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PRELIMINARY OPTIONS FOR METHODOLOGIES TO APPLY ADJUSTMENTS UNDER ARTICLE 5.2 OF THE KYOTO PROTOCOL

Fuel combustion activities

Sectoral breakdown of emissions based on international energy data

Expert report

prepared for the

UNFCCC secretariat

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This report has been prepared in response to a request by the secretariat of the United Nations Framework Convention on Climate Change. The report does not necessarily reflect the views of the secretariat; the responsibility for the text remains with the authors.

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1. Introduction

The greenhouse gas (GHG) inventories submitted by the Parties to the FCCC should conform with the requirements of the FCCC and decisions from the Conference of Parties. In particular, the completeness of the inventories and the methods used to prepare them must agree with the guidance and methodologies given within *IPCC Guidelines*. Furthermore, where inventories are incomplete or do not conform with the methodology, the Kyoto Protocol (KP), Article 5, permits their adjustment to bring them into conformity with the methodology.

The checking and adjustment procedure requires a mechanism for identifying omitted or deficient figures in inventories and generating alternative “replacement” values. The model described below offers a parallel inventory for CO_2 emissions from fuel combustion generated from available fuel use data and default emission factors given in the *IPCC Guidelines*. It is based on a carbon balance showing the supply and disposition of carbon flows. The figures the model generates may be used as checks on the reasonableness of the fuel combustion part of the CO_2 inventories and identifying deficient figures as well as providing a substitute value.

Estimates for emissions of CH_4 and N_2O are also required. The present model does not provide these directly because fuel consumption, as a proxy for the consumption activity, is only one of the factors influencing formation and emission of the gases. However, two possible methods suggest themselves for obtaining emission factors for use with the model data and these are mentioned below.

It is important to realise that the work submitted is intended to be an illustration of the principle which underlies it. A fully functioning and easily operable machine for the construction of the carbon balance can be finalised from the work offered here after discussion with users to ensure that their requirements are met and attention is paid to the issues surrounding data supply. The work described below has been based on international energy data and the provision of these data in the desired format is an essential further consideration.

2. Principles of the carbon balance model

The model uses a detailed national energy balance as the starting point for its construction. An energy balance provides a succinct summary of the supplies and uses of fuels in a country. The supplies part of the energy balance forms the basis for the IPCC Reference Approach (RA) method of estimating fuel combustion emissions of CO_2 by type of fuel. The present carbon balance extends the RA by breaking down the total figures by fuel into the source category estimates required by the UNFCCC Common Reporting Format (CRF). Emission estimates are calculated from energy data using the carbon emission factors and average oxidation factors given in the revised *IPCC Guidelines*. National inventories may use different factors in both cases as the *IPCC Guidelines* encourages countries to use local factors where these are better. The figures for CO_2 emissions from source categories provide a basis for the estimation of the CH_4 and N_2O emissions as mentioned above and as further elaborated in another paper within this project (see Working paper No. 3 (b)). In this respect the carbon balance offers greater analytical and explanatory power than the RA.

The reporting instructions require emissions from fuel using activities to be grouped into source categories which differ in some respects from the activity groupings used in energy balances.

Three of these differences are important. The first is the classification in the *IPCC Guidelines* of the autoproduction of electricity and heat, the second the treatment of emissions from transport and the third the classification of consumption for military activities.

The *IPCC Guidelines* require emissions from autoproduction to be attributed to the branches of industry containing the autoproducing enterprises whereas, in energy balances, fuel consumption by autoproducers is shown as a total figure in the "transformation" activity sector. In the absence of the information relating the fuel use for autoproduction to each branch of industry it has not been possible to divide the associated emissions between the six industrial source categories identified in the *IPCC Guidelines*. Instead, a separate "autoproduction"category has been introduced and included in the "Manufacturing and Construction" sector (1A2) thereby providing the correct total figure for the sector. There is further discussion of this point in the section entitled "Data Issues".

The *IPCC Guidelines* also require the separate estimation of emissions from mobile and stationary combustion as well as the identification of emissions from vehicles in manufacturing industry so that the emissions can be removed from manufacturing and added to the transport sector if they are not already included there. The energy and carbon balances can, only partly, meet these requirements. Energy balances show deliveries of fuels by transport mode (road, rail, air and national navigation) and deliveries of fuel to the branches of manufacturing industry. The uses of the fuels within enterprises are not shown although this information may be available nationally. As a consequence the emissions figures for the manufacturing industry generated by this model will include emissions from any vehicles operated by the enterprises which use fuels not delivered as transport fuels. These may be LPG or gas oil.

Consumption of fuels for military activities is usually concealed in energy statistics and therefore the sector or activity containing the fuel use cannot be identified. The *IPCC Guidelines* specify where they should be reported (source category 1A5) but the absence of explicit figures for the consumption in energy data means that reporting in accordance with the *IPCC Guidelines* is not possible in the model developed here.

3. **Construction details**

The model takes the form of two Excel 5 workbooks available at the UNFCCC secretariat. The first workbook provides the energy data and the second, the carbon balance. Annex 3 briefly describes how the workbooks should be handled.

The second of the workbooks, called Carbon Balances, comprises four sheets. The first is used to gather the energy data for the country of interest. The second sheet transposes the data collected in the first as the format of energy balances usually shows fuels across the columns but the *IPCC Guidelines* uses formats in which fuels are shown as rows. This sheet also assembles the data into groups to suit the ultimate source categories and changes units from ktoe to TJ. The third sheet is a carbon balance using the framework of the RA running into the format needed to show the sectoral breakdown of emissions using the *IPCC Guidelines* or CRF format. Sheet 4, "carbon dioxide", takes Sheet 3 and multiplies by average oxidation factors and 44/12 to produce estimates of emissions in terms of emitted CO_2 (see also Annex 1 for an example). In Sheet 3 , there is an intermediate part linking the RA and sectoral breakdown which will now be explained.

Simplifying a little, the heart of the RA is the supply of fossil fuels into the country from own extraction or import less fuels exported. The figures for the fuels are converted into estimates of the carbon they contain and two changes are made, the first to subtract carbon taken by vessels or aircraft undertaking foreign travel and the second to subtract carbon stored in products using fuels as raw materials. The net result is the RA method for estimating CO_2 emissions from fuel combustion. In fact the net estimate of carbon supply produced by the RA covers more than fuel combustion and the intermediate part of spreadsheet 3, "carbon balance",attempts to further subtract from the RA the uses of carbon which, if a country provides CO_2 estimates from industrial processes, solvents and fugitive emissions, will be included these parts of the inventory and not under fuel combustion. In this manner the estimates given in the sectoral part of Sheet 3 should be aligned with the estimates of fuel combustion developed by sectoral methods.

Alignment of the RA comprises several distinct activities and only some can be generated from the energy data.

The *IPCC Guidelines* recommend that the emissions from blast furnaces be considered as part of the emissions from metals production in the Industrial Processes module and not part of the fuel combustion emissions. Statistics for fuels supplied to blast furnaces are provided within energy balances but the emissions at the blast furnace from combustion are directly related to the fuels burned to heat the blast air and these data are not currently available in international energy data sets. (There will also be fugitive escapes but these are ignored here). Consequently, the emissions released at blast furnaces are estimated as a fraction (0.33) of the carbon in the blast furnace gas produced. The estimated release is subtracted from the fuel carbon shown as final consumption by the iron and steel industry. In this manner double counting of the emissions from iron and steel reported in the Industrial Processes module is avoided. The fraction, 0.33, is based on UK data but it can be as high as 0.37 in other countries. The lower figure is used as a conservative estimate.

The next four activities (soda ash, calcium/silicon carbide, ferroalloys and aluminium) cannot be estimated using the energy statistics as international data sets (and most national sets) do not contain the necessary detail. The emissions belong to the industrial processes module but are very largely derived from fossil fuel carbon delivered to the industries undertaking the activity. Where a national inventory, in accordance with the methodology, identifies emissions from these processes the carbon concerned may be entered into the alignment part of the spreadsheet and subtracted from the appropriate source category in the industrial sector. Note that, in the present spreadsheet, formulae for the subtractions have not been included.

The column for "fugitive emissions" has been included to reflect the losses of carbon during transport of fuels to final use. Energy balances usually cover this within "distribution losses" and the fuel mainly concerned is natural gas. However, the quantity contained under this heading will reflect more than losses in distribution (for example, metering differences) and so it may be argued that the quantity would be better shown under "other energy industry" (1A1c ii) emissions. Certain countries show distribution losses for solid and liquid fuels. However, it is very probable that they should have been more properly included in statistical differences by the national statisticians. Distribution losses of solid and liquid fuels have been put into "other energy industry" emissions.

The "other" column captures fossil fuel carbon-based emissions reported in other inventory modules, notably from solvents but it also acts as a place marker for the minor NMVOC emissions from road oils or organic chemicals manufactured from refinery output. In the present spreadsheet only "white spirit"and "other oils" can be included here. The latter usually contains a high proportion of the basic chemicals (benzene, toluene and xylene) entering the chemicals industry.

Some remarks should be made on the figures for international aviation bunkers and the stored carbon in the calculation of the RA estimate of emissions. The figures, as given in the international data sets, for deliveries of aircraft fuel to aircraft undertaking foreign flights are of uncertain quality. For example, the IEA 1990 data for the UK give 2636 ktoe for domestic flights and 4381 ktoe for international flights. In reality the present UK view is that about 7-10 percent of total flight fuel is for UK domestic flights, that is, between 500 to 700 ktoe in 1990. This difference in data has a significant effect on the total CO_2 emissions and an even more profound effect on the emissions attributed to the transport sector.

The model follows the *IPCC Guidelines* in attributing carbon storage to some of the natural gas used for non-energy purposes. The storage factor quoted in the *IPCC Guidelines* is 0.33 but there is no justification given for it. This factor has been used in the model against the quantities of gas entering petrochemical use. Most of the gas will be for the production of ammonia which does not lead to carbon storage. It may be necessary to examine again the validity of the 0.33 factor to see whether it is too high.

The consumption or sectoral side of the balance is clear for the activities in which fuels are finally consumed. The sectors are identified by the sector category names given in the *IPCC Guidelines* and CRF. Note, however, that the quantities of stored carbon shown in the calculation of the RA figures are subtracted from the deliveries of carbon to the chemicals industry. Similarly, any of the other alignments leading to the RA (aligned) figure are subtracted from the deliveries to the corresponding industries in sector 1A2.

Transformation sector activities need some explanation because, except for the electricity and heat industries, the fuels entering transformation industries are not proxies for the emissions from them. It is the "disappearance" of carbon that must counted against their emissions and so inputs to the energy industries sector are reckoned as positive and the production of carbon-bearing products, negative. The sum of the two over the complete range of fuels for the industry concerned will give the emissions from it.

Refinery production figures for the various petroleum products have been constructed from a composite of more detailed figures available in the energy balances. They are net so that refinery fuel use has been subtracted from the gross production of each product. In addition, any transfers of fuels from one product category to another have been added into production with due regard to the algebraic sign of the transfer. Transfers usually represent a reclassification of products, for example the separation of natural gas liquids into its components. Production of refinery products from the petrochemical industry or for use by that industry are also added into the refinery production figure, again respecting the signs of the flow.

The figures for statistical differences are taken from the energy balance and converted into carbon and carbon dioxide. They should, if all has been correctly accounted for, also balance

the “Reference Approach (aligned) and “Total Sectoral Fuel Combustion”. The model has been generated and tested on France, Hungary, New Zealand, the UK and the USA. It is probable that small imbalances will appear when other countries with unusual energy flows are used. The formulae can then be adjusted to take account of them.

4. Wastes used as fuels

The guidance given in the *IPCC Guidelines* is clear for the calculation and reporting of emissions from biomass fuels but insufficient for wastes used as fuels. In the model presented here Municipal Solid Waste (MSW) has been included with solid biomass fuels. This is probably the practice in most countries although part of MSW will be of fossil carbon origin. The international energy data also contains data for Industrial Wastes and Non-Specified Wastes. The nature of these fuels is much less clear and is probably better described as specialised wastes because their destruction needs special handling and/or combustion plant. They can range from waste materials or chemicals in chemical companies through hospital waste to scrap motor tyres. In this model Industrial and Non-Specified wastes have been considered non-renewable and included with sub-bituminous coal.

5. Other gases

The proposed model cannot estimate the emissions of CH_4 and N_2O with the degree of confidence with which it can offer CO_2 figures. However, by using the energy data providing the input to the model as a proxy for the combustion activity, then the problem becomes one of finding the appropriate emission factors. In this case, average sectoral emission factors for the gases can be derived from a case by case inspection of the most common types of combustion plant in the different source categories. The *IPCC Guidelines* contains default emission factors by type of combustion plant. Alternatively, by examining a number of national inventories, pro-rating factors can be obtained for the two other gases as fractions of the CO_2 emissions for each of the main source categories. This last approach has been developed in another paper within the project (see Working paper No. 3 (b)).

6. Data issues

There are several important considerations concerning data which have been ignored in the description above. These are:

i) what determines the choice of starting data for the model process?

ii) how will it be obtained?

iii) how will gaps in the starting data be filled?

The carbon balance draws on energy balance data as a starting point. However, there is a case for starting with the basic energy data expressed in tonnes, cubic metres or litres and these data are equally available. This has not been done because it would duplicate work done by those who prepare the energy balances and would, consequently, be a less efficient use of the present resources. Nevertheless, such preliminary data in spreadsheet form would be helpful to those who must check the inventories. When an observed emissions figure differs substantially from

that given in the carbon balance, the path used to construct the figure must be followed back to its source to see at what point the difference arises. Some of these differences will arise in the basic data or calorific values used to construct the energy figures where these have formed the basis for the national calculation. If the present method is accepted then it is recommended that the model be extended in that direction.

This leads directly into the sources of the energy data. The present work has been based on the databases available from the International Energy Agency (IEA) because the structure and content of them are well known to the consultant. The five energy balances used within the attached workbooks are taken from a database of OECD country data called “BIGBAL”which contains every energy commodity. The database is generated from similar databases of basic energy data and calorific values.

If the decision is taken to develop the carbon balance model along the lines proposed then consideration needs to be given to the provision of similar data from the UN energy database. Samples of this were provided to the consultant in the form of Excel files but their structure proved difficult to handle (one was too large to read easily) and the content unfriendly. The data will need recasting into a readily comprehensible form so that it can then act as the “front end” to the proposed model.

The problem of filling gaps in the basic energy data is a major issue, the substance of which was raised within the terms of reference for this project but in relation to the emissions data themselves. By pushing the issue back to the improvement of energy data any steps taken in this direction should also be raised and discussed with the international energy statisticians. Within this project other work is being conducted by the other project consultants which will lead to proposals for estimating missing data by extrapolation or by substitution of average values taken from similar countries (see Working papers No. 3 (b) and 3 (c)). For particularly critical data (aviation fuel use, chemical feedstock, autoproduction data) expert groups working on these problems should be consulted. Recent changes to international questionnaires should result in better information on the fuel uses for autogeneration in branches of industry but this cannot improve historical data.

7. Comparisons with the national inventories

The carbon balance model has used the IEA data for five countries: France, Hungary, New Zealand, the UK and the US. The results have been compared with the national CO_2 inventories prepared by the countries for 1990 and the differences shown in the workbook “Model comparisons”(see also Annex 1). The workbook contains comments linked to relevant cells on each sheet. The differences in layouts and methodologies used for the national inventories has prevented automation of the comparison exercise and the national figures for the main source categories have been typed into the workbook.

It is extremely improbable that the figures from the model and the inventories will agree exactly and for all source categories. There are many reasons for this and the most common are differences in activity data, emission factors and/or methodology. However, it must also be said, based on the five comparisons made here, that the great variability in the reporting has made it difficult to elucidate the differences observed and to be confident of the reasons for them.

Activity data used by national administrations are frequently not identical to the data provided by the administration to the UN and IEA in the annual energy statistics questionnaires. In some cases the person preparing the inventory may have a choice of activity data and will use a value which differs from that adopted by the energy statisticians. In other cases, notably for the transport sector, the emissions estimates may be generated from models using activity statistics other than fuel combustion. Energy statisticians may not be able to divide a figure for fuel deliveries to a group of activities between the activities which make up the group because a basis for the division is not available. The quantity may, as a result, be allocated to a total without breakdown or to an "unallocated" category. The inventory specialist, on the other hand, may feel that an estimate is possible and prepare figures for the individual activities. In this case differences emerge at the level of the activities but not for higher level aggregates.

The emission factors used in the model are those taken from the *IPCC Guidelines*. They encourage the use of national emission factors where they are available and are thought to be better. The effects of the differences in CO_2 emission factors should not be more than a few percent, however.

Differences in methodology and geographical scope can arise in many ways in the three main areas of statistical activity covered in this exercise. These areas are preparation of the national inventory, preparation of the international energy data and the construction of the parallel inventory model. Preparation of the national inventory should follow the methods given in the *IPCC Guidelines* and the parallel inventory model has been designed in accordance with the Tier 1 methods they contain. National energy statistics may be prepared using definitions and categories which differ from those required by the questionnaires which are sent to the international organisations publishing energy data. When completing the questionnaires national statisticians will, as far as possible, comply with the reporting instructions they contain. This may lead to differences between the national inventory figures and estimates generated from international energy data. An example is the separation of the emissions figures for the US Territories in the US national inventory because a breakdown by source category for this geographical region is not known. The IEA/UN energy data contain the fuel use by the US Territories but it is not immediately evident how the sectoral allocation of the fuel use has been made.

8. Main differences observed between the national inventories and the results from the model

France

The model produces a result for the total fuel combustion CO_2 emissions which is 3.1 percent less than the national inventory figure. However, there are two important points regarding this comparison. Firstly, the international energy data do not contain the fuel consumption related to the French DOM/TOMs (départements outre mers, territoires outre mers) whereas the national inventory does include these regions. Second, the figure for domestic civil aviation generated from the energy data is much lower than the inventory figure probably because of the regional differences mentioned above.

The other notable difference between the model and inventory is for the emissions from the Energy Industries. Two explanations are offered but which, if either, is correct cannot be decided without further detail in the French inventory. Either autoproduction is included in public electricity rather than manufacturing or MSW has been treated as a non-renewable solid fuel and emissions from its use in public CHP plants are included in public electricity and heat. The model developed here has included MSW with solid biomass.

Hungary

As Hungary has used the Reference Approach and also no detailed calculation for 1990 was provided, the comparison is limited to a few figures only.

The model produces a figure for total emissions which is 1.5 percent less than the national inventory. Absolute percentage differences between the values for emission from solid, liquid and gaseous fuels vary between 2.9 and 7.3 percent. It is not possible to follow through the reasons for these differences without more detailed data.

New Zealand

The model provides an estimate for total emissions which exceeds the national inventory by 7.0 percent. This difference arises mainly within the manufacturing sector where it could be due to a difference in the reporting of industrial process emissions. Inspection of the emissions given in the national inventory for industrial processes shows that the figures for the manufacture of iron and steel would account for a large part of the difference observed in the comparison. As the energy data for New Zealand do not show fuel use for the energy-intensive processes in the iron and steel industry, where most of the industrial process emissions take place, it is assumed that they do not occur. As a result there may be an overstatement of industrial process CO_2 emissions for iron and steel and an understatement of the corresponding fuel combustion emissions.

United Kingdom

The model figure exceeds the national inventory by 0.2 percent. However, this paints a favourable picture of the true difference. The figure for domestic aviation emissions is overstated by the model by approximately 5.7 Mt CO_2 because the energy data are incorrect. If they are corrected then it will cause the model to understate the inventory result by nearly 1 percent. The other features of difference between the two inventories are noted on the spreadsheet. Most of them result from differences between the national inventory and national energy statistics in the allocation of fuel consumption between sectors of economic activity (source category).

United States

The model produces a total fuel combustion CO_2 emissions figure which is 3.2 percent greater than the national inventory. This may be largely due to the inclusion in the model of industrial and non-specified wastes. It is probable that the US inventory considers these to be renewable fuels (and therefore excluded from the inventory totals) but there is no information in the inventory to clarify this. The differences on the energy industry figures and the manufacturing sectors are considerable. The US “industry” category has been inserted in the comparison table as “manufacturing”and it probably includes petroleum refining and agriculture. This will explain most of the differences between the manufacturing, energy industries and “others” sectors.

The comparison exercise has revealed that it is difficult for countries to distinguish emissions from fuel combustion in branches of manufacturing industry and emissions from processes using fossil fuel carbon as a raw material. The *IPCC Guidelines* touches on this point in the Reference Manual. Some countries appear to omit all fuel input to certain branches and report the carbon as emissions under Industrial Processes. Equally, some may not distinguish between the branches of industry but report all emissions under “other” industry. This lack of consistency complicates the checking of inventories and should be raised with the IPCC for discussion and clarification by experts and eventual change to the *IPCC Guidelines*.

9. Conclusions

The carbon balance model provides a potentially useful instrument for checking the CO_2 emissions from fuel combustion submitted in the national inventories and providing alternative estimates where energy data exist but emissions figures are omitted.

To realise the potential of the model several conditions should be satisfied.

1) The user should be satisfied that the model is entirely consistent with the methodologies contained in the 1996 revision of the *IPCC Guidelines*. Every effort has been made to make it so but some assumptions have made where the *IPCC Guidelines* are silent. In particular, see the description above of the treatment of wastes used as fuels. The process of aligning the RA with the total sectoral emissions is new and not covered in the *IPCC Guidelines*. The alignment corrections also contain certain assumptions (for example, the treatment of natural gas distribution losses as fugitive emissions) which may be disputed. However, the principle of alignment is clear and a consensus on the alignment process can be reached.

2) International energy data should be as complete as possible and consistent with the energy data used to construct the inventories. This is not the case at present but, for many countries, the international data provide a good starting point for independent assessment of a national inventory. The problem of providing estimates for missing energy data has been discussed above in “Data issues”, however, within the limited exercise conducted here, the problem has been less one of missing data and more one of differences in allocation of emissions between sectors or insufficiently detailed reporting.

The geographical definition of each country may differ between the UNFCCC requirement and that provided for international energy statistics. This is the case for France in the present project. It is difficult for national energy statisticians to include in their energy data a detailed breakdown of fuel consumption in overseas territories as the necessary bureaucratic procedures are not cost-effective. However, it may be possible to adjust the data to reflect estimates of the consumption in territories using the results of a study for this purpose. Provided that the adjustment is applied consistently from year to year the trend in results will be little affected.

3) The submitted inventories should be as identical in format as possible.

It is clear from this limited examination of five countries that the transparency of national inventories provided for this project varies considerably. The reporting practice and formats reflect national classifications and definitions. As a result, whether or by how much international energy data differ from those used within the national inventory cannot be assessed properly. The CRF should be supported by breakdowns of the main source categories by fuel groups so that reasons for differences from international energy data are more easily identified.

Annex 1

Example of sheet 4 of the carbon balance spreadsheet model

UK

		kt CO2	SUPPLY					INTERNATIONAL BUNKERS					ALIGNMENT									1A
			Production	Imports	Exports	Stock Change	CARBON SUPPLY	Aviation	Marine	Stored Carbon	Storage factor	REFERENCE APPROACH	Blast furnaces	Soda ash	Calcium-Silicon carbide	Ferroalloys	Aluminium	Fugitive emissions	Other	REFERENCE APPROACH (ALIGNED)	Statistical difference	TOTAL SECTORAL FUEL COMBUSTION
FUEL TYPES																						
Liquid Fos	Primary	Crude Oil	277 245	131 007	- 170 216	2 001	240 036					240 036								240 036	- 6 031	246 067
		NGL	10 557		- 3 505	- 202	6 851					6 851								6 851	- 1 230	8 081
		Orimulsion																			0	
	Secondary	Refinery Gas				- 6				237	0.8	237								237	- 19	249
		Gasoline		5 956	- 13 112	95	- 7 060					- 7 060								- 7 060	274	- 7 333
		Jet Kerosene		606	- 3 131	- 183	- 2 708	- 12 985				- 15 693								- 15 693	297	- 15 990
		Other Kerosene		265	- 940		- 675					- 675								- 675	106	- 781
		Gas/Diesel Oil		4 258	- 14 076	273	- 9 545		- 3 616	- 891	0.5	- 14 052								- 14 052	397	- 14 450
		Residual Fuel Oil		13 970	- 13 598	1 204	1 576		- 4 307			- 2 731								- 2 731	1 201	- 3 931
		LPG		3 229	- 1 569	230	1 890			- 1 846	0.8	45								45	2 366	- 2 321
		Ethane								- 1 069	0.8	- 1 069								- 1 069	- 1 030	- 39
		Naphtha		4 398	- 2 454	98	2 042			- 7 233	0.8	- 5 191								- 5 191	- 1 647	- 3 544
		Bitumen		170	- 119	- 32	19			- 7 996	1.0	- 7 976								- 7 976	- 80	- 7 896
		Lubricants		546	- 1 698	- 47	- 1 199			- 1 199	0.5	- 2 399								- 2 399	- 756	- 1 643
		Petroleum Coke				- 105	- 105			- 346	1.0	- 452								- 452	1 361	- 1 812
		Refinery Feedstocks		33 697	- 5 479	- 346	27 872					27 872								27 872	2 866	25 006
		Other Oil		225	- 1 736	61	- 1 450			- 160	1.0	- 1 611							1 847	- 3 458	- 1 328	- 2 130
Liquid Fossil Totals			287 802	198 326	- 231 632	3 042	257 544	- 12 985	- 7 923	- 20 741		216 132							1 847	214 285	- 3 253	217 532
Soilid Foss	Primary	Anthracite																				
		Coking Coal	4 208	23 278	- 129	5	27 363					27 363								27 363	- 1 906	29 269
		Other Bit. Coal	201 084	14 586	- 5 587	3 313	213 397					213 397								213 397	3 318	210 079
		Sub-bit Coal	54				54					54								54	- 1 040	1 094
		Lignite																				
		Peat																				
	Secondary	BKB & Patent Fuel		295	- 7	167	455					455								455	37	418
		Coke oven/Gas coke		823	- 1 220	71	- 327					- 327								- 327	- 59	- 267
Solid Fossil Totals			205 347	38 982	- 6 943	3 557	240 942					240 942								240 942	351	240 592
Gaseous F	Primary	Natural Gas	95 618	14 435		233	110 285			- 1 452	0.33	108 833						3 204		105 629	- 160	105 789
	Secondary	Coke oven gas																				0
		Blast furnace gas											4 649							- 4 649		- 4 649
Gaseous Fossil Total			95 618	14 435		233	110 285					108 833						3 204		100 979	- 160	101 140
TOTAL			**588 766**	**251 743**	**- 238 576**	**6 832**	**608 772**	**- 12 985**	**- 7 923**	**- 20 741**		**565 908**						**3 204**	**1 847**	**556 207**	**- 3 063**	**559 264**
Biomass Total			23 514				23 514					23 514								23 514	15 997	7 517
		Solid biomass	15 816				15 816					15 816								15 816	8 298	7 517
		Liquid/Gaseous	7 698				7 698					7 698								7 698	7 698	

UK

kt CO2	1A	1A1 ENERGY INDUSTRIES	1A1a PUBLIC ELECTRICITY AND H				1A1b	1A1c SOLID FUELS AND OTHER			1A2 MANUFACTURING AND CONSTRUCTION									1A3 TRANSPORT						1A4 OTHER SECTORS				
	TOTAL SECTORAL FUEL COMBUSTION	Total 1A1	Total 1A1a	Electricity plants	CHP plants	Heat plants	Refineries	Total 1A1c	Manufacture of solid fuels	Other energy industries	Total 1A2	Auto production	Iron and steel	Non-Ferrous metals	Chemicals	Pulp, paper and print	Food, beverages and tobacco	Other	Total 1A3	Domestic aviation	Road	Rail	National navigation	Other	Total 1A4	Commercial Institutional	Residential	Agriculture, forestry and fishing	OTHERS (nes)
ES																													
Crude Oil	246 067	246 067					246 067																						
NGL	8 081	8 081					7 114	966		966																			
Orimulsion																													
Refinery Gas	249	- 283					- 283				532				532														
Gasoline	- 7 333	- 82 136					- 82 136												74 803	80	74 723								
Jet Kerosene	- 15 990	- 23 801					- 23 801												7 812	7 812									
Other Kerosene	- 781	- 7 188					- 7 188				1 416							1 416	37			37			4 953	37	4 878	37	
Gas/Diesel Oil	- 14 450	- 73 561	140	140			- 74 146	445	445		7 373		60	83	891	79	537	5 723	39 509		33 846	1 910	3 753		9 980	6 968	909	2 103	2 250
Residual Fuel Oil	- 3 931	- 21 140	19 570	19 506	65		- 42 176	1 465	1 465		13 810	2 943	215	99	4 178	597	2 232	3 546	249			6	243		3 106	2 752	52	302	43
LPG	- 2 321	- 5 763					- 5 872	109		109	2 378		71		461			1 846							1 063		1 063		
Ethane	- 39	- 444					- 444				406				267			138											
Naphtha	- 3 544	- 5 352					- 5 352				1 808				1 808														
Bitumen	- 7 896	- 7 896					- 7 896																						
Lubricants	- 1 643	- 2 842					- 2 842												1 199		1 199								
Petroleum Coke	- 1 812	- 1 812					- 1 812																						
Refinery Feedstocks	25 006	25 006					25 006																						
Other Oil	- 2 130	- 2 130					- 2 130																						
	217 532	44 802	19 710	19 645	65		22 107	2 986	1 910	1 075	27 725	2 943	347	181	8 138	677	2 769	12 670	123 609	7 892	109 769	1 953	3 996		19 103	9 758	6 902	2 443	2 293
Anthracite																													
Coking Coal	29 269	29 269						29 269	29 269																				
Other Bit. Coal	210 079	180 886	176 250	176 250				4 636	4 382	254	17 379	4 737	183	174	2 468	1 496	1 101	7 220	7			7			11 807	2 576	9 188	43	0
Sub-bit Coal	1 094	1 040	1 040	416	624						54							54											
Lignite																													
Peat																													
BKB & Patent Fuel	418	- 1 215						- 1 215	- 1 215																1 633		1 633		
Coke oven/Gas coke	- 267	- 10 369						- 10 369	- 10 369		6 340		5 004	438	159			739							3 762	963	2 771	28	
	240 592	199 611	177 290	176 666	624			22 321	22 067	254	23 772	4 737	5 187	611	2 628	1 496	1 101	8 013	7			7			17 202	3 539	13 591	72	0
Natural Gas	105 789	7 000					48	6 952	21	6 931	28 589	2 100	2 443	906	6 581	1 780	3 465	11 313							60 875	6 381	54 313	180	9 326
Coke oven gas	0	- 1 285						- 1 285	- 1 285		1 285	216	990					79											
Blast furnace gas	- 4 649	- 14 089						- 14 089	- 14 089		9 440	4 465	4 975																
	101 140	- 8 375					48	- 8 422	- 15 353	6 931	39 314	6 781	8 408	906	6 581	1 780	3 465	11 392							60 875	6 381	54 313	180	9 326
	559 264	**236 038**	**197 000**	**196 311**	**688**		**22 154**	**16 884**	**8 624**	**8 260**	**90 811**	**14 461**	**13 942**	**1 698**	**17 346**	**3 953**	**7 335**	**32 075**	**123 616**	**7 892**	**109 769**	**1 960**	**3 996**		**97 180**	**19 679**	**74 807**	**2 694**	**11 619**
	7 517																								7 517		5 327	2 190	
Solid biomass	7 517																								7 517		5 327	2 190	
Liquid/Gaseous																													

Annex 2

COMPARISON OF SECTORAL CO2 EMISSIONS FROM NATIONAL INVENTORY AND CARBON BALANCE MODEL

France 1990 kt CO2	SOLIDS		LIQUIDS		GASES		TOTAL		Difference
	Inventory	Model	Inventory	Model	Inventory	Model	Inventory	Model	
TOTAL							**360 186**	**348 930**	**11 256**
Energy Industries							**65 495**	**45 504**	**19 991**
Public Elec and Heat							45 606	25 487	20 119
Refineries							13 239	14 609	- 1 370
Solid fuels manufacture							6 650	4 703	1 947
Other energy								994	- 994
Manufacturing etc							**77 747**	**91 297**	**- 13 551**
Autoproduction								18 862	
Iron & Steel								14 866	
Non ferrous metals								2 293	
Chemicals								19 007	
Pulp and paper								4 387	
Food and beverages								6 748	
Other								25 134	
Transport							**123 111**	**116 572**	**6 540**
Domestic aviation							5 851	2 219	3 632
Road							114 785	110 927	3 858
Rail							1 070	1 217	- 147
National navigation							1 169	2 209	- 1 040
Other							237	0	237
Other Sectors							**93 833**	**95 267**	**- 1 435**
Commercial & Institutional							26 482	30 240	- 3 758
Residential							57 010	55 801	1 210
Agriculture/Forest/Fish							10 340	9 226	1 114
Other							**0**	**0**	**0**

The inclusion of DOM in the French inventory may put it on a basis different from that used when they report energy statistics.

There are two possible explanations for this difference which come to mind.
1) That the French inventory has included emissions from autoproduction in Public Electricity, or
2) Municipal solid waste burned in Public heat plants is considered a non-renewable fuel. I have put it into solid biomass.

A breakdown by branch of manufacturing is needed to explain this difference.

The geographical basis of the French inventory differs from that of the IEA French energy data. The former includes the DOM/TOM.

COMPARISON OF SECTORAL CO2 EMISSIONS FROM NATIONAL INVENTORY AND CARBON BALANCE MODEL

Hungary 1990 kt CO2	Reference Approach only **SOLIDS**		**LIQUIDS**		**GASES**		**TOTAL**		**Difference**
	Inventory	**Model**	**Inventory**	**Model**	**Inventory**	**Model**	**Inventory**	**Model**	
1A TOTAL	**25 942**	**25 198**	**21 759**	**22 963**	**20 404**	**18 905**	**68 105**	**67 066**	**1 039**
1A1 Energy Industries									**0**
Public Elec and Heat									0
Refineries									0
Solid fuels manufacture									0
Other energy									0
1A2 Manufacturing etc									**0**
Autoproduction									0
Iron & Steel									0
Non ferrous metals									0
Chemicals									0
Pulp and paper									0
Food and beverages									0
Other									0
1A3 Transport									**0**
Domestic aviation									0
Road									0
Rail									0
National navigation									0
Other									0
1A4 Other Sectors									**0**
Commercial & Institutional									0
Residential									0
Agriculture/Forest/Fish									0
1A5 Other									**0**

COMPARISON OF SECTORAL CO2 EMISSIONS FROM NATIONAL INVENTORY AND CARBON BALANCE MODEL

New Zealand 1990 kt CO2	**SOLIDS** Inventory	Model	**LIQUIDS** Inventory	Model	**GASES** Inventory	Model	**TOTAL** Inventory	Model	**Difference**
1A TOTAL	**3 225**	**4 522**	**11 035**	**10 699**	**7 980**	**8 581**	**22 240**	**23 803**	**- 1 563**
1A1 Energy Industries	**481**	**455**	**222**	**- 115**	**5 337**	**5 928**	**6 040**	**6 268**	**- 228**
Public Elec and Heat	481	455	15	9	2 997	2 843	3 493	3 307	186
Refineries			207	- 125	568	2 975	775	2 850	- 2 075
Solid fuels manufacture									
Other energy					1 772	111	1 772	111	1 661
1A2 Manufacturing etc	**1 919**	**3 487**	**726**	**835**	**2 065**	**2 099**	**4 710**	**6 421**	**- 1 711**
Autoproduction		184				33		217	na
Iron & Steel		1 249		28				1 278	na
Non ferrous metals									na
Chemicals		22				824		845	na
Pulp and paper									na
Food and beverages				100				100	na
Other		2 032		706		1 242		3 980	na
1A3 Transport			**8 503**	**8 872**	**142**	**133**	**8 645**	**9 005**	**- 360**
Domestic aviation			781	810			781	810	- 28
Road			7 424	5 858	142	133	7 565	5 991	1 574
Rail			77				77		77
National navigation			221	334			221	334	- 112
Other				1 870				1 870	- 1 870
1A4 Other Sectors	**712**	**502**	**1 584**	**1 107**	**436**	**421**	**2 733**	**2 031**	**703**
Commercial & Institutional	420	170	490	489	257	246	1 168	905	263
Residential	292	288	37	30	179	175	508	493	15
Agriculture/Forest/Fish		44	1 057	588			1 057	632	424
1A5 Other	**113**	**78**					**113**	**78**	**35**

See note below [1A TOTAL]

No information is given by NZ relating to its industrial brakdown. An unknown part of the difference will be due to emissions attributed by NZ to he Industrial Processes. [1A2 Manufacturing etc]

NZ energy data to IEA do not distinguish deliveries of gas/diesel oil to road and rail transport. The total quantity is placed in the "other" category. [Transport, Other]

NZ production of motor gasoline from natural gas is included here. The NZ inventory puts these emissions in "other energy" [Refineries]

COMPARISON OF SECTORAL CO2 EMISSIONS FROM NATIONAL INVENTORY AND CARBON BALANCE MODEL

UK 1990 kt CO2	**SOLIDS**		**LIQUIDS**		**GASES**		**TOTAL**		**Difference**
	Inventory	**Model**	**Inventory**	**Model**	**Inventory**	**Model**	**Inventory**	**Model**	
1A TOTAL							**558 091**	**559 264**	**- 1 172**
1A1 Energy Industries							**229 316**	**236 038**	**- 6 723**
Public Elec and Heat							198 506	197 000	1 506
Refineries							18 342	22 154	- 3 812
Solid fuels manufacture							12 468	8 624	3 844
Other energy								8 260	- 8 260
1A2 Manufacturing etc							**94 757**	**90 811**	**3 946**
Autoproduction								14 461	- 14 461
Iron & Steel							22 836	13 942	8 895
Non ferrous metals							IE	1 698	
Chemicals							IE	17 346	
Pulp and paper							IE	3 953	
Food and beverages							IE	7 335	
Other							71 920	32 075	39 845
1A3 Transport							**116 721**	**123 616**	**- 6 894**
Domestic aviation							2 158	7 892	- 5 733
Road							109 180	109 769	- 589
Rail							1 889	1 960	- 71
National navigation							3 461	3 996	- 535
Other							34	0	34
1A4 Other Sectors							**112 032**	**97 180**	**14 852**
Commercial & Institutional							29 773	19 679	10 094
Residential							79 069	74 807	4 262
Agriculture/Forest/Fish							3 190	2 694	496
1A5 Other							**5 265**	**11 619**	**- 6 353**

Mainly upstream natural gas use. It is not clear where this is included in the UK inventory. Perhaps as a fugitive emission.

The IEA figure for domestic aviation fuel use is too high.

This is largely commercial sector use of natural gas but UK/IEA energy statistics do not show it as such.

Includes emissions from the four cells above.

COMPARISON OF SECTORAL CO2 EMISSIONS FROM NATIONAL INVENTORY AND CARBON BALANCE MODEL

USA 1990 kt CO2	SOLIDS		LIQUIDS		GASES		TOTAL		Difference
	Inventory	Model	Inventory	Model	Inventory	Model	Inventory	Model	
1A TOTAL	**1 765 735**	**1 972 941**	**2 114 630**	**2 058 067**	**1 001 295**	**1 004 443**	**4 881 878**	**5 035 451**	**- 153 573**
1A1 Energy Industries	**1 499 679**	**1 553 050**	**97 628**	**292 556**	**151 057**	**197 130**	**1 748 582**	**2 042 735**	**- 294 153**
Public Elec and Heat		1 472 831		87 695		152 659		1 713 185	
Refineries		290		200 221		36 748		237 259	
Solid fuels manufacture		79 928		0		- 59 760		20 168	
Other energy		0		4 640		67 483		72 123	
1A2 Manufacturing etc	**251 043**	**334 919**	**367 226**	**168 891**	**433 229**	**388 472**	**1 051 498**	**892 283**	**159 215**
Autoproduction		149 357		0		57 059		206 416	
Iron & Steel		14 052		0		42 154		56 206	
Non ferrous metals		9 293		0		0		9 293	
Chemicals		39 977		29 631		0		69 609	
Pulp and paper		26 940		0		0		26 940	
Food and beverages		15 547		0		0		15 547	
Other		79 753		139 259		289 260		508 272	
1A3 Transport		**0**	**1 463 145**	**1 407 667**	**36 025**	**36 013**	**1 499 170**	**1 443 680**	**55 490**
Domestic aviation		0		201 987		0		201 987	
Road		0		1 153 844		0		1 153 844	
Rail		0		32 626		0		32 626	
National navigation		0		11 165		0		11 165	
Other		0		8 045		36 013		44 058	
1A4 Other Sectors		**14 515**		**188 953**		**382 828**	**549 339**	**586 296**	**- 36 957**
Commercial & Institutional	8 741	8 985	66 061	65 851	142 436	143 149	217 238	217 985	- 747
Residential	5 824	5 530	87 728	79 435	238 548	239 679	332 101	324 644	7 457
Agriculture/Forest/Fish		0		43 668		0		43 668	- 43 668
1A5 Other	**448**	**70 457**	**32 842**	**0**	**na**	**0**	**33 289**	**70 457**	**- 37 168**

The model includes about 225 000 kt CO2 arising from combustion of industrial and non-specified wastes in "other" manufacturing and autoproduction. These have been treated as non-renewable fuels. It is not clear how these fuels are handled in the US inventory.

US inventory departs from the standard format. The US "industry" source category, entered here as "manufacturing", probably includes agriculture.

It would seem that refinery emissions have been included in this sector.

The "others" category has been used to store the US Territories figure which is not available by source category.

See note on A12 Manufacturing.

Annex 3

Operating the model.

The electronic files are available from the UNFCCC secretariat upon request.

The two Excel 5 workbooks are named, "BIGBAL revised" and "Carbon Balances". BIGBAL must be opened before Carbon Balances because data retrieval in Sheet 1 of Carbon Balances uses the INDIRECT command to gather the data. This allows the change of country name in the cell A2 of Sheet 1 to order the corresponding data. It follows that the formats of each sheet in BIGBAL must be identical and any new data should be requested in this format.

If Carbon Balances is opened before BIGBAL it is not a disaster. Carbon Balances will not find the data and cells will be filled with REF errors.

No part of either work book is protected so make a copy of each to provide a backup.

The work has been done using Excel 8 and the workbooks saved as Excel 5. This may mean that small formatting errors occur on titles and box lining. A copy in Excel 8 can be provided if required.

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