Energy data for IPCC methodology

UNFCCC/IEA meeting

virtual, 25 and 27 November 2020
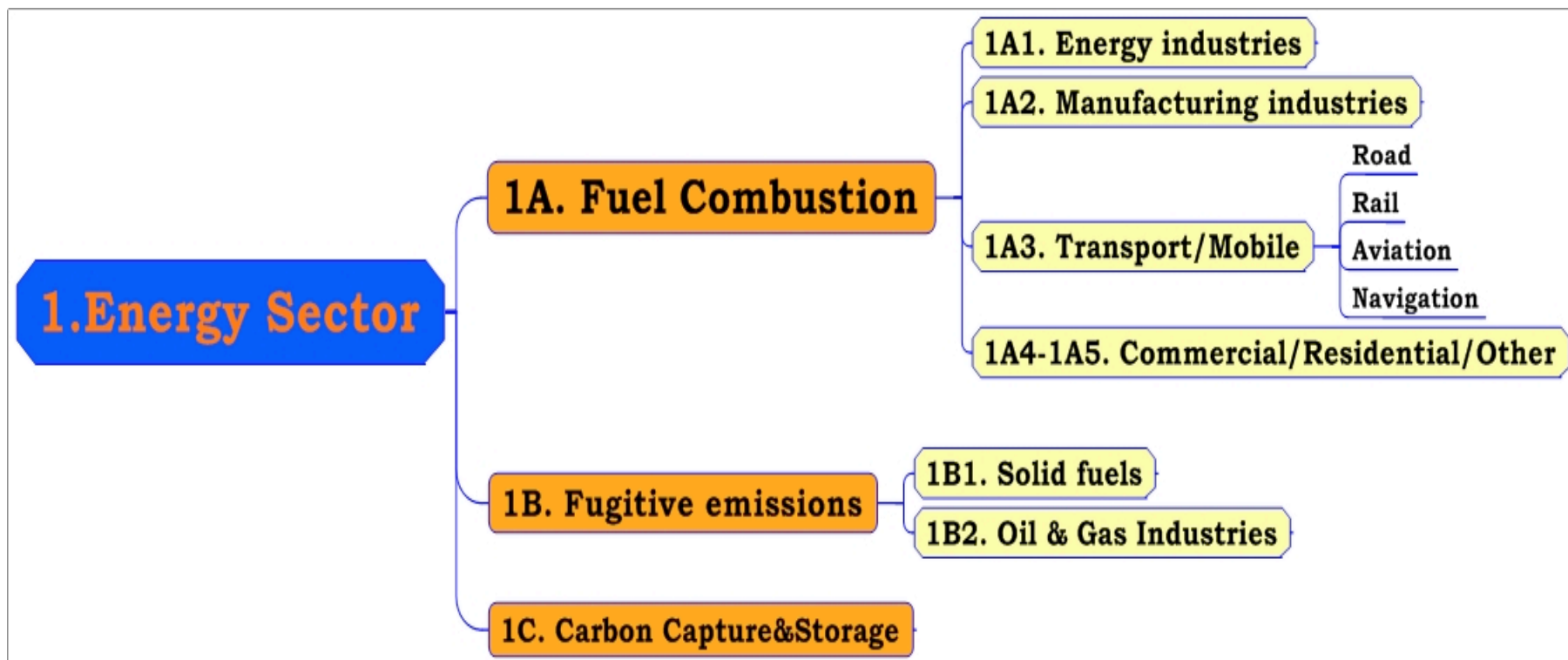
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Energy Sector – 2006 IPCC Guidelines

Source categories

The energy sector comprises:

- ✓ exploration and exploitation of primary energy sources (1.B)

- ✓ conversion of primary energy sources into more useable energy forms in refineries and power plants (1.A & 1.B)

- ✓ transmission and distribution of fuels (1.B)

- ✓ use of fuels in stationary and mobile applications (1.A)

- ✓ Capture, transport and storage of combusted CO_2 (1.C)

Emissions (CO_2, CH_4, N_2O) arise from these activities by combustion and as fugitive emissions, or escape without combustion (CO_2, CH_4)

Generic methodology

Infer emissions based on parameters (EF) associated with activities (AD). For example:

- ✓ Amount of fuel burnt (AD)
- ✓ Carbon content in fuel determines the amount of CO_2 emitted from a unit of fuel burnt (EF)
- ✓ CO_2 proportional to amount of fuel burnt (E)

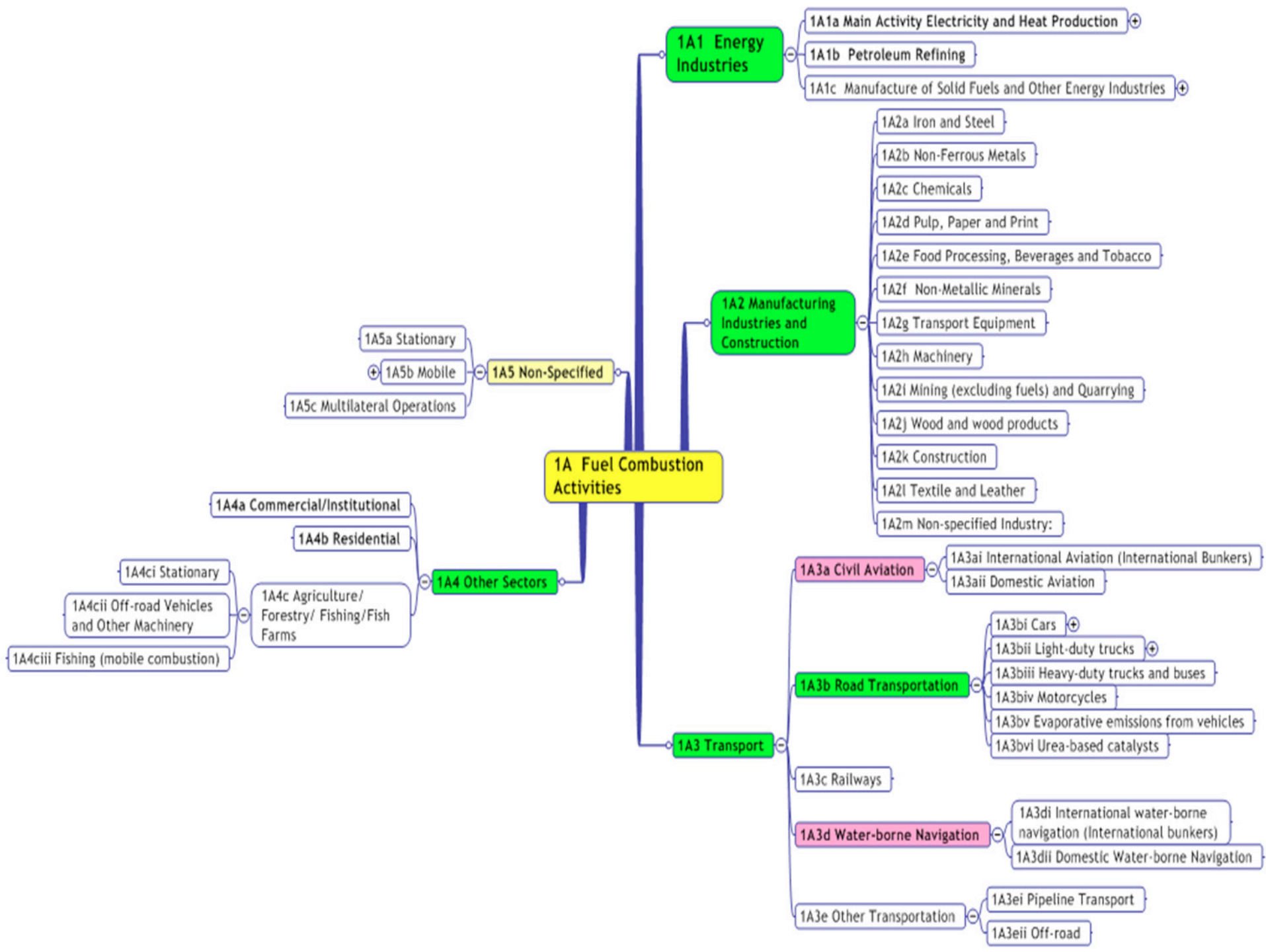$$E_{GHG} = AD \times EF_{GHG}$$

Where: E = Emission; AD = Activity Data; EF = Emission Factor

95% Confidence Interval of AD, EFs, and Estimates is to be calculated

1.A. Fuel Combustion activities

intentional oxidation of materials within an apparatus that is designed to provide heat or mechanical work to a process, or for use away from the apparatus

$$E_{GHG} = Fuel \times NCV \times EF_{GHG}$$

1A Fuel Combustion Activities

1A1 Energy Industries
- 1A1a Main Activity Electricity and Heat Production ⊕
- 1A1b Petroleum Refining
- 1A1c Manufacture of Solid Fuels and Other Energy Industries ⊕

1A2 Manufacturing Industries and Construction
- 1A2a Iron and Steel
- 1A2b Non-Ferrous Metals
- 1A2c Chemicals
- 1A2d Pulp, Paper and Print
- 1A2e Food Processing, Beverages and Tobacco
- 1A2f Non-Metallic Minerals
- 1A2g Transport Equipment
- 1A2h Machinery
- 1A2i Mining (excluding fuels) and Quarrying
- 1A2j Wood and wood products
- 1A2k Construction
- 1A2l Textile and Leather
- 1A2m Non-specified Industry:

1A3 Transport
1A3a Civil Aviation
- 1A3ai International Aviation (International Bunkers)
- 1A3aii Domestic Aviation

1A3b Road Transportation
- 1A3bi Cars ⊕
- 1A3bii Light-duty trucks ⊕
- 1A3biii Heavy-duty trucks and buses
- 1A3biv Motorcycles
- 1A3bv Evaporative emissions from vehicles
- 1A3bvi Urea-based catalysts

1A3c Railways

1A3d Water-borne Navigation
- 1A3di International water-borne navigation (International bunkers)
- 1A3dii Domestic Water-borne Navigation

1A3e Other Transportation
- 1A3ei Pipeline Transport
- 1A3eii Off-road

1A4 Other Sectors
- 1A4a Commercial/Institutional
- 1A4b Residential
- 1A4c Agriculture/ Forestry/ Fishing/Fish Farms
  - 1A4ci Stationary
  - 1A4cii Off-road Vehicles and Other Machinery
  - 1A4ciii Fishing (mobile combustion)

1A5 Non-Specified
- 1A5a Stationary
- 1A5b Mobile ⊕
- 1A5c Multilateral Operations

Fuel Combustion – Activity Data [Gg (TJ)]

➢ For each source category, **fuel consumption/sales** of fuel:

  ✓ LIQUID FOSSIL FUELS *(Crude oil and petroleum products)*

  ✓ SOLID FOSSIL FUELS *(Coal and coal products)*

  ✓ GAS FOSSIL FUELS *(Natural Gas)*

  ✓ OTHER FOSSIL FUELS *(e.g. waste)*

  ✓ PEAT *(CO_2 adds to the Energy sector total)*

  ✓ BIOMASS *(bioliquid, biosolid and biogas fuels, waste bio-fraction; CO_2 does NOT add to the Energy sector total)*

➢ In statistics data on fuels consumption/sale are in physical units, e.g. in tonnes or cubic metres

Fuel Combustion – Net Calorific Value [TJ/Gg]

➢ To convert AD to energy units requires calorific values.

➢ IPCC Guidelines use the **net calorific values** (NCVs), expressed in SI units.

➢ Some statistical offices use gross calorific values (GCVs).
  The difference between NCV and GCV is the latent heat of vaporisation of the water produced during fuel combustion.

➢ Calorific value is fuel specific and thus independent of combustion technology.

Fuel Combustion – EF [kg/TJ]

➢ Default assumption is that all carbon contained in the fuel is oxidised to CO_2 *(this in practice includes the indirect CO_2 emissions caused by the subsequent oxidation in atmosphere of non-CO_2 carbon emissions).* Thus,

  ✓ CO_2 EFs are based on the **C-content of the fossil fuel**

  ✓ Since independent of combustion technology, same fuel-specific default CO_2 EF is applicable to all combustion processes

➢ CH_4 and N_2O emissions are strongly dependent on the technology applied in both stationary and mobile combustions, thus EFs vary accordingly

Tips

➢ All fuel sold in a country is included in national estimates even if a vehicle crosses a border or fuel exported in fuel tanks of vehicles

➢ C is also emitted from urea based catalysts and included in Road transportation category (not strictly combustion)

➢ Caution with "fuel sold" data:
  • overlaps with off-road and potentially other sectors (e.g. agriculture)
  • blended fuels (e.g. bio-ethanol) and lubricants
  • Smuggling

➢ Waste as a fuel when incinerator produces heat or power for use:
  o Avoid double counting in waste
  o Exclude CO_2 from the bio-fraction of waste

2006 IPCC Guidelines: Reference Approach

➢ The Reference Approach is based on the principle of mass conservation, and it is used for CO_2 only.

➢ C brought into a national economy in the form of a fuel, it is either released into the atmosphere as GHG, or it is diverted *(e.g., increased fuel stocks, feedstocks, stored in products, left unutilised in ash)* and does not enter the atmosphere.

➢ It is *good practice* to apply both a sectoral approach and the reference approach to estimate a country's CO_2 emissions from fuel combustion and to compare the results of these two independent estimates. Significant differences may indicate possible problems with AD, NCVs, carbon content, excluded carbon calculation, etc

Energy Balance CO$_2$ Estimation Reference Approach (QC)

$$E = \Sigma_{allfuels}[(ApparentConsumption_{fuel} - ExcludedCarbon_{fuel}) \times COF_{fuel}] \times 44/12$$

- ✓ ApparentConsumption =
Production(primary fuels) + Imports – Exports - International bunkers – Stock change (in CC)

- ✓ ExcludedCarbon = CC in feedstocks and non-energy use excluded from combustion

- ✓ COF = C oxidised fraction. By default = 1 (complete oxidation). Lower values used to count for C retained indefinitely in ash or soot

- ✓ CC = Carbon Content

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INTERGOVERNMENTAL PANEL ON climate change

Excluded Carbon/Non-Energy Use of Fuels

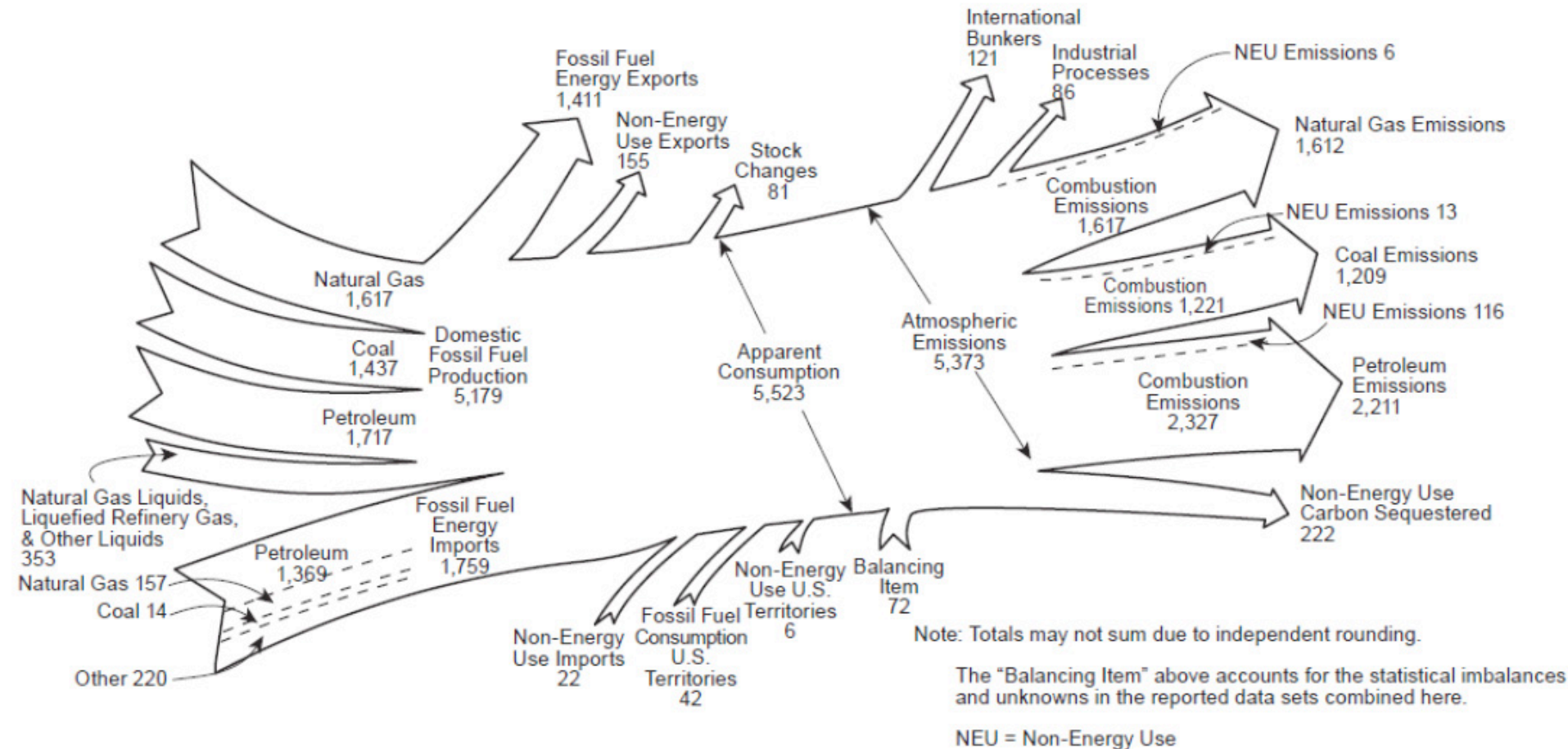| TABLE 1.2 — TYPES OF USE AND EXAMPLES OF FUELS USED FOR NON-ENERGY APPLICATIONS			
Type of use	**Example of fuel types**	**Product/process**	**Chapter**
Feedstock	natural gas, oils, coal	ammonia	3.2
	naphtha, natural gas, ethane, propane, butane, gas oil, fuel oils	methanol, olefins (ethylene, propylene), carbon black	3.9
Reductant	petroleum coke	carbides	3.6
	coal, petroleum coke	titanium dioxide	3.7
	metallurgical cokes, pulverised coal, natural gas	iron and steel (primary)	4.2
	metallurgical cokes	ferroalloys	4.3
	petroleum coke, pitch (anodes)	aluminium [1]	4.4
	metallurgical coke, coal	lead	4.6
	metallurgical coke, coal	zinc	4.7
Non-energy product	lubricants	lubricating properties	5.2
	paraffin waxes	misc. (e.g., candles, coating)	5.3
	bitumen (asphalt)	road paving and roofing	5.4
	white spirit[2], some aromatics	as solvent (paint, dry cleaning)	5.5

[1] Also used in secondary steel production (in electric arc furnaces) (see Chapter 4.2).

[2] Also known as mineral turpentine, petroleum spirits, industrial spirit ('SBP').

US Carbon Flow 2018

Figure 3-2: 2018 U.S. Fossil Carbon Flows (MMT CO_2 Eq.)

Figure 3-2: 2018 U.S. Fossil Carbon Flows (MMT CO_2 Eq.)

International Bunkers 121
Industrial Processes 86
NEU Emissions 6
Natural Gas Emissions 1,612
Combustion Emissions 1,617
NEU Emissions 13
Coal Emissions 1,209
Combustion Emissions 1,221
NEU Emissions 116
Petroleum Emissions 2,211
Combustion Emissions 2,327
Atmospheric Emissions 5,373
Non-Energy Use Carbon Sequestered 222

Fossil Fuel Energy Exports 1,411
Non-Energy Use Exports 155
Stock Changes 81
Apparent Consumption 5,523

Natural Gas 1,617
Coal 1,437
Domestic Fossil Fuel Production 5,179
Petroleum 1,717

Natural Gas Liquids, Liquefied Refinery Gas, & Other Liquids 353
Natural Gas 157
Coal 14
Other 220
Petroleum 1,369
Fossil Fuel Energy Imports 1,759

Non-Energy Use Imports 22
Fossil Fuel Consumption U.S. Territories 42
Non-Energy Use U.S. Territories 6
Balancing Item 72

Note: Totals may not sum due to independent rounding.

The "Balancing Item" above accounts for the statistical imbalances and unknowns in the reported data sets combined here.

NEU = Non-Energy Use

Note: Tracking Carbon in Fuel (!!)

1.B. Fugitive Emissions (Tier 1)

emissions of gases or vapour from equipment due to leaks and other unintended or irregular releases of gases, from activities associated with the production and distribution of fossil fuels.

$$E = AD \times EF$$

AD:
- *Coal production; Volume of Methane flared; N of Coal mines abandoned,*
- *Amount of oil&gas production/refinery/transport/transmission/storage*

1B. Fugitive Emissions

Tips

Underground and **surface coal mines GHG (mostly CH$_4$)** emissions:

- ✓ **Mining emissions**, *caused by fracturing coal during mining. Gas may be collected (for safety) and flared or used for energy.*
  Emission can continue after mine closure

- ✓ **Post-mining emissions**, *during processing, handling and distribution*

- ✓ **Low temperature oxidation**, *to CO$_2$ when exposed to the air (slow)*

- ✓ **Uncontrolled combustion**, *can also occur naturally*

Oil & Gas fugitive emissions
- ✓ all emissions from oil and gas systems *(except those for the use of oil and gas for energy purpose or as a feedstock)*

Includes equipment leaks, evaporation loses, venting, flaring and accidental releases

1.C. CO_2 Transport, Injection and Geological Storage

Capture+Imports= Injection+Leakage+Exports

Capture estimated where it occurs
Leakage estimated under this category

the SRCCS (2005) states that >99% of the CO_2 stored in appropriately selected and managed geological reservoirs is likely to remain there for over 1,000 years.
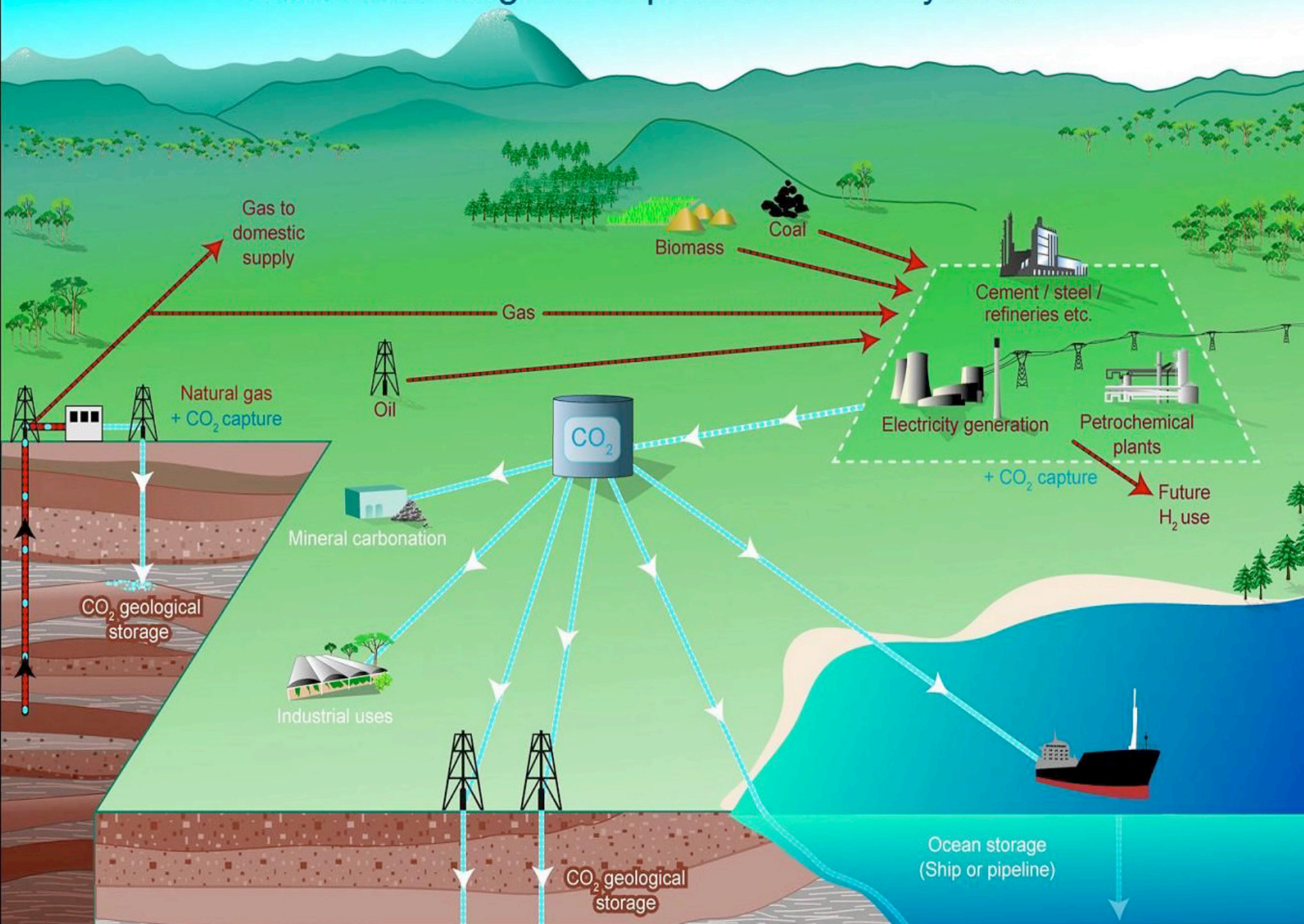
TABLE 5.4

OVERVIEW TABLE: OVERVIEW OF CO_2 CAPTURE, TRANSPORT, INJECTION AND CO_2 FOR LONG-TERM STORAGE

Category	Activity		CO_2 (Gg) [1]
	Data Source	**Unit**	
Total amount captured for storage (A)	Summed from all relevant categories	Gg	
Total amount of import for storage (B)	Data from pipeline companies, or statistical agencies	Gg	
Total amount of export for storage (C)	Data from pipeline companies, or statistical agencies	Gg	
Total amount of CO_2 injected at storage sites (D)	Data from storage sites provided by operators, as described in Chapter 5	Gg	
Total amount of leakage during transport (E1)	Summed from IPCC reporting category 1 C 1	Gg	
Total amount of leakage during injection (E2)	Summed from IPCC reporting category 1 C 2 a	Gg	
Total amount of leakage from storage sites (E3)	Summed from IPCC reporting category 1 C 2 b	Gg	
Total leakage (E4)	E1 + E2 + E3	Gg	
Capture + Imports (F)	A + B	Gg	
Injection + Leakage + Exports (G)	D + E4 + C	Gg	
Discrepancy	F - G	Gg	

[1] Once captured, there is no differentiated treatment between biogenic carbon and fossil carbon: emissions and storage of both will be estimated and reported.

Schematic diagram of possible CCS systems

Gas to domestic supply

Biomass

Coal

Cement / steel / refineries etc.

Gas

Oil

Natural gas + CO₂ capture

CO₂

Electricity generation

Petrochemical plants

+ CO₂ capture

Future H₂ use

Mineral carbonation

CO₂ geological storage

Industrial uses

CO₂ geological storage

Ocean storage (Ship or pipeline)

Tips

- ✓ **Energy Sector = Fuel combustion** (mobile and stationary) **+ Fugitive emissions + CO_2 Capture** & **Storage** (**CCS**)

- ✓ **Energy emissions are the largest fraction of total national GHG emissions**
  - ✓ CO_2 **from fuel combustion is major source**
  - ✓ CH_4 **mainly comes from fugitive emissions**

- ✓ CO_2 **EF depends on carbon content of fuel, non-CO_2 EFs on the technology used**

- ✓ **Methodological issues** (biomass, international bunker, excluded carbon)

- ✓ **Reference approach is used for verification** (CO_2)

Thank you

https://www.ipcc-nggip.iges.or.jp/index.html