

**TRAINING COURSES FOR NATIONAL
EXPERTS INVOLVED IN THE
DEVELOPMENT OF GHG INVENTORY
– ENERGY SECTOR**

Reference approach

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Overview

- The IPCC Reference approach is a method that allows estimation of CO₂ emissions from fuel combustion in a straightforward manner using relatively easy available energy statistics.
- According to the IPCC Guidelines Parties should compare their national estimates of CO₂ emissions from fuel combustion with those estimates obtained using the IPCC reference approach, and report the results of this comparison in the NIR
- Fuels delivered to and consumed by **international bunkers should be subtracted from the fuel supply to the country.**

Overview (cont.)

The IPCC reference approach is a top-down method, which basically uses the apparent consumption of each fuel as the AD (apparent consumption = production + imports – exports – international bunkers – stock change) and the corresponding C contents as the EFs. To avoid double counting of C mass flows, production of primary fuels is only considered to estimate apparent consumption, while the production (or manufacture) of secondary fuels is left out of the calculations because the C in these fuels is already included in the supply of primary fuels from which they were derived. The amount of C that does not lead to fuel combustion emissions (i.e. C in feedstocks and non-energy use) is excluded from the estimation because the aim is to provide an estimate of fuel combustion emissions.

Methodological approach (IPCC, 1996)

The apparent consumption of *primary* fuels is, therefore, calculated from the above data as:

$$\text{Apparent Consumption} = \text{Production} + \text{Imports} - \text{Exports} - \text{International Bunkers} - \text{Stock Change.}$$

An increase in stocks is a positive stock change which withdraws supply from consumption. A stock reduction is a negative stock change which, when subtracted in the equation, causes an increase in apparent consumption.

Apparent consumption of secondary fuels should be added to primary apparent consumption. The production (or manufacture) of secondary fuels should be ignored in the calculations because the carbon in these fuels will already have been included in the supply of primary fuels from which they were derived; for instance, the estimate for apparent consumption of crude oil already contains the carbon from which gasoline would be refined. Apparent consumption of secondary fuels is calculated as follows:

$$\text{Apparent Consumption} = \text{Imports} - \text{Exports} - \text{International Bunkers} - \text{Stock Change.}$$

Note that this calculation can result in negative numbers for apparent consumption. This is a perfectly acceptable result for the purposes of this calculation since it indicates a net export or stock increase in the country.

Methodology approach (IPCC, 2006)

The Reference Approach methodology breaks the calculation of carbon dioxide emissions from fuel combustion into 5 steps:

Step 1: Estimate Apparent Fuel Consumption in Original Units

Step 2: Convert to a Common Energy Unit

Step 3: Multiply by Carbon Content to Compute the Total Carbon

Step 4: Compute the Excluded Carbon

Step 5: Correct for Carbon Unoxidised and Convert to CO₂ Emissions

These steps are expressed in the following equation:

$$\begin{aligned} & \text{EQUATION 6.1} \\ & \text{CO}_2 \text{ EMISSIONS FROM FUEL COMBUSTION USING THE REFERENCE APPROACH} \\ & CO_2 \text{ Emissions} = \sum_{\text{all fuels}} \left[((\text{Apparent Consumption}_{\text{fuel}} \cdot \text{Conv Factor}_{\text{fuel}} \cdot \text{CC}_{\text{fuel}}) \cdot 10^{-3}) \right. \\ & \quad \left. - \text{Excluded Carbon}_{\text{fuel}} \right) \cdot \text{COF}_{\text{fuel}} \cdot 44/12 \end{aligned}$$

Where:

CO₂ Emissions = CO₂ emissions (Gg CO₂)

Apparent Consumption = production + imports – exports – international bunkers - stock change

Conv Factor (conversion factor) = conversion factor for the fuel to energy units (TJ) on a net calorific value basis

CC = carbon content (tonne C/TJ)

Note that tonne C/TJ is identical to kg C/GJ

Excluded Carbon = carbon in feedstocks and non-energy use excluded from fuel combustion emissions (Gg C)

Carbon stored

For the IPCC Reference Approach, the suggested formula for estimating carbon stored in products for each country is:

$$\begin{aligned} \text{Total Carbon Stored (Gg C)} = & \\ & \text{Non-Energy Use (10}^3 \text{ t)} \\ & \times \text{Conversion Factor (TJ/10}^3 \text{ t)} \\ & \times \text{Emission Factor (t C/TJ)} \\ & \times \text{Fraction Carbon Stored} \\ & \times 10^{-3} \end{aligned}$$

Currently the fraction of carbon stored applied to the carbon content of the fuels used for product manufacture takes into account the release of carbon from the use or destruction of the products in the short term. The fraction is therefore lower than the fraction of carbon entering the products (see Box 2). The emissions resulting from the use or destruction of the products may occur in:

- industrial processes – both the production of non-fuel products from energy feedstocks, and the emissions from use of these products in industrial processes (e.g., oxidation of anodes made from petroleum coke which occurs during aluminium production);
- other end uses of products (e.g., lubricants oxidised in transportation);
- waste disposal – particularly incineration of plastics and other fossil fuel based products.

Excluded carbon

The amount of C that is not destined for combustion is excluded from the total C amount that is combusted in the reference approach algorithm. This C excluded from combustion is either emitted in another sector of the inventory (typically the IPPU sector) or is stored in some product.

Three main types of carbonaceous products are considered in the calculation of excluded C, namely those used as:

- feedstock (ethane, gas/diesel oil, kerosene, LPG, naphtha, natural gas, refinery gas);
- reductant (coal and coal tar/pitch, oven coke, petroleum coke, natural gas); and
- non-energy products (bitumen, lubricants, paraffin waxes, white spirit).

As discussed previously, the use of fuels as feedstock and/or reductants may generate subproducts that may be combusted for energy purposes. When these subproducts are exported from the IPPU sector to the Energy sector, the associated emissions from combustion are estimated and reported under the Energy sector. However, for simplicity, this rule is not applied in the IPCC reference approach, which assumes complete exclusion of C in:

- feedstock;
- fuels used as reductant (coke, coal and derived coal products, natural gas); and
- lubricants and paraffin waxes.

The effect of this complete exclusion may be reflected as a difference between the CO₂ estimates, depending on the uses for energy purposes of the possible subproducts from feedstock and reductants and of lubricants and waxes. This fact should be taken into account to explain the differences between the national estimates of CO₂ emissions and those from the IPCC reference approach.

Regarding CCS, because the IPCC reference approach does not include any feature to account for amounts of captured CO₂, the comparison with national totals should be carried out with CO₂ emissions before these amounts are subtracted out.

The quantity of carbon to be excluded from the estimation of fuel combustion emissions is calculated according to following equation.

EQUATION 6.4
CARBON EXCLUDED FROM FUEL COMBUSTION EMISSIONS

$$Excluded\ Carbon_{fuel} = Activity\ Data_{fuel} \cdot CC_{fuel} \cdot 10^{-3}$$

Where:

- Excluded Carbon = carbon excluded from fuel combustion emissions (Gg C)
- Activity Data = activity data (TJ)
- CC = carbon content (tonne C/TJ)

The activity data for each relevant product are given in Table 6.2.

Excluded carbon (cont.)

TABLE 6.2 ACTIVITY DATA FOR EXCLUDED CARBON FLOWS	
Fuel	Activity data ¹
LPG, ethane, naphtha, refinery gas ² , gas/diesel oil, kerosene	Deliveries to petrochemical feedstocks ³
Bitumen	Total deliveries
Lubricants	Total deliveries
Paraffin waxes ²	Total deliveries
White spirit ²	Total deliveries
Cokes <i>Calcined</i> petroleum coke Coke oven coke	Total deliveries Deliveries to the iron and steel and non-ferrous metals industries
Coal Tar Light oils from coal Coal tar/pitch	Deliveries to chemical industry Deliveries to chemical industry and construction
Natural gas	Deliveries to petrochemical feedstocks and for the direct reduction of iron ore in the iron and steel industry
Notes:	
¹ Deliveries refers to the total amount of fuel delivered and is not the same thing as apparent consumption (where the production of secondary fuels is excluded).	
² Refinery gas, paraffin waxes and white spirit are included in "other oil".	
³ For the purposes of the Reference Approach, the deliveries used as activity data should be net of any oils returned to refineries from petrochemical processing.	

Carbone stored

- According to the Revised 1996 IPCC Guidelines, carbon that remains unoxidised is stored indefinitely.

Coal ^(a)	0.98
Oil and Oil Products	0.99
Gas	0.995
Peat for electricity generation ^(b)	0.99
(a) This figure is a global average but varies for different types of coal, and can be as low as 0.91.	
(b) The fraction for peat used in households may be much lower.	

- According to the 2006 IPCC Guidelines

A small part of the fuel carbon entering combustion escapes oxidation but the majority of this carbon is later oxidised in the atmosphere. It is assumed that the carbon that remains unoxidised (e.g. as soot or ash) is stored indefinitely. For the purposes of the Reference Approach, unless country-specific information is available, a default value of 1 (full oxidation) should be used.

Discrepancies between Reference and Sectoral approaches

- In the case of discrepancies between the approaches is more than 2%, it is expected that the Party investigate and document the reasons for such difference.
- The IPCC Guidelines discuss main possible reasons for discrepancy of CO₂ emissions calculated by the Reference and Sectoral approaches (section 6.8, v.2, the 2006 IPCC Guidelines)
- To decrease discrepancies the same values of NCVs and carbon contents should be used as for stationary combustion at sectoral approach.

Exercise 5

- Accounting of non-energy use of fuels
(difference between the Revised 1996 IPCC Guidelines and the IPCC 2006 Guidelines)

Calculate for the 2013 using both methodologies

Indicate, where the accompanying emission should be reported

Exercise 6

- Comparison between reference and sectoral approaches

What could be the main reasons for difference in CO₂ emissions calculated by the two approaches in Moldova?