Main Contents of 2006 IPCC Guideline Vol.2 (Energy)

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- Methodical Approach: Tier Levels
- Methodical Approach: Fuel combustion
- Methodical Approach: Fugitive emissions
- Methodical Approach: CCS

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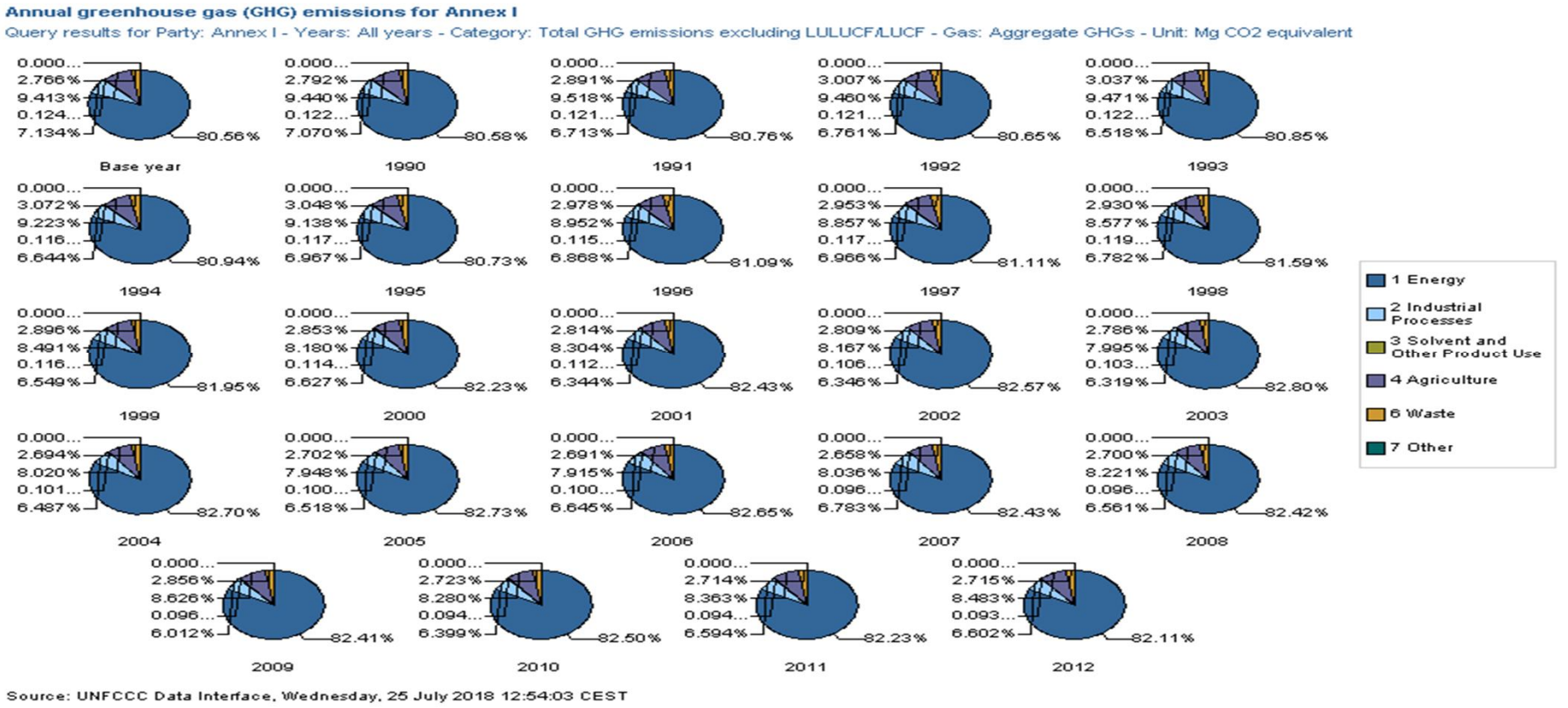
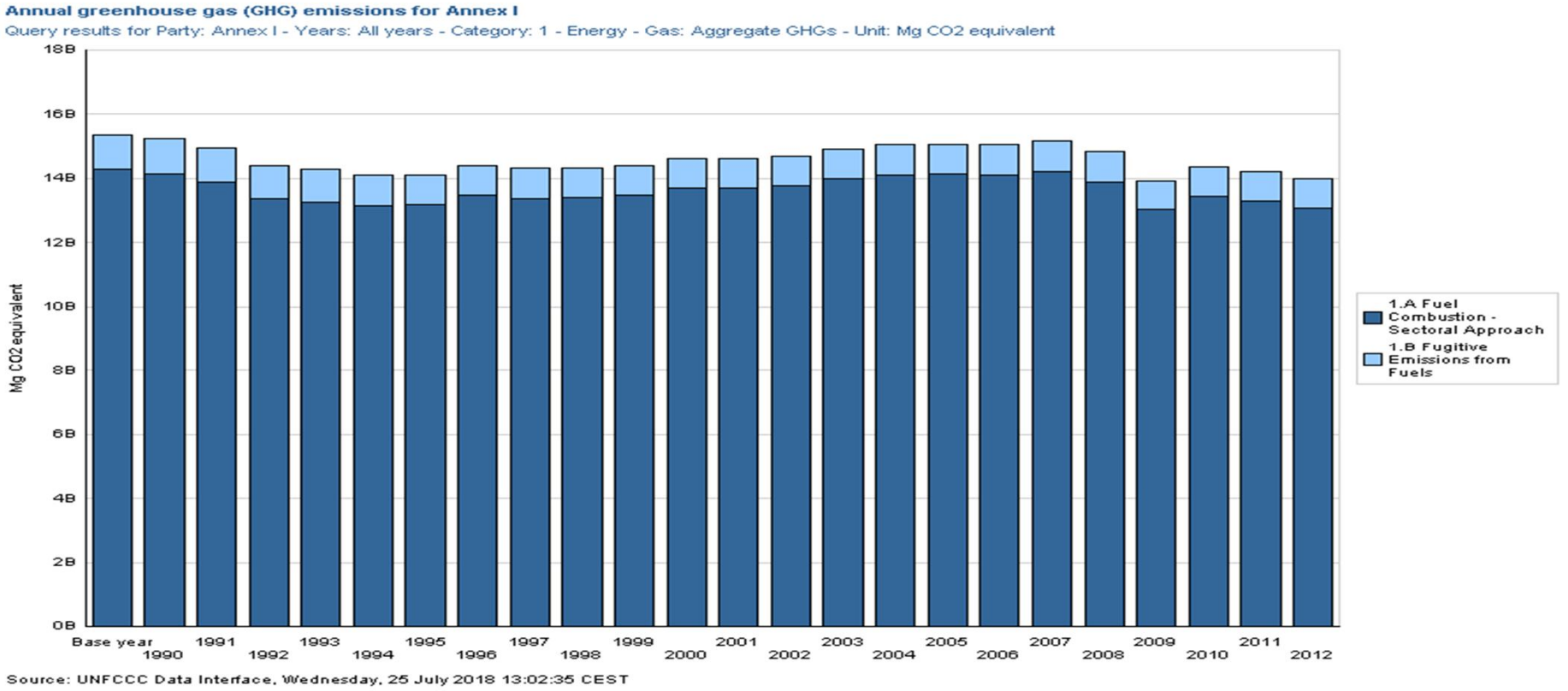
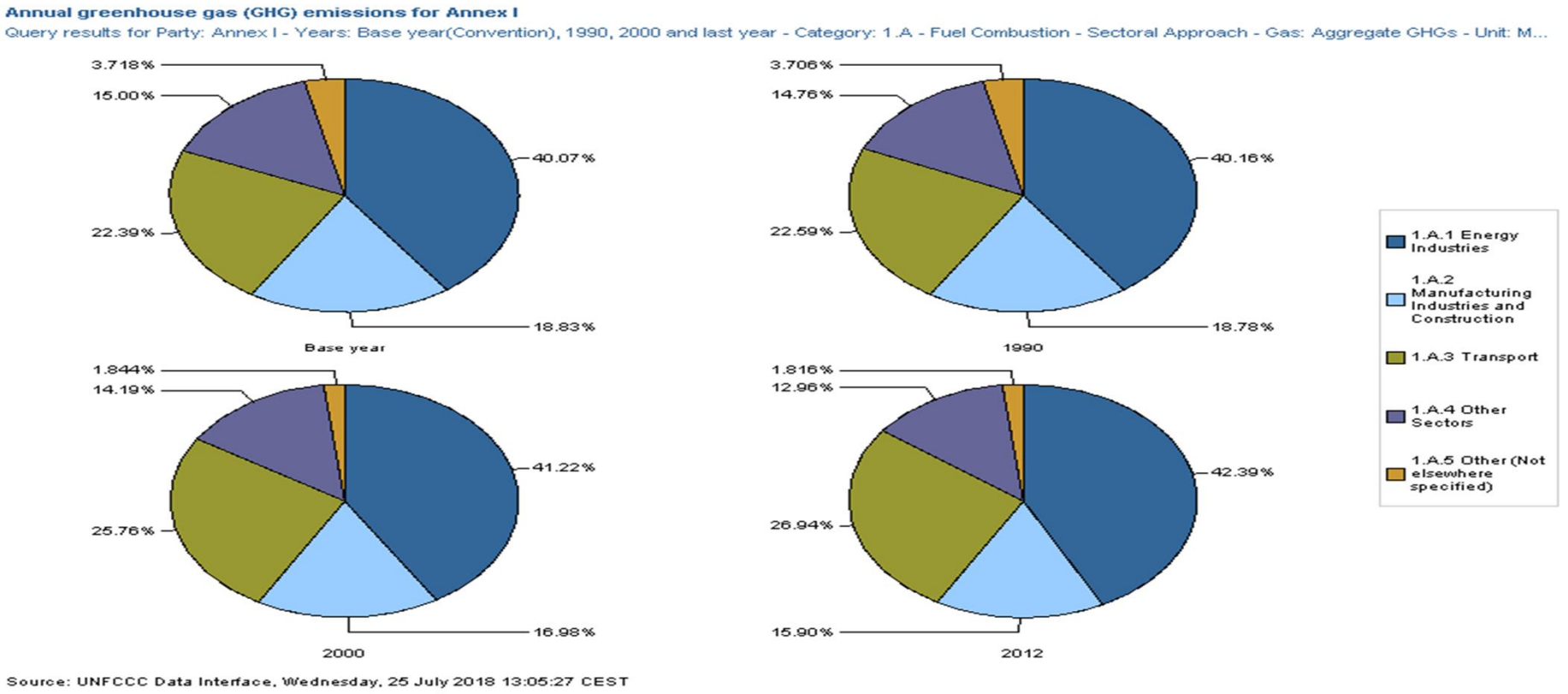
Energy sector: Total GHG emissions for Annex I countries



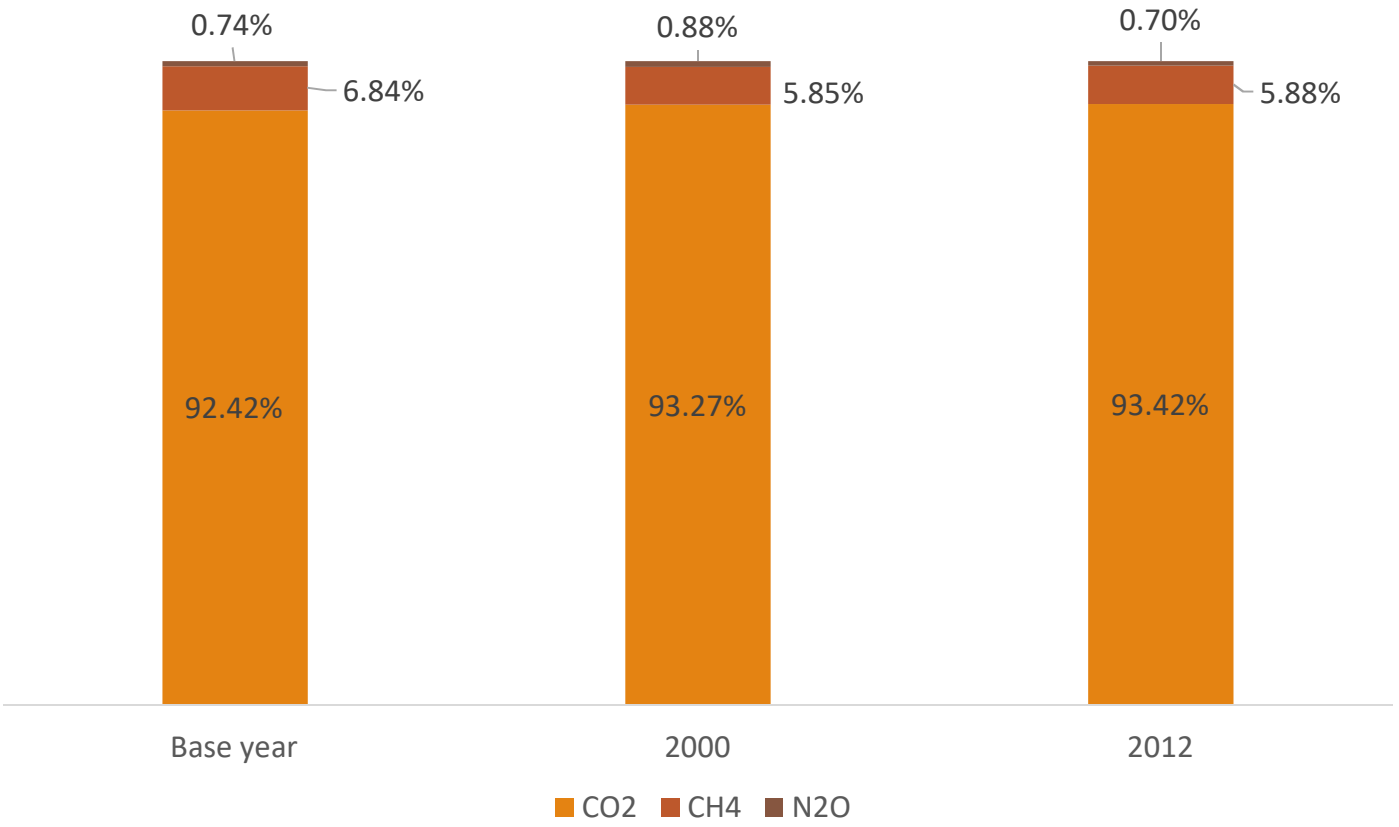
Energy sector: Energy sector emissions



Energy sector: Fuel combustion emissions by sector



Energy sector: Emissions by gas



Energy sector: Scope and Coverage

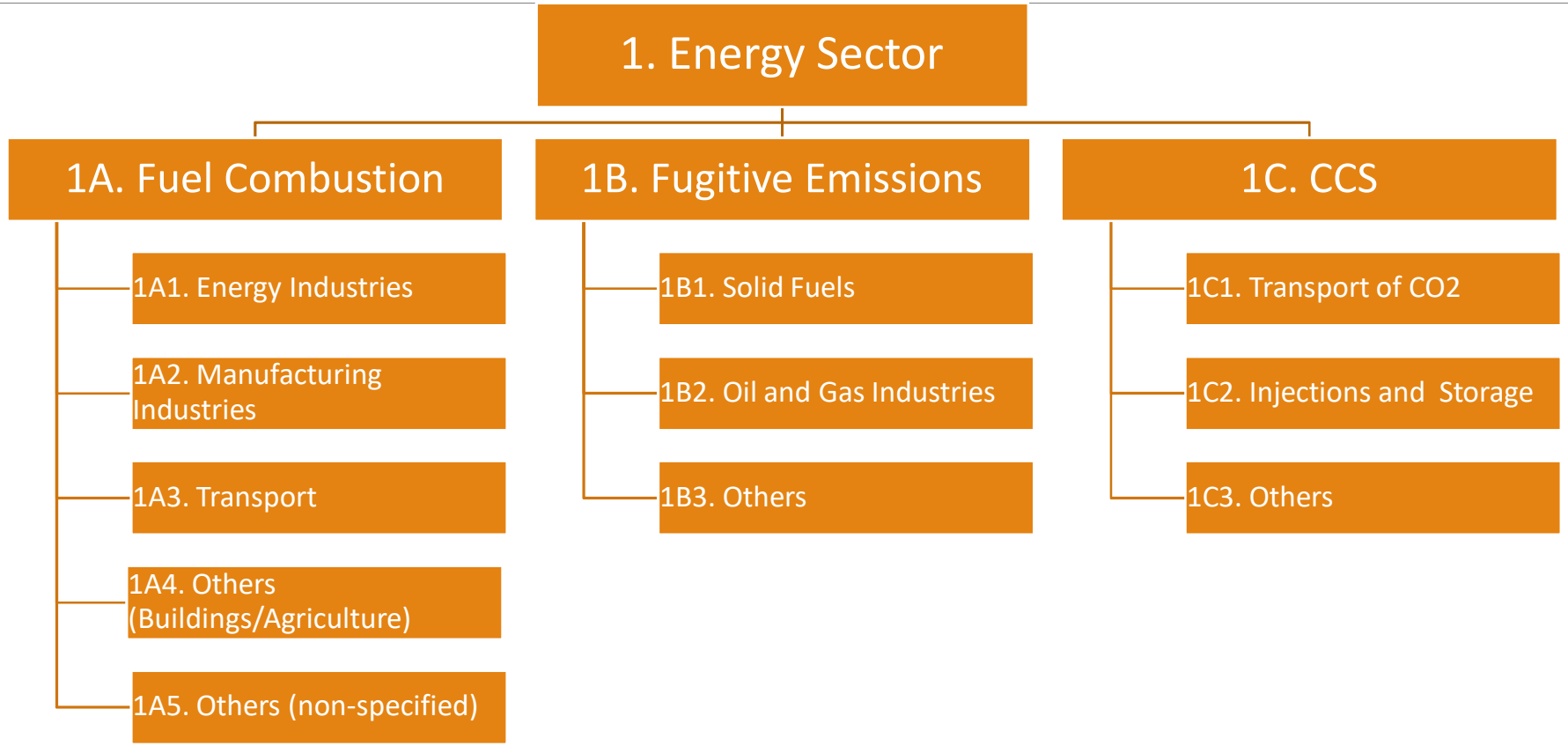
- Exploration and exploitation of primary energy sources
- Conversion of primary energy sources into more useable energy forms in refineries and power plants
- Transmission and distribution of fuels
- Use of fuels in stationary and mobile applications

Energy sector: Scope and Coverage

- Coal mines fires, Gas flaring are covered in Fugitive Emissions

- Not covered by Energy Sector:
  - if energy is not recovered, waste incineration is covered by Waste
  - use of fossil fuels as a raw material in the Industrial Sector is covered by IPPU
  - biomass fires/open burning is covered by AFOLU

Energy sector: Scope and Coverage



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- Energy Sector
- Methodical Approach: Tier Levels
- Methodical Approach: Fuel combustion
- Methodical Approach: Fugitive emissions
- Methodical Approach: CCS

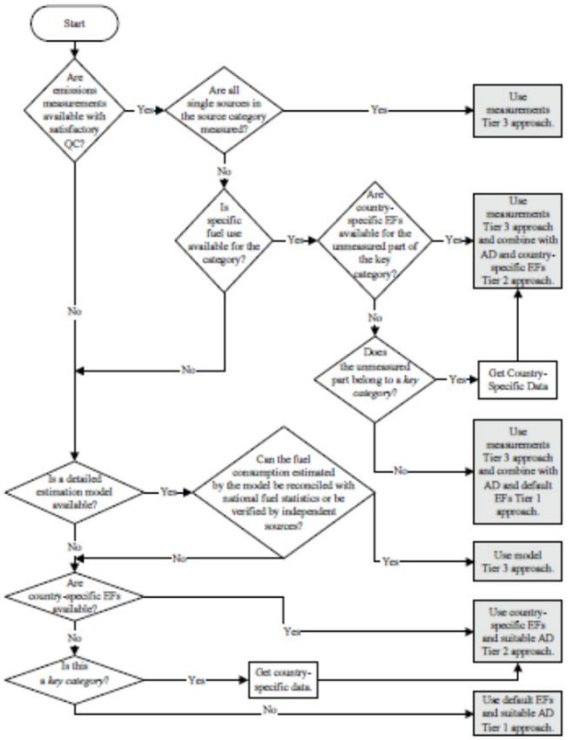
Methodical Approach: Tier Levels

- Three tier levels are defined;
  - The Tier 1 method is fuel-based, since emissions from all sources of combustion can be estimated on the basis of the quantities of fuel combusted (usually from national energy statistics) and average emission factors. Tier
  - In the Tier 2 method for energy, emissions from combustion are estimated from similar fuel statistics, as used in the Tier 1 method, but country-specific emission factors are used in place of the Tier 1 defaults.
  - In the Tier 3 methods for energy, either detailed emission models or measurements and data at individual plant level are used where appropriate.

Methodical Approach: Tier Levels

- Three tier levels are defined;
  - Tier 1 :Activity data, default NCV, EF, oxidation (complete oxidation)
  - Tier 2 : Activity data, country-specific NCV, EF, oxidation
  - Tier 3: Fuel type, technology, operating conditions, quality of maintenance, – plant-specific EFs (measurements)

Methodical Approach: Tier Levels



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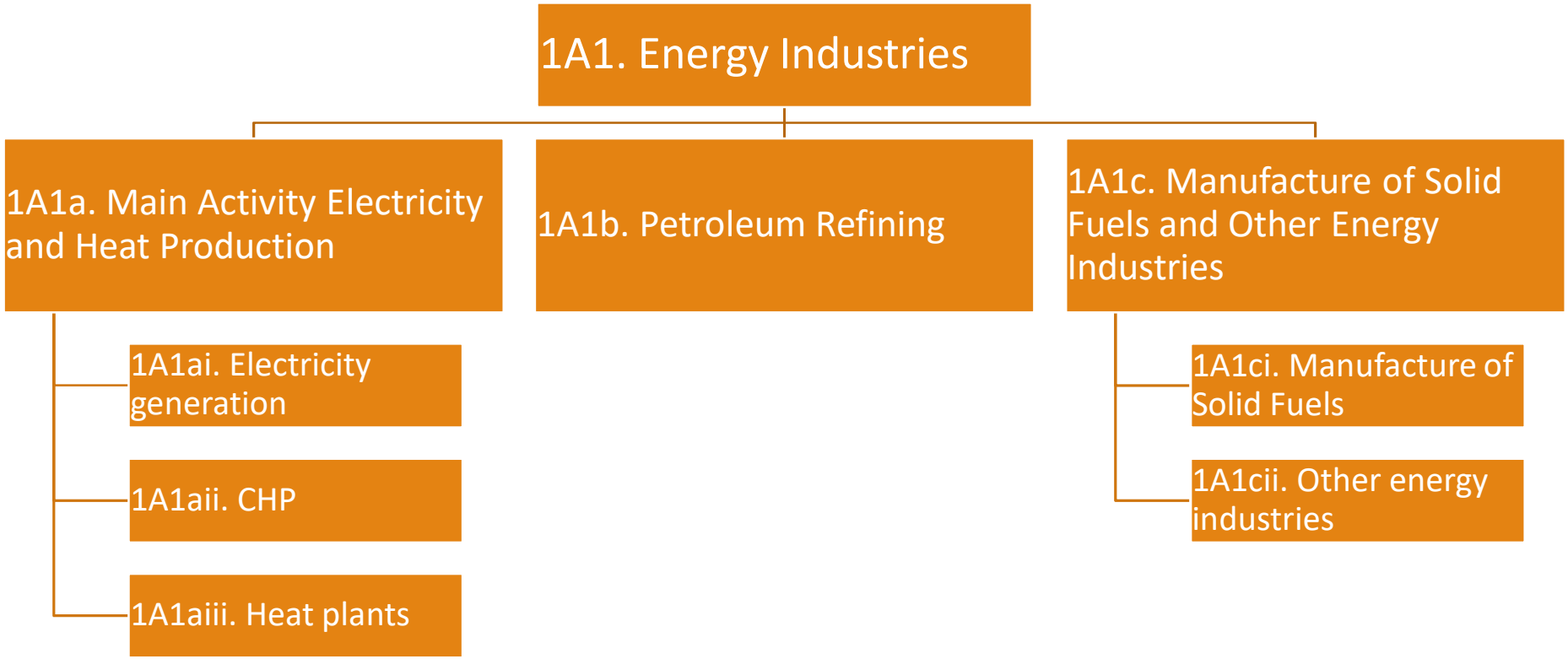
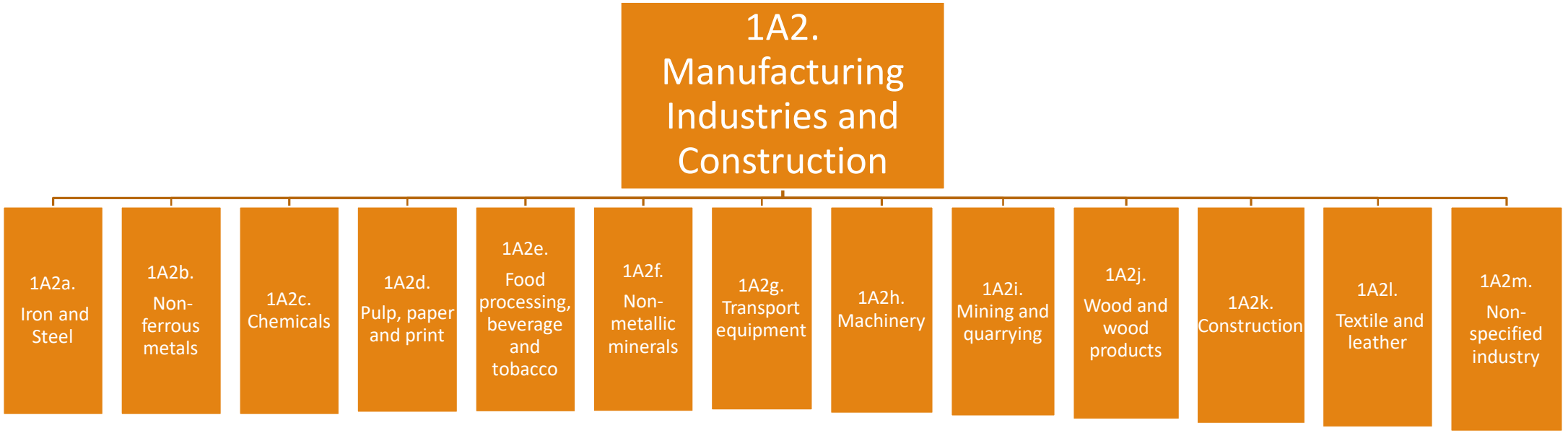
Methodical Approach: Fuel Combustion



Methodical Approach: Fuel Combustion



Methodical Approach: Fuel Combustion

- Emission are calculated by the formula below;
  - Emissions= Activity data*carbon content*oxidation factor

- Almost entire carbon content of the fuel is oxidized during the combustion process. Generally only less than 1% is un-oxidized. So for the tier 1 formula would be;
  - Emissions= Activity data*carbon content* 1

- The carbon content could be based on mass, volume or energy content. However carbon content based on mass or volume may vary considerably. By converting to energy units this variability is reduced.

- Carbon content is calculated on energy level. Which is equal to;
  - Carbon content: Emission factor*Net calorific value

Methodical Approach: Fuel Combustion

- Units for the calculation factors in the guideline:
  - Activity data --- Gg
  - NCV --- TJ/Gg
  - EF --- kg/TJ

	NCV (TJ/Gg)	EF (kg/TJ)
Lignite	8.9	101000
Diesel oil	43	74100
Natural gas	48	56100

Methodical Approach: Fuel Combustion

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- Carbon content is calculated on energy level. Which is equal to;
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Methodical Approach: EF

CO_2 emissions factor depend on the carbon content of the fuel and the oxidation factor.

Thus;

$C + O_2 = CO_2$

1 tonne C => 3.667 (44/12) tonne CO_2

And;

EF = Carbon content * Oxidation fraction * 44/12

Methodical Approach: NCV

❖Gross CV (GCV) or ‘higher heating value’ (HHV) is the calorific value under laboratory conditions.

❖Net CV (NCV) or 'lower heating value' (LHV) is the useful calorific value in boiler plant. The difference is essentially the latent heat of the water vapour produced.

❖Conversions - Gross/Net (per ISO, for As Received* figures) in MJ/kg:

$$NetCV = GrossCV - 0.212H - 0.0245M - 0.008Y$$

where M is percent Moisture, H is percent Hydrogen, Y is percent Oxygen (from ultimate analysis which determines the amount of carbon, hydrogen, oxygen, nitrogen and sulphur) As Received (i.e. includes Total Moisture (TM)).

Methodical Approach: Calculation exercise

- Fuel type: Lignite
- Activity data: 1,000 tones
- Chosen tier level: 1
- EF: 101,000 kg/TJ
- NCV: 8.9 TJ/Gg
- Oxidation factor: 1

CO_2 emissions = Activity data * NCV * EF * OF

CO_2 emissions = 1 * 8.9* 101,000= 898,900kg CO_2

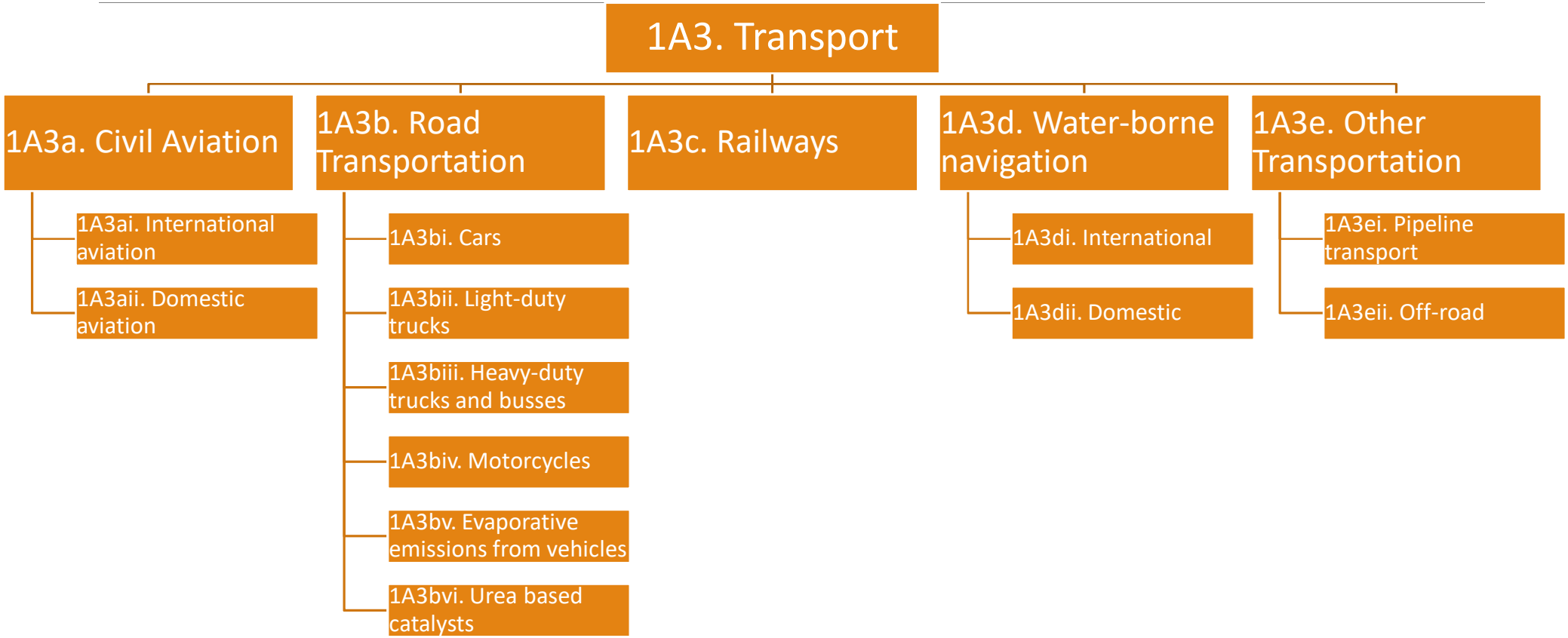
Methodical Approach: Non-CO2 emissions

- Energy sector related non-CO2 gasses are N2O and CH4.
- Emission of the N2O and CH4 depends on fuel and technology used. Emission factors vary considerably like the technologies.
- Therefore it is not useful to provide default emission factors for these gases on the basis of fuels only. Tier 1 default emission factors are therefore provided in the subsequent chapters for each subsector separately.

Methodical Approach: Biomass

- CO_2 emissions from biomass combustion are not included in the total national inventory. Biomass emissions are reported separately (information item)
- The AFOLU Volume 4 Chapter 4 (Forest Land) provides an alternative method to estimate activity data for fuel wood use.
- Peat is not treated as biomass in these guidelines, therefore CO_2 emissions from peat are estimated.

Methodical Approach: Fuel Combustion



Methodical Approach: Civil aviation

- For consistency, it is good practice to use similar definitions of domestic and international activities for aviation and water-borne navigation.
- Emissions from aviation come from the combustion of jet fuel (jet kerosene and jet gasoline) and aviation gasoline.
- Aircraft engine emissions are roughly composed of about 70 percent CO2, a little less than 30 percent H2O, and less than 1 percent each of NOx, CO, SOx, NMVOC, particulates, and other trace components including hazardous air pollutants.
- Emissions depend on the number and type of aircraft operations; the types and efficiency of the aircraft engines; the fuel used; the length of flight; the power setting; the time spent at each stage of flight; and, to a lesser degree, the altitude at which exhaust gases are emitted.

Methodical Approach: Road transportation

- Emissions can be estimated from either the fuel consumed (represented by fuel sold) or the distance travelled by the vehicles. In general, the first approach (fuel sold) is appropriate for CO2 and the second (distance travelled by vehicle type and road type) is appropriate for CH4 and N2O.

- Where cross-border transfers take place in vehicle tanks, emissions from road vehicles should be attributed to the country where the fuel is loaded into the vehicle.

- Bio-fuels carbon are reported separately

- CH4 and N2O strongly technology related.

Methodical Approach: Water-borne navigation

- This source category covers all water-borne transport from recreational craft to large ocean-going cargo ships that are driven primarily by large, slow and medium speed diesel engines and occasionally by steam or gas turbines.

- Water-borne navigation causes emissions of carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O), as well as carbon monoxide (CO), non-methane volatile organic compounds (NMVOCs), sulphur dioxide (SO_2), particulate matter (PM) and oxides of nitrogen (NOx).

- Domestic emissions included in National Total, International emissions reported separately as "Bunker Fuels"

Methodical Approach: Fuel Combustion

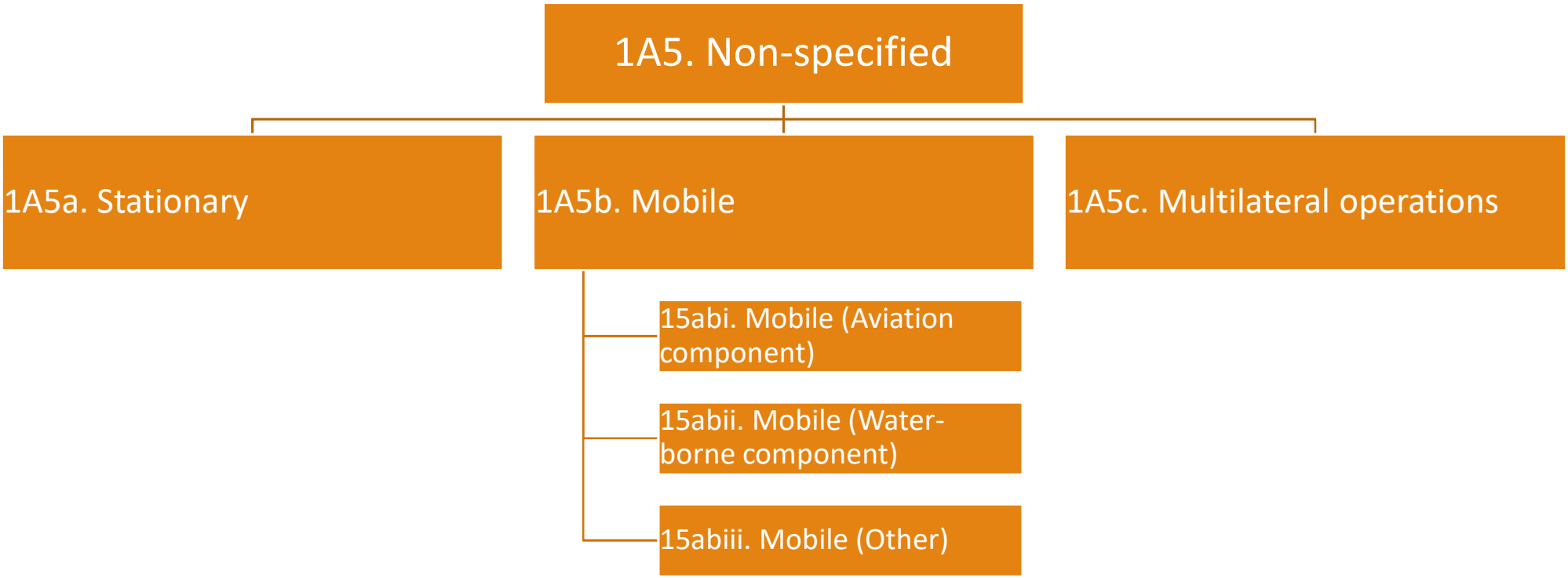
Methodical Approach: Reference approach

- CO_2 emissions from fuel combustion dominate ghg emissions, so it is good to use an independent check.

- The Reference Approach provides a methodology for producing a first-order estimate of national greenhouse gas emissions based on the energy supplied to a country.

- The Reference Approach is based on the assumption that, once carbon is brought into a national economy in the form of a fuel, it is either released into the atmosphere in the form of a greenhouse gas, or it is diverted and does not enter the atmosphere as a greenhouse gas. So; Reference Approach is a top-down approach, using a country's energy supply data to calculate the emissions of CO_2 from fuel combustion:

Methodical Approach: Fuel Combustion



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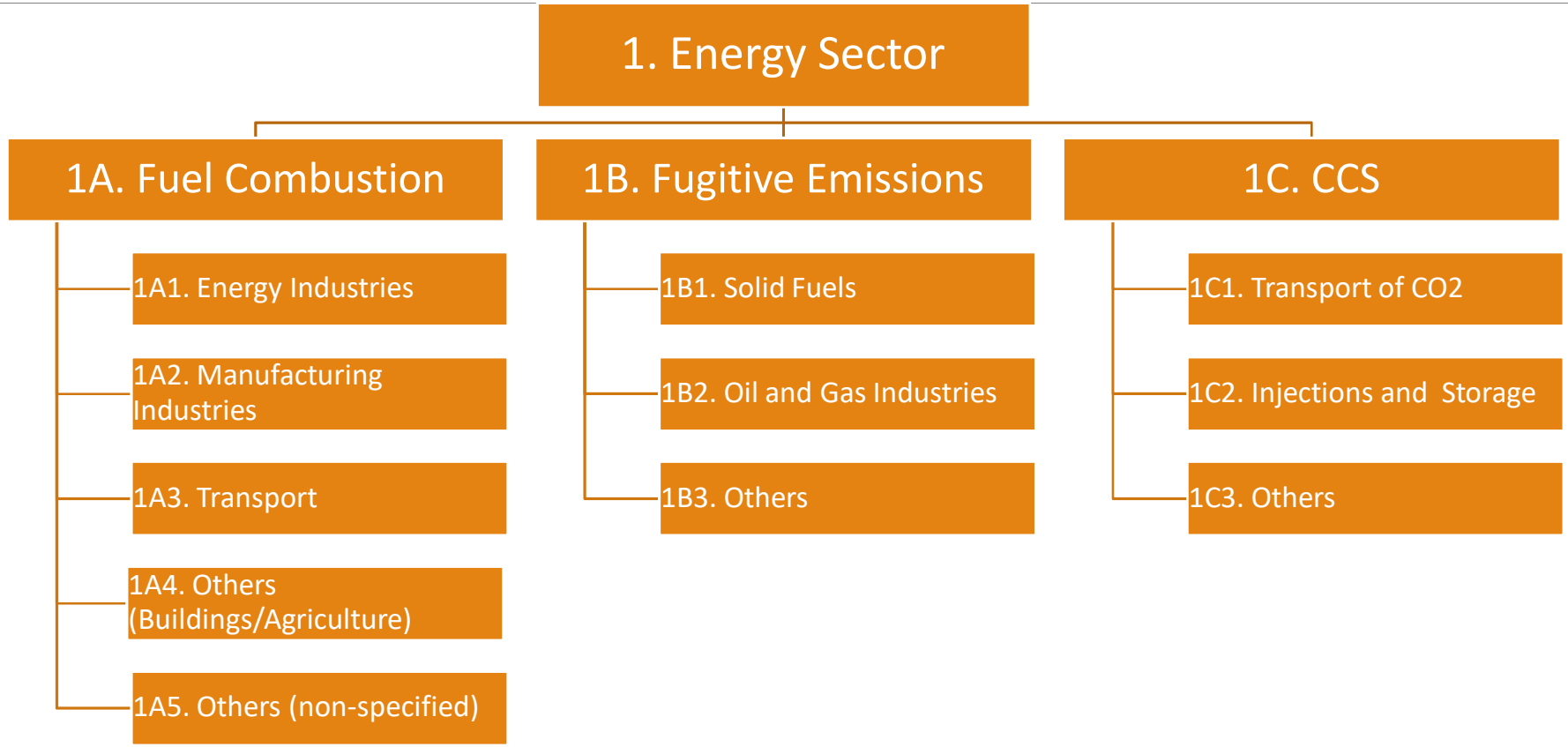
Methodical Approach: Fugitive Emissions

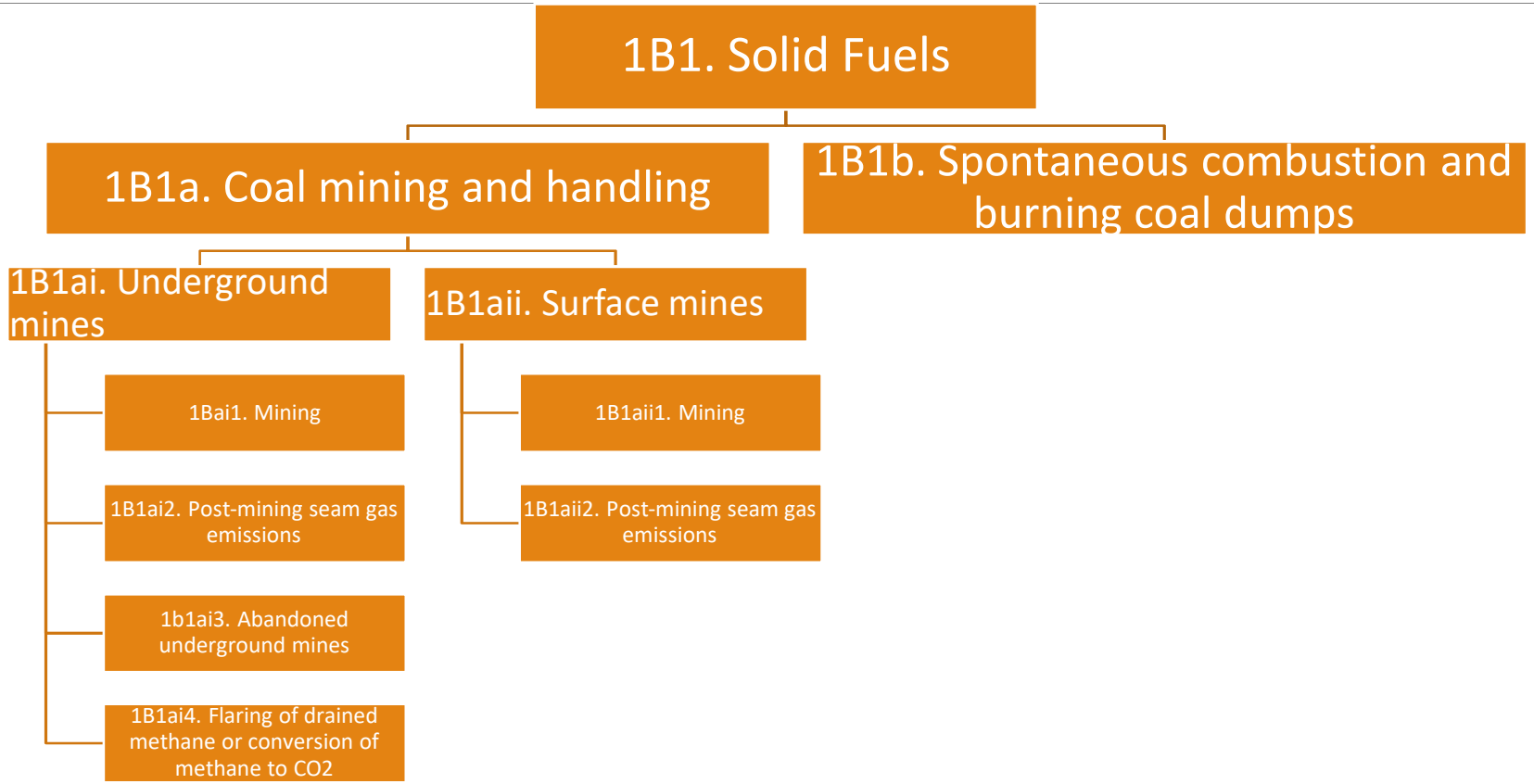


Methodical Approach: Fugitive Emissions

- Intentional or unintentional release of greenhouse gases may occur during the extraction, processing and delivery of fossil fuels to the point of final use. These are known as fugitive emissions.

- Tier 1 provides standard emission factors. For higher tier levels details of the technology should be known.

Methodical Approach: Fugitive Emissions



Methodical Approach: Solid fuels

- The geological processes of coal formation produce methane (CH_4), and carbon dioxide (CO_2) may also be present in some coal seams. CH_4 is the major greenhouse gas emitted from coal mining and handling.

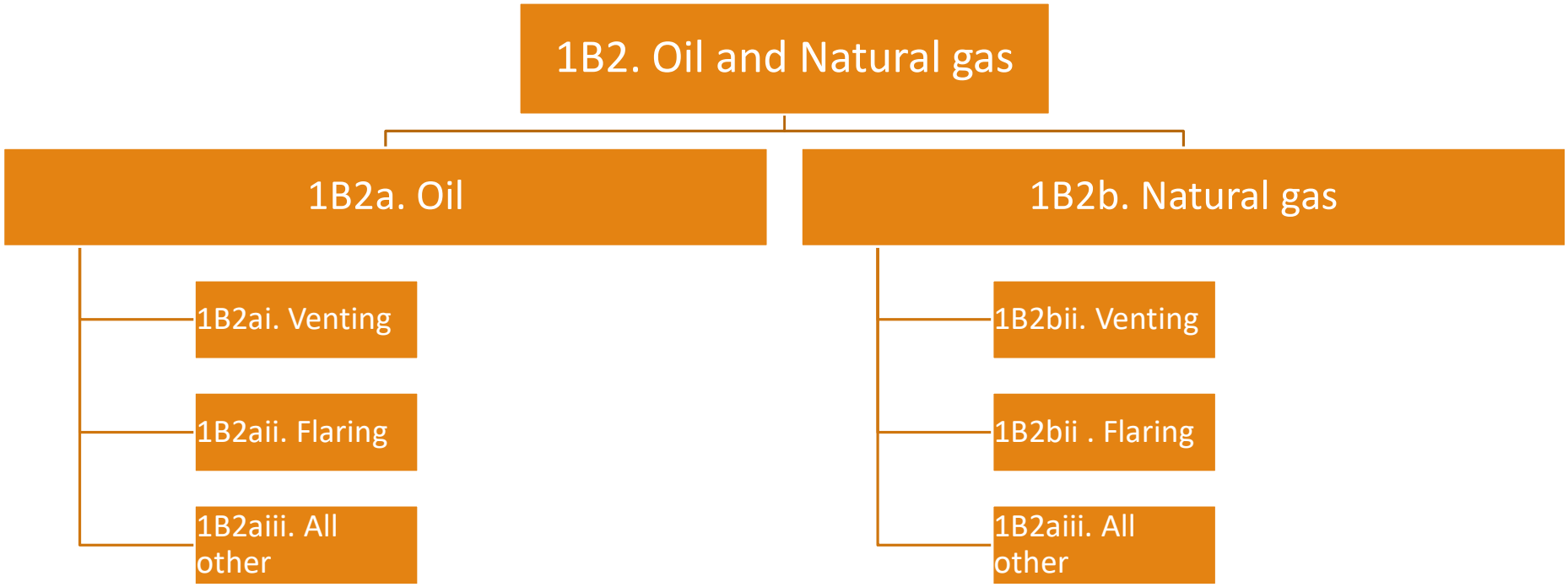
- The major stages for the emission of greenhouse gases for both underground and surface coal mines are:
  - Mining emissions
  - Post-mining emissions
  - Low temperature oxidation
  - Uncontrolled combustion

- After mining has ceased, abandoned coal mines may also continue to emit methane.

Methodical Approach: Solid fuels

- Fugitive emissions from underground mining arise from both ventilation and degasification systems.
- For surface mining the emissions of greenhouse gases are generally dispersed over sections of the mine and are best considered area sources.
- Abandoned underground mines present difficulties in estimating emissions, although a methodology for abandoned underground mines is included in guideline.
- Methane recovered from drainage, ventilation air, or abandoned mines may be mitigated in two ways:
  - direct utilization as a natural gas resource or
  - by flaring to produce CO2, which has a lower greenhouse warming potential than methane.

Methodical Approach: Oil and natural gas



Methodical Approach: Oil and natural gas

- The term fugitive emissions is broadly applied here to mean all greenhouse gas emissions from oil and gas systems except contributions from fuel combustion.

- Oil and natural gas systems comprise all infrastructure required to produce, collect, process or refine and deliver natural gas and petroleum products to market. Emissions excluded from this category are as follows:
  - Fuel combustion for the production of useful heat or energy
  - Fugitive emissions from carbon capture and storage projects, the transport and disposal of acid gas from oil and gas facilities by injection into secure underground formations, or the transport, injection and sequestering of CO2 as part of enhanced oil recovery (EOR), enhanced gas recovery (EGR) or enhanced coal bed methane (ECBM) projects
  - Fugitive emissions that occur at industrial facilities other than oil and gas facilities, or that are associated with the end use of oil and gas products at anything other than oil and gas facilities
  - Fugitive emissions from waste disposal activities that occur outside the oil and gas industry

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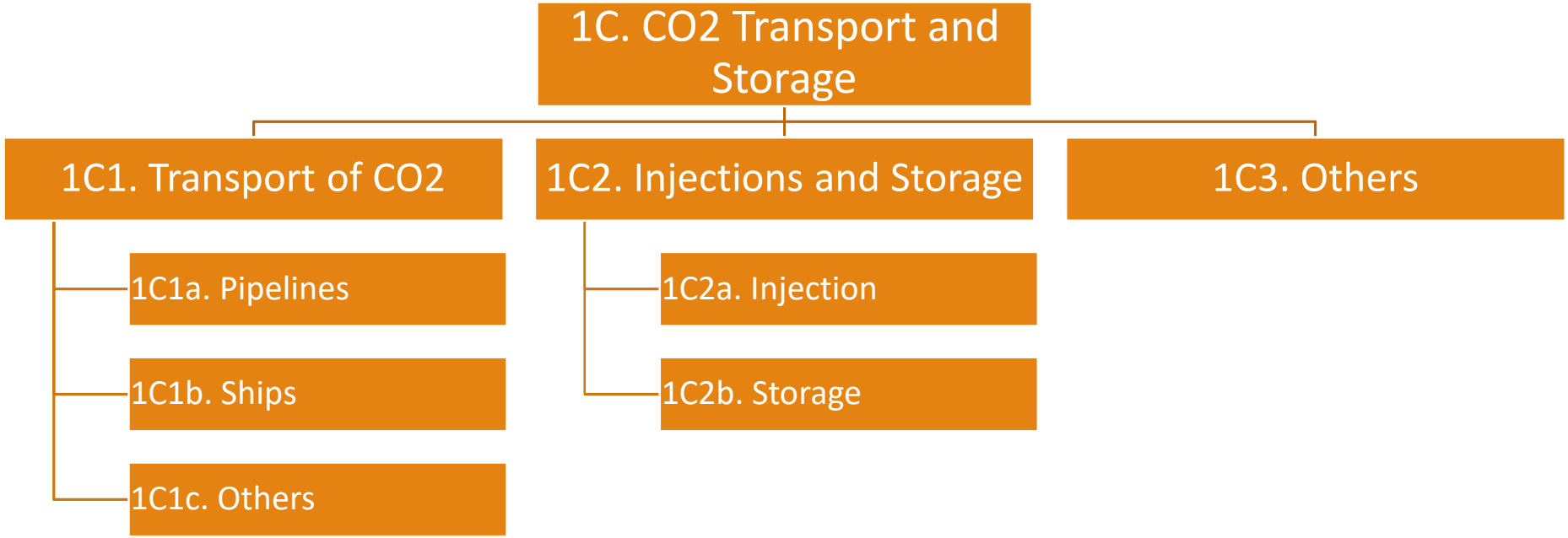

Methodical Approach: CCS

- Carbon dioxide (CO2) capture and storage (CCS) is an option in the portfolio of actions that could be used to reduce greenhouse gas emissions from the continued use of fossil fuels.

- At its simplest, the CCS process is a chain consisting of three major steps: the capture and compression of CO2, its transport to a storage location and its long-term isolation from the atmosphere.

- CCS is divided into four systems:
  - Capture and compression system.
  - Transport system.
  - Injection system.
  - Storage system.

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