18.7	64.6	0.0	4.1	**92.9**
25	Rubber and plastic	12.5	0.0	2.1	80.8	3.6	1.0	**26.6**
26	Other non-metallic miner-al products	29.7	14.1	7.4	48.3	0.0	0.5	**62.1**
27	Basic metals	44.2	0.0	4.0	49.5	0.0	2.2	**50.9**
28-35	Metal Products	16.7	0.6	10.3	69.9	0.0	2.6	**117.3**
36 - 37, 19, 23	Manufacturing n.e.c.	11.5	0.0	8.1	80.4	0.0	0.0	**17.1**
40 - 41	Electricity, gas and water supply	25.8	20.7	36.4	1.0	0.6	15.6	**381.0**

Source: Adapted from CSO, 2000b

C.3.3 CSO Trade Statistics

Monthly import and export values are published by the CSO. In the December issue the year totals are reported together with the previous year's figures. Table C.6 contains the 1998 values published in the issue for December 1999 (CSO, 2000).

Table C.6. Irish International Trade in Energy 1998 (million euro)

	Coal	Oil	Gas	Electric current	Total
Imports	129.894	736.321	139.544	2.286	1,008.045
Exports	38.854	108.563	2.666	0.635	150.718

Source: Trade Statistics (CSO, 2000)

These Trade Statistics do not distinguish between crude oil and oil products or between coal and peat. According to the IEA, Ireland did not export any crude oil or coal in 1998. Therefore, the export figure for oil applies to oil products only, and the figure for coal (including peat) only applies to peat.

Crude oil imports and imports of refined oil products are disaggregated using quantity shares derived from IEA quantities shown in Table 1 in the main text. The share of oil products in total oil imports in 1998 was 62.6 percent. Imports of peat are separated from coal imports in the same manner. The share of peat in total solid fuel imports in 1998 was 1.2 percent. The implicit assumptions are that the prices of a TOE of imported crude oil and a TOE of oil products are equal and that the price of a TOE of imported coal equals that of a TOE of peat, *i.e.*, that for similar types of fuel, their value is related to their energy content. The resulting values are included in Table 2 in the main text.

In the ESAM, imports of 'Mining and quarrying' are divided into imports of CRUD, imports of COAL, imports of PEAT, imports of NGAS, and imports of MINE. After deducting the energy imports in Table 2, a value of 168.3 million euro remains for imports of other mining and quarrying products:

$$IMP(MINE)^{ESAM} = IMP(MINE)^{SAM} - [\ IMP(CRUD) + IMP(COAL) + IMP(PEAT) + IMP(NGAS)\ ]$$

The same approach was used to calculate imports of OMAN in the ESAM.

C.3.4 The Economic and Social Research Institute

The Economic and Social Research Institute (ESRI) produces economic forecasts using a macro-econometric model. This model requires time series data, which the ESRI maintains in their Databank. The model has an energy module and the Energy Research Centre of the ESRI has gathered a substantial amount of additional energy data, including energy prices. Sustainable Energy Ireland has provided some prices and the ESRI further selected and converted prices from the IEA, Eurostat and the Irish Energy Centre, and derived prices of peat and coal from annual reports of Bord na Móna. Table C.7 reports a choice of the prices provided by ESRI. Apart from the prices for peat products and the price of coal other than for electricity generation, these are converted from the IEA prices in Table C.3. The column labelled 'user' indicates which sectors the ESRI estimates pay the corresponding prices and taxes for each energy source. The users are assumed to pay an average price, but in some cases the price of the same energy source is different for different users, e.g., due to discounts on purchases in bulk. In the case of electricity the price depends on the voltage, *i.e.*, industrial customers buy high voltage, whereas other users have to buy the more expensive low voltage electricity. As can be observed in the second row of this Table, Ireland does not use aircraft kerosene for air transport. The fuel actually used in aircraft is a light fuel oil. Like industry, this sector pays a low excise tax.

Table C.7. Energy Prices and Taxes in Ireland, 1998 (euro per TOE)

Energy Source	User	Basic Price	Excise tax	VAT
Heavy Fuel Oil	Electricity generation	70.47	14.02	-
Light Fuel Oil	Industry, Air transport	182.50	61.16	-
Light Fuel Oil	Households	262.88	61.16	40.51 (12.5%)
Diesel	Services, Transport, Agriculture	290.03	379.80	-
Diesel	Households	291.18	379.80	140.41 (21%)
Natural Gas	Electricity generation	102.84	-	-
Natural Gas	Industry	170.14	-	-
Natural Gas	Households	370.58	-	46.32 (12.5%)
Coal	Electricity generation	54.08	-	-
Coal	Industry	82.01	-	-
Coal	Households	336.72	-	42.09 (12.5%)
Electricity (high voltage)	Industry	617.44	-	-
Electricity (low voltage)	Households	1136.95	-	142.12 (12.5%)
Milled Peat	Electricity generation	100.10	-	-
Peat briquettes	Services	276.09	-	-
Peat briquettes	Households	276.09	-	34.51 (12.5%)

Source: ESRI, 2003

In line with the allocation of electricity used on farms to 'residential', the IEA would have included fuel bought by farmers for their cars with 'residential' as well. The IEA would have recorded only tractor fuel in the agriculture row, so all of this fuel can be assumed not to be subject to VAT.

Households also pay VAT at 12.5 percent for light fuel oil, electricity, gas and peat and at 21 percent for diesel oil. VAT is calculated over the price including excise tax. The household sector uses more than one type of oil. A weighted average price is calculated for the commodity category oil products (OILS). Households use 461.9 KTOE of kerosene which is labelled 'light fuel oil' in the Taxes and Prices publication of the IEA. They use 223.6 KTOE of diesel oil. The 66.7 KTOE of LPG used is not taken into account. The weights of kerosene and diesel in total oil use are 0.674 and 0.326. The weighted average price of oil for households is thus 272.11 euro per TOE, with excise tax averaging 165.04 and VAT 73.08 euro per TOE.

Excise tax applies to all oil products regardless of who buys them. There are some exceptions though. For instance in agriculture, fuels used in machinery are exempt from tax. Value added tax (VAT) paid on intermediate inputs is rebated, but households have to pay VAT on all energy products. The amount of excise tax to be paid per unit of different oil products and the amount of VAT households have to pay on energy commodities are shown in Table C.6, expressed in euro per TOE and for VAT also in percentages.

Excise tax must be excluded from prices used to calculate consumption values. The amounts of tax paid must be calculated separately for inclusion in one of the government rows in the ESAM, *i.e.*, the 'net taxes on products' row. The various amounts of excise tax paid in total in 1998 are displayed in Table C.8.

Table C.8. Excise Tax on Oil Products paid by each Sector in 1998 (thousand euro)

Sector	Excise Tax
Oil refinery	1 371
Coal industry	-
Peat briquetting	145
Electricity generation and distribution	15 258
Gas extraction and distribution	-
Agriculture	93 163
Mining and Quarrying	1 804
Food and Tobacco	9 620
Chemical	6 379
Petrochemical	407
Other Non-Metallic Minerals	6 961
Iron and Steel and Non-Ferrous Metals	15 316
Transport Equipment and Machinery	4 158
Wood and Wood Products	845
Textile and Leather	1 961
Construction	-
Non-specified (Industry)	3 163
Air Transport	28 464
Road, Rail and Water Transport	1 103 066
Hotels, Restaurants, Bars	19 913
Other Commercial Services	167 489
Non-Commercial Services	85 381

Calculated as relevant entries in Table C.6 multiplied by Oil products column of Table 1 in the main text.

For each commodity, the total amount of VAT paid by households in 1998 appears in Table C.9.

Table C.9. Value Added Tax paid by Households on Purchases of Energy Commodities in 1998 (thousand euro)

Energy Commodities	VAT	%
Oil	57773.58	16.7
Coal	11392.77	12.5
Peat	13606.52	12.5
Electricity	74457.78	12.5
Gas	15646.72	12.5
Renewables	-	-

Calculated as relevant entries in Table C.6 multiplied by 'Residential' row of Table 1 in the main text, and transposed.

C.3.5 Final Assumptions

To produce Table 2 in the main text, additional data is required, but not available. Prices of some fuels differentiated by user are lacking. First it can be assumed that all industrial users pay the same price for a particular energy source and the same for all users in the services sectors. Then the following prices are still lacking:

1. Prices of crude oil and oil products used in oil refinery and in peat;
2. Price of electricity used or lost in electricity generation;
3. Price of peat used or lost in the peat industry;
4. Prices of renewable energy.

Assumptions made for each of these four (sets of) prices listed above are:

1. These prices are the same as the price of oil used in electricity generation;
2. This price is equal to the price of electricity used in industry;
3. This price equals the price of peat used in electricity generation;
4. Renewable energy is priced as electricity.

The first three assumptions are based on the principle of opportunity costs. Since renewables have been defined as electricity from renewable resources, the last assumption should be realistic enough.

It is assumed that all commercial and private transport vehicles and tractors use diesel. This is not too far from the truth even now in 2006.

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