Energy Sector

Technical Support Unit, IPCC TFI

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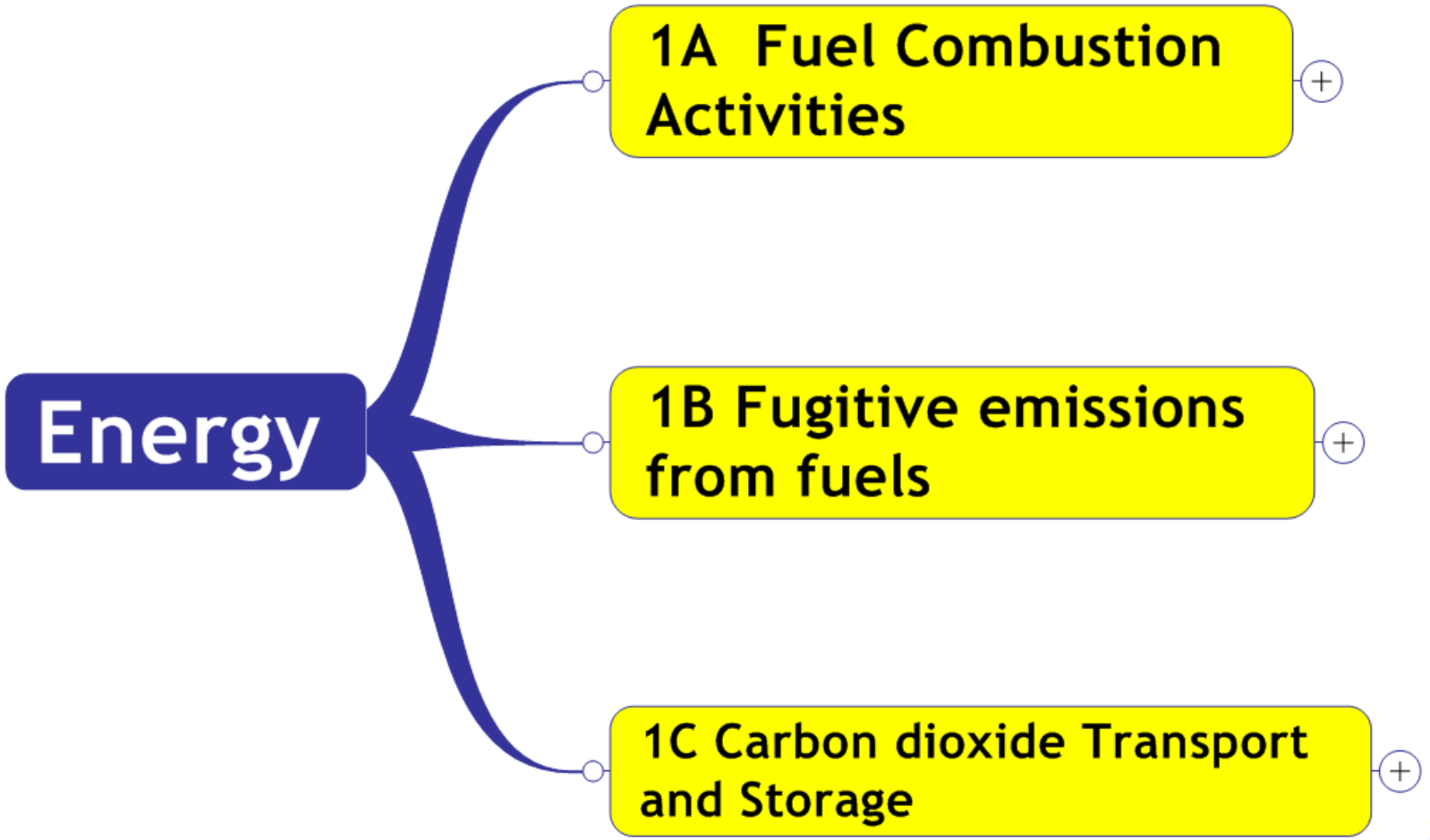
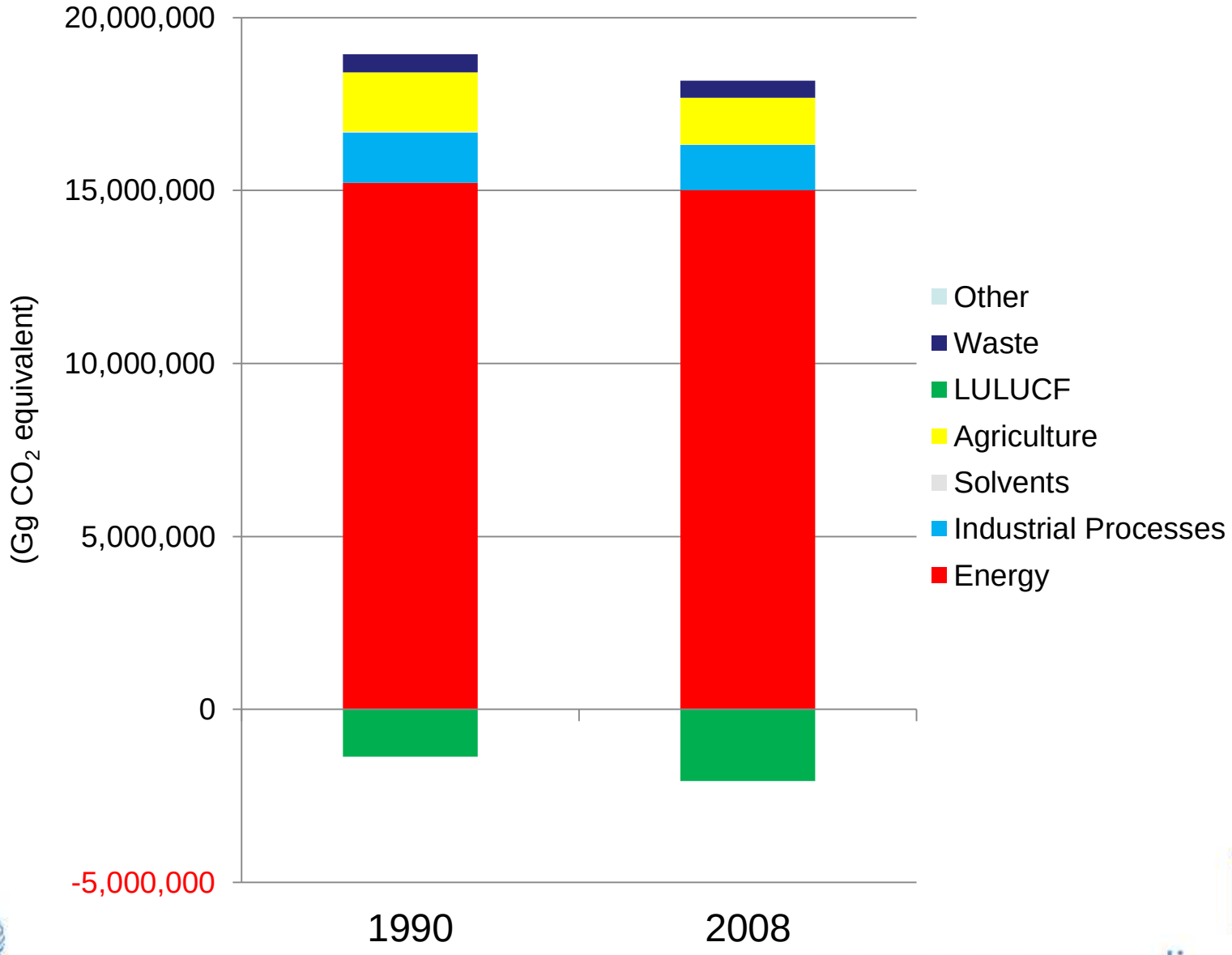
Energy Sector



Annex 1 – Emissions



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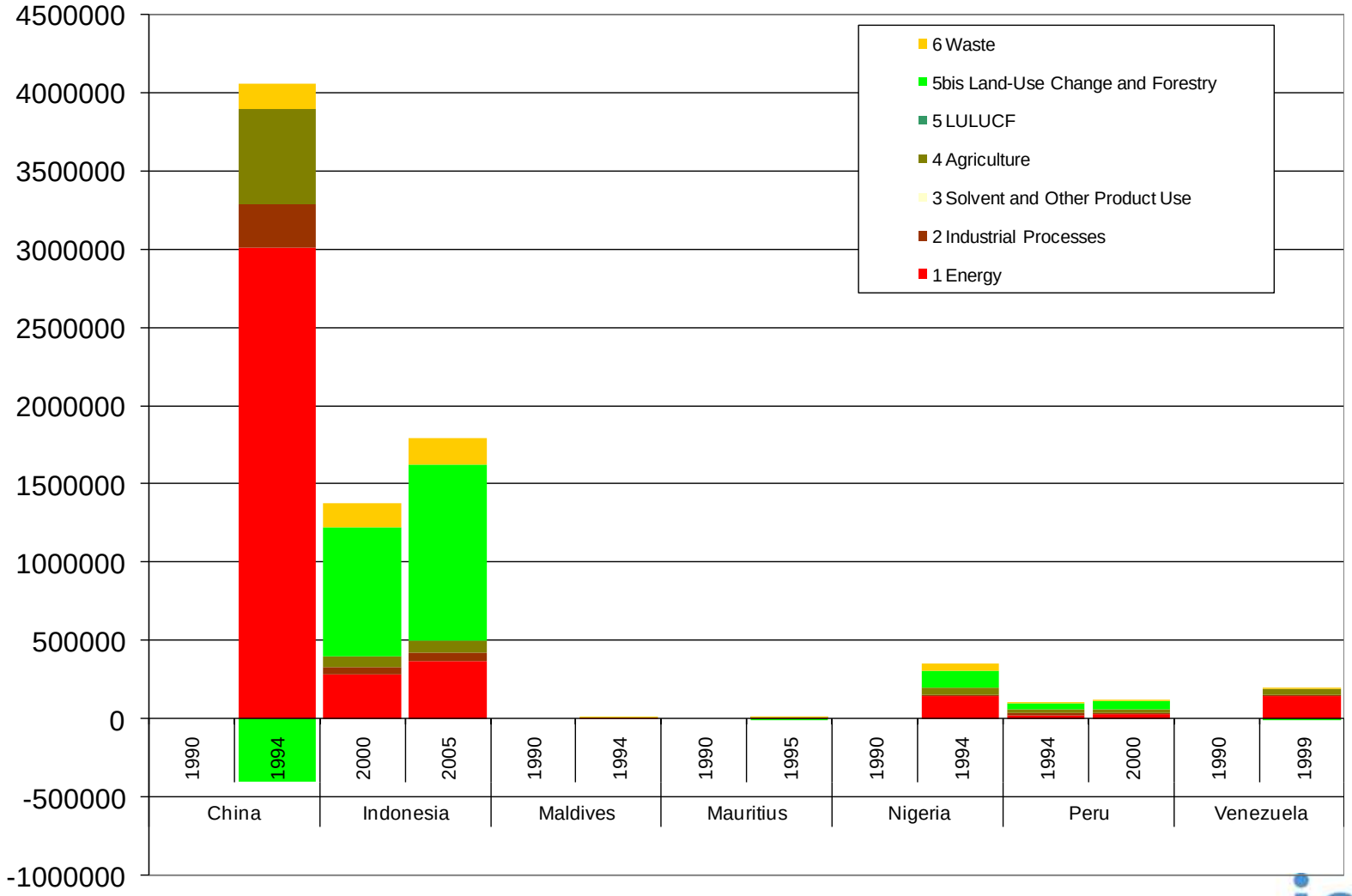
National Emissions



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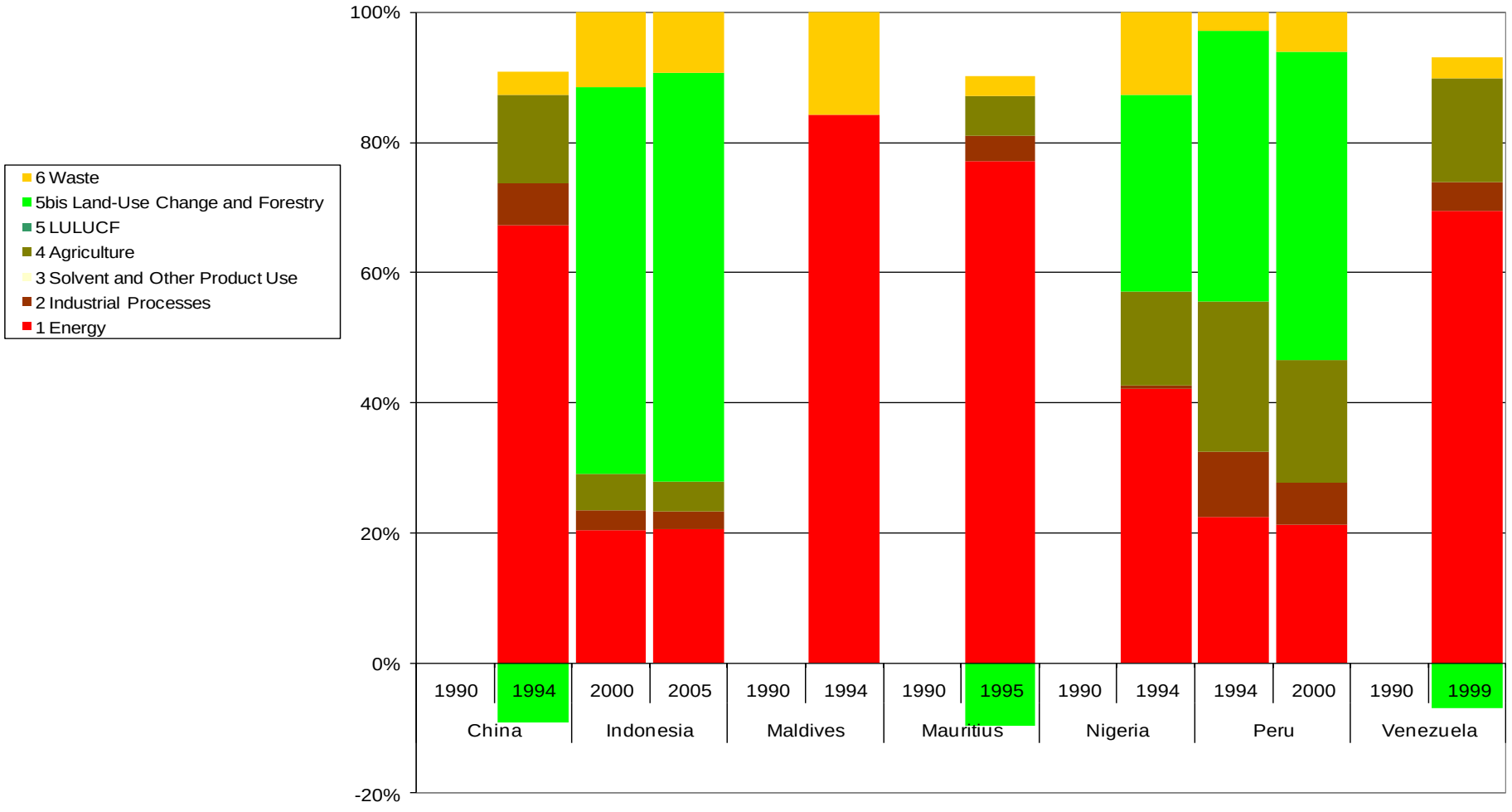
Emissions as % of total



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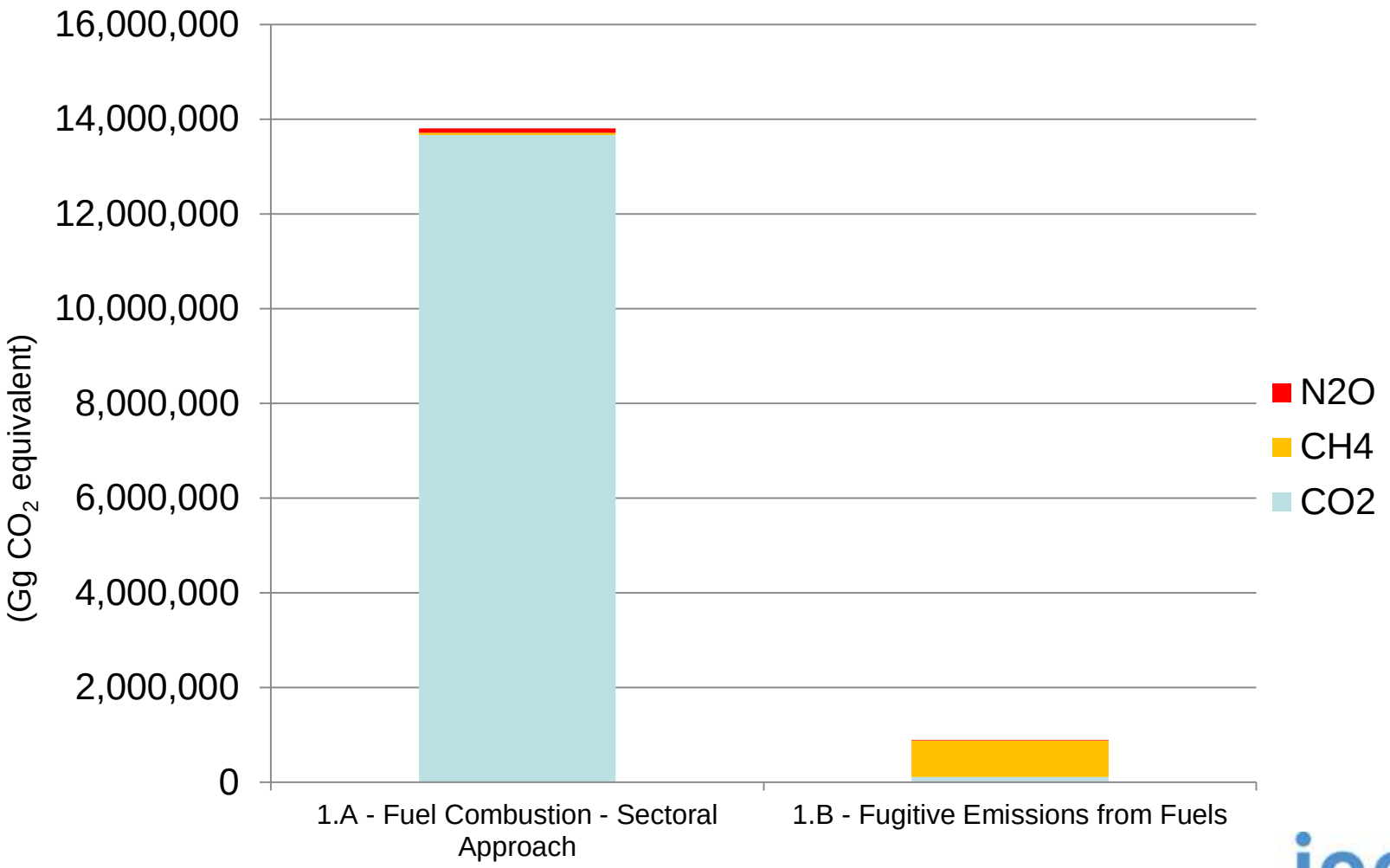
Annex 1 – Energy Emissions (2008)



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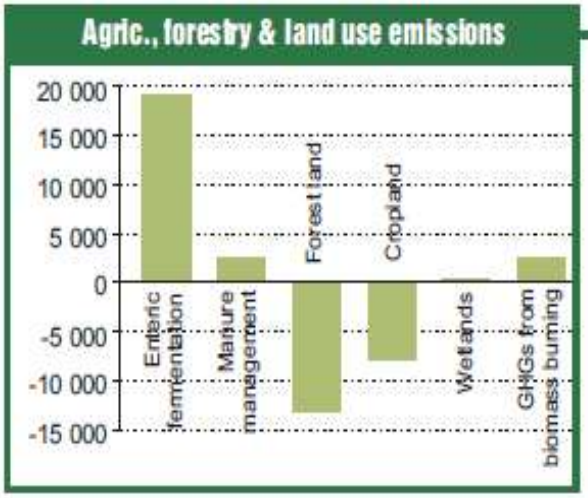
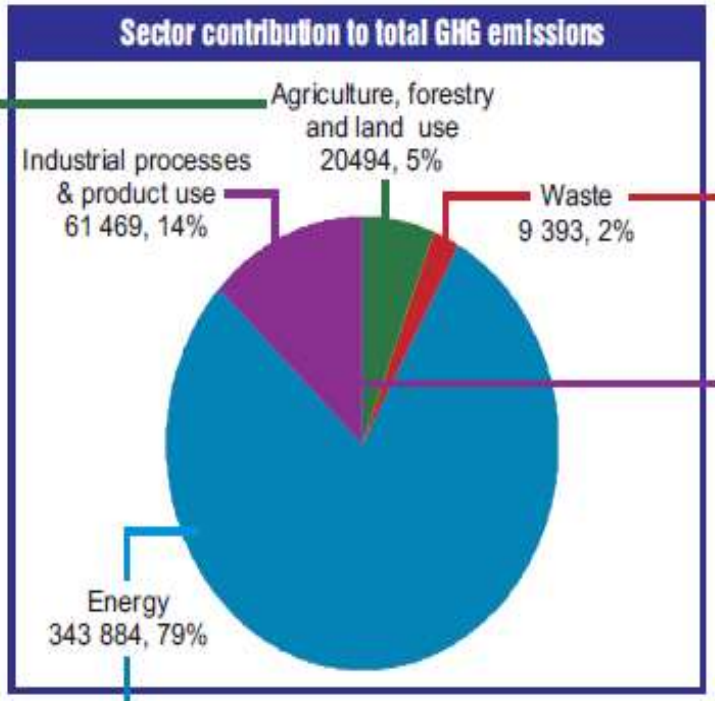
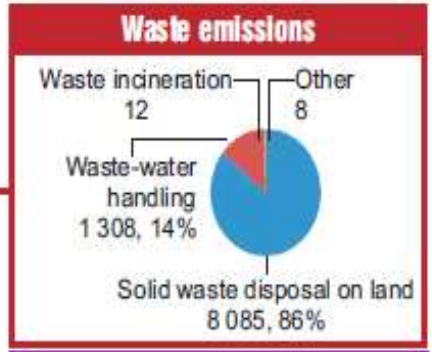
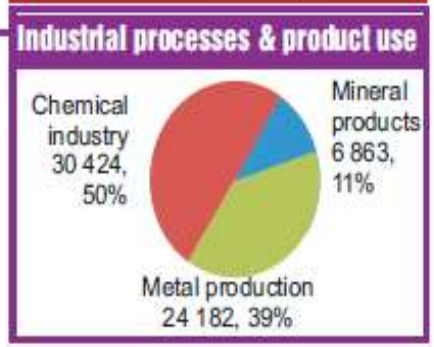
Sectoral Overview (2000)_ SA

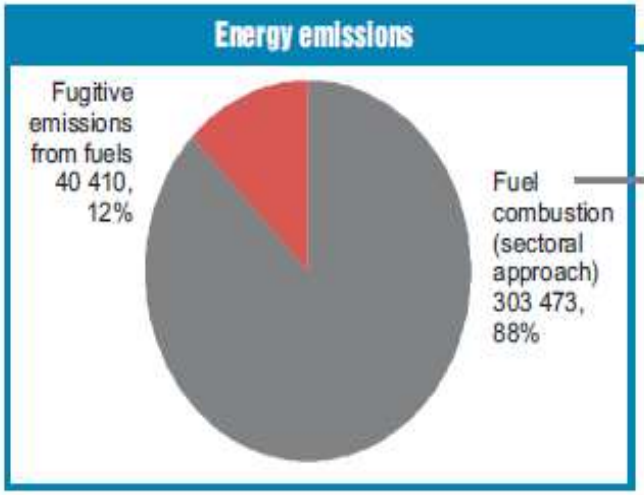


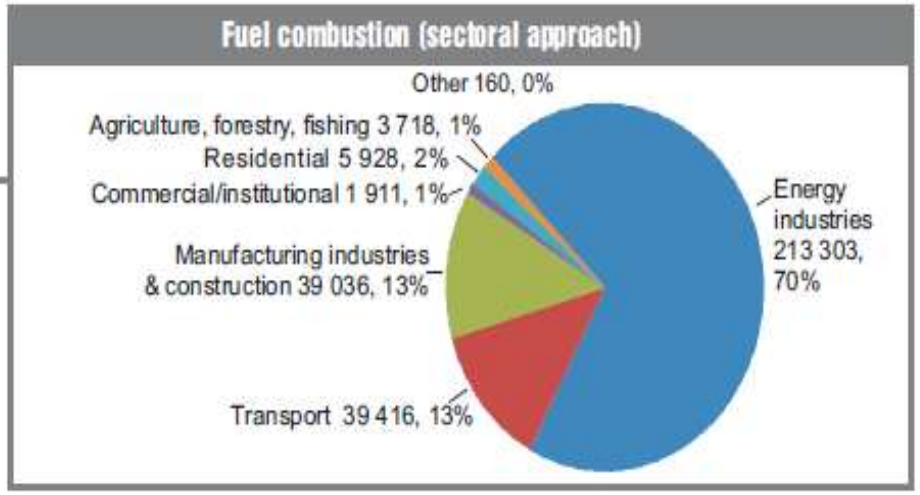
All units in $GgCO_2eq$

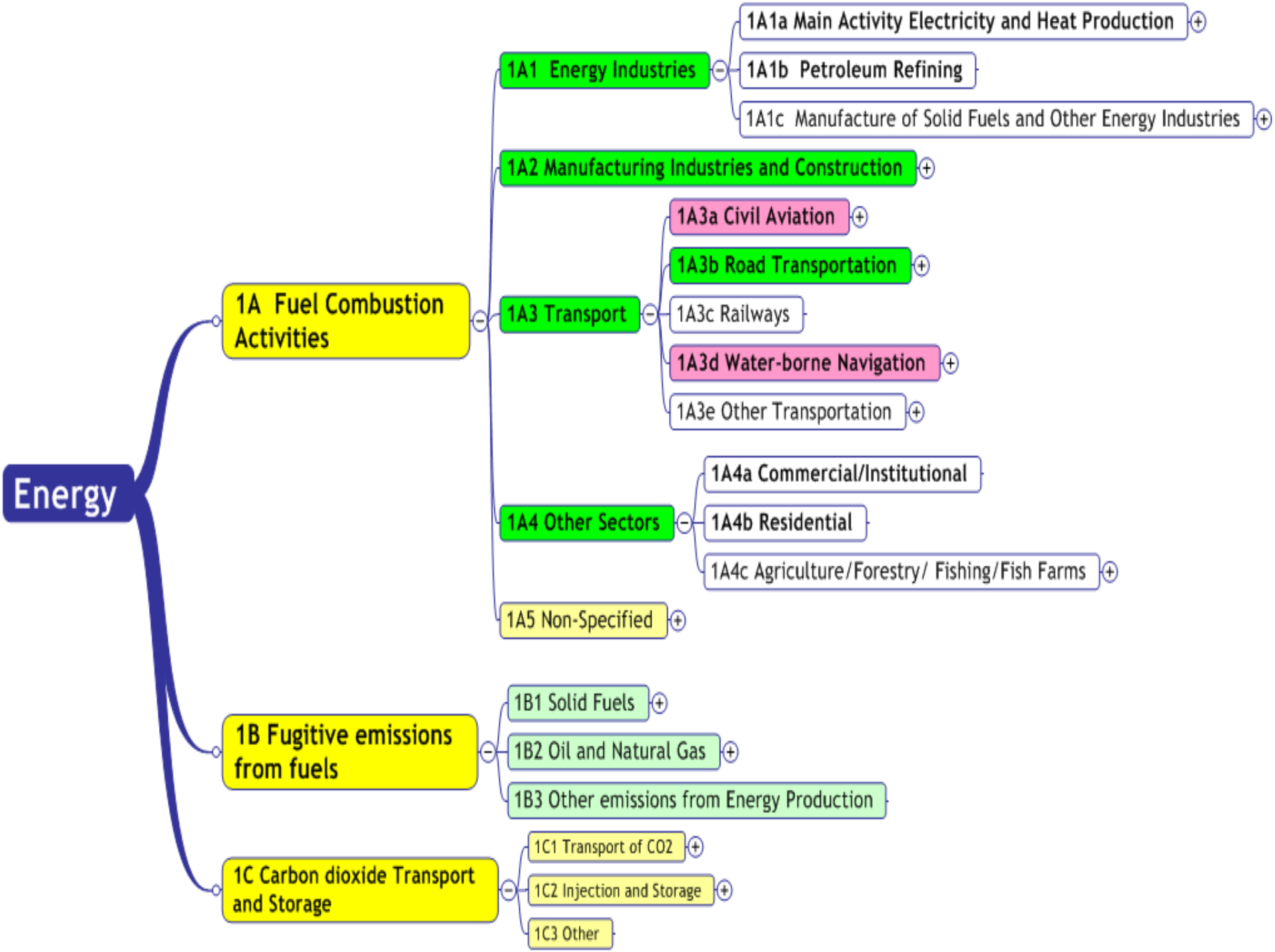




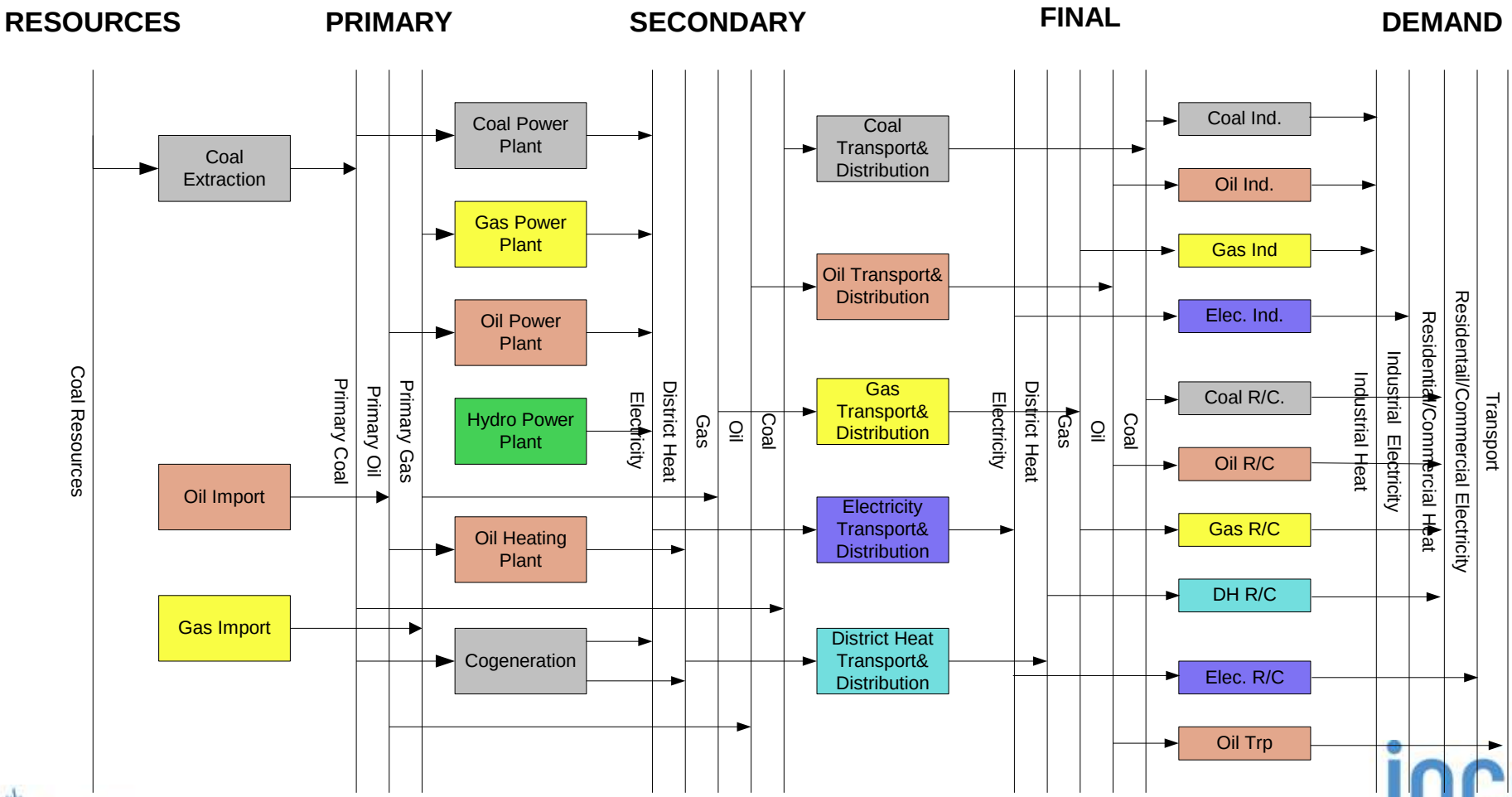







Energy
1A Fuel Combustion Activities
1A1 Energy Industries
1A1a Main Activity Electricity and Heat Production
1A1b Petroleum Refining
1A1c Manufacture of Solid Fuels and Other Energy Industries
1A2 Manufacturing Industries and Construction
1A3 Transport
1A3a Civil Aviation
1A3b Road Transportation
1A3c Railways
1A3d Water-borne Navigation
1A3e Other Transportation
1A4 Other Sectors
1A4a Commercial/Institutional
1A4b Residential
1A4c Agriculture/Forestry/ Fishing/Fish Farms
1A5 Non-Specified
1B Fugitive emissions from fuels
1B1 Solid Fuels
1B2 Oil and Natural Gas
1B3 Other emissions from Energy Production
1C Carbon dioxide Transport and Storage
1C1 Transport of CO2
1C2 Injection and Storage
1C3 Other

Reference Energy System [RES]



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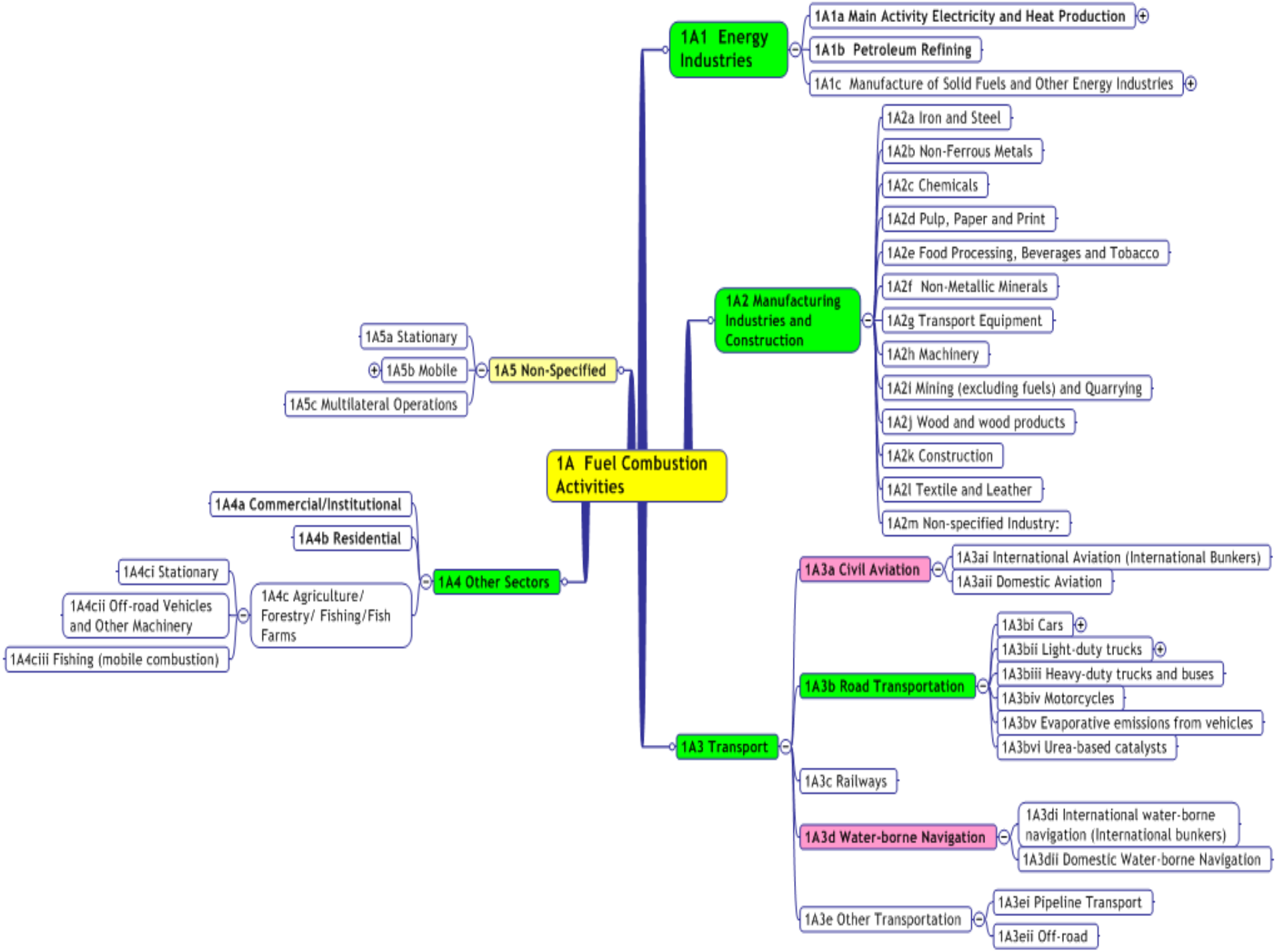
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1A2a Iron and Steel
1A2b Non-Ferrous Metals
1A2c Chemicals
1A2d Pulp, Paper and Print
1A2e Food Processing, Beverages and Tobacco
1A2f Non-Metallic Minerals
1A2g Transport Equipment
1A2h Machinery
1A2i Mining (excluding fuels) and Quarrying
1A2j Wood 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

Combustion Emissions

- CO_2 emissions depend:
  - Almost entirely on the carbon content of the fuel
  - A small amount of carbon is un-oxidised (usually >1%)
- CH_4 and N_2O Emissions depend on
  - Type of fuel
  - Combustion technology
  - Operating conditions
  - Control technology
  - Quality of maintenance
  - Age of equipment

Fuels

- SOLID (Coal and Coal Products)
  - Inc. coal, coke and derived gases.
- LIQUID (Crude Oil and Petroleum Products)
  - Fuel Oil, Gasoline, LPG, Ethane and Petroleum Coke
- GAS (Natural Gas)
- OTHER FOSSIL FUELS
  - Non-biomass municipal & Industrial wastes, waste oils
- PEAT (treated as fossil fuel)
- BIOMASS
  - Wood, Charcoal, Biofuels, Biomass fraction of MSW
    - CO_2 Emissions not included in total Energy Emissions

Biomass

- CO_2 emissions from biomass combustion are not included in the national total
  - Although they are reported separately
  - Non-CO_2 emissions are reported in the national total
- Net carbon emissions are accounted for in the LULUCF/AFOLU sector
- Peat is treated as a fossil fuel

Combustion Emissions – Tier 1

$$E=F \bullet A$$

Where:

E = Emission of Greenhouse Gas

A = Amount of fuel burnt

F = Emission Factor.

For CO_2, F = C, the Carbon content of fuel

For other gases F is measured

Coal Use – Africa – IEA data 2006 (Original Units)

Data: IEA 2009 (http://www.iea.org/Textbase/stats/index.asp)

,	Coking Coal	Other Bituminous Coal	Peat	Patent Fuel	Coke Oven gas	Gas Coke	Gas Works Gas	Coke Oven Gas	Blast Furnace Gas
Unit			*kT*					*TJ*	
Electricity Plants		*124764*							
Energy Sector					*18*				
Industry	*14*	*12,921*			*841*	*55*	*86,586*	*16,763*	*32,341*
Transport		*8*							
Residential		*4,942*	*4*	*104*			*380*		
Commercial and Public Services		*2,589*					*326*		
Agriculture / Forestry		*265*							
Fishing									
Other Non-Specified		*397*							
Non-Energy Use		*2,220*							
cv (TJ/Gg)	*28.2*	*25.8*	*9.76*	*20.7*	*28.2*	*28.2*			

Energy Units

- Energy statistics are often specified in physical units, e.g. in tonnes or m^3
- To convert these data to energy units, eg joules, requires calorific values.
- The IPCC Guidelines use net calorific values (NCVs), expressed in SI units.
- Some statistical offices use gross calorific values (GCV).
  - The difference between NCV and GCV is the latent heat of vaporisation of the water produced during combustion of the fuel.
  - for coal and oil, the NCV is about 5 % less than the GCV
  - For most natural and manufactured gas, the NCV is about 10 % less.
- Where fuel characteristics (moisture, hydrogen and oxygen contents) are known the 2006 Guidelines give a more precise method to convert GCV to NCV data

Specific Net Calorific Values

Crude Oil*

	toe/tonne
Saudi Arabia	1.016
United States	1.029
Russia	1.005
Iran	1.019
Mexico	1.054
China	1.000
Venezuela	1.069
Canada	1.022
Norway	1.022
Kuwait	1.016

** for selected countries.*

Petroleum Products*

	toe/tonne
Refinery gas	1.150
LPG	1.130
Ethane	1.130
Naphtha	1.075
Motor Gasoline	1.070
Jet Fuel	1.065
Kerosene	1.045
Gas/Diesel Oil	1.035
Heavy Fuel Oil	0.960
Other Products	0.960

** selected products - average values.*

Coal*

	toe/tonne
China	0.531
United States	0.634
India	0.441
Australia	0.614
South Africa	0.564
Russia	0.545
Indonesia	0.615
Poland	0.551
Kazakhstan	0.444
Ukraine	0.505

** steam coal production for selected countries.*

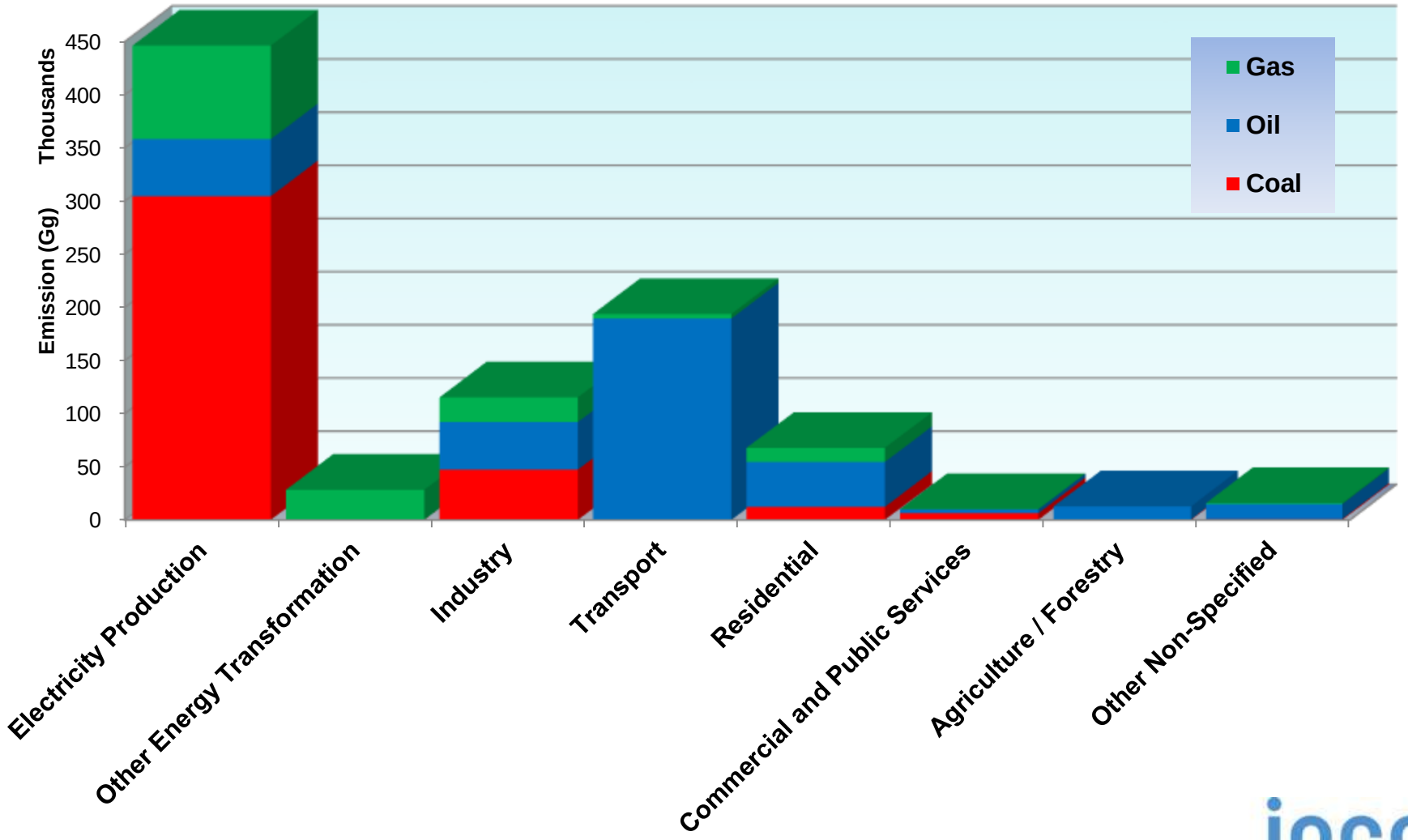
Coal Use – Africa – IEA data 2006 (Energy)

,	Coking Coal	Other Bituminous Coal	Peat	Patent Fuel	Coke Oven gas	Gas Coke	Gas Works Gas	Coke Oven Gas	Blast Furnace Gas
Unit			*TJ*					*TJ*	
Electricity Plants	-	*3,218,911*	-	-	-	-	-	-	-
Energy Sector	-	-	-	-	*508*	-	-	-	-
Industry	*395*	*333,362*	-	-	*23,716*	*1,551*	*86,586*	*16,763*	*32,341*
Transport	-	*206*	-	-	-	-	-	-	-
Residential	-	*127,504*	*39*	*2,153*	-	-	*380*	-	-
Commercial and Public Services	-	*66,796*	-	-	-	-	*326*	-	-
Agriculture / Forestry	-	*6,837*	-	-	-	-	-	-	-
Fishing	-	-	-	-	-	-	-	-	-
Other Non-Specified	-	*10,243*	-	-	-	-	-	-	-
Non-Energy Use	-	*57,276*	-	-	-	-	-	-	-
Emission Factors kg/TJ	***94,600***	***94,600***	***106,000***	***97,500***	***107,000***	***107,000***	***44,400***	***44,400***	***260,000***

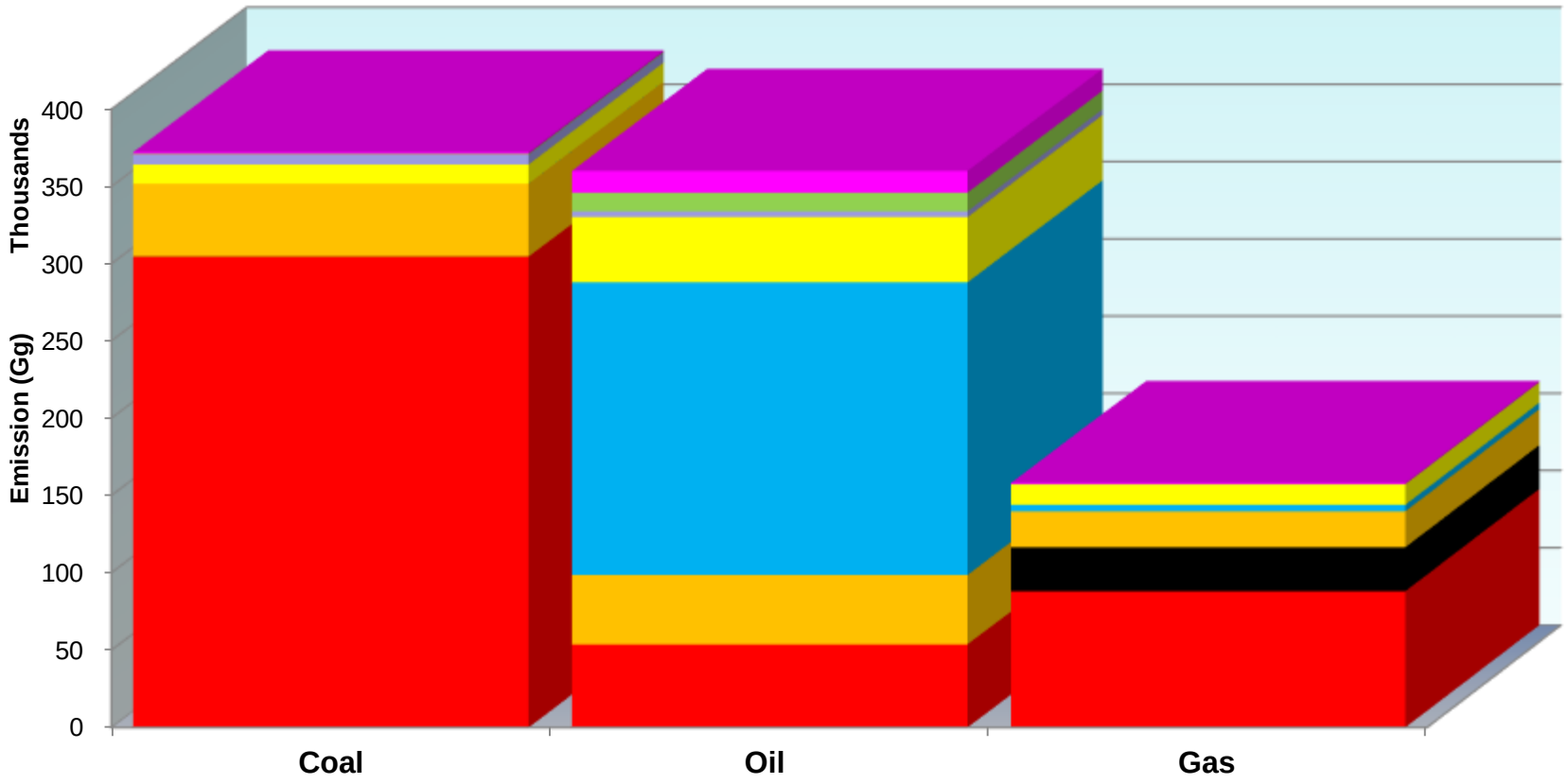
Coal Use – Africa – IEA data 2006

	Coking Coal	Other Bituminous Coal	Peat	Patent Fuel	Coke Oven gas	Gas Coke	Gas Works Gas	Coke Oven Gas	Blast Furnace Gas
Unit	*Gg (ktonne)*								
Electricity Plants	-	304,509	-	-	-	-	-	-	-
Energy Sector	-	-	-	-	54	-	-	-	-
Industry	37	31,536	-	-	2,538	166	3,844	744	8,409
Transport	-	20	-	-	-	-	-	-	-
Residential	-	12,062	4	210	-	-	17	-	-
Commercial and Public Services	-	6,319	-	-	-	-	14	-	-
Agriculture / Forestry	-	647	-	-	-	-	-	-	-
Fishing	-	-	-	-	-	-	-	-	-
Other Non-Specified	-	969	-	-	-	-	-	-	-
Non-Energy Use	-	5,418	-	-	-	-	-	-	-
Total Emissions	**37**	**356,061**	**4**	**210**	**2,592**	**166**	**3,876**	**744**	**8,409**

African CO_2 Emissions -2006



African CO_2 Emissions -2006



- Other Non-Specified
- Agriculture / Forestry
- Commercial and Public Services
- Residential
- Transport
- Industry
- Other Energy Transformation
- Electricity Production

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Combustion Emissions – Higher Tiers

- Country Specific emission factors – carbon contents are needed
- For CO_2, F = C•O
  - C = Carbon content of fuel; O = oxidation factor (fraction of fuel C oxidised to CO_2)
- Any abatement needs to be taken into account
- May need to stratify fuel use by abatement type and oxidation rate (technology)
- Non-CO_2 emissions technology dependent
- Measurements are a Tier 3 approach – can be combined with emission factor tier 1/2 approaches if sufficient data available [Sometimes this includes use of Models]

Reference Approach

- A simple basic method based on imports, production and exports.
- Essentially:

$$Emission = Production + Imports - Exports - NonEnergyUse$$

- CO_2 only!
- Used as a check on the sectoral approach described above
  - Differences due to non-energy use of fuel, as well as differing quality data sets

African Energy Use – Energy Balance

ktonne oil equivalent (ktoe)

SUPPLY and CONSUMPTION	Coal and Peat	Crude Oil	Petroleum Products	Gas
Production	141,801	495,846	0	169,668
Imports	7,698	42,879	45,214	4,030
Exports	-46,879	-401,357	-43,524	-96,473
International Marine Bunkers**	0	0	-6,035	0
Stock Changes	-39	-336	-1,113	0

African Energy Emissions

SUPPLY and CONSUMPTION	Coal and Peat	Crude Oil	Petroleum Products	Gas
Production	5,936,924	20,760,080	0	7,103,660
Imports	322,300	1,795,258	1,893,020	168,728
Exports	-1,962,730	-16,804,015	-1,822,263	-4,039,132
International Marine Bunkers**	0	0	-252,673	0
Stock Changes	-1,633	-14,068	-46,599	0

Total Emission = 978,092 Gg

Data: IEA 2009 (http://www.iea.org/Textbase/stats/index.asp)

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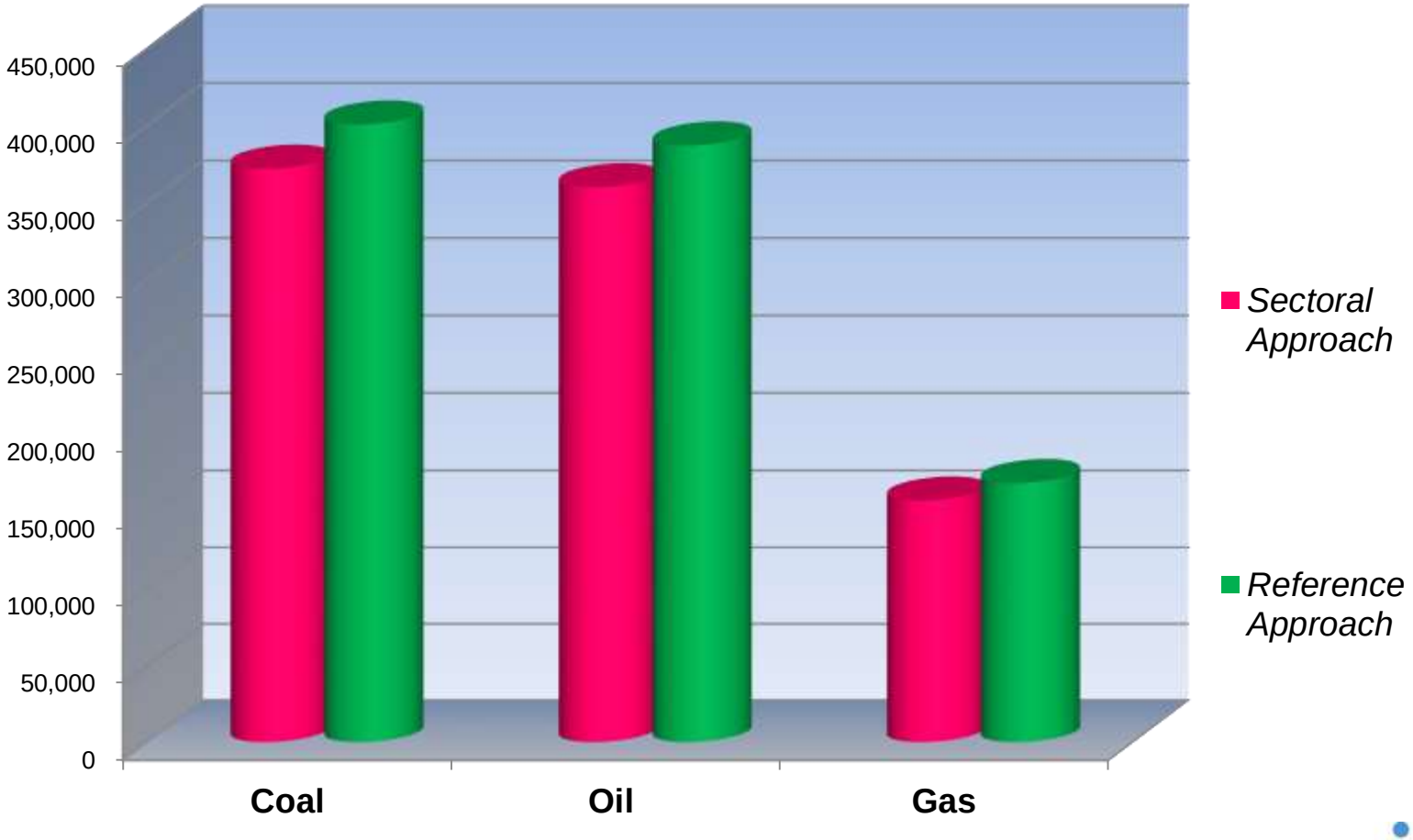
African CO_2 Emissions – Sectoral and Reference Emission Estimates



Road Transport

- CO_2 Emissions from C in fuel used
  - Bio-fuels carbon removed form total and reported separately
  - Carbon is also emitted from urea based catalysts and included here (not strictly combustion?)

$$Emission = Activity \bullet \frac{12}{60} \bullet Purity \bullet \frac{44}{12}$$

  - CH_4 and N_2O strongly technology related. At higher tiers need to know technologies in fleet (especially type and proportion of catalysts)
- Caution with "fuel sold" data
  - overlaps with off-road and potentially other sectors (e.g. agriculture)
  - Blended fuels (e.g. with bio-ethanol and lubricants)
  - Smuggling
- All fuel sold in country included – even if fuel exported in fuel tanks of vehicles and used elsewhere

Aviation and Shipping

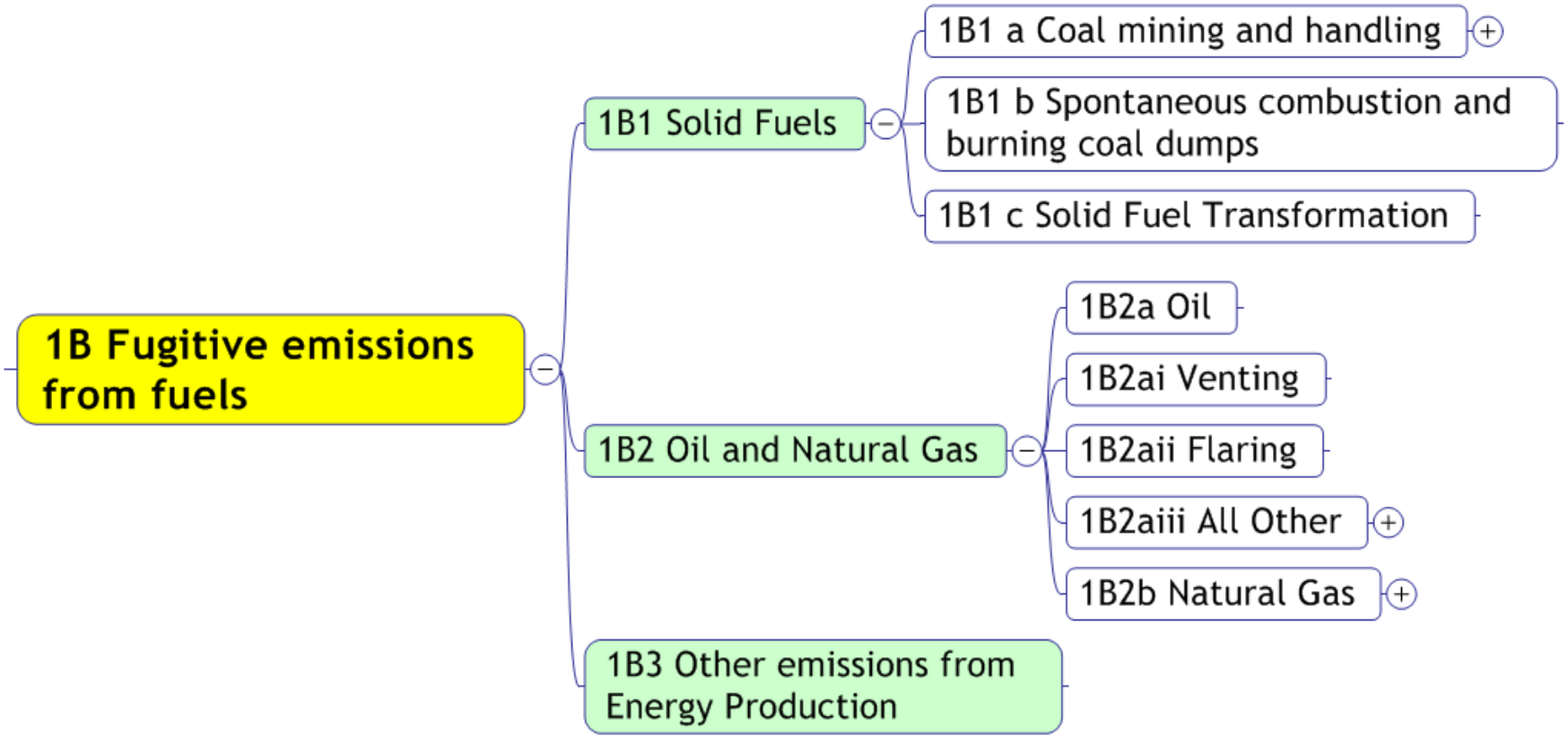
- Aviation and Shipping
  - Domestic Emissions included in National Total
  - International Emissions Reported separately "Bunker Fuels"
  - Domestic are legs of journeys between points in one country
  - International are trips between countries

Non-Energy Use of Fuels

Types of use and examples of fuels used for non-energy applications			
Use	**Example of fuel types**	**Product/process**	**Ch**
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').

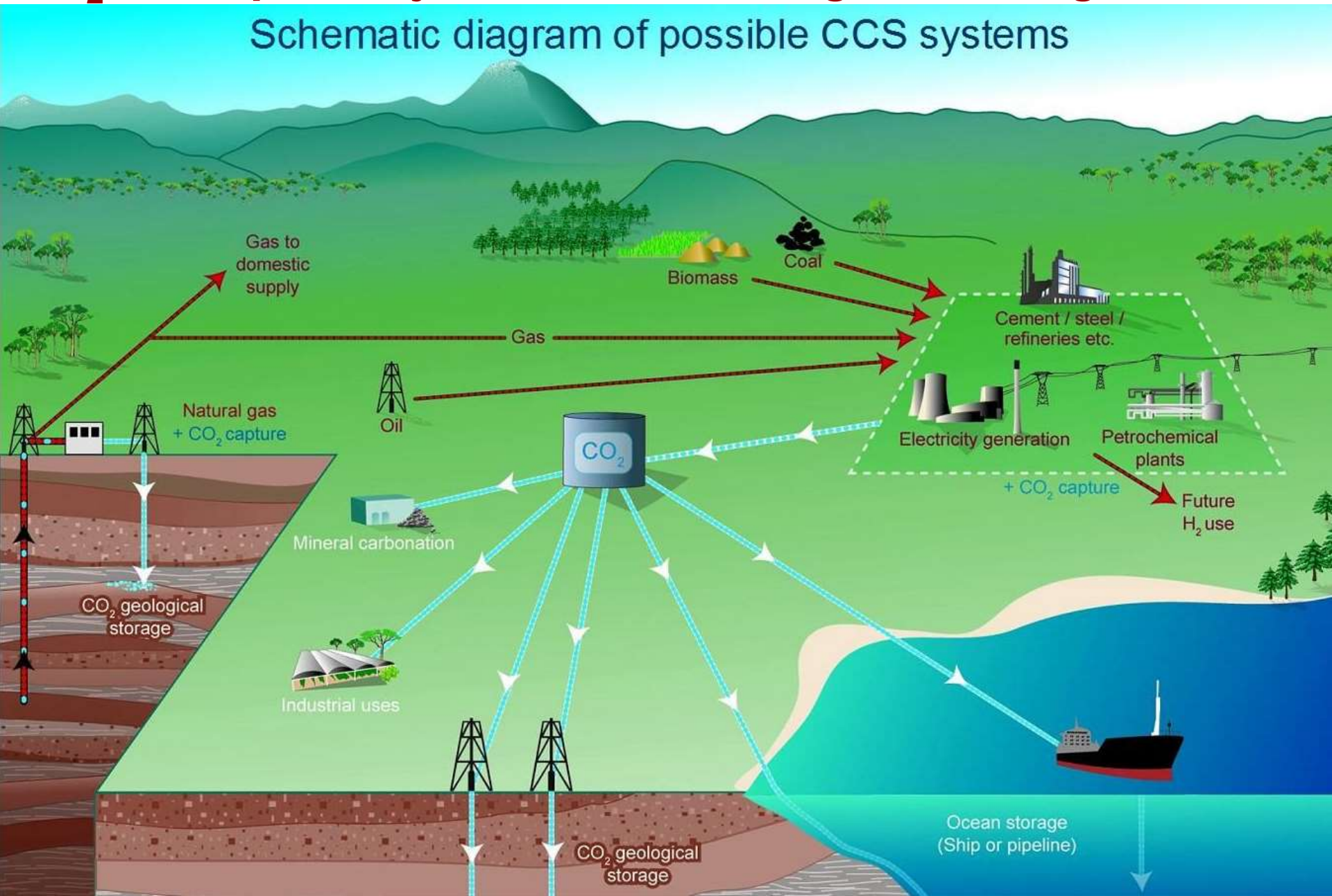
Fugitive Emissions



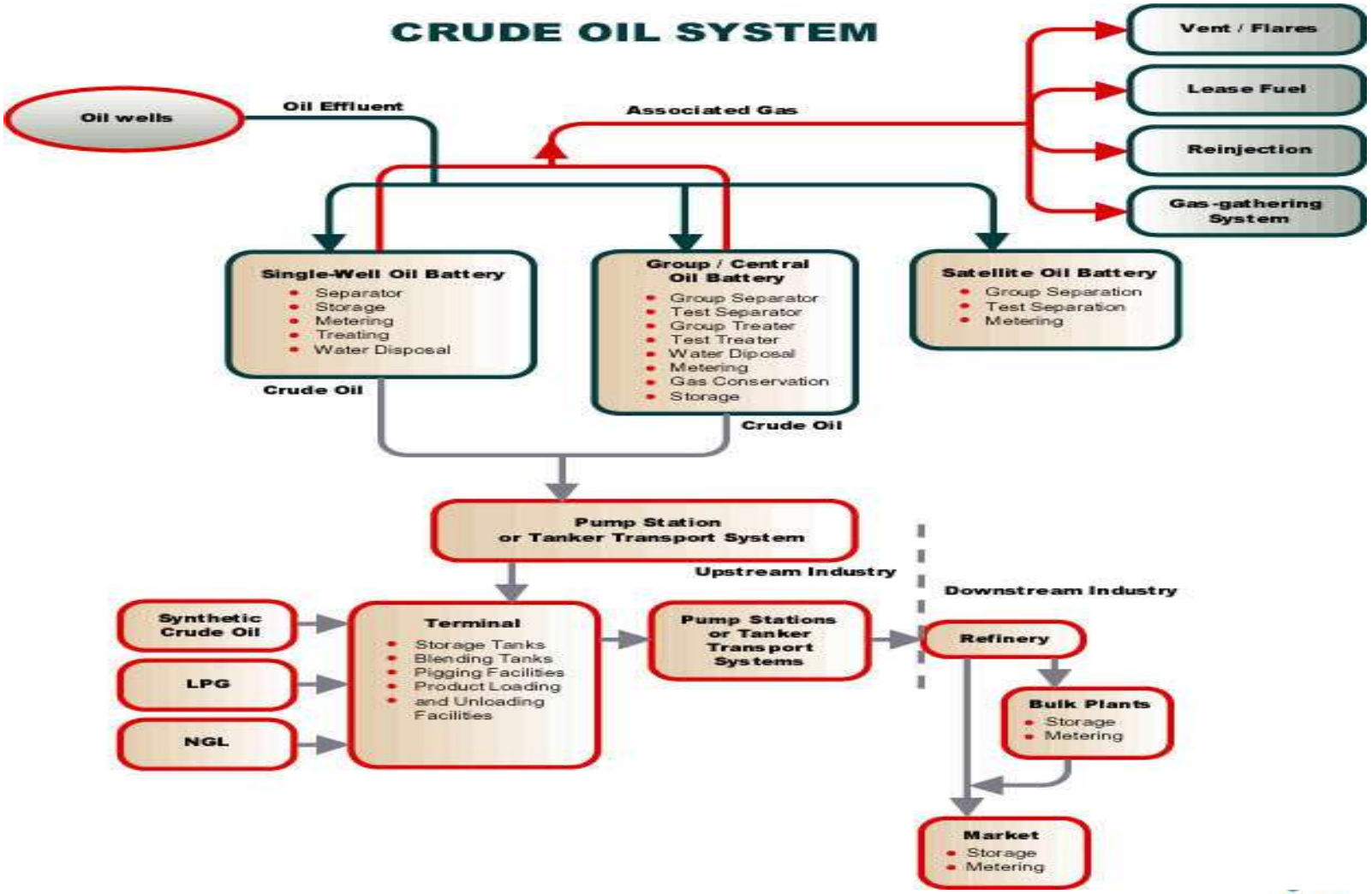
Fugitive Emissions

- Covers a wide range of sources associated with the production and distribution of fossil fuels
- Significant CH_4 emissions from mines and leaks
- Simple Emission Factor methods at Tier 1
- Higher tiers need more detail on technologies and age of plant/mines etc.
- Includes:
  - Active and abandoned mines
  - Venting and flaring from oil & gas industry
  - Leakages from distribution (e.g., gas pipelines)

CO_2 Transport, Injection and Geological Storage



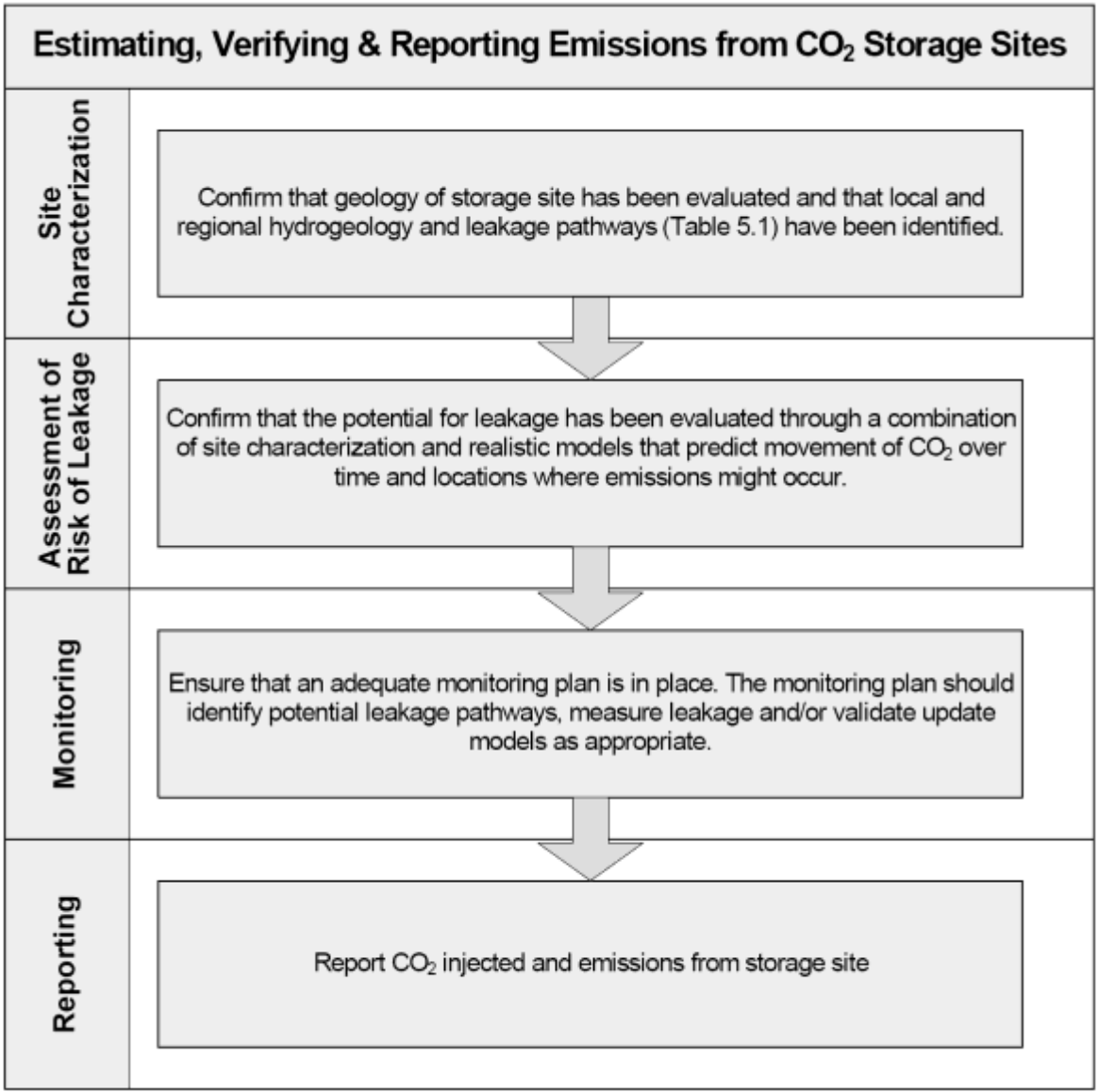
Fugitive Emissions - Sources



Emissions

- Estimate/measure emissions without capture.
- Measure amount captured
- Plant emission is the difference
- All leaks after measurement point are transport emissions
- Transport emissions are fugitive emission and use similar methods.

CO_2 – Leakage from storage site



Summary

- Energy Emissions are usually the most important
  - CO_2 from fuel combustion is major source
  - CH_4 mainly comes from fugitive emissions
- CO_2 emission factor depends on carbon content of fuel.
- Reference approach used for checking

Any Questions?

Greenhouse Gas Inventory Hands-on Training Workshop

Energy Sector – Fugitive Emissions

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Outline of course - Fugitive Emissions

Fugitives

- Introduction
- Coal mining and handling
- Oil and natural gas systems
- Data issues
- References

Introduction

- **Fugitives**: the sum of emissions from accidental discharges, equipment leaks, filling losses, flaring, pipeline leaks, storage losses, venting and all other direct emissions except those from fuel use
- Mainly **methane (CH_4)**
- Entrained **CO_2** can be significant in some cases
- Minor **N_2O** emissions from flaring

Sources of Fugitives

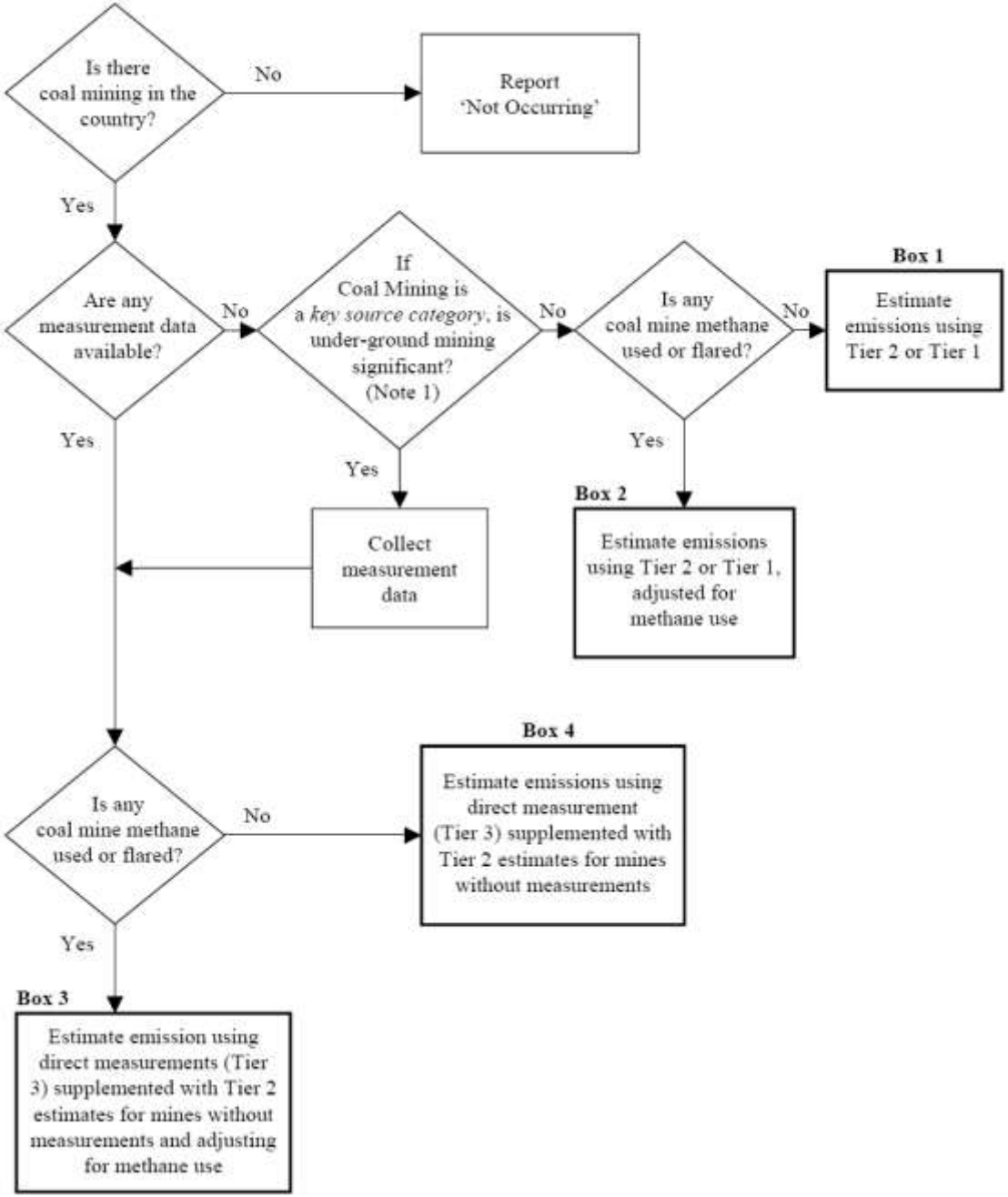
- **Solid fuels (primarily coal)**
  - mining, handling, processing and storage

- **Oil and natural gas systems**
  - exploration, production, processing, refining, transmission, storage and distribution

Coal Mining and Handling

- Release of trapped methane during mining
- In-situ methane content of coal can vary widely
- Most fugitive emissions occur at the mine
- Some residual emissions occur from post-mining handling / processing activities

Figure 2.10 Decision Tree for Underground Coal Mining and Handling



Surface vs. Underground

- Two types of coal mines
- Higher emissions for **underground mines**
- Emissions increase with depth of mine
- Emissions also depend on gas content of coal
  - Some gas may remain in the coal
  - 60%–75% gas released during mining activity

Abandoned Mines

- Emissions may continue after the mines have stopped producing coal
- Typically, emissions decline rapidly once deep mine coal production stops
- In some cases, emissions by the surrounding strata may be significant and continue for years afterwards.
- Coal waste or reject piles are minor source of emissions
- Flooding of mines can prevent emissions

Controlling Emissions

- Degasification wells
  - Gas conservation
  - Flaring
- Use of catalytic combustors on the outlet of ventilation systems for underground mines

Monitoring and Activity Data

- Methane content of exhausted ventilation air (Tier 3)
- Coal production (Tier 1 or 2)
- Imports and exports by type of coal
  - Post-mining emission, likely to be minor
- Information on the depth of each mine (Tier 2)

Tier 1 and Tier 2

EQUATION 2.12

Emissions = Coal Production (Surface or Underground) • Emission Factor

EQUATION 2.13

Total Emissions = Underground Mining Emissions + Surface Mining Emissions + Post-Mining Emissions – Methane Recovered and Used or Flared

- Tier 1 global average emission factors
- Tier 2 country or basin-specific emission factors based on actual CH_4 content of coal mined

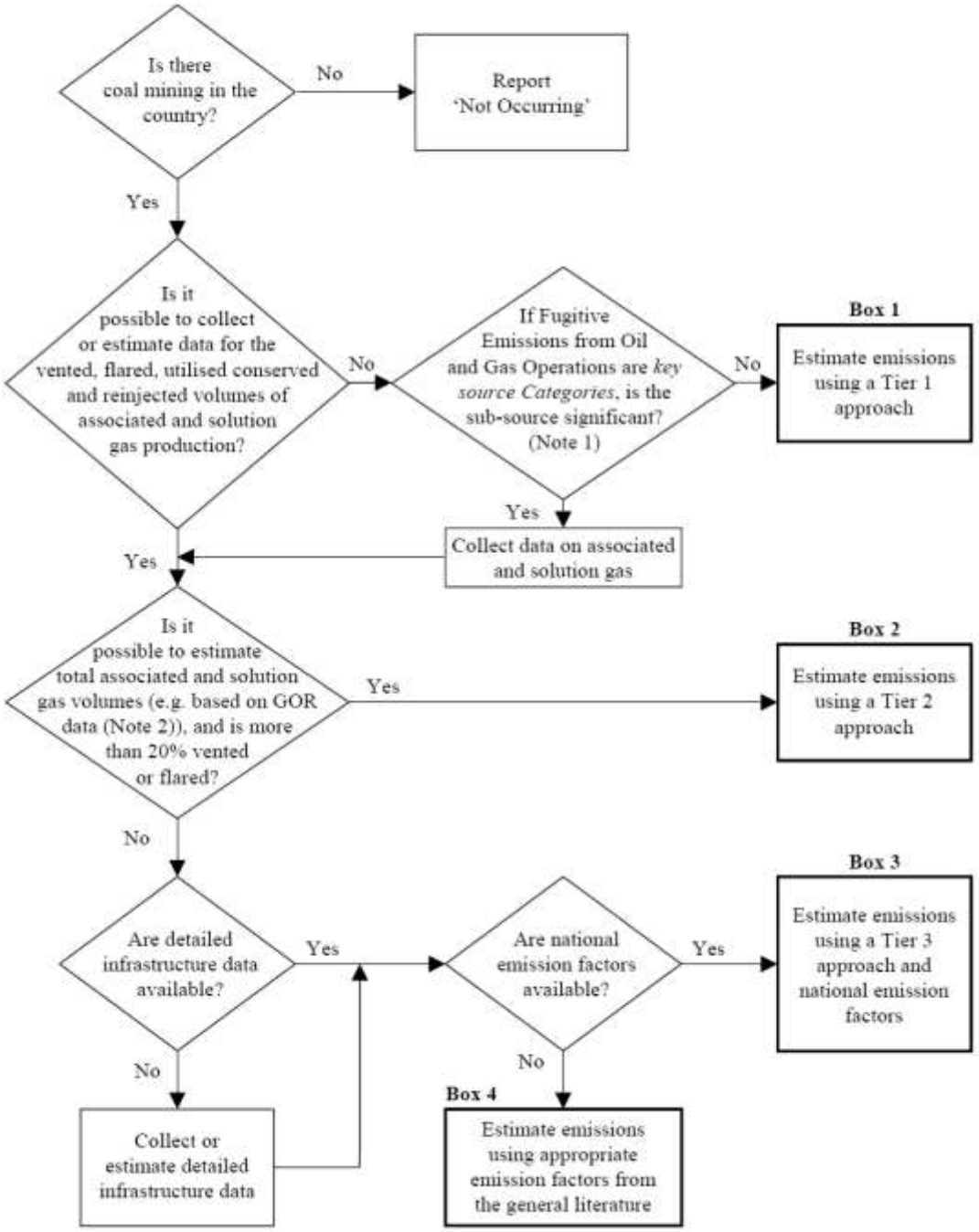
Coal Mining References

- **Coal statistics are available** for most countries from:
  - **U.S. Energy Information Administration (EIA)** <http://www.eia.gov/>
  - **United Nations Statistics Department (UNSD)**
    < http://unstats.un.org/unsd/default.htm>
  - **International Energy Agency (IEA)** <http://www.iea.org/>

Oil and Natural Gas Systems

- Equipment leaks
- Process venting and flaring
- Evaporation losses (i.e. from product storage and handling, particularly where flashing losses occur)
- Accidental releases or equipment failures

Figure 2.13 Decision Tree for Crude Oil Production and Transport



Emission Rates Depend On…

- Characteristics of hydrocarbons being produced, processed or handled
  - Conventional crude oil
  - Heavy oil
  - Crude bitumen
  - Dry gas
  - Sour gas (more than 10 ppmv of hydrogen sulphide (H_2S))
  - Associated gas

i.e.,
methane content of fuel and leakiness of equipment

- Equipment numbers, type and age
- Industry design, operating and maintenance practices
- Local regulatory requirements and enforcement

Emissions From Venting and Flaring Depend On…

- The amount of process activity
- Operating practices
- On-site utilization opportunities for methane
- Economic access to gas markets
- Local regulatory requirements and enforcement

Accidental Releases…

- Difficult to predict
- Can be a significant contributor
- Can include:
  - Well blowouts
  - Pipeline breaks
  - Tanker accidents
  - Tank explosions
  - Gas migration to the surface around the outside of wells
  - Surface casing vent blows
  - Leakage from abandoned wells

Equipment Leaks

- Tend to be continuous emitters
- Low to moderate emission rates
- All equipment leaks to some extent
- Only a few per cent of the potential sources at a site actually leak sufficiently at any time to be in need of repair or replacement.
- If less than 2% of the total potential sources leak, the facility is considered well-maintained

Fugitives Data

- **Poor quality and incomplete data** about **venting and flaring** is common
  - Contact industry representatives for standard practices to split venting and flaring

- **Data about equipment leaks** at minor facilities is **unavailable or incomplete**
  - Well-site facilities
  - Field facilities

Fugitives Data (cont.)

- Collection of activity data for fugitives sources is difficult and resource intensive…
- There are no real shortcuts available
- First step can be to interview experts in industry on common practices and processes…
- …have them compare national practices with those of countries with a known emissions profile (e.g. an Annex I country).

Thank You