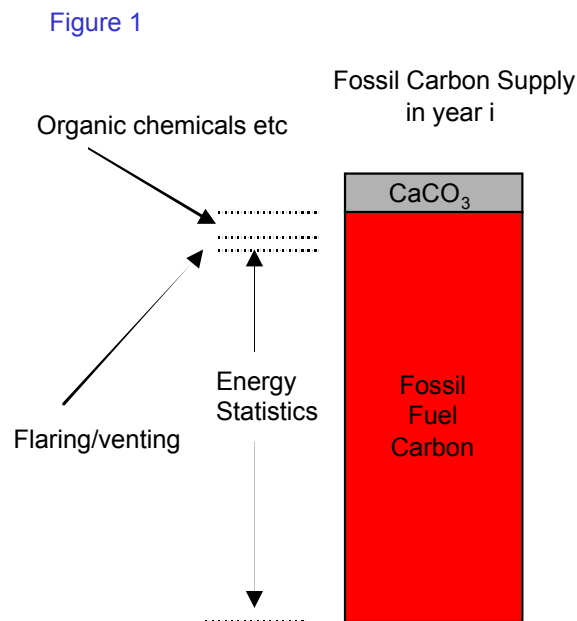


Fossil Carbon Flows and Inventory Structure

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Annual emissions of carbon into the atmosphere come, almost entirely, from fossil or biomass origins. The sources of fossil carbon are fossil fuels and calcium carbonate. The annual national supply of fossil carbon is the primary production (extraction) of fossil carbon plus the net imports (imports – exports) and any stock draw of materials containing carbon (not only primary fuels). The major contribution comes from fossil fuels with smaller amounts from calcium carbonate and the net import of materials manufactured from fossil fuels. See Figure 1

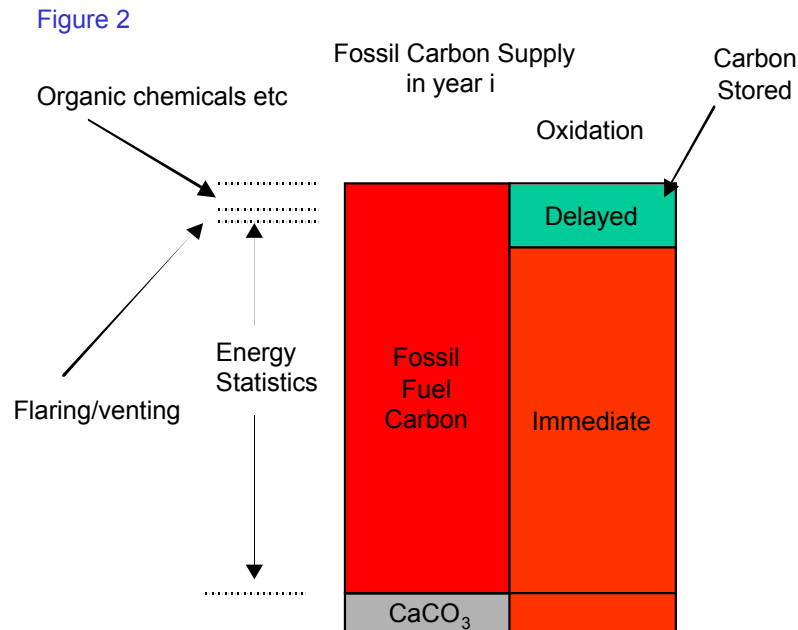


Statistics on the supplies of fuels are, generally, well collected and presented in national energy statistics. Countries which have their own production of oil and gas will, if they conform with the international definition of production, exclude quantities of gas not „won and saved“. These quantities usually comprise gas which was vented or flared.

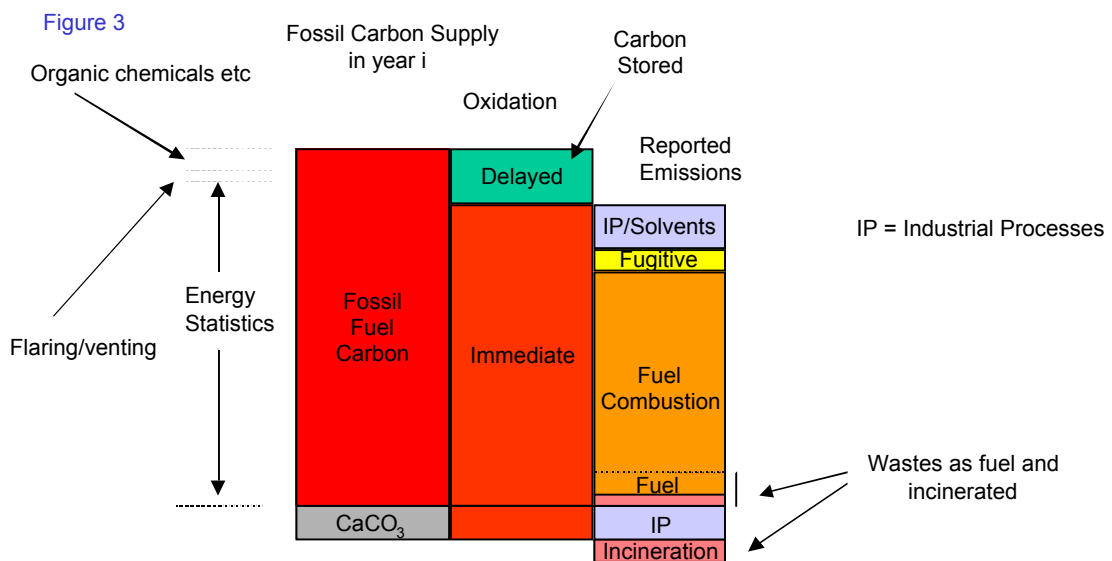
Estimates of the national supply of carbon from fossil fuels can therefore be made using energy statistics adjusted for any gas vented or flared and any net imports of other organics derived from fossil carbon. Carbon from calcium carbonate must be added.

Carbon enters the atmosphere in a number of carbon-based molecular forms. CO₂ is the dominant form but other forms are direct or indirect GHGs. Of these CO, CH₄ and NMVOCs are assumed to oxidise rapidly to CO₂ and their emissions from fuel combustion are included in the national CO₂ inventory for the year of their emission as well as in their own inventory. There are small but important emissions of other carbon gases which do not oxidise rapidly to CO₂ (HFCs, PFCs) and these will be mentioned later. This note concentrates on CO₂.

Some of the pool of carbon supplied in a calendar year will lead to CO₂ emissions in that year and some will lead to CO₂ emissions in later years. The assumption is that carbon released into the atmosphere within the year is considered immediately oxidised. The remainder of the carbon pool will lead to „delayed“ oxidation and CO₂ emissions occurring in later years. See Figure 2. Emissions *reported* for a year will comprise the emissions from immediate oxidation and emissions from oxidation of carbon supplied in earlier years.



National inventories of CO₂ emissions must estimate the emissions according to the source categories defined in the IPCC Guidelines and report them using the Common Reporting Framework promulgated by the UNFCCC/SBSTA. Figure 3 shows the broad relationship between the main source category divisions and the division of the carbon pool into immediate and delayed oxidation.



The largest example of immediate oxidation is fuel combustion which dominates the major source category, „Energy“. Fuel combustion is defined only indirectly in Vol 3 of the IPCC Guidelines, in the discussion of Industrial Process emissions. Oxidation of carbon with the release of useful heat may take place in a number of industrial processes which are not undertaken for heat raising purposes. These are considered to lead to industrial process emissions and the „not for heat raising“ criterion has provided the *de facto* basis for distinguishing between an industrial process oxidation and fuel combustion emissions. This seems to imply that, where carbon fuels are burned for heat raising, it is fuel combustion. The criterion is also used to place flaring in the fugitive emissions category and waste incineration under waste.

CO₂ emissions from industrial processes are usually second in importance to those from fuel combustion. Typical examples are the emissions from the manufacture of metals, some soda ash processes and carbides. Solvents lead to NMVOC emissions and CaCO₃ contributes to carbon emissions in cement clinker manufacture and some metal manufacturing processes.

Fugitive emissions result from the transport and use of fuels, the flaring of gases and the release of gases during coal mining. Fugitive emissions which take place during the manufacture of products (whether in the energy sector or elsewhere) are considered as industrial process emissions.

Wastes may be destroyed through incineration or used as a fuel for heat raising. In the latter case they form part of the energy statistics and are considered „new“ fuel. On a strict methodological emissions basis this is incorrect but, at present, it constitutes only a small error. The fossil carbon in the wastes comes, in part, from this year's supply and in part from the supplies in previous years. The emissions attributable to the *incineration* of the earlier supply are shown as additional to the emissions from supply in the present year.

What implications does this have for the Reference Approach (RA)?

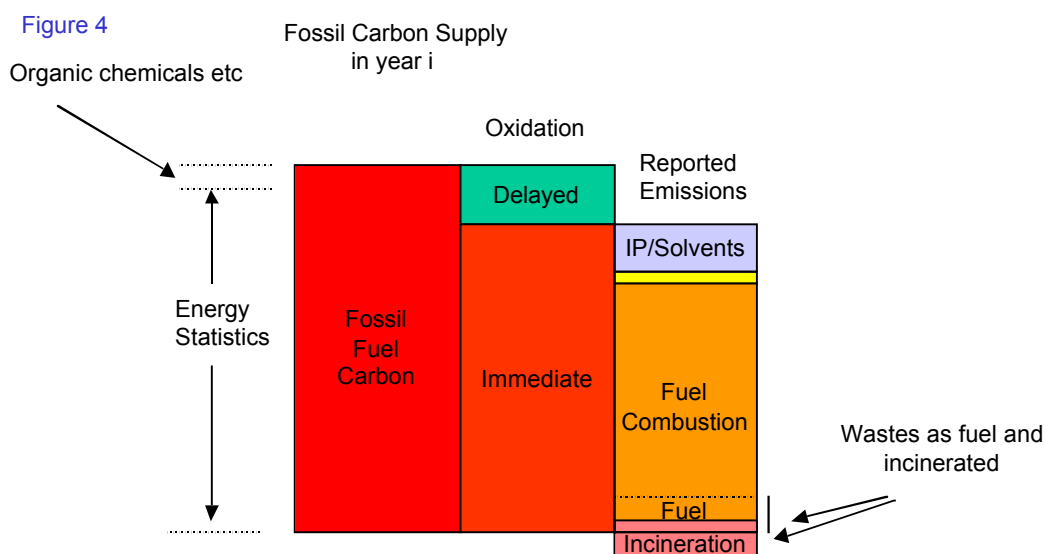
In the following discussion, in order to simplify the arguments, the carbon emissions arising from the fuel use by air and sea international transport are not considered or excluded from the national total.

The RA was proposed as a simple means of using energy statistics to estimate the CO₂ emissions from fuel combustion. Only later, was the definition of fuel combustion as combustion for heat raising introduced. By their nature, covering all uses of fuels, energy statistics cover more than this narrower definition of fuel combustion and uses of fuels which produce heat used for energetic ends would be included.

Figure 3 can be simplified slightly for an examination of the RA. In Figure 4, calcium carbonate has been dropped as has gas flaring and venting. All of these sources lead to immediate oxidation of carbon but can be handled separately. For oil/gas producing countries most of the fugitive emissions arise from production of these fuels and the remaining fugitive emissions are very small.

The relationship between the RA and immediate and delayed oxidation of fossil fuel carbon is easier to explore initially. See Figure 4. If the RA is to provide an estimate of immediate oxidation then an estimate is required of the amount of

carbon supply entering materials (and fuels) oxidising within six months of manufacture. The „six month“ definition of „immediate“ is chosen to maximise the correspondence between the carbon supply and emissions into the atmosphere in the same calendar year. Conversely, an estimate of the carbon entering materials with longer lives, leading to delayed emissions, could be used. In reality, a choice of products is required in which carbon oxidation is likely to be delayed and it is here that the NEAT model can help not only by identifying the products but also by determining the share of fossil fuel feedstock carbon entering the products.. Care is needed when deciding the „state“ of oxidation for lubricants and, perhaps, other products. Some of the carbon they contain will be oxidised immediately and some when waste oil is recovered and used as an energy source. At present, it is assumed that 50 percent of the supply is oxidised immediately.



In this note, delayed oxidation has been assumed to be the same as delayed release of the carbon molecule into the atmosphere. The rapid oxidation of CO, CH₄ and NMVOCs and their equivalence to CO₂ has already been mentioned. However, carbon in HFCs and PFCs released into the atmosphere are not converted to CO₂ rapidly and are treated as separate GHGs. The carbon they contain is part of the „delayed“ oxidation pool and in strict analysis should be excluded from further consideration in the carbon flow for CO₂ emissions purposes. There is a contribution made to carbon supply by the non-fuel materials imported directly by the petrochemical industry and other users (for example, carbon anodes). Their importance depends on the contribution they make to immediate oxidation. If it is large then they should be included in the carbon pool for the current year and estimates are required to enlarge the RA.

With care and attention to the particular hydrocarbon processing conditions of each country the RA principle can be used to provide a good estimate of immediate oxidation of the carbon supply. However, this is not the same as fuel combustion and the relationship between the carbon in the immediate oxidation pool and the source categories is now considered.

Source categories

Figure 4 shows the links between immediate oxidation and emissions by source category. Immediate oxidation is divided between industrial processes, solvents and other product use, fuel combustion, fugitive emissions and wastes. If the RA is to approximate fuel combustion, defined as the combustion of fuels for heat raising, then the total carbon supply considered as immediately oxidised needs further restriction. Any estimates for oxidation emissions within industrial processes should be removed, probably all solvent manufacture (if these have not already been excluded as „delayed“ oxidation), and any estimates available of residual fugitive emissions from oil and gas after they have been recorded as production. This alignment of the RA with fuel combustion can then act as an estimate for it. Where a country does not have independent estimates (and the related parts of the inventory) for industrial processes, then the RA estimate for immediate oxidation can serve as an estimate for fuel combustion.

