Operations of aircraft are divided into two parts:

- *The Landing/Take-Off (LTO) cycle*[4] which includes all activities near the airport that take place under the altitude of 914 metres (3000 feet). This includes taxi-in and out, climbing and descending.
- *Cruise* is defined as all activities that take place at altitudes above 914 metres (3000 feet). No upper limit is given.

Data sources

Locally available data should be used whenever possible. The fuel consumption and LTO information can be obtained from the national airports. Total number of aircraft per type and engines types can be obtained from the airline companies. Some emission factors are in the *Reference Manual* tables. At the Tier 2 level, emission factors are based on the specific national aircraft fleet and typical airport TIM (ICAO Engine Exhaust Emissions Databank, International Civil Aviation Organization). Another possibility is US EPA (1985): *Compilation of air pollutant emission factors,* Vol. II: Mobile sources, 4th edition, or US Office of Environment and Energy (1991) *FAA Aircraft Emission Database User's Manual.*

Methodology

To use the Tier 2 method, the aircraft types used for both domestic and international flights, as well as the number of LTO's carried out by the various aircraft types, must be known. If this information on a per aircraft type basis is not available, it is recommended that the Tier 1 method be used.

The Tier 2 Approach breaks the calculation of emissions from aviation into 4 steps:

Step 1: Estimate the total fuel consumption for domestic and international aviation

Step 2: Estimate the fuel consumption for LTO activities by aircraft type

Step 3: Estimate the fuel consumption for cruise activities by aircraft type

Step 4: Estimate the emissions for each gas

Completing the Worksheet

Use WORKSHEET 1-5: EMISSIONS FROM AIRCRAFT (TIER 2) to enter the data for this submodule.

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[4] Some statistics count either a landing or a take-off as one operation. **However it is *both* one take-off and one landing, that together define one LTO-operation.**

STEP 1 ESTIMATE THE FUEL CONSUMPTION FOR DOMESTIC AND INTERNATIONAL AVIATION

1 Enter the total amount of fuel sold for all flights (in kt) in Column A.

2 Enter the total amount of fuel sold for domestic flights (in kt) in Column B.

3 Calculate the total amount of fuel sold for international flights by subtracting the total amount of fuel sold for domestic flights (Column B) from the total fuel sold (Column A) and enter in Column C.

STEP 2 ESTIMATE THE FUEL CONSUMPTION FOR LTO CYCLES BY AIRCRAFT TYPE

Do the following calculations for domestic aviation and international aviation separately.

1 Enter the total number of LTO's carried out per aircraft type ($a_1..a_n$) and ($b_1..b_n$) in Column D.

2 Enter the appropriate fuel consumption per LTO (in t/LTO) in Column E (see *Reference Manual*, Section 1.5.3.5 for default values).

3 Calculate the fuel consumption for LTO activity per aircraft type ($a_1..a_n$) and ($b_1..b_n$) in tonnes by multiplying the fuel use per LTO (Column E) by the number of LTO's carried out for that specific aircraft type (Column D) and enter the results in Column F.

4 Calculate the total fuel use for LTO activities by summing the results of the individual aircraft type in Column F and enter the results in the $Total_a$ and $Total_b$ rows of Column F.

STEP 3 ESTIMATE THE FUEL CONSUMPTION FOR CRUISE ACTIVITIES BY AIRCRAFT TYPE

Do the following calculations for domestic aviation and international aviation separately.[5]

1 Enter the total amount of fuel sold for domestic flights in tonnes (Column B multiplied by 1000) and the total amount of fuel sold for international aviation in tonnes (Column C multiplied by 1000) in Column G.

---

[5] This method assumes that the share in fuel consumption in the cruise mode by a type of aircraft will by and large be proportional to the number of LTO cycles of that type of aircraft. It is recognised that by using this method the contribution from larger aircraft may be underestimated. However, this simplifying assumption has been made in order to minimise the amount of aircraft specific data required for the Tier 2 method.

2 Calculate the total fuel consumption for *cruise* by subtracting the total amount of fuel for LTO activities (total from Column F) from the total fuel sold (Column G) and enter the results in Column H.

3 Calculate the fuel consumption for *cruise activities* for each aircraft type as: total fuel used for cruise activities (total in Column H) x (number of LTO's carried out by aircraft type (Column D) / total number of LTO's (total in Column D)) and enter in Column I.

STEP 4 ESTIMATE THE EMISSIONS FOR EACH GAS

Photocopy Sheet 3 seven times and do the following calculations for each gas (CO_2, CH_4, N_2O, NO_x, CO, NMVOC and SO_2). The calculations for domestic aviation and international aviation should be done separately.

1 Enter the emission factors per LTO for each aircraft type (in kg/LTO) in Column J. Default emission factors are available in Section 1.5.3.5 in the *Reference Manual*.

2 Calculate the emissions from LTO's for each aircraft type (in tonnes) by multiplying the total number of LTO's per aircraft type (Column D) by the emission factors per LTO (Column J) and then dividing by 1000. Enter the results in Column K.

3 Enter the emission factors per fuel consumption for cruise activities for various engine types (in kg/t) in Column L. Default emission factors are available in the *Reference Manual*, Section 1.5.3.5.

4 Calculate the emissions from cruise activities for each aircraft type (in tonnes) by multiplying the fuel used for cruise activities (Column I) by the emission factors per fuel consumption for cruise activities (Column L) and then dividing by 1000. Enter the results in Column M.

5 Calculate the total emissions by type of aircraft (in Gigagrams) by adding the emissions from LTO activities (Column K) and the emissions from cruise activities (Column M) and dividing by 1000. Enter the results in Column N.

6 Calculate total emissions from aircraft by summing the results of the individual aircraft type in Column N and enter the results in the $Total_a$ and $Total_b$ rows of Column N.

FUGITIVE SOURCES

1.5 Methane Emissions from Coal Mining and Handling

Introduction

The process of coal formation, commonly called coalification, inherently generates methane and other by-products. The degree of coalification (defined by the rank of the coal) determines the quantity of methane generated and, once generated, the amount of methane stored in coal is controlled by the pressure and temperature of the coal seam and by other, less well-defined characteristics of the coal. The methane will remain stored in the coal until the pressure on the coal is reduced, which can occur through the erosion of overlying strata or the process of coal mining. Once the methane has been released, it flows through the coal toward a region of lower pressure (such as a coal mine) and into the atmosphere.

The amount of CH_4 generated during coal mining is primarily a function of coal rank and depth, as well as other factors such as moisture. If two coal seams have the same rank, the deeper seam will hold larger amounts of CH_4 because the pressure is greater at lower depths, all other things being equal. As a result, most methane released to the atmosphere from coal mining is assumed to come from underground rather than surface mining. As a result, the methane emission factors for surface-mined coal are assumed to be lower than for underground mining.

Methane is also emitted from post-mining activities such as coal processing, transportation, and utilisation. Methane is released mainly because the increased surface area allows more CH_4 to desorb from the coal. Transportation of the coal contributes to CH_4 emissions, because CH_4 desorbs directly from the coal to the atmosphere while in transit (e.g., in railroad cars). Coal may also release methane during its preparation for final use. For instance, in steel production coal is crushed to a particle size of less than 5 mm, vastly increasing the surface area of the coal and allowing more CH_4 to desorb.

Data Sources

The basic data necessary to perform these calculations are, at a minimum, quantity of coal mined by type of mine (underground or surface). Use locally available data where these are reliable.

Country statistics on underground and surface coal production are available from the OECD/IEA (for certain OECD Member countries). Data on coal production by type (hard coal and lignite) are also available for most countries in the world.

Methodology

On the advice of an expert group (see the Section 1.7 in the *Reference Manual*), calculations have been organised around a single formula which relates tonnes of coal production to total CH_4 emissions from *mining* and *post-mining* activities.

The *Workbook* enables the user to operate at several different levels of detail or "tiers" (discussed in more detail in the *Reference Manual*).

Tier 1 is the least accurate and is based upon global average emission factors.

Tier 2 is possible when a country has enough information to develop average emission factors of its own. More detailed calculations can be accommodated by making extra copies of the worksheet and breaking the calculations into sub-national components for which more specific emissions factors may be available.

Tier 3 is based on mine-specific measurement of emissions from mine ventilation and degasification. This method is recommended if data are available as it should provide much more accurate country-based estimates.

The equation for calculating CH_4 emissions from mining activities is:

CH_4 Emissions	**=**	**Coal Production**	**x**	**Emission Factor**	**x**	**Conversion Factor**
(Gg)		**(10^6 t)**		**(m^3 CH_4 / tonne coal)**		**(Gg CH_4 / 10^6 m^3 CH_4)**

ALTERNATIVE LEVELS OF DETAIL - TIERS

The information provided in this *Workbook*, including global default emission factors, allows for calculation at the *Tier 1* level. *Tier 2* calculations follow the same structure, but would use country or basin-specific emission factors if available locally. If a country is capable of *Tier 3* estimates this would indicate that the emissions estimates are already available (having been directly measured) and the *Workbook* methodology for calculating emissions is not needed. Countries with *Tier 3* estimates can move directly to the *Reporting Instructions* volume of these *Guidelines* for guidance on reporting and documenting emissions estimates.

The highest tier of estimation methodology possible should be used for each component of mining activity. It is acceptable to provide estimates using different tiers for various components, provided that the level of calculation is clearly identified in each component. For example, even if *Tier 3* is used to estimate underground emissions, *Tier 1* or *2* can be used to estimate emissions from other components of mining activity.

Completing the Worksheet

Use WORKSHEET 1-6: METHANE EMISSIONS FROM COAL MINING AND HANDLING to enter your data for this submodule.

STEP 1 ESTIMATING METHANE EMISSIONS FROM COAL MINING AND HANDLING

1 Enter the amount of coal produced by each type of mining activity, in millions of tonnes, in Column A.

The total amount of coal should be consistent with that used in the CO_2 from Energy submodule (Worksheet 1-1, Sheet 1, Column A).

2 Select an Emission Factor using Table 1-5 below. Do this for each type of mining activity involved in your inventory. Select a point within the possible range of values which is appropriate to your country. If you do not have the information to select a point, use an average value. Enter the value in Column B.

USING THE WORKSHEET

- Copy the worksheet at the end of this section to complete the inventory.
- Keep the original of the worksheet blank so you can make further copies if necessary

TABLE 1-5
HIGH AND LOW EMISSION FACTORS FOR MINING ACTIVITIES (M^3/TONNE)

	Type of Mine/Activity	
Emission Factor	*Underground*	*Surface*
Mining	10 - 25	0.3 - 2.0
Post-mining	0.9 - 4.0	0 - 0.2

Source: Compiled from various country studies as summarised in Reference Manual

3 Multiply the Amount of Coal Produced (Column A) by the Emission Factor (Column B) to give Methane Emissions (in millions of cubic metres) for each type of mining activity. Enter the result in Column C.

STEP 2 CONVERTING METHANE EMISSIONS IN M^3 TO METHANE EMISSIONS IN GIGAGRAMS

1 Enter a Conversion Factor in Column D.

The conversion factor converts volume of CH_4 to a weight measure (gigagrams) using the density of methane at 20^oC and at a pressure of 1 atmosphere. This conversion factor, expressed in a form suitable for this *Workbook*, is 0.67 $Gg/10^6$ m^3.

2 Multiply the Methane Emissions in millions of m^3 by the Conversion Factor to give the Methane Emissions in gigagrams. Enter the result in Column E. Sum the figures and enter the total in the Total box at the bottom of the column.

1.6 Methane Emissions from Oil and Natural Gas Activities

Introduction

Fugitive emissions of methane from oil and gas activities probably account for about 30 to 70 teragrams per year of global methane emissions. The category includes all emissions from the production, processing, transport and use of oil and natural gas, and from non-productive combustion. It excludes use of oil and gas or derived fuel products to provide energy for internal use, in energy production processing and transport. The latter are considered fuel combustion and treated in an earlier section of this chapter. Fugitive emissions do include, however, emissions which result from the combustion of natural gas during flaring operations. Sources of emissions within oil and gas systems include:

- emissions during normal operation, such as emissions associated with venting and flaring during oil and gas production, chronic leaks or discharges from process vents;
- emissions during repair and maintenance, ; and
- emissions during system upsets and accidents.

To calculate methane emissions from oil and gas activities in your country, you require the following energy data:

Oil	**Gas**
Number of wells drilled	Quantity of gas produced
Quantity of oil produced	Quantity of gas consumed
Quantity of oil refined	

In addition, emission factors will be required as discussed below.

Data sources

Locally available data should be used wherever possible. Energy data for a large number of countries are also published by the International Energy Agency and the United Nations Statistical Division. See *Reference Manual* Sections 1.8.2 and 1.8.3.

In addition to energy data, default emissions factors and other input assumptions, are provided in the *Workbook* methodology where available. In calculating national emissions, users of this method are free to override any of these assumptions or recommendations if other information is preferred. Wherever information is used other than the values recommended in the *Workbook*, this should be noted and documentation should be provided on the sources of the information.

Users should ensure that data used in this section are consistent with those entered in the *CO_2 from Energy* calculations. Countries which have significant emissions from oil and natural gas should consult the discussion in the *Reference*

Manual and look for locally available data which will allow the development of more country-specific factors.

Methodology

Three different *tiers* or levels of detail for calculating these emissions are presented in the *Reference Manual*.

- Tier 1 Production-Based Average Emission Factors Approach
- Tier 2 Mass Balance Approach
- Tier 3 Rigorous Source-Specific Approach

Only Tier 1 is presented in this *Workbook*.

This requires assembling activity data (production etc.) for the country, selecting emission factors based on information in the tables of typical regional values (or from locally available data), and multiplying through to produce emissions estimates by major subcategory. Explanations of the regions used are provided below.

Regional Definitions

Regions have been defined recognising the limitations in data on emissions factors and activity levels, and key differences in oil and gas activities throughout the world. The following five regions have been chosen:

- **USA and Canada**:
- **Former USSR and Eastern Europe**: This region includes the former USSR (which is by far the largest oil and gas producer in the region), Albania, Bulgaria, Czech & Slovak Republics, Hungary, Poland, Romania, and the former Yugoslav republics.
- **Western Europe**: This region includes: Austria, Belgium, Denmark, Faroe Islands, Finland, France, Germany, Gibraltar, Greece, Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and the United Kingdom.
- **Other Oil Exporting Countries**: This region includes the world's other major oil producing countries: the 11 OPEC members (Algeria, Libya, Nigeria, Venezuela, Indonesia, Iran, Iraq, Kuwait, Qatar, Saudi Arabia and the United Arab Emirates) Gabon, Ecuador and Mexico.
- **Rest of the World**: This region includes the remaining countries of Asia, Africa, Middle East, Oceania and Latin America.

Completing the Worksheet

Use WORKSHEET 1-7: METHANE EMISSIONS FROM OIL AND GAS ACTIVITIES (TIER 1) to enter your data for this submodule.

ESTIMATING THE AMOUNT OF METHANE EMITTED BY OIL AND GAS ACTIVITIES

1 Enter data for each type of oil and gas production activity in Column A.

Data sources are discussed above. Ensure that the data you use are consistent with the activity data used to calculate CO_2 from Energy Sources in the first submodule of this module.

2 For each type of activity enter an Emission Factor in Column B.

Use locally available data or the data in Table 1-6 below. Note that these tables provide a range of values to account for the uncertainty implicit in this method. You should use your judgement to select a single value from this range. You are also encouraged to provide an estimate of uncertainty with the values (see the *Greenhouse Gas Inventory Reporting Instructions*).

3 Multiply the amounts of oil and gas for each Activity (Column A) by the Emission Factor (Column B) to give the amount of CH_4 emitted in kilograms CH_4. Enter the results in kilograms in Column C.

4 Divide the emissions of CH_4 in kilograms (Column C) by 10^6 to convert to gigagrams. Enter the results, in gigagrams CH_4, in Column D and complete the "total" boxes.

EXPLORATION AND DRILLING

A category of exploration and drilling is included on the worksheet. However, no sources of activity data or default emissions are provided. If you have locally available data for these values, enter this. If you are working from default sources you should ignore this category which is only expected to be a small component of emissions.

TABLE 1-6
REVISED REGIONAL EMISSION FACTORS FOR METHANE FROM OIL AND GAS ACTIVITIES SYSTEMS (kg/PJ)

Source Type	Basis	Western Europe	USA & Canada	Former USSR, Central & Eastern Europe	Other Oil Exporting Countries	Rest of the World
OIL & GAS PRODUCTION						
Fugitive and Other Routine Maintenance Emissions from Oil Production	Oil Produced	300 - 5 000	300 - 5 000	300 - 5 000	300 - 5 000	300 - 5 000
Fugitive and Other Routine Maintenance Emissions from Gas Production	Gas Produced	15 000 - 27 000	46 000 - 84 000	140 000 - 314 000	46 000 - 96 000	46 000 - 96 000
Venting & Flaring from Oil and Gas Production	Oil & Gas Produced[a]	-	3 000 - 14 000	-	-	-
	Oil Produced	1 000 - 3 000	-	-	-	-
	Gas Produced	-	-	6 000 - 30 000	758 000 - 1 046 000	175 000 - 209 000
CRUDE OIL TRANSPORTATION, STORAGE AND REFINING						
Transportation	Oil Tankered	745	745	745	745	745
Refining	Oil Refined	90 - 1 400	90 - 1 400	90 - 1 400	90 - 1 400	90 - 1 400
Storage Tanks	Oil Refined	20 - 250	20 - 250	20 - 250	20 - 250	20 - 250
NATURAL GAS PROCESSING, TRANSPORT AND DISTRIBUTION						
Emissions from Processing, Transmission and Distribution	Gas Produced	-	-	288 000 - 628 000	288 000 (high)[b]	288 000 (high) [b]
	Gas Consumed	72 000 - 133 000	57 000 - 118 000	-	118 000 (low) [c]	118 000 (low) [c]
Leakage at industrial plants and power stations	Non-residential Gas Consumed[d]	-	-	175 000 - 384 000	0 - 175 000	0 - 175 000
Leakage in the residential and commercial sectors	Residential Gas Consumed[e]	-	-	87 000 - 192 000	0 - 87 000	0 - 87 000

(a) In the United States and Canada, the emissions are based on total production of both oil and gas produced.

(b) The emission factor of 288 000 kg/PJ of gas produced is used only for the high emissions estimate.

(c) The emission factor of 118 000 kg/PJ of gas consumed is used only for the low emissions estimate.

(d) Gas consumption by utilities and industries.

(e) Gas consumption by the residential and commercial sectors.

Source: Constructed from the literature summarised in the *Reference Manual*

1.7 Ozone Precursors and SO_2 Emissions from Oil Refining

Introduction

A basic refinery converts crude petroleum into a variety of sub-products. Principal products of a refinery may include liquid fuels, coke, feedstocks and primary petrochemicals (like ethylene). This section covers basic refineries, not the synthesis of petrochemicals. Chemical production is included in Chapter 2, Industrial Processes, whether or not the actual production takes place at a refinery or in a separate plant.

Data Sources

Data on crude oil throughput, required for the simplified Tier 1 approach, is usually readily available from national sources or international compendia of energy statistics. The Tier 2 methods require data on internal refinery operations which can be obtained only locally either through a national industry association including refiners or by direct contact with the refiners. These contacts also provide the opportunity to obtain local emission factors for use in place of the default factors provided below.

Completing the Worksheet

Use WORKSHEET 1-8 OZONE PRECURSORS AND SO_2 EMISSIONS FROM OIL REFINING to enter your data for this submodule.

ESTIMATING EMISSIONS OF CO, NO_x, NMVOC AND SO_2

Tier 1 - Using Crude Oil Throughput

A simple estimation method uses average default emission factors for all four pollutants based on the crude oil throughput of the refineries. Local emission factors should be used wherever possible as values, particularly for NMVOCs, can vary widely.

Using Worksheet 1-8, Sheet 1

1 Enter the crude oil throughput of the refinery(ies) in Column A expressed in 1000 tonnes.

2 In Column C, overwrite the default emission factors with local values if available.

3 Multiply, in turn, the figure in Column A by each of the emission factors entered in Column C and place the results in the corresponding rows of Column D.

4 Divide the figures in Column D by 1000 to convert to gigagrams and place the results in Column E.

Tier 2 Methods

Separate methods for the estimation of the four pollutants from catalytic cracking, SO_2 from desulphurisation and NMVOCs from oil storage are presented below.

The discussion in Section 1.8.9 of the *Reference Manual* makes clear that the default emission factors for SO_2 and NO_x are subject to wide ranges. Efforts should be made to use local values for these pollutants and for NMVOCs.

ESTIMATING EMISSIONS OF OZONE PRECURSORS AND SO_2 FROM CATALYTIC CRACKING

Using Worksheet 1-8, Sheet 2

1 Enter the oil throughput of the catalytic cracker units in Column A expressed in 1000 tonnes.

2 In Column C, overwrite the default emission factors with local values if available.

3 Multiply, in turn, the figure in Column A by each of the emission factors entered in Column C and place the results in the corresponding rows of Column D.

4 Divide the figures in Column D by 1000 to convert to gigagrams and place the results in Column E.

ESTIMATING EMISSIONS OF SO_2 FROM DESULPHURISATION

Using Worksheet 1-8, Sheet 3

1 Enter the quantity of sulphur recovered in tonnes in Column A.

2 Multiply this figure by 139 (the default emission factor in kg/t) and place the result in Column C.

3 Divide the figure in kg in Column C by 10^6 to convert to gigagrams and put the result in Column D.

ESTIMATING EMISSIONS OF NMVOCS FROM OIL STORAGE

Using Worksheet 1-8, Sheet 4

1 For each refinery in the country, identify the major storage type. Sum the crude oil throughputs for each storage type and enter the result in Column A expressed in 1000 tonnes.

2 Multiply the emission factor by the crude oil throughput in Column A and place the result in the appropriate row in Column D.

3 Divide the figure in Column D by 1000 and put the result in gigagrams in Column E.

MODULE	ENERGY
SUBMODULE	CO_2 FROM ENERGY SOURCES (REFERENCE APPROACH)
WORKSHEET	1-1
SHEET	1 OF 5

			STEP 1					
			A Production	B Imports	C Exports	D International Bunkers	E Stock Change	F Apparent Consumption
FUEL TYPES								F=(A+B -C-D-E)
Liquid Fossil	Primary Fuels	Crude Oil						
		Orimulsion						
		Natural Gas Liquids						
	Secondary Fuels	Gasoline						
		Jet Kerosene						
		Other Kerosene						
		Shale Oil						
		Gas / Diesel Oil						
		Residual Fuel Oil						
		LPG						
		Ethane						
		Naphtha						
		Bitumen						
		Lubricants						
		Petroleum Coke						
		Refinery Feedstocks						
		Other Oil						
Liquid Fossil Totals								
Solid Fossil	Primary Fuels	Anthracite[(a)]						
		Coking Coal						
		Other Bit. Coal						
		Sub-bit. Coal						
		Lignite						
		Oil Shale						
		Peat						
	Secondary Fuels	BKB & Patent Fuel						
		Coke Oven/Gas Coke						
Solid Fossil Totals								
Gaseous Fossil		Natural Gas (Dry)						
Total								
Biomass Total								
		Solid biomass						
		Liquid biomass						
		Gas biomass						

(a) If anthracite is not separately available, include with Other Bituminous Coal.

MODULE	ENERGY
SUBMODULE	CO_2 FROM ENERGY SOURCES (REFERENCE APPROACH)
WORKSHEET	1-1
SHEET	2 OF 5

			STEP 2		STEP 3		
			G[a] Conversion Factor (TJ/Unit)	H Apparent Consumption (TJ)	I Carbon Emission Factor (t C/TJ)	J Carbon Content (t C)	K Carbon Content (Gg C)
FUEL TYPES				H=(FxG)		J=(HxI)	K=(Jx10^{-3})
Liquid Fossil	Primary Fuels	Crude Oil					
		Orimulsion					
		Natural Gas Liquids					
	Secondary Fuels	Gasoline					
		Jet Kerosene					
		Other Kerosene					
		Shale Oil					
		Gas / Diesel Oil					
		Residual Fuel Oil					
		LPG					
		Ethane					
		Naphtha					
		Bitumen					
		Lubricants					
		Petroleum Coke					
		Refinery Feedstocks					
		Other Oil					
Liquid Fossil Totals							
Solid Fossil	Primary Fuels	Anthracite					
		Coking Coal					
		Other Bit. Coal[b]					
		Sub-bit. Coal					
		Lignite					
		Oil Shale					
		Peat					
	Secondary Fuels	BKB & Patent Fuel					
		Coke Oven/Gas Coke					
Solid Fossil Totals							
Gaseous Fossil		Natural Gas (Dry)					
Total							
Biomass Total							
		Solid biomass					
		Liquid biomass					
		Gas biomass					

(a) Please specify units.
(b) If anthracite is not separately available, include with Other Bituminous Coal.

MODULE	ENERGY					
SUBMODULE	CO_2 FROM ENERGY SOURCES (REFERENCE APPROACH)					
WORKSHEET	1-1					
SHEET	3 OF 5					
			STEP 4		STEP 5		STEP 6
			L Carbon Stored (Gg C)	M Net Carbon Emissions (Gg C)	N Fraction of Carbon Oxidised	O Actual Carbon Emissions (Gg C)	P Actual CO_2 Emissions (Gg CO_2)
FUEL TYPES				M=(K-L)		O=(MxN)	P=(Ox[44/12])
Liquid Fossil	Primary Fuels	Crude Oil					
		Orimulsion					
		Natural Gas Liquids					
	Secondary Fuels	Gasoline					
		Jet Kerosene					
		Other Kerosene					
		Shale Oil					
		Gas / Diesel Oil					
		Residual Fuel Oil					
		LPG					
		Ethane					
		Naphtha					
		Bitumen					
		Lubricants					
		Petroleum Coke					
		Refinery Feedstocks					
		Other Oil					
Liquid Fossil Totals							
Solid Fossil	Primary Fuels	Anthracite					
		Coking Coal					
		Other Bit. Coal[(a)]					
		Sub-bit. Coal					
		Lignite					
		Oil Shale					
		Peat					
	Secondary Fuels	BKB & Patent Fuel					
		Coke Oven/Gas Coke					
Solid Fossil Totals							
Gaseous Fossil		Natural Gas (Dry)					
Total							
Biomass Total							
		Solid biomass					
		Liquid biomass					
		Gas biomass					

(a) If anthracite is not separately available, include with Other Bituminous Coal.

MODULE	ENERGY
SUBMODULE	CO_2 FROM ENERGY SOURCES (REFERENCE APPROACH)
WORKSHEET	1-1
SHEET	4 OF 5 EMISSIONS FROM INTERNATIONAL BUNKERS (INTERNATIONAL MARINE AND AIR TRANSPORT)

		STEP 1	STEP 2		STEP 3		
		A Quantities Delivered[a]	B Conversion Factor (TJ/unit)	C Quantities Delivered (TJ)	D Carbon Emission Factor (t C/TJ)	E Carbon Content (t C)	F Carbon Content (Gg C)
FUEL TYPES				C=(AxB)		E=(CxD)	F=(E x 10^{-3})
Solid Fossil	Other Bituminous Coal						
	Sub-Bituminous Coal						
Liquid Fossil	Gasoline						
	Jet Kerosene						
	Gas/Diesel Oil						
	Residual Fuel Oil						
	Lubricants						
			Total				

(a) Enter the quantities from Table 1-1, Sheet 1, Column D: "International Bunkers".

MODULE	ENERGY
SUBMODULE	CO_2 FROM ENERGY SOURCES (REFERENCE APPROACH)
WORKSHEET	1-1
SHEET	5 OF 5 EMISSIONS FROM INTERNATIONAL BUNKERS (INTERNATIONAL MARINE AND AIR TRANSPORT)

		STEP 4			STEP 5		STEP 6
		G Fraction of Carbon Stored	H Carbon Stored (Gg C)	I Net Carbon Emissions (Gg C)	J Fraction of Carbon Oxidised	K Actual Carbon Emissions (Gg C)	L Actual CO_2 Emissions (Gg CO_2)
FUEL TYPES			H=(FxG)	I=(F-H)		K=(IxJ)	L=(Kx44/12)
Solid Fossil	Other Bituminous Coal	0	0				
	Sub-Bituminous Coal	0	0				
Liquid Fossil	Gasoline	0	0				
	Jet Kerosene	0	0				
	Gas/Diesel Oil	0	0				
	Residual Fuel Oil	0	0				
	Lubricants	0.5					
						Total[a]	

(a) The bunker emissions are not to be added to national totals.

MODULE	**ENERGY**
SUBMODULE	**CO_2 FROM ENERGY**
WORKSHEET	**AUXILIARY WORKSHEET 1-1: ESTIMATING CARBON STORED IN PRODUCTS**
SHEET	**1 OF 1**

	A	B	C	D	E	F	G	H
	Estimated Fuel Quantities	Conversion Factor (TJ/Units)	Estimated Fuel Quantities (TJ)	Carbon Emission Factor (t C/TJ)	Carbon Content (t C)	Carbon Content (Gg C)	Fraction of Carbon Stored	Carbon Stored (Gg C)
FUEL TYPES			C=(AxB)		E=(CxD)	F=(Ex10^{-3})		H=(FxG)
Naphtha[a]							0.80	
Lubricants							0.50	
Bitumen							1.0	
Coal Oils and Tars (from Coking Coal)							0.75	
Natural Gas[a]							0.33	
Gas/Diesel Oil[a]							0.50	
LPG[a]							0.80	
Ethane[a]							0.80	
Other fuels[b]								

(a) Enter these fuels when they are used as feedstocks.

(b) Use the Other fuels rows to enter any other products in which carbon may be stored

MODULE	ENERGY
SUBMODULE	CO_2 FROM FUEL COMBUSTION BY SOURCE CATEGORIES (TIER I)
WORKSHEET	1-2 STEP BY STEP CALCULATIONS
SHEET	1 OF 16 ENERGY INDUSTRIES

	STEP 1	STEP 2		STEP 3		
Energy Industries	A Consumption	B Conversion Factor (TJ/unit)	C Consumption (TJ)	D Carbon Emission Factor (t C/TJ)	E Carbon Content (t C)	F Carbon Content (Gg C)
			C=(AxB)		E=(CxD)	F=(E x 10^{-3})
Crude Oil	(a)					
Natural Gas Liquids						
Gasoline						
Jet Kerosene						
Other Kerosene						
Gas/Diesel Oil						
Residual Fuel Oil						
LPG						
Ethane						
Naphtha						
Lubricants						
Petroleum Coke						
Refinery Gas						
Anthracite						
Coking Coal						
Other Bituminous Coal						
Sub-Bituminous Coal						
Lignite						
Peat						
Patent Fuel						
Brown Coal Briquettes						
Coke Oven Coke						
Gas Coke						
Gas Works Gas						
Coke Oven Gas						
Blast Furnace Gas						
Natural Gas						
Municipal Solid Waste						
Industrial Waste						
		Total				
Memo items:						
Wood/Wood Waste						
Charcoal						
Other Solid Biomass						
Liquid Biomass						
Gaseous Biomass						
		Total Biomass				

(a) Include only consumption of crude oil that is burned, not crude oil which is refined into petroleum products.

MODULE	ENERGY
SUBMODULE	CO_2 FROM FUEL COMBUSTION BY SOURCE CATEGORIES (TIER I)
WORKSHEET	1-2 STEP BY STEP CALCULATIONS
SHEET	2 OF 16 ENERGY INDUSTRIES

	STEP 4			STEP 5		STEP 6
Energy Industries	G Fraction of Carbon Stored	H Carbon Stored (Gg C)	I Net Carbon Emissions (Gg C)	J Fraction of Carbon Oxidised	K Actual Carbon Emissions (Gg C)	L Actual CO_2 Emissions (Gg CO_2)
		H=(FxG)	I=(F-H)		K=(IxJ)	L=(K x [44/12])
Crude Oil						
Natural Gas Liquids						
Gasoline						
Jet Kerosene						
Other Kerosene						
Gas/Diesel Oil						
Residual Fuel Oil						
LPG						
Ethane						
Naphtha						
Lubricants	(a)					
Petroleum Coke						
Refinery Gas						
Anthracite						
Coking Coal						
Other Bituminous Coal						
Sub-Bituminous Coal						
Lignite						
Peat						
Patent Fuel						
Brown Coal Briquettes						
Coke Oven Coke						
Gas Coke						
Gas Works Gas						
Coke Oven Gas						
Blast Furnace Gas						
Natural Gas						
Municipal Solid Waste						
Industrial Waste						
					Total	
Memo items:						
Wood/Wood Waste						
Charcoal						
Other Solid Biomass						
Liquid Biomass						
Gaseous Biomass						
					Total Biomass	

(a) Use a value of 0.5 for lubricants.

MODULE	**ENERGY**
SUBMODULE	**CO_2 FROM FUEL COMBUSTION BY SOURCE CATEGORIES (TIER I)**
WORKSHEET	**1-2 STEP BY STEP CALCULATIONS**
SHEET	**3 OF 16 MANUFACTURING INDUSTRIES AND CONSTRUCTION**

	STEP 1	STEP 2		STEP 3		
	A	B	C	D	E	F
Manufacturing Industries and Construction	Consumption	Conversion Factor (TJ/unit)	Consumption (TJ)	Carbon Emission Factor (t C/TJ)	Carbon Content (t C)	Carbon Content (Gg C)
			C=(AxB)		E=(CxD)	F=(E x 10^{-3})
Crude Oil						
Natural Gas Liquids						
Gasoline						
Jet Kerosene						
Other Kerosene						
Gas/Diesel Oil						
Residual Fuel Oil						
LPG						
Ethane						
Naphtha						
Lubricants						
Petroleum Coke						
Refinery Gas						
Anthracite						
Coking Coal						
Other Bituminous Coal						
Sub-Bituminous Coal						
Lignite						
Peat						
Patent Fuel						
Brown Coal Briquettes						
Coke Oven Coke						
Gas Coke						
Gas Works Gas						
Coke Oven Gas						
Blast Furnace Gas						
Natural Gas						
Municipal Solid Waste						
Industrial Waste						
		Total				
Memo items:						
Wood/Wood Waste						
Charcoal						
Other Solid Biomass						
Liquid Biomass						
Gaseous Biomass						
		Total Biomass				

Note: To separately identify emissions associated with autogeneration from those associated with process heat, photocopy sheets 3 and 4, clearly indicating the source of the emissions.