Llywodraeth Cynulliad Cymru
Welsh Assembly Government

Welsh Assembly Government

Experimental Environmental Satellite Accounts for Wales

Final report

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Executive Summary

Overview

DTZ and Cardiff Business School's Centre for Business Relationships, Accountability, Sustainability and Society (BRASS) and Welsh Economy Research Unit (WERU) were commissioned by the Welsh Assembly Government (WAG) in January 2006 to undertake independent research into an experimental Environmental Satellite Account (ESA) for Wales. The purpose of this research is to construct an experimental ESA for Wales as a means of providing robust information to inform and support sustainable development policy in Wales.

The first stage of our research provided a detailed review of the availability, suitability and quality of the required statistical data needed to construct an experimental ESA for Wales. Based on the first stage findings, Figure 1 shows the initial probability of producing tables for Wales similar to those in the UK ESA.

The second stage of our research described how an experimental ESA for Wales was constructed and presented data for as many of the tables as possible. Figure 2 shows coverage of the experimental ESA for Wales across the tables comprising the ESA for the UK. Experimental data have been provided for 15 of the 18 UK ESA tables. Additionally, supplementary tables have been provided for Wales to provide a broader context for the core tables.

All of the tables outlined in this report are consistent and comparable with the UK ESA published by the ONS and, by extension, also comparable with ESAs for many other European countries. An electronic database containing the experimental ESA for Wales has been provided to WAG.

Linking the experimental ESA to the Welsh economy

The experimental ESA for Wales is the most detailed and up-to-date of its type available for any UK nation or region at the present time. Used appropriately, it provides a consistent, coherent and flexible tool for a wide variety of analyses relating to specified characteristics of the Welsh environment and economy, particular when used in conjunction with an Input-Output table. Most analyses using the model fall into the following generic categories:

- *Database analyses:* The tables make analyses of the environment far easier than would otherwise be the case. The richness of analyses can be greatly increased if comparisons of Welsh results could be made with equivalents for other areas, and this can certainly be done with respect to the UK and other European countries.

- *Analyses of the base ESA model*: When used with an Input-Output table the ESA can 'explain' observed environmental outcomes in Wales. Analyses of the base model that may be of interest include attribution of pollution to final demand markets, trade in pollution and whether Wales is a net polluter or not.

- *What if scenarios:* The ESA used in conjunction with an Input-Output table can encapsulate a wide range of possibilities including for example, which areas of pollution are most or least affected if a particular scenario develops in Wales?

- *Comparative analyses*: The ESA and an Input-Output table may be used to address hypothetical questions centred on regional and international comparisons. For example how would the level of pollution change if selected characteristics of the Welsh economy were like that in Sweden or the Netherlands?

- *Projections:* The ESA and an Input-Output table may provide an indication of the requirements for natural resources across a range of future growth scenarios. For example high-tech/high growth versus low-tech/low growth projections.

- *Hypothetical impact studies:* The ESA and an Input-Output table would allow a wide range of hypothetical impact studies, for example what would be the impact on household waste generated given changes in domestic consumption patterns? Alternatively the environmental impact of a significant inward investment may be considered.

Next steps

There are a number of issues that inform the future research priorities relating to updating and developing the experimental ESA for Wales. First, there is a need to consider the extent to which the accounts, or further iterations of the accounts, are expected to be useful to WAG and other stakeholders. Second, how far ESA tables can be practically extended given current information and expected developments in the underlying survey instruments, and then, finally, it is important to balance issues of the marginal cost of account improvements against benefits of improvements to policymakers and others. Key recommendations across each of the ESA pillars are outlined below:

- Natural resources

  In terms of the natural resource elements of the ESA it is unlikely that detailed information on 'regionally' recoverable oil and gas reserves will become available in the short term and there is limited value for WAG in pursuing development of these tables at the current time.

  Accounts for other areas of natural resources including coal and aggregates, land cover, fish stocks and catch can be readily updated at minimal marginal cost with the underlying statistics being produced for other purposes.

- Physical flows

  The physical flows elements of the ESA are where WAG resources might be more focused in the cause of updating and improvement. It is within this pillar of the ESA that comparisons between regions and nations can be most useful in assessing the relationship between progress as conventionally measured and the creation of harmful externalities.

  In terms of the physical flows section of the ESA the main challenge is ensuring that Welsh industries, Welsh patterns of consumption, and production are adequately represented in underlying surveys which inform the tables. In the pilot ESA development the main concerns are in relation to the material flows account where many elements are modelled, and with rows unfilled due to a lack of information.

The pilot materials flow table really represents the area where incremental research would be most useful to WAG and other stakeholders. The table is important because it reveals flows of resources from the environment to the economy, and then flows back from the economy to the environment in terms of items such as waste. It might be argued that this is the heart of the ESA, yet it is the element that can be most difficult to estimate. It is recommended that resources are targeted on developing this table, and more accurately gauging imports and exports of materials.

- Monetary accounts

  The elements of the ESA dealing with defensive expenditures and environmental taxation and revenues represent a useful statement of account. These tables, in general, can be readily updated at low cost. It is not recommend that significant resources are targeted on developing these tables further. The perspectives gained from these tables cannot always be related to the sustainable development indicator set, and the information therein may not be as important for regionally-based policymakers as those in the physical flows and natural resources elements of the ESA.

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Figure 1: Initial probability of producing Wales tables similar to UK

Natural resources

Table in UK ESA	Probability of producing Wales tables similar to UK
1.1 Oil & gas reserves	Medium to low
1.2 Oil & gas monetary balance sheet	Medium to low
1.3 Land cover account	High
1.4 Imports and exports of wood products	High to medium
1.5 Fish stocks	Medium

Physical flows

Table in UK ESA	Probability of producing Wales tables similar to UK
2.1 Energy consumption (industries)	High to medium
2.2 Atmospheric emissions (over time)	High to medium
2.3. Atmospheric emissions (over time)	High to medium
2.4 Bridging table: Atmospheric emissions	High to medium
2.5 Material flows	Low to medium
2.6 Waste arisings	High
2.7 Radioactive waste	High to medium
2.8 Water consumption by industry sector	High to medium

Monetary accounts

Table in UK ESA	Probability of producing Wales tables similar to UK
3.1 Government revenue from environmental taxes	Medium to low
3.2 Environmental taxes breakdown by industry	Medium to low
3.3 Environmental protection spending by public sector	High to medium
3.4 Environmental protection spending by public sector	High to medium
3.5 Environmental protection spending in industries	Low

Figure 2: Final coverage of an experimental ESA for Wales

Natural resources

Table in UK ESA	Coverage for Wales
1.1 Oil & gas reserves	Partial
1.2 Oil & gas monetary balance sheet	Not available
1.3 Land cover account	Covered
1.4 Imports and exports of wood products	Covered
1.5 Fish stocks	Covered

Physical flows

Table in UK ESA	Coverage for Wales
2.1 Energy consumption (industries)	Covered
2.2 Atmospheric emissions (over time)	Covered
2.3. Atmospheric emissions (over time)	Covered
2.4 Bridging table: Atmospheric emissions	Not available *(but not relevant)*
2.5 Material flows	Partial
2.6 Waste arisings	Covered
2.7 Radioactive waste	Covered
2.8 Water consumption by industry sector	Covered

Monetary accounts

Table in UK ESA	Coverage for Wales
3.1 Government revenue from environmental taxes	Covered
3.2 Environmental taxes breakdown by industry	Partial
3.3 Environmental protection spending by public sector	Covered
3.4 Environmental protection spending by public sector	Covered
3.5 Environmental protection spending in industries	Not available

Figure 3: Additional future research priorities

Natural resources

Table in UK ESA	Priority for Wales
1.1 Oil & gas reserves	Medium to low
1.2 Oil & gas monetary balance sheet	Low
1.3 Land cover account	Medium to low
1.4 Imports and exports of wood products	Medium to low
1.5 Fish stocks	Medium

Physical flows

Table in UK ESA	Priority for Wales
2.1 Energy consumption (industries)	Medium to low
2.2 Atmospheric emissions (over time)	Medium
2.3. Atmospheric emissions (over time)	Medium
2.4 Bridging table: Atmospheric emissions	Low *(not relevant)*
2.5 Material flows	High
2.6 Waste arisings	Medium
2.7 Radioactive waste	Medium
2.8 Water consumption by industry sector	Medium

Monetary accounts

Table in UK ESA	Priority for Wales
3.1 Government revenue from environmental taxes	Low to medium
3.2 Environmental taxes breakdown by industry	Low to medium
3.3 Environmental protection spending by public sector	Low to medium
3.4 Environmental protection spending by public sector	Low to medium
3.5 Environmental protection spending in industries	Low

1 Introduction and approach

1.1 Background

DTZ and Cardiff Business School's Centre for Business Relationships, Accountability, Sustainability and Society (BRASS) and Welsh Economy Research Unit (WERU) were commissioned by the Welsh Assembly Government (WAG) in January 2006 to undertake independent research into an experimental Environmental Satellite Account (ESA) for Wales. The purpose of this research is to construct an ESA for Wales as a means of providing robust information to inform and support sustainable development policy in Wales.

The first stage of our research provided a detailed review of the availability, suitability and quality of the required statistical data needed to construct an experimental ESA for Wales. The second stage of our research described how an experimental ESA for Wales was constructed and presented data for as many of the tables as possible. This report assimilates both stages of our research, considers the possibility of linking the ESA to the Welsh economy and outlines future research priorities in order to update and improve the experimental ESA for Wales.

1.2 What is an ESA?

Environmental Accounts are "satellite accounts" to economic accounts. Satellite accounts are extensions to economic accounts, which allow analysis of the wider environmental impact of economic change. Environmental Accounts are used to inform sustainable development policy, the model impacts of fiscal or monetary measures and to evaluate the environmental performance of different industrial sectors.

There are a number of approaches that are being explored in Wales to monitor and measure progress towards sustainable development objectives. These approaches include the ecological footprint, the index of sustainable economic welfare, the ESA and environmental Input-Output tables. In Wales there are challenges with each of the approaches outlined, but the development of an ESA could potentially provide a useful policy analysis tool.

The ESA has the potential to enable environmental factors to be connected more readily to conventional regional accounting aggregates such as Gross Value Added (GVA) or Gross Domestic Product (GDP). Concerns over the validity of GDP as a 'real' measure of progress precipitated the construction of UK environmental satellite accounts (see UK NATIONAL ACCOUNTS, 2001). The outcomes of this research are likely to be highly relevant to other UK and European regions, which are also seeking methods of monitoring and measuring progress towards sustainable development.

1.3 Data identification and review

Stage one provided an initial scoping of the UK Environmental Accounts; the latest published UK Environmental Accounts at the outset of this research were for 2005. The purpose here was to outline the nature of the individual tables, their relevance for UK policymakers and others, and the practicality of constructing tables for Wales.

The scoping exercise was developed for each table in the ESA examining:

- What the table covers;
- Why the particular table is reported in the ESA;
- How relevant the table could be for Wales;
- Whether the table has links to other parts of the ESA;
- The data sources for the UK table;
- Problems connected to constructing this table at UK level, such as data quality or theoretical and conceptual problems;
- Data that would be available to inform construction of the table in full (or in part) for Wales;
- Specific problems in producing the table for Wales; and
- Recommendations on potential solutions.

1.4 Construction and analysis of the experimental ESA for Wales

Following the scoping study an experimental ESA for Wales was provided to WAG summarising the 18 tables shown in the UK Environmental Accounts published by the UK Office for National Statistics (ONS) in November 2005. Individual tables fall within three pillars covering:

- Natural resources;
- Physical flows; and
- Monetary accounts.

The tables were constructed following consultations with the ONS, the Department for the Environment, Food and Rural Affairs (DEFRA) and other public sector bodies. Secondary data to build the tables were sourced from official published sources and recent information developed by research organisations across the UK. Surveys and other primary research were not carried out as part of this study.

All of the tables comprising the experimental ESA for Wales are consistent with the UK Environmental Accounts developed and published by the ONS. All required modifications to the standard approach are clearly stated and were agreed with the WAG steering group.

2 Natural resources

2.1 Estimates of remaining recoverable oil and gas reserves (ESA 1.1)

What is the table about?

The table provides an estimate of UK oil and gas reserves. A problem here is that there is very little information on the oil and gas reserves which might be considered 'Welsh', and with expected reserves in the Irish Sea and elsewhere not yet economic, and more often in the 'possible' as opposed to 'proven' category. However, it is likely that reserves off North Wales and in the Irish Sea could become economic in the future and 'proxy' figures for Wales could be of interest. Particularly relevant for Wales could be the levels of coal reserves with the advent of clean coal technology.

Our approach

Following the initial data scoping exercise it was decided that it was unlikely that detailed accounts could be produced to demonstrate recoverable oil and gas reserves. However, there was seen to be value in working towards an estimate of recoverable mineral deposits, together with an estimate of current consumption levels with the possibility that this data would also inform the development of the materials flow table (W2.5).

2.1.1 Coal: Deep Mined

An in-depth analysis of the deep mines operating in the UK in 2002 was carried out by IMC (who had carried out a similar study in 1998, see IMC Group Consulting *A review of the remaining reserves at deep mines for the DTI,* 2002, at http://www.dti.gov.uk/files/file15982.pdf). The IMC study included production at Tower Colliery, Aberpergym and Betws (Ammanford). However, Betws closed down in June 2003. An evaluation of the future potential coal production in the UK was undertaken by Mott MacDonald in 2004 using the figures produced by IMC (*UK Coal Production Output 2004-16"* March 2004, http://www.dti.gov.uk/files/file14151.pdf.

Coal supply figures are divided into two main categories of deep-mined and opencast. Output of deep-mined coal in Wales in 2004-05 was an estimated 0.667 mt (largely from Tower Colliery). There are 3 smaller deep-mined collieries: Aberpergwm- which employs about 65 people in Neath, and produces around 65,000 tonnes per annum; Blaentillery- in Torfaen, a small mine, producing less than 10,000 tonnes per annum, and Nanthir- in Seven Sisters (Neath) also producing less than 10,000 tonnes per annum.

Deep mine reserves are difficult to estimate. Table W1.1 shows estimates from the IMC Group study for the two largest deep mines that were open in Wales in 2002. Reserves are that portion of the coal resource that is considered to be extractable under current economic conditions and existing technology. Total reserves at the two deep mines were around 3.1million tonnes in 2002. However, there are further categories of reserves including Resource and Mineral Potential. Resource is the area of mineral in which there is an economic interest, with seam properties and geological environment known to a specific region. The Resource estimate for the two mines is 10.1m tonnes. Mineral Potential is any area of seam that could fall into a Reserve or Resource category when planning permissions/lease/licences are obtained. Here the estimate increases to 19.0mt.

Table W1.1.1
Reserve estimates at Deep Mines in Wales (Millions Tonnes), end 2002

	Reserves	Resource	Mineral Potential
Tower	2.6	6.3	19.0
Aberpergym	0.48	3.8	**Na**

Source: IMC Group Consulting, 2002

There have been a number of developments since 2002, which affect the figures in W1.1.1. It was announced in January 2006 that Tower Colliery would close when the coal seams currently being worked will be exhausted. Table W1.1.1 reveals that there is no shortage of coal at Tower, but that reaching these reserves would need significant investment. Furthermore, Betws Colliery closed in June 2003. The estimate of reserves is still very relevant for Wales with the advent of clean coal technology and with new technologies enabling coal to be burned at source to develop power.

2.1.2 Coal: Opencast

Statistics on opencast mining were historically collected and published by the Planning Officers' Society. This series ceased in 1999. The Office of the Deputy Prime Minister (ODPM), WAG and the Scottish Executive have agreed that it would be valuable for a summary of opencast coal statistics to be continued. The British Geological Survey (BGS) now undertakes this collation in collaboration with the Coal Authority and Planning Authorities with opencast coal resources in their areas. Table W1.1.2 shows saleable opencast coal production in Wales, together with an estimate of permitted reserves at sites for 2004.

There were nine main opencast mining sites in Wales in 2004 including: Brymbo Steelworks; Cwm Yr Onen; Margam Opencast; Nant Helen Extension; Selar; Nant Melyn; and Bwlch Ffos. Opencast estimated total annual production in Wales was 1.4 million tonnes in 2004/5 (1.2 million tonnes in 2001/2), and with the bulk of opencast production centred on the Neath valleys. Unlike Table W1.1.1, the table for opencast production does not show *potential* reverses.

Table W1.1.2
Saleable opencast production, and permitted reserves Wales 2004-05

Mineral planning authority	2004-5 tonnes production	2004-05 permitted reserves tonnes	Number of sites operational
Carmarthenshire	29,838	159,119	1
Neath Port Talbot	916,196	1,081,188	6
Powys	380,596	2,753,569	1
Wrexham	78,863	38,558	1
Wales	1,405,493	4,032,434	9
GB	11,992,713	37,246,066	42
Wales % GB	11.8%	10.8%	21.4%

Source: The Coal Authority

2.1.3 Aggregates

The estimation of reserves of aggregates is made with reference to the annual reports of the Regional Aggregates Working Parties ((RAWPS) for South Wales and North Wales. Table W1.1.3 shows production of aggregates for the period 2000-2002/03. The latest figures for North Wales relate to 2002, and for South Wales to 2003. Crushed rock includes limestone**,** sandstone and igneous rock. Sand and gravel is derived from land won sources and from marine sources. Permitted reserves are the current stocks of planning permissions for the winning and working of minerals. Then an estimate of land bank can be derived by dividing the permitted reserves by the average of the last three years of production. Clearly, this will be a very approximate estimate, as this takes no account of long run changes in future demand for aggregates, or for reserves on which no permissions are extant.

Table W1.1.3 reveals that in 2002 total regional production of crushed rock was an estimated 16.06m tonnes, and of sand and gravel was 2.51m tonnes. For the South Wales RAWP area there was an estimated permitted reserve of 612.72m tonnes of crushed rock in 2003. Average production in the South Wales area for the period 2001-03 was around 10.22m tonnes giving a land bank of just under 60 years. Similar calculations for sand and gravel for the RAWP South Wales area reveal a land bank of just under 9 years. Comparable figures for the North Wales RAWP area, and using regional production figures for 2000-02 are a crushed rock land bank of just under 65 years, and for sand and gravel of 18 years.

Table W1.1.3
Regional production of aggregates (m tonnes) and reserve estimates (years)

	2000	2001	2002	2003	Permitted reserve (latest estimate)	Estimated landbank years
Crushed rock						
South Wales	9.82	10.00	9.54	11.12	612.72	60.00
North Wales	8.01	7.20	6.52	Na	467.00	64.48
Total crushed rock	**17.83**	**17.20**	**16.06**	**Na**	**1079.72**	**63.40**
Sand & gravel						
South Wales	1.22	1.36	1.16	1.17	10.90	8.86
North Wales	1.53	1.39	1.35	Na	26.00	18.27
Total sand & gravel	**2.75**	**2.75**	**2.51**	**Na**	**36.90**	**13.82**
Overall total	**20.58**	**19.95**	**18.57**	**Na**	**1116.62**	**56.68**

Source: South Wales Regional Aggregate Working Party, Annual Report, 2003; North Wales Regional Aggregate Working Party, Annual Report, 2002
Note: Latest estimate for permitted reserves for North Wales RAWP area is 2002, and for South Wales RAWP area is 2003. Land bank is estimated by dividing permitted reserve by average production over last three periods. This means the total land bank figures in the table are an estimate based on 2000-2002 figures for South and North Wales RAWP areas.

2.2 Oil and gas monetary balance sheet (ESA 1.2)

What is the table about?

The table links closely with ESA 1.1 and attempts to place a value on reserves so that they can be compared with other economic assets. This is a time series (1994-2004 in the *Environmental Accounts,* 2005). Opening stocks value is adjusted for extraction, 'revaluation based on passage of time', volume changes, changes in rents and holding gains to come to a value for closing stocks.

Our approach

Our initial scoping exercise concluded it was unlikely that data could be estimated for this table due to a lack of data on oil and gas reserves for Wales. Furthermore, at this time the table is likely to be of limited use for informing policy in Wales. Data for coal and other mineral reserves were considered instead (see Tables W1.1.1-W1.1.3).

2.3 Land Cover Account: Changes between 1990 and 1998 (ESA 1.3)

What is the table about?

The GB table provides an estimate of the GB land stock classified in terms of woodland, intensive agricultural land, semi-natural land, water bodies, developed and other. Under each sub-head there are a number of individual categories. The GB table gives the stock as at 1990 for each type of land cover and then an account of changes i.e. due to woodland creation, development etc, and then a finishing stock of land as at 1998.

Our approach

As highlighted in our scoping exercise of the land cover account for GB makes use of Countryside Survey (2000) data, which together with earlier survey rounds permits a dynamic analysis of changes in land cover. In the 2005 UK Environmental Accounts this covers the period between 1990 and 1998. Whilst the *Countryside Survey* (2000: http://www.cs2000.org.uk) covered Wales there were issues over the size of the sample used.

Moreover, the Countryside Survey was not designed with regionally-specific Welsh results in mind, and was reported at a Broad Habitat level. The Centre for Ecology and Hydrology (Bird *et al*., 2003) has produced a report demonstrating what would be required for a 'Wales only' Countryside Survey with the expectation that this could form an important baseline when produced in 2007. They note that it is "essential that the national continuity of the *Countryside Survey* is not compromised. Modification to address BAP Priority Habitat or Tir Gofal reporting needs may be valuable in policy terms but, if not carefully implemented could invalidate general results".

As highlighted in our scoping exercise there are regionally developed sources of information, notably the *Habitat Survey of Wales,* which report land cover at Priority Habitat level; see Howe et al (2005) for a summary. The latter provides details of Phase 1 classification of habitats as at 1997, and reflects a detailed programme of research extending over a decade.

There would be value in the regional environmental account of reporting results from both surveys. However, in the absence of a reliable *Countryside Survey* reference point, the compromise adopted for this pilot work is to report *Habitat Survey of Wales* results in Table W1.3.1 below. This is followed by a set of Habitat Survey findings re-categorised into the Countryside Survey classification, which reports their results in terms of the *Countryside Survey* broad habitat categories.

The matching process is not perfect. For example, under the Phase 1 habitat categories there are no data recorded for the following *Countryside Survey* (2000) categories:

- Rivers & streams;
- Boundaries and linear features;
- Sea; and
- Unknown.

Furthermore, all the land recorded under "upland" in Phase 1 has been recorded as "montane" in the *Countryside Survey* (2000) framework. The upland classification on the *Habitat Survey for Wales* is all land above the limit of enclosure. This limit is usually around 300 metres.

Table W1.3.1
Summary Data for selected Phase 1 habitats in Wales

	Area (ha) *		
	Lowland	**Upland**	**Total**
Woodland			
Semi-natural broadleaved woodland	80,300	2,300	**82,600**
Planted broadleaved woodland	6,000	110	**6,100**
Planted coniferous woodland	123,900	43,700	**167,700**
Dense scrub	13,300	660	**14,000**
Grassland			
Unimproved acid grassland	19,600	108,100	**127,600**
Semi-improved acid grassland	19,900	5,100	**25,100**
Unimproved neutral grassland	1,700	<5	**1,700**
Semi-improved neutral grassland	33,100	300	**33,400**
Unimproved calcareous grassland	860	640	**1,500**
Semi-improved calcareous grassland	300	10	**310**
Marshy grassland	35,200	29,200	**64,400**
Improved grassland	1,012,700	14,000	**1,026,700**
Tall herb and fern			
Bracken	30,100	32,600	**62,700**
Tall ruderal herb	1,000	<5	**1,000**
Heathland			
Dry acid heath	8,800	69,600	**78,400**
Dry basic heath	120	0	**120**
Wet heath	3,600	9,400	**13,000**
Lichen/bryophyte heath	0	130	**130**

Table W1.3.1
Summary Data for selected Phase 1 habitats in Wales (continued)

	Area (ha) *		
	Lowland	**Upland**	**Total**
Mire			
Blanket bog	500	22,600	**23,000**
Raised bog	990	40	**1,000**
Wet modified bog	2,000	23,600	**25,500**
Dry modified bog	160	8,000	**8,100**
Acid/neutral flush	2,000	12,500	**14,600**
Basic flush	50	90	**140**
Fen	1,900	1,300	**3,200**
Modified fen	770	300	**1,100**
Swamp	1,800	20	**1,800**
Open water			
Marginal and inundation vegetation	70	20	**90**
Standing water	7,400	2,000	**9,400**
Coastal			
Salt marsh	5,800	0	**5,800**
Vegetated dune	3,700	0	**3,700**
Open dune	2,600	0	**2,600**
Hard cliff	890	0	**890**
Soft cliff	80	0	**80**
Coastal grassland	1,600	0	**1,600**
Coastal headland	950	0	**950**
Rock exposures			
Cliff rock	260	1,200	**1,500**
Scree rock	270	3,300	**3,600**
Other rock	330	3,700	**4,000**
Miscellaneous			
Arable	59,800	220	**60,100**
Amenity grassland built up	10,400	10	**10,400**
Introduced scrub, ephemerals and bare ground built up	1,000	310	**1,300**
Quarry, spoil, mine, refuse-tip urban	5,800	1,700	**7,400**
Urban and other built-up land	146,000	340	**146,300**
Not accessed	8,000	3,000	**11,000**
TOTAL	**1,655,600**	**400,100**	**2,055,610**

Source: Habitat Survey for Wales
Note: Data are given to nearest 100ha, or to the nearest 10ha if the total is less than 1000ha; total of rows may then not sum due to rounding.

Table W1.3.2
Habitat Survey findings modified to CS (2000) categories

Type	Estimated reconciliation with W.1.3.1 above i.e. Phase 1 categories	Area (Total ha)
Broadleaved & mixed woodland	Semi-natural and planted broadleaf woodland and scrub	99,600
Coniferous woodland	Planted coniferous woodland	123,900
Woodland subtotal		**223,500**
Arable & horticultural	Arable	59,800
Improved grassland	Improved grassland	1,012,700
Intensive arable subtotal		**1,072,500**
Neutral grassland	Unimproved and semi-improved neutral grassland	34,800
Calcareous grassland	Unimproved and semi-improved calcareous grassland	1,160
Acid grassland	Unimproved and semi-improved acid grassland	39,500
Bracken	Bracken and tall ruderal herb	31,100
Dwarf shrub heath	Dry acid heath, dry basic heath, wet heath and lichen/bryophyte heath	12,520
Fen marsh & swamp	Marsh grassland and acid neutral flush, basic flush, fen, modified fen and swamp	41,720
Bog	Blanket, raised, wet and dry modified bog	3,650
Montane	Sum of all upland categories in Habitat Survey for Wales	400,100
Coastal habitats	Salt marsh, vegetated dune, open dune, hard and soft cliff, coastal grassland and heathland	15,620
Semi natural subtotal		**580,170**
Standing open waters & canals	Marginal and inundation vegetation, and standing water	7,470
Rivers & streams	No comparator	
Water bodies subtotal		**7,470**
Inland rock	Cliff, scree and other rock	860
Built up areas & grasslands	Amenity grassland, introduced scrub, ephemerals and bare ground, quarry spoil, mine, refuse tip, urban and other built up land	163,200
Boundary and linear features		
Developed sub total		**164,060**
Sea		
Unknown		
Unsurveyed urban land	**Not accessed**	**8,000**
Total		**2,055,700**

Source: Countryside Council for Wales

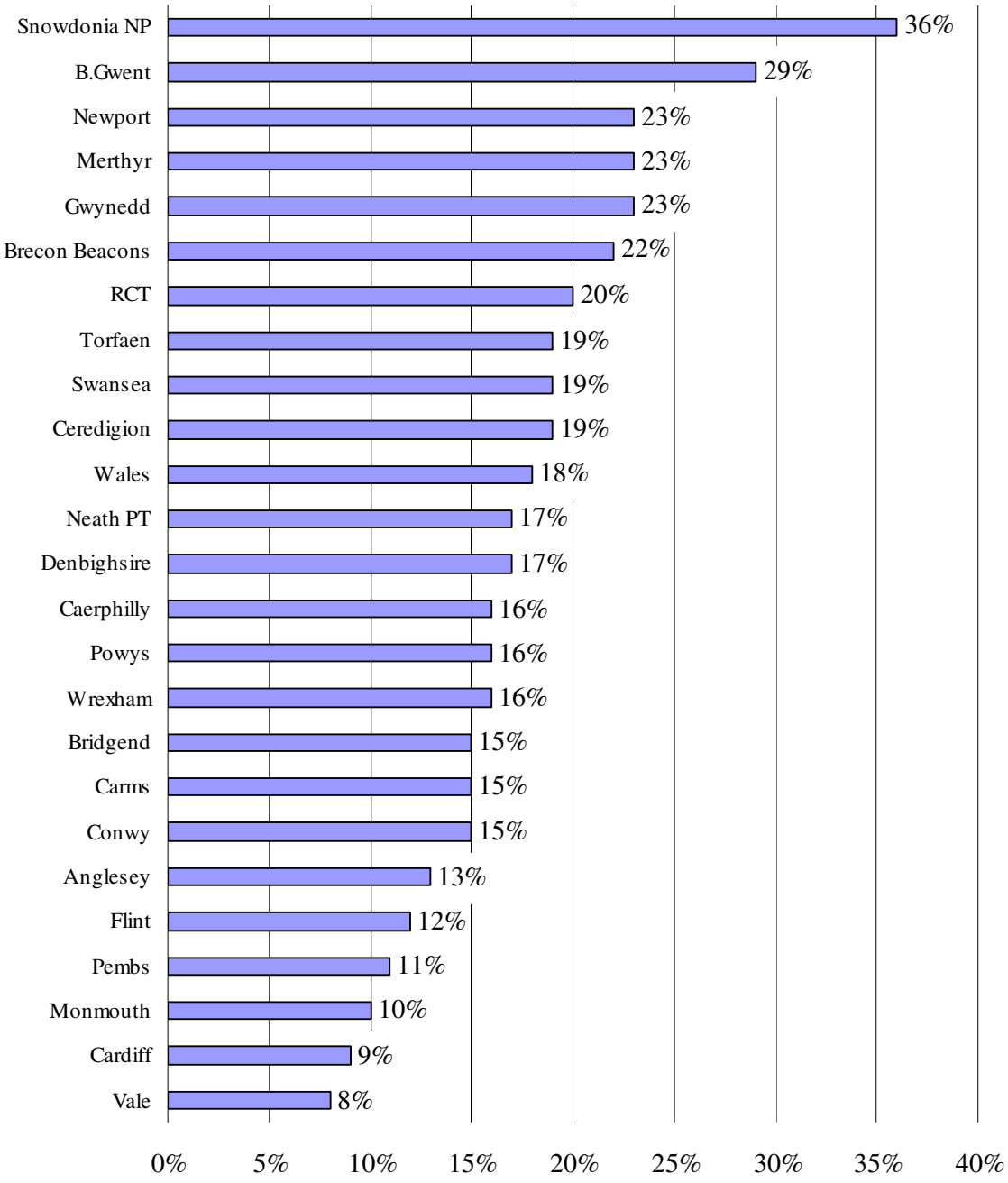
Improved grassland covers around 48% of the land area of Wales. In terms of woodland it is planted coniferous which dominates (62% if total woodland area), although with some expectation that planted broadleaf woodland will increase in line with recent interventions including the Woodland Grant Scheme, and with poor markets for softwoods removing the incentive for extensive replanting and restocking.

Built up areas covered an estimated 7% of the total land area of Wales. Uplands as a whole made up an estimated 19% of the regional land area. The authors of the *Habitat Survey for Wales* make several more specific observations from the findings:

- The scarcity and fragmentation of lowland wet heath land, with this being taken to make improved grassland, conifer plantations of scrub; and
- Better than expected presence of good wet grassland in the Welsh lowlands, but with these areas under threat from agriculture and the development of new business and industrial space.

We suggest that this element of the experimental ESA for Wales should be accompanied by outputs from the LANDMAP system. There is also the opportunity to provide a subsidiary table showing the habitat extent for priority habitats within Welsh local BAP areas. Figure W1.3.3 provides a summary. This reveals, for example, that in the Snowdonia LBAP area an estimated 36% represents priority habitat types. This percentage falls to just 8% and 9% in the Vale of Glamorgan and Cardiff respectively.

Table W1.3.3
Priority habitat extent (%) in Welsh local BAP areas



Source: Countryside Council for Wales
Note: Priority habitats are upland oak wood, upland mixed ash wood, wet woodland, lowland beech and yew, lowland mixed deciduous, lowland meadows, lowland calcareous and dry acid grassland, purple moor grass and rush pasture, lowland heath land, reed bed, fern, lowland raised bog, coastal and floodplain grazing, upland heath land, blanket bog, upland calcareous grassland, limestone pavement, maritime cliff and slope, coastal vegetated shingle, sand dune, salt marsh.

2.4 Production, imports and exports of wood products (ESA 1.4)

What is the table about?

The table provides information on domestic production and consumption of sawn wood, wood-based panels, and paper. Estimates of imports and exports of these goods are provided. The latest table in the *Environmental Accounts* Autumn 2005 provides data for 1994-2004.

Our approach

The UK ESA 1.4 reveals domestic consumption of sawn wood, wood-based panels, and paper. The data scoping section of this report revealed that some elements of this table could be produced for Wales. However, it is important to note that in the most recent UK Environmental Accounts for 2005, the table on wood products sits between a commentary on woodland area change in the UK, and then an outline of the recreational use of forestry. Then the Welsh ESA 1.4 could also be contextualised within a commentary on Welsh forestry cover (i.e. which is the source of a high proportion of soft round wood used in Wales by local sawmills), and visitor use of the resource. This would also provide a link to the general land cover account within a pilot Welsh ESA.

2.4.1 Forestry Cover Account

Forestry cover statistics are produced by the Forestry Commission, together with details of new planting and restocking. Table W1.4.1 then examines changes in forestry cover before moving on to examine the use of locally sourced forest products in local industry.

Table W1.4.1
Wales: Forestry Cover Account (000s ha)

Cover	1980	1990	2000	2005
Forestry Commission (FC) woodland	138	130	116	109
FC – other land	23	11	12	17
Non FC woodland	94	118	173	177
All woodland area	**232**	**248**	**289**	**286**
FC new planting and restocking	2.0	1.6	1.8	1.3
Non FC new planting and restocking	0.7	0.8	1.6	0.8
All new planting and restocking	**2.7**	**2.3**	**3.4**	**2.1**

Source: Forestry Commission

Table W1.4.1 demonstrates the steady increase in woodland area in Wales, and the progress of replanting. Since the early 1990s there has been very little new planting on Forestry Commission land, with much of the activity being in replanting conifers and hardwoods on land that has been harvested.

2.4.2 Welsh production of wood-based products

The UK ESA Table 1.4 works to produce an estimate of domestic consumption of sawn wood, wood-based panels, and paper. The key problem in developing this table for Wales is the virtual absence of import and export information on sawn wood, wood-based panels, and paper.

There is a further complication in that the vast majority of wood-based panel production in Wales is centred on Kronospan in Chirk and any information on the regional production of wood-based panels would potentially disclose plant level information. The remaining mill (Cape Boards, Ystrad Mynach) produces far smaller quantities of wood based panels, and uses very small amounts of wood-based raw materials.

Similar issues concern paper production. In 2004, there were 2 paper mills in Wales using wood-based inputs (St Regis at Sudbrook, and the very large Shotton Paper Mill on Deeside). However, St Regis used relatively small amounts of Welsh hardwoods in production, and has recently announced (Spring 2005) that it will close. Shotton historically used logs, woodchips and recycled fibre in its newsprint mill, but has slowly reduced its inputs of logs through time in favour of recycled materials. It has the capacity to use up to 600,000 tonnes of recycled paper waste, and is no longer dependent on round wood log inputs.

Finally, there are other industries that use large quantities of Welsh forestry products including the fencing sector, pallet and packaging manufacturers. These end user industries are ignored in the UK account.

The above issues mean that a full account of wood product consumption in physical terms would be impossible to develop without extensive survey resources. However, a partial account can be developed revealing:

- Soft wood removals from Welsh forests from Forestry Commission and Non-Forestry Commission land;
- Consumption of wood inputs and production of sawn wood by regional saw mills;
- An estimate of Welsh pulpwood exports, and Welsh roundwood supplied to UK pulp and paper mills; and
- An estimate of the tonnes of timber and wood boards imported into Welsh ports.

The information in Table 1.4.2 below is in terms of green tonnes (freshly felled trees including moisture) unless otherwise states.

Table W1.4.2
Welsh production of wood-based products

Production	2002	2003	2004
Softwood removals from FC and non-FC land (000s green tonnes)	1,271	1,227	1,092e
Consumption of all round wood in regional saw mills (000s green tonnes)	729	790	826e
Production of sawn wood in regional saw mills ($000m^3$)	389	402	418e
Consumption of Welsh round wood to UK pulp and paper mills (000s green tonnes)	160	170	14
Welsh pulpwood exports (000s green tonnes)	10	28	57
Estimated imports of timber and board through Welsh ports (000s tonnes)	**Na**	288	Na

Source: Derived from UK Timber Statistics, various; UK Sawmill Survey; Associated British Ports
Note:
1. 2004 data on softwood removals is estimated based on an 11% reduction in removals of softwoods from Forestry Commission plantations. No data was available for non Forestry Commission removals for this year, so an 11% reduction has been assumed across the board for illustrative purposes.
2. 2004 figures for sawmill production and consumption are based on softwood consumption and production figures of 813,000 green tonnes, and 409,000m^3 respectively, and with a small addition to cover an estimate of hardwood inputs based on figures for the previous year.

The table is partial but reveals the main sources of demand and supply for Welsh softwoods, with regionally produced hardwoods having much smaller markets – for example, less than 2% of total Welsh sawmill consumption in 2003 were hardwoods. Softwood removals were over 1.2m tonnes in 2002 and 2003, with the figure for 2004 estimated because of the absence of data on softwood removals from non Forestry Commission land.

The information in the table relating to saw mills is for Welsh saw mills, which are using round logs. This does not include mills that are processing imported sawn wood. It is reasonable to assume that the former are mills that are in large measure using timber cut in Wales. The very high transport costs associated with logs prohibits imports from other areas of England (Kielder Forest) and Scotland. Then in 2002 Welsh saw mills used over 800,000 tonnes of round timber, the majority of which was from Welsh forests, and this resulted in the production of over 400,000m^3 of sawn wood.

The fourth row of the table highlights the consumption of Welsh round wood in UK pulp and paper mills. This is in large measure softwood logs going to Shotton, with the other large UK paper mills (i.e. in Cumbria and Scotland) using inputs from English and Scottish forests. Some Welsh logs are exported for pulping i.e. an estimated 57,000 green tonnes in 2004. The large drop in consumption of Welsh round wood in paper mills was due to Shotton Paper Mill bringing new recycling capacity fully on line in 2004-05.

Finally, the table provides an estimate of timber and board being imported through Welsh ports. Much of this is semi-processed timber, and with much of this moving straight out of Wales to consumer and industry markets in the wider UK. This figure is based on information derived from Associated British Ports.

The UK *Environmental Accounts* provide a short account of the wider role of forests as a means of levering tourism income. This could also be undertaken for Wales, with the *Wales All Forest Visitor Survey 2004* commissioned by the Forestry Commission providing useful information on visits and spending, and the demography of visitors. An estimated 4.1m visits were made to Welsh Assembly Government woodlands in 2004. It was estimated that visitors to the forests spent an estimated £13 per visit. Visitors who said that the presence of the forest was an important factor in their decision to visit, spent an estimated total of £30m through the year on their visits.

2.5 Fish stocks (ESA 1.5)

What is the table about?

The UK table in the *Environmental Accounts* for 2005 covers 2001 and was the result of an ONS report in 2003, which was looking to construct physical and economic accounts for UK fisheries. The UK table then records 'total' and 'UK' catch by key white fish (five) species, across 3 main fisheries areas.

Our approach

In the data scoping report it was noted that there are several issues in developing this table for Wales. Indeed the UK 'Fish Stocks' table merely records the catch of selected demersal species, value at first landing for one year and some subsidiary comments on selected stocks. For Wales the most useful table would relate to landings of sea fish, but with an additional table highlighting the stock position in adjacent sea areas to the region. In the case of river and still water fisheries there are fewer pressures on resident stocks.

2.5.1 Quantity and value of fish landings into Wales by UK vessels

Key sources for landings data are South Wales Sea Fisheries Committee statistics (www.swsfc.org.uk/landing2003.htm) on landings into their district, and with limited additional information available from North Wales and North West Sea Fisheries Committee (www.nwnwsfc.org/fisheries). However, much of the data from the individual Sea Fisheries Committees comes from the Marine Fisheries Agency *UK Sea Fisheries Statistics*, and it is suggested that this should be the overarching source for the Welsh fish 'landings' and 'stocks' table largely because this covers the whole of Wales (landings), and can be easily linked for comparative purposes to the wider UK sea fisheries statistics base, which itself provides comparators with EU states.

Information on the quantity and value of fish landings from DEFRA (published as part of *Sea Fisheries Statistics*) is reproduced below as Table W1.5.1. We believe that there is little value in presenting data for just one year but rather that the table for Wales should show changes through time. This is particularly important with respect to sea fish where the reduced landings for demersal species highlight the decimation of the underlying stock.

There are several caveats with this table:

- It includes landings into Wales by UK registered vessels. Some foreign registered vessels also land into Wales;
- The quantity of landed fish and shellfish prior to 1994 reflect landed weight as opposed to live weight from 1994. This makes strict comparisons through the years difficult;
- The quantity of landed fish and shellfish includes those caught in areas outside the areas covered by the SWSFC and NWNWSFC. This is less of a problem with respect to shellfish landings which largely involve locally registered boats fishing inshore; and
- Sea fisheries statistics on landings are likely to under-represent the actual landings with the industry prone to serial under-recording of catches. The scale of this problem with shellfish landings came to light in South Wales following the Sea Empress disaster where many fisherman faced difficulties reconciling compensation claims to recorded catches in prior years.

Table W1.5.1
Quantity (tonnes) of fish landings into Wales by UK vessels (and total value £m)

	1991		2001		2005	
	Tonnes	£000s	Tonnes	£000s	Tonnes	£000s
Demersal and pelagic						
Cod	337	424	135	202	21	35
Plaice	201	205	67	72	22	27
Skate and rays	915	736	676	827	303	386
Sole	94	417	87	440	39	263
Other demersal	2,381	3,708	3,038	5,185	1,906	3,767
Total demersal	**3,928**	**5,490**	**4,003**	**6,727**	**2,290**	**4,477**
Total pelagic	**33**	**20**	**1**	**2**	**1**	**0**
Total demersal and pelagic	**3,961**	**5,509**	**4,004**	**6,728**	**2,291**	**4,478**
Shellfish						
Cockles	2,614	288	3,278	711	8,774	6,207
Lobsters	70	494	115	1,219	36	531
Mussels	1,196	444	9,848	3,828	910	Na
Other shellfish	1,778	1,424	4,576	3,539	5,497	4,404
Total Shellfish	**5,658**	**2,650**	**17,818**	**9,297**	**15,217**	**11,141**
Total all fish	**9,618**	**8,159**	**21,822**	**16,026**	**17,508**	**15,619**

Source: DEFRA (but now Marine Fisheries Agency), Sea Fisheries Statistics
Notes:
More detailed breakdowns are available for shellfish landings from South Wales Sea Fisheries Sea Committee, and with cockles landings by main area, and mussels landings by type (see Appendix table 1.5.3).

The table reveals the sharp reductions in landings of demersal species over the two decades, particularly the premium species of cod, plaice and sole. 'Other demersal' landings have been maintained, and within this classification are species as whiting which are also now coming under severe pressure in waters off Wales.

The pelagic landings were, in 1991, dominated by mackerel. Landings in these classes have fallen to almost nothing. The reduction in landings of demersal fish have been countered by increases in shell fish landings which in 2005 made up nearly two-thirds of the value of the total landings into Wales by UK vessels.

2.5.2 Selected Main Stocks

We now turn to stocks. As highlighted above the UKEA did not include a stock table in 2005, but rather a commentary on levels. Any discussion of stocks faces problems of attribution. From *Sea Fisheries Statistics* it is possible to derive information on estimated stocks of premium fish in International Committee for Exploration of the Sea (ICES) defined fishing areas which are adjacent to Welsh coastlines. These are Irish Sea (ICES area VIIa), Bristol Channel (VIIf) and Western Approaches (VIIg).

Table W1.5.2
Selected Main Stocks in ICES Fishing Areas adjacent to Wales (000s tonnes)

	1980	1990	2000	2004
Irish Sea (VIIa)				
Cod	12.8	9.3	2.3	4.3
Plaice	4.5	5.6	4.8	9.5
Sole	5.4	3.9	3.6	3.9e
Whiting	18.6	8	1.4	1.2e
Celtic Sea (VIIf&g)				
Plaice	1.8	3.5	1.2	1.1
Sole	3.9	2.3	1.9	3

Source ICES ad ASFM reports within Marine Fisheries Agency, UK Sea Fisheries Statistics
Note: Figures are for spawning stock biomass, which is the total weight of a species population capable of reproducing. ICES areas are shared with England and Ireland

The information in the table provides a concise summary of the stock position on premium species in sea areas close to Wales. Clearly an issue is that these stocks are not under 'regional control', and with no information of this type available for shell fish.

The table reveals the serious situation with respect to premium fish stocks in areas close to Wales. Cod and whiting stocks in the Irish Sea are seriously depleted and with this also reflected in landings. With premium fish stocks at or below precautionary levels in sea areas adjacent to Wales tight quotas will continue and with a zero catch option possible in some areas to aid recovery.

2.5.3 District Landings of Fish and Shellfish: South Wales Sea Fisheries Committee area

In addition to information shown in Table W1.5.1 data made available by the South Wales Sea Fisheries Committee provides an overview of landings value by detailed fish and shellfish type. The South Wales data are also more up to date covering 2003.

Table W1.5.3.
District Landings of Fish and Shellfish: South Wales Sea Fisheries Committee area

	2000 landings tonnes	2003 landings tonnes	Change %	2003 landings value £000s
Cockles	7,135	3,400	-52.3	2,900.0
Mussels	962	2,780	189.0	223.7
Winkles	15	13	-13.3	19.5
Oysters	10	10	0	28.5
Scallops	204	46	-77. 5	203.7
Whelks	708	861	21.6	482.0
Total molluscs	**9,034**	**7,109**	**-21.3**	**3,857.5**
Bass	26	15	-42.3	66.4
Demersal	3,504	1,755	-49.9	3,115.0
Pelagic	3	14	366. 7	10.0
Squid	12	90	650.0	272.0
Total fin fish	**3,534**	**1,874**	**-47.0**	**3,463.4**
Lobster	45	83	84.4	830.0
Edible & spider crabs	448	667	48.9	747.0
Other crustaceans	20	15	-25.0	66.0
Total crustaceans	**513**	**765**	**49.1**	**1,643.0**
Overall total	**1,3092**	**9,748**	**-25.5**	**8,964.0**

Source: South Wales Sea Fisheries Committee
Notes:
1. Demersal and pelagic are normally caught outside the district area. The district is a six mile limit running from a little east of Cardiff to Cemmaes Head in Cardigan Bay.
2. Demersal figures include Anglo-Spanish fleet landings at Milford Haven.
3. Table does not include outputs from the North Wales fishery i.e. mussels fisheries in Menai Straits, lobstering right around the North Wales coastline, Whelks off Holyhead. However relatively few trawling boats operate in NWNWSFC area, and much of inshore catch is accounted for by angling boats.

In addition to the above tables the same sources of data can be used to show foreign landings into Wales in 2005 totalled 3,742 tonnes with a value of £9.6 million. In 2005 total landings abroad by Welsh vessels were 6,613 tonnes with a value of £11.4 million

3 Physical flows

3.1 Energy consumption (ESA: 2.1)

What is the table about?

The table provides an estimate of the use of energy, in tonnes of oil equivalent, by 76 industries including direct generation and domestic households. Information is also provided on transformation losses and use of non-FF energy sources (nuclear, imports and renewables). The latest table in the *Environmental Accounts* Autumn 2005 gives time-series data for 1990 to 2003.

Our approach

The REWARD project (www.reward-uk.org) provides the energy consumption data by fuel type and industry for 2003, which forms the basis of this table. This is broken down into four main categories:

- Final electricity consumption by end users;
- Fuel used in the energy generation sector;
- Fuel consumption in economic sectors excluding power production; and
- Energy production by road transport.

In this database, all energy amounts are expressed in Petajoules, which have to be converted into million tonnes of oil equivalent in order to construct the ESA table. We have employed the following formula, as used by the DTI (www.dti.gov.uk/energy/inform/energy_stats/explanatory/explanatory_notes.shtml), to make this conversion:

One thousand tonnes oil equivalent = 41.87 TJ (1 petajoule = 1 million terajoules)

$$\textit{Therefore, 1 Petajoule} = \frac{1{,}000}{41.87 \times 1{,}000{,}000} = 0.023883 \text{ MTOES (million tonnes oil equivalent)}$$

3.1.1 Table W2.1 Energy consumption (expressed in Petajoules)

It was necessary to reorganise the REWARD data to fit the layout of Table W2.1. For the section on direct use of energy from carbon fuels, we have summarised data on fuel used in industry, fuel used in electricity generation and energy production by road transport. The second part of Table W2.1 shows all direct use of energy including electricity; hence here we have combined the direct use of energy from carbon fuels with the final electricity consumption by end users.

It has not been possible to directly calculate the equivalent final part of the UK ESA table 2.1 reallocated use of energy, due to a lack of data on the level of transformation and distributional losses by the electricity generation sector in Wales. The DTI has developed estimated of transformation and distributional losses in Wales based on UK data (http://www.dti.gov.uk/files/file18558.pdf). In converting the DTI estimates *1 petajoule is equal to 278 Gigawatt Hours (GWh).*

Table W2.1
Energy consumption (expressed in Petajoules)

Energy consumption	Wales (2003)	UK (2003)
Direct Use of Energy from Carbon Fuels		
Agriculture	0.1	0.8
Mining & Quarrying	0.1	7.3
Manufacturing	3.4	41.4
Energy, Gas & Water Supply	5.9	61.7
Construction	0.1	2.5
Wholesale & Retail Trade	0.3	5.5
Transport & Communication	1.1	32.4
Other Business Services	0.3	2.5
Public Administration	0.2	3.7
Education, Health & Social Work	0.2	4.7
Other Services	0.1	1.7
Domestic	4.0	60.8
Total Use of Energy from Carbon Fuels	**15.7**	**225.0**
Energy from other sources (including imports of energy)	**Na**	20.6
Total Energy Consumption of Primary Fuels and Equivalents	**Na**	245.5
Direct Use of Energy including Electricity		
Agriculture	0.1	1.2
Mining & Quarrying	0.1	7.5
Manufacturing	3.9	49.3
Energy, Gas & Water Supply	5.9	55.1
of which transformation losses	1.3	46.8
of which distribution losses	4.7	2.6
Construction	0.1	2.6
Wholesale & Retail Trade	0.4	8.4
Transport & Communication	1.1	33.6
Other Business Services	0.3	4.9
Public Administration	0.2	4.3
Education, Health & Social Work	0.2	5.9
Other Services	0.1	2.0
Domestic	4.6	70.7
Total Energy Consumption of Primary Fuels and Equivalents	**17.1**	**245.5**

SOURCE: The REWARD project (www.reward-uk.org) and UK ESA

In terms of carbon fuels, manufacturing and electricity, gas and water supply account for a higher proportion of energy consumption in Wales compared to the UK. Just over one third of all total energy consumption of primary fuels and equivalents in Wales are from the energy, gas and water supply sector, this compares to around one quarter for the UK as a whole.

3.2 Atmospheric Emissions (ESA: 2.2 & 2.3)

What is the table about?

The table estimates the levels of emissions into the atmosphere of a variety of gases, volatile organic compounds and metals-as-gases. The policy focus of this table however, is on those emissions that contribute to climate change ('greenhouse gases') of which there are six, usually reported as carbon-equivalents; and those which affect acid rainfall (sulphur/nitrous oxides and ammonia).

Our approach

Again, the REWARD project provides data for this table for Wales. The data is collected by type of emission and industry, with road transport emissions shown separately. Emissions are measured both in tonnes and in the case of greenhouse gases, in terms of tonnes of CO2 equivalent. These CO2 equivalent values are calculated using accepted conversion factors.

Data on emissions of PM10, CO and NMVOC are taken directly from the REWARD database. Data on greenhouse gas emissions are presented by type of emission in the REWARD database, it was necessary to combine these emission types (CH4, CO2, HFC, N2O, PFC, SP6) to calculate the total greenhouse gases for Wales (measured in tonnes CO2 equivalent).

AEA Technology Environment's National Environmental Technology Centre (Netcen) produces emission inventories for a large range of pollutants including ammonia, which could also be used in the development of an ESA. The REWARD project is a one-off, and AEA Technology Environment's Netcen is potentially a more useful source of data for future ESAs.

3.2.1 Table W2.2 Atmospheric Emissions

In the UK ESA, Table 2.2 contains data on acid rain precursors including emissions of SO2, NOx and ammonia, measured in tonnes of SO2 equivalent. The REWARD database holds data on emissions of SO2 and NOx, but not ammonia, however data is held in terms of tonnage of emissions of each gas. Therefore it was necessary to convert the emissions of NOx into SO2 equivalent, using the following conversion factor from the Institute for Applied Ecology (www.oeko.de/oekodoc/151/2003-039-en.pdf):

1 tonne NOx = 0.7 tonnes SO2 equivalent

Acid rain precursors in Table W2.2 do not include ammonia emissions and it was not possible to obtain data on emissions of Benzene, Butadiene, Lead, Cadmium or Mercury, since these are not included in the REWARD database.

Table W2.2
Atmospheric Emissions (weight in thousand tonnes unless otherwise stated)

	Wales (2003 Emissions Summary)										UK (2003 Emissions Summary)									
Source	**Greenhouse gases1**	**Acid rain precursors2**	**PM103**	**CO4**	**NMVOC5**	**Benzene**	**Butadiene**	**Lead (tonnes)**	**Cadmium (tonnes)**	**Mercury (tonnes)**	**Greenhouse gases1**	**Acid rain precursors2**	**PM103**	**CO4**	**NMVOC5**	**Benzene**	**Butadiene**	**Lead (tonnes)**	**Cadmium (tonnes)**	**Mercury (tonnes)**
Agriculture	3,821	1.1	0.6	2.8	23.3	-	-	-	-	-	48,413	490.1	17.8	24.9	76.3	0.1	0.0	0.1	0.0	0.0
Mining and quarrying	848	1.9	16.5	9.0	1.9	-	-	-	-	-	30,500	65.2	10.5	47.6	198.6	0.3	0.0	0.2	0.1	0.0
Manufacturing	22,385	64.5	4.6	241.9	29.0	-	-	-	-	-	129,267	436.8	35.9	771.4	355.3	2.9	0.5	97.7	4.0	3.4
Electricity, gas and water supply	11,258	42.8	0.7	4.4	2.1	-	-	-	-	-	192,598	938.2	11.3	92.3	54.7	0.6	0.0	22.8	0.6	1.8
Construction	177	1.2	0.3	7.9	2.8	-	-	-	-	-	7,392	21.9	6.1	39.6	56.7	0.1	0.1	4.1	0.0	0.0
Wholesale and retail trade	636	1.5	0.2	6.5	5.3	-	-	-	-	-	17,523	44.8	5.2	50.5	74.1	0.2	0.1	0.2	0.0	0.0
Transport and communication	1,600	8.7	0.6	9.0	2.1	-	-	-	-	-	95,745	855.1	18.4	155.3	46.4	3.2	0.8	4.2	3.2	0.2
Other business services	430	1.0	0.1	6.2	0.8	-	-	-	-	-	6,964	14.9	2.1	45.6	4.9	0.1	0.0	0.1	0.1	0.0
Public administration	448	1.1	0.1	0.8	0.1	-	-	-	-	-	9,514	33.3	1.2	28.4	2.4	1.7	1.5	0.4	0.1	0.0
Education, health and social work	387	0.8	0.1	1.1	0.2	-	-	-	-	-	10,992	17.1	0.8	6.3	1.8	0.0	0.0	0.3	0.1	0.0
Other services	988	0.5	0.1	1.1	0.7	-	-	-	-	-	15,807	45.0	1.5	33.1	12.9	0.9	0.0	0.4	0.0	1.9
Domestic	7,552	20.3	2.7	156.1	27.8	-	-	-	-	-	157,612	312.1	38.1	1549.7	291.8	11.0	1.1	6.1	0.4	0.2
Total	**50,530**	**145.5**	**26.6**	**446.8**	**96.2**	**-**	**-**	**-**	**-**	**-**	**722,328**	**3274.6**	**148.9**	**2844.7**	**1175.8**	**21.2**	**4.3**	**136.8**	**8.5**	**7.5**
Of which, emissions from road transport	1,661	7.3	0.8	15.7	3.0	-	-	-	-	-	127,804	479.3	38.6	1366.3	162.7	2.0	1.9	2.0	0.4	0.0

SOURCE: The REWARD project (www.reward-uk.org) and UK ESA
NOTES:
1 Carbon dioxide, methane, nitrous oxide, hydro-fluorocarbons, perfluorocarbons and sulphur hexafluoride expressed in thousand tonnes of carbon dioxide equivalent.
2 Sulphur dioxide, nitrogen oxides and ammonia expressed as thousand tonnes of sulphur dioxide equivalent (does not include Ammonia for Wales).
3 PM10s are carbon particles in air arising from incomplete combustion.
4 Carbon monoxide.
5 Non-methane Volatile Organic Compounds including benzene and 1,3-butadiene.

3.2.2 Table W2.3 Greenhouse gas and acid rain precursor emissions

Table 2.3 in the UK ESA provides a time-series of data on greenhouse gas emissions and acid rain precursor emissions, going back to 1990. A limited set of data relating to Wales can be accessed through the National Environmental Technology Centre for Gas Emissions (NETCEN). NETCEN provide a time series of data on emissions by type of greenhouse gas, measured in tonnes of carbon equivalent. It was necessary to convert this to tonnes of CO2 equivalent in order to be compatible with the UK ESA table 2.3. The Greenhouse Gas Inventories for England, Scotland, Wales and Northern Ireland, 1990-2003' published by NETCEN in September 2005 using the following conversion:

'To convert emissions expressed in weight of carbon, to emissions in weight of carbon dioxide, multiply by 44/12'

The main limitation of this dataset is that it presents the total for all of Wales, without any industry breakdown. Furthermore, data is only available for greenhouse gas emissions, not acid rain precursor emissions. It is also important to note that strictly these figures are not on a national accounts basis, as they do not include estimates of emissions from residents abroad. However, emissions for Wales from residents abroad would be near impossible to measure, and it is reasonable to assume emissions from residents abroad accruing to Wales will be small.

Table W2.3
Greenhouse Gas and Acid Rain Precursor Emissions in Wales

Source	1990	1995	1997	1998	1999	2000	2001	2002	2003
Greenhouse Gases - CO2, CH4, N2O, HFC, PFCs, and SF6 [1]									
Agriculture	-	-	-	-	-	-	-	-	3,821
Mining and quarrying	-	-	-	-	-	-	-	-	848
Manufacturing	-	-	-	-	-	-	-	-	22,385
Electricity, gas and water supply	-	-	-	-	-	-	-	-	11,258
Construction	-	-	-	-	-	-	-	-	177
Wholesale and retail trade	-	-	-	-	-	-	-	-	636
Transport and communication	-	-	-	-	-	-	-	-	1,600
Other business services	-	-	-	-	-	-	-	-	430
Public administration	-	-	-	-	-	-	-	-	448
Education, health and social work	-	-	-	-	-	-	-	-	387
Other services	-	-	-	-	-	-	-	-	988
Domestic	-	-	-	-	-	-	-	-	7,552
Total greenhouse gas emissions	**52,433**	**49,133**	**Na**	**51,700**	**51,700**	**54,633**	**51,700**	**48,033**	**50,530**
Of Which Emissions from Road Transport	-	-	-	-	-	-	-	-	1,661

Table W2.3 (continued)
Greenhouse Gas and Acid Rain Precursor Emissions in Wales

Source	1990	1995	1997	1998	1999	2000	2001	2002	2003
Acid Rain Precursor emissions - SO2, Nox, NH3 [2]									
Agriculture	-	-	-	-	-	-	-	-	1.1
Mining and quarrying	-	-	-	-	-	-	-	-	1.9
Manufacturing	-	-	-	-	-	-	-	-	64.5
Electricity, gas and water supply	-	-	-	-	-	-	-	-	42.8
Construction	-	-	-	-	-	-	-	-	1.2
Wholesale and retail trade	-	-	-	-	-	-	-	-	1.5
Transport and communication	-	-	-	-	-	-	-	-	8.7
Other business services	-	-	-	-	-	-	-	-	1.0
Public administration	-	-	-	-	-	-	-	-	1.1
Education, health and social work	-	-	-	-	-	-	-	-	0.8
Other services	-	-	-	-	-	-	-	-	0.5
Domestic	-	-	-	-	-	-	-	-	20.3
Total greenhouse gas emissions	-	-	-	-	-	-	-	-	**145.5**
Of Which Emissions from Road Transport	-	-	-	-	-	-	-	-	7.3

SOURCE: The REWARD project (www.reward-uk.org), NETCEN (National Environmental Technology Centre for Gas Emissions) and UK ESA
NOTES:
1 Carbon dioxide, methane, nitrous oxide, hydro-fluorocarbons, perfluorocarbons and sulphur hexafluoride expressed in thousand tonnes of carbon dioxide equivalent.
2 Sulphur dioxide, nitrogen oxides and ammonia expressed as thousand tonnes of sulphur dioxide equivalent (does not include Ammonia for Wales).

3.3 Bridging table: atmospheric emissions (ESA: 2.4)

What is the table about?

The table converts the greenhouse gas emission estimates in ESA 2.2 into a format suitable for reporting to the Intergovernmental Panel on Climate Change (IPCC).

Our approach

The bridging table requires data that are not available for Wales, for example emissions made by residents abroad and emissions from deforestation, soils and changes in forest and other woody biomass. The bridging table was not produced for Wales, however this table is not directly relevant for Wales.

3.4 Material flow accounts (ESA: 2.5)

What is the table about?

The Material Flow Accounts (MFA) estimates flows of (raw, natural) materials between the environment and economy of the UK and vice versa, as the former provides inputs that are then consumed in economic production, and outputs that flow from the economy into the environment (for example as waste).

The account also estimates the levels of materials that are imported and exported to/from the UK, such that an overall account can be made of material:

- Inputs (UK extraction + imports);
- Consumption (UK extraction + imports – exports); and
- Total material requirement (direct input + indirect and hidden flows).

The account only examines flows at the *boundary* of the economy and environment. Thus, inter-industry material flows are not addressed.

Our approach

The pilot table is drawn from two sources. The minerals data is drawn from the *Aggregates Minerals Survey* for England and Wales published by the British Geological Survey on behalf of ODPM. This survey has been carried out at 4-year intervals since 1973. The remainder of the data is drawn from the Stockholm Environment Institute report for WWF Cymru *"Reducing Wales' Ecological Footprint - A Resource accounting tool for sustainable consumption"* published in 2003.

The minerals data is drawn from a relatively comprehensive survey that benefits from extremely high response rates, and thus it is likely that quality should not be a significant issue at the regional level.

The remainder of the table is more problematic. The data in the Ecological footprint report is largely modelled, rather than actual, using proxy indicators such as the road transport of goods by region. Moreover, the positioning of the MFA as 'complementary' to Footprint analysis may mean that modelling was not as rigorous as it might have been. For example, in the fossil fuels section the initially derived MFA had a modelled 12.6m tonnes of natural gas and crude oil attributable to Welsh domestic extraction. This was removed from the table because whilst there are sea areas close to Wales under license for gas extraction, few have been commercially exploited to date. Moreover, estimates for fish-related and timber biomass do not correspond with estimated tonnages in the fish stocks account, and the wood based inputs elements of the pilot account. Additionally, the WWF report makes no estimate of hidden flows that are included in the MFA for the UK – and as such, a full MFA cannot be derived.

Although Table W2.5 is largely modelled, the methodology employed follows the approach used to construct the equivalent table for the UK. The UK table also relies on significant modelling inputs rather than empirical data alone.

The MFA for the UK is estimated for every year, currently ending at 2004. The Wales partial MFA and regional import-export balance is currently estimated for 2001, although some elements (e.g. on minerals and coal production) would be available for later years. There is currently little possibility of producing an MFA time series for Wales. Minerals data will likely continue to be updated by BGS for UK government departments. The WWF report however was sponsored by Biffaward on a 'one off' basis, and whilst other developments of the Footprint have been undertaken, it is unlikely that this source would (or indeed should) comprise the basis for an MFA for Wales going forward.

Table W2.5 reveals the estimated components of Wales' material flows. In 2001, estimated biomass was 1.94m tonnes, this largely made up from agricultural related extractions. Mineral extraction is dominated by crushed stone from quarries. The total minerals output here is a modelled estimate. Fossil fuels extractions were limited to an estimated 3.11m tonnes of coal. In total estimated domestic extraction was 34.2m tonnes. Total imports of materials were estimated at 4.07m tonnes, with exports of 9.83m tonnes, with much of this in terms of aggregates. The estimate of domestic material requirement was around 38m tonnes in 2001.

Table W2.5
Materials Flows

	2001 (partial balance) millions of tonnes
Domestic extraction	
Biomass	
Agriculture Total	1.36
Agricultural harvest	*Na*
Animal grazing	*Na*
Timber (potentially an under-estimate see W1.4.1)	0.55
Fish (potentially an overestimate – see W1.5.1)	0.04
Total biomass	**1.94**
Minerals	
Ores	Na
Clay	Na
Other industrial minerals	Na
Primary Aggregates*	19.88
*Sand and Gravel**	*2.68*
*Crushed Stone**	*17.20*
Total minerals (ex metals) *modelled output*	**29.13**
Fossil fuels	
Coal	3.11
Natural gas	Na
Total fossil fuels	**3.11**
Total domestic extraction	**34.20**

Table W2.5
Materials Flows (continued)

	2001 (partial balance) millions of tonnes
Imports	
Biomass	2.26
Primary Aggregates*	1.24
*Sand & Gravel**	*0.33*
*Crushed Rock**	*0.91*
Fossil fuels - coal	0.58
Fossil fuels - other	Na
Other Products	Na
Total imports	**4.07**
Exports	
Biomass	0.91
Primary Aggregates*	6.28
*Sand & Gravel**	0.55
*Crushed Rock**	5.74
Fossil fuels - coal	2.63
Fossil fuels - other	Na
Other Products	Na
Total exports	**9.83**
Indirect flows	
- from domestic extraction (excl soil erosion)	Na
Of which:	
unused biomass	Na
fossil fuels	Na
Minerals and ores	Na
soil excavation and dredging	Na
- from production of raw materials and semi-natural products imported	Na
Indicators - Partial balances as noted above	
Physical Trade Balance (exports - imports)	5.75
DIRECT MATERIAL INPUT (domestic extraction + imports)	38.27
DOMESTIC MATERIAL CONSUMPTION (domestic extraction + imports - exports)	28.44
TOTAL MATERIAL REQUIREMENT (direct material input + indirect flows)	Na

Source: Stockholm Environment Institute (2005) ***Reducing Wales' Ecological Footprint - A Resource accounting tool for sustainable consumption*** **Cardiff: WWF Cymru except *: British Geological Survey (2003)** ***Collation of the Results of the Aggregates Minerals Survey for England and Wales, 2001*** **for Office of the Deputy Prime Minister, CR/03/53N, Nottingham: BGS**
Notes:
1.Figures for production of primary aggregates from ***Aggregates Minerals Survey, 2001*****. Figures for total mineral production from** ***Stockholm Environment Institute*** **and thus not comparable but both reproduced for completeness.**
2.Mineral import-export totals primarily inter-regional but will include small international flows. I-E balance and direct material requirement produced for available elements only.

3.5 Waste arisings (ESA: 2.6)

What is the table about?

The table contains information on levels and types of waste arising from industries and municipal/household activities. Some information is also available on exports and imports of waste.

Our approach

A number of data sources have been used to construct this table, namely:

- Commercial and Industrial Waste survey 2002/3 Wales, DEFRA/Cardiff University BRASS centre;
- Municipal Waste Survey 2004/05, Environment Agency Wales; and
- Construction and Demolition waste data, SmithsGore/Welsh Assembly Government.

Data from the Commercial and Industrial Waste survey was provided by the Environment Agency. This survey presents data for 21 industrial sectors, by 16 waste types, and replicates a similar survey undertaken in England by the Environment Agency. After consultation with a contact in the Environment Agency (England) we were able to establish how the 16 waste types in the survey were amalgamated to form the 7 waste types reported in the UK ESA, as follows:

UK ESA waste categories	Commercial and Industrial Waste Survey waste categories
Inert, construction & demolition	Construction and demolition
Paper & Card	Paper & card
Animal & Vegetable	Food Other animal and vegetable Waste
General	Sorting residues Other mixed general waste
Metal and Scrap Equipment	Metallic Waste Discarded equipment

UK ESA waste categories	Commercial and Industrial Waste Survey waste categories
Mineral	Combustion wastes Other mineral waste
Other Waste	Oils & solvents Paints, varnishes etc. Industrial sludges Other chemical wastes Other non-metallic, non-mineral waste

The main limitation with this dataset is that it does not include data on the following sectors:

- Agriculture;
- Mining & Quarrying;
- Construction; and
- Households.

The Municipal Waste Survey 2004/05 provides headline time-series data on the level of household waste in Wales. We have used the data point for 2002-03 for consistency with the rest of ESA table 2.6 (hence 1,488 thousand tonnes of waste). This source only provides the headline figure for total household waste, not waste by type.

We have been able to access Construction and Demolition waste data collected by SmithsGore through the Environment Agency Wales. This gives a total figure of 6,014,000 tonnes of construction and demolition waste arising in Wales in 2003. As in the UK ESA table 2.6, a small amount of construction and demolition waste arises from sectors other than the construction sector.

We have identified data on construction and demolition waste arising in a number of sectors through the Commercial and Industrial waste survey, however, as noted above, this does not cover all sectors. Nonetheless, we have been able to compute a figure for the level of construction and demolition waste arising in the construction sector with a reasonable level of accuracy (by subtracting waste for other sectors from the C&I waste survey from the SmithsGore data total).

Lastly, whilst we acknowledge that there are still some data points missing from the table, we have computed a total for all waste arising in Wales, as follows:

Total waste highlighted in C&I waste survey	5,272 thousand tonnes
Total household waste (from municipal waste survey)	1,488 thousand tonnes
C&D waste arising in the construction sector	5,952 thousand tonnes
Total	**12,712 thousand tonnes**

Table W2.6 is shown below with equivalent waste arisings data from the UK ESA (Table 2.6). Waste arisings for Wales reflect the industrial structure of the Welsh economy with Wales responsible for over one third of all waste arisings in the UK metal products sector. Wales also accounts for over one tenth of all waste arisings in the UK waste water services sector.

Table W2.6 Total waste arisings

	Wales (thousand tonnes, 2002/03)								UK (million tonnes, 2002/03)							
	Inert, Construction Demolition	Paper, Card	Animal & Vegetable	General	Metal & Scrap Equipment	Mineral	Other Waste	Total	Inert, Construction Demolition	Paper, Card	Animal & Vegetable	General	Metal & Scrap Equipment	Mineral	Other Waste	Total
Agriculture	-	-	-	**Na**	-	-	-	-	-	-	-	0.4	-	-	-	0.4
Mining & Quarrying	-	-	-	-	-	**Na**	-	-	-	-	-	-	-	95.9	-	95.9
Food Drink & Tobacco	0	18	210	95	2	0	7	332	-	0.3	4.9	2.2	0.1	0.8	0.3	8.6
Textiles & Clothing	-	2	0	10	0	0	3	16	-	-	-	0.8	-	-	0.6	1.5
Pulp, Paper, Printing & Publishing	1	71	0	85	1	5	198	360	-	2.3	-	1.9	0.1	0.1	0.4	4.7
Chemicals	2	28	0	60	2	2	71	164	0.1	0.2	-	1.4	0.1	0.1	4.3	6.2
Non-metallic mineral products	18	3	0	20	0	9	6	56	0.8	-	-	0.3	0.2	1.3	-	2.7
Metal products	1	2	0	187	11	2505	35	2742	0.1	0.1	-	0.6	1.4	4.9	0.5	7.5
Machinery & Equipment	1	12	0	78	9	5	53	157	-	0.2	-	0.7	0.4	0.3	0.2	1.7
Transport Equipment	4	3	0	43	15	2	15	82	-	0.1	-	0.5	0.9	0.2	0.1	1.7
Other Manufacturing	0	7	0	41	1	0	35	84	-	0.1	-	2.3	0.1	-	-	2.5
Electricity, Gas & Water supply	0	0	0	4	1	240	3	248	-	-	-	0.3	0.1	7.1	0.3	7.8
Construction	5952	-	-	-	-	0	-	5952	105.6	-	-	-	-	16.6	-	122.1
Wholesale & Retail	5	78	12	118	14	1	38	266	0.1	4.2	1.9	7.3	0.6	-	0.4	14.7
Hotels & Catering	4	8	3	144	2	0	24	185	-	0.2	0.2	3.5	-	-	0.1	4.0
Transport & Communications	3	5	13	27	5	0	12	64	-	0.4	0.1	1.4	0.1	-	0.4	2.5
Finance & Other Services	16	23	1	110	10	67	14	242	0.5	1.3	0.1	5.3	0.2	0.2	0.5	8.0
Public Administration, Health & Education	4	14	6	108	1	0	14	147	0.2	0.8	0.2	3.7	0.1	-	0.9	5.9
Waste Water Services	3	5	26	50	1	0	44	129	-	-	1.1	-	-	-	-	1.1
Households	-	72	77	1281	29	29	-	1488	-	1.5	1.6	26.6	0.6	0.6	-	30.9
Total Waste Arisings	6014	353	348	2461	103	2863	571	12712	107.5	11.5	10.1	59.4	4.9	128.1	9.0	330.4

SOURCE: Commercial and Industrial Waste survey 2002/3 Wales, DEFRA/Cardiff University BRASS centre, Municipal Waste Survey 2004/05, Environment Agency Wales, Construction and Demolition waste data, SmithsGore/Welsh Assembly Government, UK ESA
NOTES: By convention a dash indicates zero, however minimal waste is undoubtedly generated by these sectors

Wales ESA 2.7 Stock and disposals of radioactive waste by source

3.6 Radioactive waste (ESA: 2.7)

What is the table about?

The table documents the stocks and arisings of radioactive waste according to level of contamination – low, intermediate or high – and origin – nuclear fuel, medicinal and defence-related. Unlike some other countries, the ESA does not distinguish between the half-lives of the materials involved.

Our approach

Table W2.7 shows the stock of radioactive waste by type (high level, intermediate level, low level), and disposals of low-level waste. Data is produced by Electrowatt-Ekono Ltd, and is accessible through NIREX (www.nirex.co.uk). The relevant reports provided by NIREX were as follows:

- 2004 UK Radioactive Waste Inventory – Main Report; and
- UK Radioactive Waste Inventories for 1990, 1991, 1994, 1998 & 2001.

For the UK, we were able to update the UK ESA table 2.7 to reflect the latest data available through the 2004 waste inventory report. For Wales, it was possible to report the majority of data required for table 2.7 for the years 1991, 1994, 1998, 2001 and 2004.

The main sources of radioactive waste in Wales are:

- Trawsfynydd power station;
- Wylfa power station; and
- Amersham International (Cardiff based, medical waste).

Overall, it was possible to report the stocks of intermediate and low-level waste by type, and size as stored and when conditioned. There are no radioactive waste arisings from defence in Wales and neither are there stocks of high-level radioactive waste. Disposals of intermediate-level waste in Wales were only presented in the 1990 report, which did not provide any of the other information listed above.

Table W2.7 shows the total stock of all radioactive waste in Wales has risen from just over 2,500 million cubic metres of waste in 1991 to nearly 3,300 million cubic metres of waste in Wales by 2004.

Table W2.7 Stock and disposals of solid radioactive waste by source (all units are cubic metres)

		Wales						UK					
		1990	**1991**	**1994**	**1998**	**2001**	**2004**	**1990**	**1991**	**1994**	**1998**	**2001**	**2004**
Stock of high level waste[2]													
Nuclear fuels													
As stored[3]			0	0	0	0	0		1,686	1,639	1,804	1,766	1,890
When conditioned[4]			0	0	0	0	0		681	653	717	195	
Stock of intermediate level waste[5]													
As stored[3]	Nuclear fuels		2,346	2,270	2,038	2,029	2,528		49,232	58,459	67,262	70,826	77,698
	Medicinal		130	162	170	189	213		380	290	293	358	592
	Defence		0	0	0	0	0		1,946	2,745	3,393	4,092	4,210
	Total		**2,476**	**2,432**	**2,208**	**2,218**	**2,740**		**51,558**	**61,494**	**70,948**	**75,276**	**82,500**
When conditioned[4]	Nuclear fuels		**Na**	2,670	5,539	3,123	**Na**		75,931	63,020	71,133	71,141	
	Medicinal		**Na**	162	170	189	**Na**		605	597	293	345	
	Defence		**Na**	0	0	0	**Na**		1,976	2,485	2,705	2,886	
	Total		**Na**	**2,832**	**5,709**	**3,311**	**Na**		**78,512**	**66,102**	**74,131**	**74,372**	
Disposals of low level waste[6]													
	Nuclear fuels	214							22502				
	Medicinal								1055				
	Defence								1543				
	Total	**214**						**32,500**	**25,100**	**26,300**	**12,600**	**6,100**	**11,200**
Stock of low level waste[3]													
	Nuclear fuels		38	170	161	633	558		4,998	5,801	6,287	12,654	18,441
	Medicinal		18	5	0	0	0		55	5	0	0	259
	Defence		0	0	0	0	0		1,199	2,076	1,696	1,650	2,200
	Total		**56**	**175**	**161**	**633**	**558**		**6,252**	**7,882**	**7,983**	**14,304**	**20,900**
Total stock of all radioactive waste			**2,532**	**2,607**	**2,369**	**2,851**	**3,298**		**59,496**	**71,015**	**80,735**	**91,346**	**105,290**

SOURCE: 2004 UK Radioactive Waste Inventory - Main Report, UK Radioactive Waste Inventories for 1990, 1991, 1994, 1998 & 2001, UK ESA

NOTES:
Latest Radioactive Waste Inventory data have been added to the UK ESA data
1 UK figures for stocks of waste only available from inventories for January 1991, April 1994 and April 1998.
2 High level waste comes from the reprocessing of irradiated nuclear fuel.
3 "As stored" is the form in which the waste is currently stored, except for low level waste, which is the estimated volume after supercompaction. Most low level waste is in short term storage prior to disposal.
4 "When conditioned" is the estimated volume when waste is converted into a form in which it is placed in long term storage.
5 Intermediate level waste has a lower radioactivity content and heat output than high level waste, but a radioactivity content which exceeds the upper limits for low level waste.
6 Up to and including 1993 UK figures are net waste volumes, and from 1994 are packaged waste volumes. Supercompaction was introduced in 1995 for all wastes sent to Drigg. This has significantly reduced volumes of disposals. The breakdown by source is not available after 1993.

3.7 Consumption of water resources by industry sector (ESA: 2.8)

What is the table about?

This table provides information on domestic consumption of water (from supplies of public water, groundwater abstraction and non-tidal waters abstraction) by industrial sector. The latest table in the *Environmental Accounts* Autumn 2005 gives data for 1997-98.

Our approach

In developing consumption of water resources by industrial sector for Wales, reports by the Environment Agency (*Water Resources for the Future: a Strategy for England & Wales*, March 2001) and AEAT (*Key Industrial Environmental Pressures- Water Use*, November 2002) were used as key source material.

The Environment Agency water resources strategy document contains regional data (by Environment Agency area) for 1997/8, the same year as the UK figures in the latest version of the UK ESA, and includes breakdowns by public water supply and direct abstraction. Water use is described by major industrial categories. These are more general than those appearing in the UK table. Therefore, to supplement this original source, data from the AEAT was used.

This latter report (which was compiled for the Environment Agency and is published under the REWARD banner) produced figures for the political Wales region, for domestic consumption and industrial use, by a number of standard industrial classifications. However, the AEAT did not publish breakdowns by public water supply and direct abstraction due to issues such as accuracy of datasets and conflicts of different categorisation systems (each water supply company having a distinctive classification system for its distribution by industry, indicative of the local industrial make-up). Furthermore, as data from the Severn Trent water supply company (who cover the north of Powys and a small section of Gwynedd) was absent from the AEAT study, it was decided to use the findings of this report to help balance and fill gaps in the data from the Environment Agency only.

Control totals for water consumption in Wales were informed by the Environment Agency Water Resources Strategy document, in particular:

- Components of non-tidal demand [Table 3.4 in the document];
- Direct abstraction by primary industry [Table 3.5]; and
- Public water supply – non-household [Table 3.6].

Supplemental data from the AEAT study (Table 5 *RDA and Welsh Industrial Use of Water in ML/d by RDA and Wales Industrial SIC-92 sector*) was added. It is worth noting that although the AEAT study estimates were for 1999 they were themselves based on 1998 data, which had been scaled-up. In this exercise "…most changes were minimal and thus did not have a great effect on the overall usage figures…".

Assumptions in Categories:

Agriculture and fisheries- The Environment Agency water resources strategy noted that limited attention had been paid to agricultural use of water besides spray irrigation. Data from the AEAT study was thus incorporated to account for animal watering, chemical spray dilution, cleaning etc., with the ratio of public water supply to direct abstraction being informed by the UK ESA section. In the absence of detailed information on the sector, fisheries were grouped with agriculture.

Rubbers and plastic/ Mineral products- The more detailed breakdown of the AEAT report was utilised to produce estimates for these categories- SIC 25 and 26 respectively (in order to constrain to control totals these additions were balanced by subtractions from the metal manufacturing and products sector which evidence from the AEAT study would suggest may be over-inflated). Proportional splits for public water supply and direct abstraction were calculated from the UK ESA.

Manufacture, machinery and Transport equipment- This category was derived from the engineering figure in the Environment Agency water resources strategy. "Manufacture and machinery" and "Transport equipment" are separate categories in the UK ESA but were combined here because of a lack of a detailed breakdown.

Electrical equipment- The AEAT study divisions of "office machinery & PCs" (SIC30), "Electrical machinery" (SIC 31), and "Radio, TV & Communications" (SIC 32) were combined to estimate this category.

Other manufacturing including recycling- This figure was calculated from the remainder of the Environment Agency Water Resources Strategy "Business Services" category after "wholesale, hotels and catering" and "electrical equipment" had been subtracted.

Wholesale, hotels and catering- The AEAT study hotels SIC 55 division was used as the basis for this category.

It should be further noted that figures for power generation have not been included in the table due to the massive quantities of water used in Wales for hydroelectric schemes – where the same water is used over and over again (estimated at 9,771 million litres a day in 1997/98 by the Environment Agency).

An attempt was made to build up a table for a more recent time period than 1997/8. The Environment Agency's National Water Demand Management Centre, which collates water use statistics from the water supply companies, require the permission of the companies to release this data to third parties. At the present time, of the three water supply companies covering the Wales area, DwrCymru, Severn Trent and Dee Valley, permission to access such data had only been granted from the latter.

If these requests were granted and the information supplied there would potentially be significant work involved to group together this data into the required categories, in order to recreate ESA 2.8. In the meantime, the table below is a best-estimate for Wales (excluding at it does some data for north Powys and including some data for Herefordshire to cover the Environment Agency Wales boundary).

The 2004 figures in the final column are estimated. The basis for the estimate is figures for industrial consumption of water per £m GVA for 1997-98. These estimates are then applied to deflated Welsh industry GVA figures for 2004. Clearly this assumes the technical coefficients for water use did not change in the six year period to 2004, and we assume no efficiency savings in the period. The footnote to the Table W2.8 also shows the process for estimating domestic consumption for 2003-04.

The table provides evidence on how recent changes in the industrial structure of Wales are changing patterns of water consumption. Reductions in GVA in selected manufacturing sectors are working to reduce water consumption, particularly in metal manufacturing and electricals. Losses due to leakages are falling, whilst consumption in elements of the non-market economy are increasing. The overall effects of industrial change are to reduce water consumption to an estimated 494 million cubic metres in 2004, a fall of 15%.

Domestic Use Estimates for Wales

	Population	**l/head/day**	**Million Litres Day**
Wrexham	129,700	151	19.6
Powys north	64,650	136	8.8
Powys south	64,650	149	9.6
Rest of Wales	2,679,000	149	*399.2*
Total consumption			**437.2**

Table W2.8
Industrial water consumption 1997-8 (Millions cubic metres)

	Public water supply	Direct abstractions from groundwater and non-tidal waters	Total groundwater and non-tidal abstractions, 1997-8	Estimated total g/water and non-tidal abstractions 2004
Agriculture & fisheries	0.9	30.3	31.2	32.2
Mining and extraction	0.0	3.5	3.5	2.0
Food, drink and tobacco	9.6	6.8	16.4	15.5
Textiles	0.0	2.2	2.2	1.0
Pulp, paper, printing and publishing	0.0	8.7	8.7	8.0
Fuel processing	0.0	0.0	0.0	0.0
Chemicals	10.8	2.5	13.3	12.7
Rubbers and plastics	0.0	4.7	4.7	3.6
Mineral products	0.5	3.2	3.7	3.5
Metal manufacturing and products	7.8	134.8	142.6	75.7
Manufacture and machinery/ Transport equipment	9.1	0.2	9.3	8.5
Electrical equipment	21.4	0.0	21.4	15.2
Other manufacturing including recycling	8.6	0.0	8.6	7.2
Unspecified industry	0.0	0.0	0.0	0.0
Electricity and gas production	0.0	0.0	0.0	0.0
Water supply [1] inc leakage	124.1	0.0	124.1	113.6
Construction	0.3	0.3	0.5	0.8
Wholesale, hotels and catering	6.3	0.0	6.3	7.1
Education and health	10.9	0.0	10.9	14.8
Other services	10.6	0.0	10.6	13.3
Domestic	160.6	0.0	160.6	159.6
Other abstractions	0.0	0.0	0.0	0.0
Statistical discrepancies	0.0	0.0	0.0	0.0
Total use of groundwater and non-tidal waters	**381.5**	**197.0**	**578.5**	**494.3**

Source:
Environment Agency "Water Resources for the Future: a Strategy for England & Wales" March 2001. Chapter 3: *State of water resources*
www.environment-agency.gov.uk/commondata/acrobat/national_report_english.pdf
Tables *3.2, 3.4, 3.5 & 3.6* AEAT report for the Environment Agency "Key Industrial Environmental Pressures- Water Use" November 2002.
www.wwflearning.org.uk/data/files/water-use-166.pdf

Notes:
2004 Water Supply: leakage estimate*:* OFWAT figures for England & Wales indicate a decrease in leakages & distribution loss of 8.5% from 1997/8 to 2003/4 (from 3,989 Ml/d in 1997/8 to 3,649 Ml/d in 2003/4). Therefore the 1997/8 estimate for Wales has been adjusted down accordingly for 2003/4
www.defra.gov.uk/environment/statistics/inlwater/download/xls/iwtb26.xls
2003-04 Domestic water use: estimate Calculated by proportioning Water Supply Company estimates from OFWAT (l/head/d) to Welsh UA populations Population Mid-Year-Estimates (ONS) for 2003. Total = 437.2 Ml/d, which = 159.6 million cubic metres

4 Monetary accounts

4.1 Government revenue from environmental taxes (ESA: 3.1)

What is the table about?

The table provides time-series information on the proceeds from energy, transport, pollution and resource environmental taxes. It also details the extent of environmental taxes as a percentage of all taxes, and as a percentage of Gross Domestic Product (GDP). The latest table in the *Environmental Accounts* Autumn 2005 gives data for the period 1993-2004.

An Environmental tax is defined as a tax whose base is a physical unit (or a proxy for it) that has a proven negative impact on the environment. In addition to pollution related taxes, all energy and transport taxes are classified as environmental taxes.

Our approach

Government revenues from environmental taxes are detailed in the UK ESA by broad section and detailed sub-sections. Our approach used a range of data sources to apportion UK government revenues from environmental taxes to Wales. This worked well for sub-sections for which reliable data were available. For example, the Department for Trade and Industry (DTI) publishes regional and local road transport consumption statistics (www.dti.gov.uk/energy/statistics/regional/index.html) including consumption of road fuel by region. This was useful in apportioning the duty on hydrocarbon oil such as petrol or diesel with VAT on duty at 17.5% for both Wales and the UK.

Reliable data were also available on vehicle ownership and excise duty, published by the Department for Transport in their Regional Transport Statistics series. (www.dft.gov.uk/stellent/groups/dft_transstats/documents/divisionhomepage/038060.hcsp)

Taken together; duty on hydrocarbon oil, VAT on duty and vehicle excise duty accounted for 92.3% of all UK government revenues from environmental taxes in 2003, the equivalent estimated figure for Wales is 93.7%, as shown in Table W3.1. Given the significant coverage of all government revenues from environmental taxes by the aforementioned sub-sections the estimates for Wales are reasonable.

Other useful sources of data were used to apportion taxes to Wales; the Civil Aviation Authority publishes the number of passengers on domestic and international flights from Cardiff International Airport. Passenger numbers were used to estimate air passenger duty for Wales. All other sub-sections were estimated using ABI data or turnover data from Input-Output Tables for Wales covering energy sectors and extraction activities.

Table W3.1
Government revenues from environmental taxes (£ millions)

Section	Sub-section	Wales		UK	
		2002	2003	2002	2003
Energy					
	Duty on hydrocarbon oil	1,041	1,069	22,070	22,476
	VAT on duty	182	187	3,862	3,933
	Fossil fuel levy	1	0	32	0
	Gas levy	-	-	-	-
	Climate change levy	33	33	825	828
	Hydro-benefit	2	2	44	44
Road vehicles					
	Vehicle excise duty	196	213	4294	4595
Other environmental taxes					
	Air passenger duty	7	7	814	781
	Landfill tax	31	35	541	607
	Aggregates levy	15	24	213	340
Total environmental taxes		**1,506**	**1,567**	**32,695**	**33,604**

SOURCE:
Input-Output Tables for Wales, Civil Aviation Authority, Department for Transport, Regional Transport Statistics, National Assembly for Wales: Municipal Waste Management Survey 2003-04: Results of the Survey for Wales, Management of Municipal Waste in 1996/97 to 2003/04 by Region and Authority Type, Scottish Environment Protection Agency: Waste Data Digest, Annual Business Inquiry (part 2, financial data), DTI, Regional and local road transport consumption statistics and UK ESA

Table W3.1 suggests that government revenues from environmental taxes account for a higher proportion of the economy in Wales compared to the UK but per capita taxes in Wales are lower.

Government revenues from environmental taxes % of GVA				Government revenues from environmental taxes per capita			
Wales		UK		Wales		UK	
2002	**2003**	**2002**	**2003**	**2002**	**2003**	**2002**	**2003**
4.3%	4.2%	3.5%	3.4%	£515	£536	£551	£566

SOURCE: Experimental ESA for Wales Table W3.1 (DTZ and Cardiff Business School), Regional GVA (ONS), and Mid-year population estimates (ONS)

4.2 Environmental taxes breakdown by industry (ESA: 3.2)

What is the table about?

This table provides information on the total environmental tax revenue from the main manufacturing and service industries, the household sector and the rest of the world. Taxes are divided in the table into four main categories: *energy products*; *transport*; *pollution;* and *resources*. The latest table in the *Environmental Accounts* Autumn 2005 provides data for 2002.

Our approach

Environmental taxes breakdown by 13 industries in the UK ESA are based on Table 3.1 with total government revenues from environmental taxes equal to total environmental taxes by industry. Sub-sections from Table 3.1 are reorganised into the following categories:

- Energy;
- Transport;
- Pollution; and
- Resources.

Effectively Table W3.2 restates Table W3.1 although environmental taxes associated with resources are only borne by the mining and quarrying industry. An attempt was made to distribute environmental taxes based on the industrial structure of the Welsh economy but was unable to capture the difference in intensity of environmental taxation between sectors in Wales and the rest of the UK. Table W3.2 also shows environmental taxes associated with energy, transport, pollution and resources for Wales during 2003.

Table W3.2
Environmental taxes breakdown by 13 industries (£ million)

Industry	Wales (2002)					UK (2002)				
	Energy	Transport	Pollution	Resources	Total	Energy	Transport	Pollution	Resources	Total
Agriculture	**Na**	**Na**	**Na**	0	**Na**	234	49	2	0	285
Mining and quarrying	**Na**	**Na**	**Na**	24	**Na**	95	6	3	213	316
Manufacturing	**Na**	**Na**	**Na**	0	**Na**	1,533	115	93	0	1,741
Energy, gas and water supply	**Na**	**Na**	**Na**	0	**Na**	333	3	6	0	342
Construction	**Na**	**Na**	**Na**	0	**Na**	246	82	5	0	333
Wholesale and retail trade	**Na**	**Na**	**Na**	0	**Na**	2,142	204	45	0	2,390
Transport and communication	**Na**	**Na**	**Na**	0	**Na**	6,718	121	25	0	6,865
Other business services	**Na**	**Na**	**Na**	0	**Na**	1,426	186	60	0	1,672
Public administration	**Na**	**Na**	**Na**	0	**Na**	183	3	205	0	390
Education, health and social work	**Na**	**Na**	**Na**	0	**Na**	279	7	29	0	314
Other services	**Na**	**Na**	**Na**	0	**Na**	379	29	69	0	476
Households	**Na**	**Na**	0	0	**Na**	13,089	4,076	0	0	17,615
Rest of the world	**Na**	**Na**	0	0	**Na**	178	228	0	0	406
Total (2002)	**1,289**	**220**	**35**	**24**	**1,567**	**26,833**	**5,108**	**541**	**213**	**32,695**
Total (2003)	**1,257**	**203**	**31**	**15**	**1,506**	**27,281**	**5,376**	**607**	**340**	**33,604**

SOURCE: SOURCE: Experimental ESA for Wales Table W3.1 (DTZ and Cardiff Business School), Regional GVA (ONS), and Mid-year population estimates (ONS)

4.3 Environmental protection expenditure by the public sector (ESA: 3.3 & 3.4)

What are the tables about?

The tables provide information on how much the public sector spends annually on protecting the environment. Spending included in the survey is that incurred by the public sector where the primary aim is to reduce environmental pollution caused during normal operations. The definition of environmental protection expenditure has been agreed by all EU countries and includes the purchase price of capital goods, operational costs of environmental management/ control activities, and payments to others for environmental protection services. The latest tables in the Environmental Accounts Autumn 2005 give data for 2003 (ESA 3.3) and 2004 (ESA 3.4).

Our approach

Table W3.3 is based on Public Expenditure Statistical Analyses (PESA) data published by HM Treasury. The data shown in Table W3.3 is not strictly comparable with data in the UK Environmental Accounts. PESA uses a broader definition of environmental protection to that used in Environmental Accounts and so the figures in Table W3.3 are slightly higher.

To allow a direct comparison, PESA data for the UK are also shown in Table W3.3. Data available for the last 3 years suggests that environmental protection expenditure per head is higher in Wales compared to the UK (excluding expenditure outside of the UK).

TABLE W3.3
Environmental protection capital and current expenditure by public sector
(£ million)

	Wales			UK (excluding expenditure outside of the UK)		
	2003-04	**2004-05**	**2005-06**	**2003-04**	**2004-05**	**2005-06**
Environmental protection	397	438	433	5,562	6,345	7,698
Index of environmental protection expenditure by public sector per capita (£) UK = 100	145	140	114	-	-	-

SOURCE: HM Treasury, PESA and Mid-year population estimates (ONS)

4.4 Environment protection spending in industries (ESA: 3.5)

What is the table about?

This table provides information on how much industry spends annually on protecting the environment. Spending included in the survey is that incurred by companies where the primary aim is to reduce environmental pollution caused during normal operations (it does not include spending on health and safety).

The latest table in the Environmental Accounts Autumn 2005 gives data for 2003.

Our approach

Data for Table 3.5 in the UK ESA is based on a survey carried out by URS. DEFRA indicated that estimates by region are not available, and would not in any case be reliable because of the low response rate. It was therefore not possible to construct this table for Wales.

5 Linking an ESA to the economy

Overview

The terms of reference state that:

> *"As a part of this data review, the Contractor will be expected to also review and make appropriate recommendations on the role and value of Input-Output tables in the development and analysis of an experimental ESA for Wales."*

Use of environmental Input-Output in the UK has been limited to academic applications, with environmental modelling in public and private sectors comprising, for example, of national models to monitor and predict water and air pollution. Within the context of devolved regional government in the UK there is scope for an economic-environmental accounting and modelling framework.

A complete Environmental Input-Output (ENVIO) model would capture all interactions between the economy and the environment, and could be represented by the partitioned matrix below:

A_1	A_4
A_2	A_3

A_1 a matrix of coefficients representing economy-economy interactions;

A_2 a matrix of coefficients representing economy–environment transactions (showing the output of environmental good per unit of economic good);

A_3 a matrix of coefficients representing environment-environment interactions; and

A_4 a matrix of coefficients representing environment-economy transactions (showing the output of economic good per unit of environmental good).

Few practical studies incorporating all elements of the above model have been undertaken. Hence, only the more restricted approaches (that have usually involved the addition of the A_2 matrix to a pre-existing A_1 matrix) are available, and this approach has been followed in pilot work for Wales (see Munday and Roberts, 2006, Collins et al., 2007). Already in Wales regionally derived information on air and other emissions has been combined with information from the 2000 Welsh Input-Output tables. Then data on emissions and natural resources are used in conjunction with the Input-Output framework to generate the direct and indirect volume of the given pollutant generated by changes in final demands in each industry. As a consequence an industry's production can be linked with another industry's pollution creation.

The paper by Munday and Roberts (2006) in *Regional Studies* details the process and some indicative results, together with a review of the strengths and weaknesses of the approach. Applications of the pilot ENVIO in Wales have included research to evaluate the environmental and economic impacts of the FA Cup Final 2003-04, the World Rally Championship round in Wales in 2005, the Wales-Scotland Rugby International in 2006, and with more recent work linking the developing tourism satellite account framework in Wales to an environmental module (see Jones and Munday, 2006)

The broad ENVIO approach links closely with the production of a regional ESA, and can also be used for policy-making purposes. Ultimately environmental extensions to basic Input-Output tables provide a further statement of environmental account, allow investigation of selected environmental trade-offs of industrial development, and could inform the production of, for example, economic, waste and natural resource strategies. The outputs of policy simulations using ENVIO could potentially be used as 'inputs' to predict possible wider outcomes on other sustainable indicators or tools, and to practically support planning and evaluation processes.

In summary it is important to recognise that Input-Output can play two distinct roles within the development and analysis of an ESA. Firstly, Input-Output relationships can be used to help build an ESA; and secondly they can be used to explore how industrial change can be linked to environmental externalities. The issues and potential interest in linking industrial change to the environment are outlined above.

5.1 Using Input-Output tables to develop ESA tables

Input-Output tables could be used in the future construction of the following ESA tables for Wales (detailed earlier in this report):

- Table 2.5 Material flows;
- Table 3.2 Environmental taxes breakdown by industry; and
- Table 3.5 Environmental protection spending in industries.

It is worth noting that the UK ESA contains a number of tables developed using Input-Output information. For example, the ONS rely heavily on the UK Input-Output tables to estimate environment taxes by industry. In all cases the accuracy of modelled or estimated results will in turn depend on the accuracy of the Input-Output tables, which can require considerable primary research to ensure fitness for purpose.

Input-Output tables provide detailed transactions of products both within the Welsh economy and the external sector through imports and exports. Where transactions and consumption of materials are not available through empirical data they may be estimated based on Input-Output transactions to help develop Table 2.5.

Environmental taxes are associated with particular goods and services falling within the broad categories of energy, pollution, resources and transport. Table 3.2 for the UK is developed by distributing environmental taxes across industrial sectors based on sector expenditures across goods and services; the same approach could be employed for Wales. The link between sectoral environmental protection spending and sectoral overall expenditure patterns is weaker but a similar approach could be employed for Table 3.5.

5.2 Analysing an ESA

Analysis of Environmental Satellite Accounts can explain the contemporary Welsh economy, and establish key relationships that can be used for comparative purposes, showing how pollution can be attributed and whether Wales is a net polluter or not.

Linking the experimental ESA for Wales to the Welsh economy does not necessarily require an Input-Output table. For example, the table below shows how data from regional accounts published by ONS can be linked with the experimental ESA for Wales.

Utilities add little value per unit of energy consumed, but the rest of the Welsh economy in turn consumes this. It is therefore appropriate that some of this consumption is allocated to other regions, so the energy will be implicitly embedded in the final sales of goods and services provided by the rest of the economy. These types of relationships can only be established through an Input-Output framework.

Energy use per unit of value added

Sector	Energy use from carbon fuels (petajoules)	Gross Value Added (£millions)	Gross Value Added per petajoule (£billions)
Agriculture	0.1	590	£6.0
Mining & Quarrying	0.1	125	£1.8
Manufacturing	3.4	7,219	£2.1
Energy, Gas & Water Supply	5.9	871	£0.1
Construction	0.1	2,404	£33.9
Wholesale & Retail Trade	0.3	5,390	£16.0
Transport & Communication	1.1	2,401	£2.3
Other Business Services	0.3	8,040	£31.5
Public Administration	0.2	2,349	£13.7
Education, Health & Social Work	0.2	6,713	£40.8
Other Services	0.1	1,983	£28.8

Source: Direct Use of Energy from Carbon Fuels (expressed in Petajoules) (Part of Table W2.1)

5.3 Why Input-Output?

The experimental ESA is the most detailed and up-to-date of its type available for any UK nation or region at the present time. Used appropriately, it provides a consistent, coherent and flexible tool for a wide variety of analyses relating to specified characteristics of the Welsh environment and economy. In general terms, it is probable that most of the analyses using the model will fall into one or other of the following generic categories:

(a) *Analyses using the ESA database*

The model contains core data that is obtainable elsewhere. However, the compilation and processing of such data within the ESA framework may make analyses of certain existing aspects of the environment far easier than would otherwise be the case. Such analyses are essentially descriptive, but this does not mean they cannot provide policy-relevant information.

The richness of these types of exercises would be greatly increased if comparisons of Welsh results could be made with equivalents for other areas, and this can certainly be done with respect to the UK and other European countries.

(b) *Analyses of the base ESA model.*

Within a particular theoretical framework, the ESA can 'explain' observed environmental outcomes in Wales. These explanations may be in terms of the level and pattern of sectoral output, the extent of local interactions and the production processes in use. Moreover, this explanation is *transparent,* i.e. the precise causal path by which environmental outcomes can be identified and quantified.

Analyses of the base model that may be of interest include attribution of pollution to final demand markets, trade in pollution and whether Wales is a net polluter or not.

(c) *Applications using the ESA*

As with any economic model, one of the major areas of application of the ESA is likely to be the analysis of the effects on outcome values of environmental variables of specified *changes* from base values in various aspects of Welsh economic activity. Particular analyses of this type will generally fall into one or more of the following categories: impact studies, 'what if' scenarios/simulations and projections.

At least in technical terms, the simplest type of impact analysis relates to estimating the effects of specified changes in final demand, either in particular markets, sectors or groups of sectors. Formally, it is a variant of this type of analysis which allows the derivation of multipliers i.e. summary measures of the outcome effects of initial shocks. The ESA potentially allows the derivation of a very large number of industry multipliers of various types.

More ambitious 'impact' studies require changes in one or more of the model's coefficient matrices, perhaps reflecting a change in existing industry technology or the creation of a new industry in Wales. The impact is then estimated as the difference between new and base equilibrium outcomes.

In principle, 'what if' scenarios encapsulate a very wide range of possibilities, perhaps involving quite extensive changes to many base model parameters. Though the list is not exhaustive, among the major uses of 'what if' simulations are:

- **Projections:** what are the estimated requirements for natural resources in high tech/high growth versus low tech/low growth projections for Wales?

- **Sensitivity analysis:** what areas of pollution are most/least affected if 'X' happens in Wales?

- **Comparative analyses:** what would be the level of pollution if 'Y' characteristic of the Welsh economy were like that in the UK (or Sweden etc)?

- **Hypothetical impact studies:** what would be the impact on household waste generated with a change in domestic consumption patterns?

Technically, many ‘what if’ simulations will require the ESA or Input-Output tables to be re-calibrated and re-run in its entirety. Technical issues do not cause particular difficulties here. The real problems arise in *finding or generating the data inputs* required to implement the simulation ‘sensibly’. As elsewhere, the 'garbage in garbage out' (GIGO) principle applies here.

An obvious point is that comparative analyses require that the necessary comparison data is available. However, more fundamental issues arise when a simulation envisages that the initial shock to the system is primarily intended to affect the supply-side rather than the demand-side.

For example, a marketing campaign is undertaken to improve the ‘attractiveness’ of recycling. In order to calculate the impact of this on household waste, it is necessary to provide estimates of the changes in waste attributable to the campaign and this cannot be done within an ESA/Input-Output model itself.

To summarise, some desirable simulations may not be amenable to implementation within an ESA/Input-Output framework. Others may require considerable ‘off-model’ work to articulate the data inputs in the form required for incorporation.

6 Conclusions and next steps

Introduction

There are a number of issues that inform the future research priorities relating to updating and developing the pilot environmental satellite accounts for Wales. First, there is a need to consider the extent to which the accounts, or further iterations of the account, are expected to be useful to the Welsh Assembly Government and other groups. Second, how far ESA tables can be practically extended given current information and expected developments in the underlying survey instruments, and then, finally, it is important to balance issues of the marginal cost of account improvements against benefits of improvements to policymakers and others.

In what follows we revisit elements of the pilot ESA with these issues in mind and make recommendations for where future resources might be placed.

6.1 Natural resources

In terms of the natural resource elements of the ESA it is unlikely that detailed information on 'regionally' recoverable oil and gas reserves (ESA 1.1. and 1.2) will become available in the short term. We acknowledge that these tables are important in terms of their association with the overall system of national accounts, but believe there is limited value for WAG in pursuing development of these tables at the current time, and with issues regarding what would constitute Welsh oil and gas reserves. However, the pilot work has revealed real value in other elements of the resource accounts. Accounts for coal and aggregates can be readily updated at minimal marginal cost with the underlying statistics being produced for other purposes. These elements of the natural resources account are also useful because they link to important elements of the physical flows accounts, and to the WAG sustainable development indicator set. It is recommended that these elements are regularly updated.

Similar conclusions apply to the land cover account (ESA 1.3). The information contained within the pilot ESA is essentially a reasonable baseline based on contributions from the Habitat Survey and the Countryside Survey. Clearly there are still issues with these survey resources, and the classification system, but updating will be important. For the first time the region is in a position to track the use of the scarcest of resources through time in a fairly consistent manner. UK priorities will drive forward the Countryside Survey and then with regional challenges encompassing the need to insure there adequate resources for the Welsh survey element. This part of the developing Welsh ESA needs to be prioritised in terms of resource support because of the link to overarching sustainable development sets, but also because of the association with the physical flows elements of the ESA.

The table relating to the physical volumes of wood and wood-based products (ESA 1.4) being consumed in Wales clearly links to the land cover account, and more importantly to the materials flow account (ESA 2.5). Establishing the physical volumes consumed in Wales once allowance is made for imports and exports will continue to be problematic with limited information on the tonnages of wood-based material in and out of the region. Notwithstanding this table can be estimated in the future at relatively low costs, and with much of the imported material coming through the South East Wales ports and accurately recorded by organisations such as ABP. In summary, the costs in further developing and updating this tables are largely in terms of developing extant information, and with a reasonable set of assumptions linking volumes to traded values.

A similar set of issues occur with ESA 1.5 examining fish stocks and catch. There does not seem to be a fixed format for ESA 1.5 in the UK Environmental Accounts (i.e. emphasis on catch as opposed to stocks). Updating the information in the pilot from sources such as South Wales Sea Fisheries Committee, and the Marine Fisheries Agency can be undertaken at low cost. The pilot exercise also reveals that the Marine Fisheries Agency hold additional information on landings into Welsh ports by species which means that information on catches and value could be much improved. Information on stocks is also updateable, but with the issue here regarding what would actually constitute a Welsh stock.

The recommendation here is that the Welsh ESA should major on elements of the catch and value, and then report stock data from the Marine Fisheries Agency in adjacent sea areas to the Welsh coastline. There is little value in trying to establish the nature of a 'Welsh' stock for policymaking purposes, but with landings informing biomass estimates in the materials flows account (ESA 2.5).

6.2 Physical flows

The physical flows elements of the ESA are, we believe, the ones where WAG resources might be more focused in the cause of updating and improvement. Each of the tables in the physical flows section links closely to overarching sustainable development indicators for Wales (and the UK). Moreover, elements relating to energy consumption and emissions relate to international treaty objectives. It is in these elements of the ESA that comparisons between regions and nations can be most useful in assessing the relationship between progress as conventionally measured and the creation of harmful externalities.

In terms of the physical flows section of the ESA the main challenge is ensuring that Welsh industries, Welsh patterns of consumption, and production are adequately represented in underlying surveys which inform the tables. Evidently the information that has come out of the REWARD (2003) database is useful but it is not yet clear how often the regional information will be updated in terms of emissions, and waste.

In the pilot ESA development the main concerns are in relation to the material flows account where many elements are modelled, and with rows unfilled due to a lack of information. The pilot materials flow table really represents a challenge for more information. The table is important because it reveals flows of resources from the environment to the economy, and then flows back from the economy to the environment in terms of items such as waste. It might be argued that this is the heart of the ESA, yet it is the element that can be most difficult to estimate. It is recommended that resources are targeted on developing this table, and more accurately gauging imports and exports of materials.

6.3 Monetary accounts

The elements of the ESA treating with defensive expenditures and environmental taxation and revenues represent a useful statement of account. These tables, in general, can be readily updated at low cost. We do not recommend that significant resources are targeted on developing these tables further. We accept that information on defensive expenditures is relevant in the development of selected indicators of long-term welfare. However, the perspectives gained from these tables cannot always be related to the sustainable development indicator set, and the information therein may not be as important for regionally-based policymakers as those in the physical flows and natural resources elements of the ESA.