GHG Training

Energy Sector Background Information

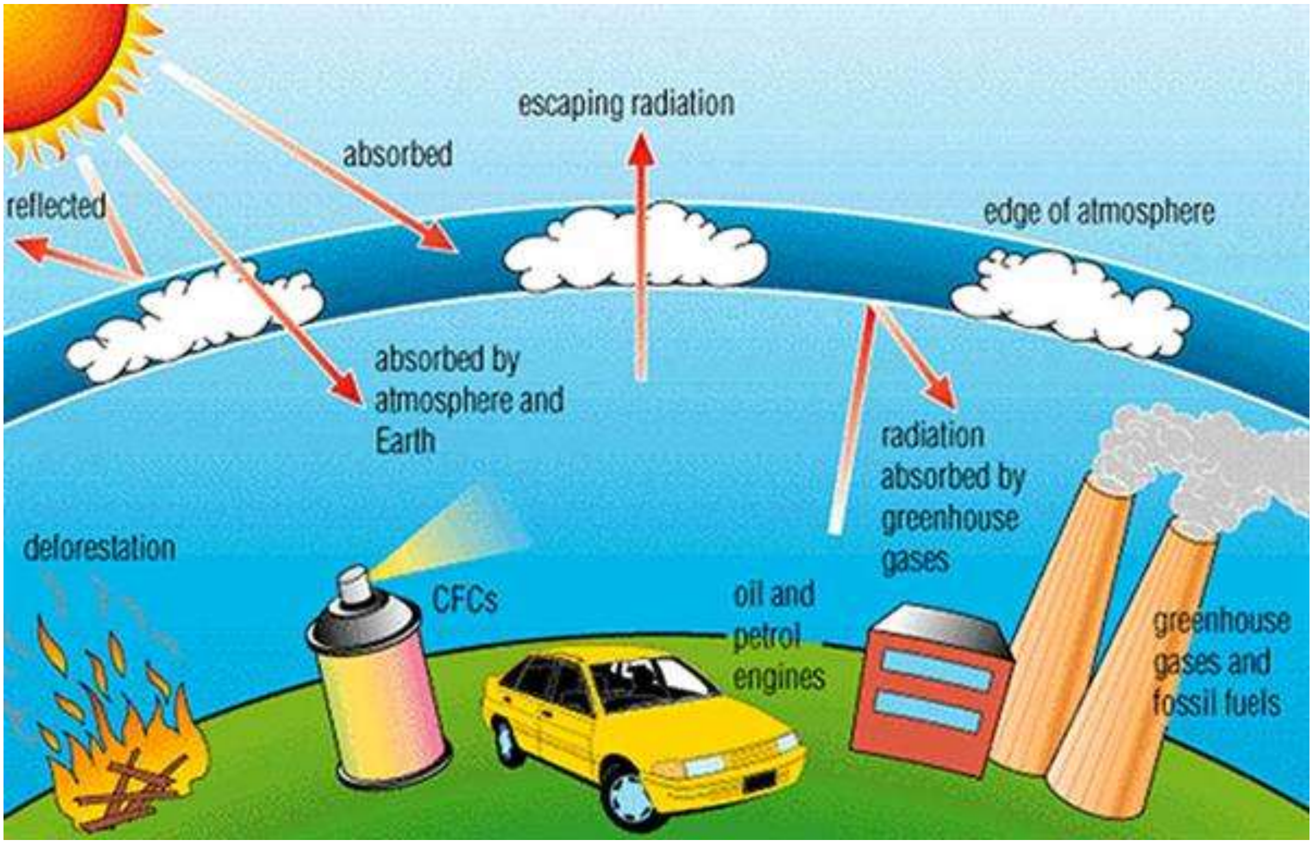

Table of Contents

List of Figures and Tables

Electricity Generation

South Africa's largest power producer generates 95% of electricity in South Africa and about 45% in Africa (GCSI, 2009). Approximately 88% of South Africa's electricity is generated in coal fired power stations, 6.5% capacity from Koeberg Nuclear Station, 2.3% is provided by hydroelectric and other renewable (GCSI, 2009).

The largest public electricity producer in South Africa is Eskom. Eskom generates 95% of the electricity used in South Africa (Eskom, 2011). Eskom generates, transmits and distributes electricity to various sectors such the industrial, commercial, agricultural and residential. The South African energy demand profile reveals that the industry/manufacturing sector utilizes the largest amount of electricity followed by mining, commercial and residential sectors (DoE, 2009). In an event of any power disruptions, these sectors are more likely to be impacted the most. In the case of the manufacturing/industry, mining and commercial sectors, this can result in reduced productivity.

Eskom uses coal, diesel and natural gas to produce electricity, based on their 2010 annual report, the fuel consumption figures are as follows in the table below.

Table 1 Electricity generation data (Eskom)

Eskom Electricity Generation			
Year	**Coal Consumed (kt)**	**Diesel (Litres)**	**Natural Gas**
2000	**88470**	**21088**	**231**
2001	**92454**	**25072**	**241**
2002	**94136**	**29056**	**251**
2003	**94460**	**33040**	**95**
2004	**104370**	**37024**	**310**
2005	**109508**	**41008**	**375**
2006	**136437**	**44992**	**395**
2007	**112096**	**48976**	**415**
2008	**119113**	**52960**	**435**
2009	**122960**	**56944**	**456**

Questions

Using on the information provided solve the following problems:

a) Where in the IPCC categories will these emissions be reported to and why?

b) Convert the consumption of coal; diesel and natural gas from mass units to energy units (refer to IPCC guidelines)

c) Estimate the GHG emissions from the consumption of coal, diesel and natural gas.

d) Calculate the CO_2 equivalence from the consumption of coal, diesel and natural gas

e) Estimate SO2, CO, and NMVOCs from the consumption of coal and diesel

f) Can you use the estimated results of SO_2, CO, and NMVOCs to conduct air quality modelling? Explain

Manufacturing industry and Construction

This category is comprised of a variety of fuel combusted emission sources, mainly in the industrial sector. In manufacturing industries, raw materials are converted into products using fuels as the main source of energy. The industrial sector consumes 40.8% of the final energy supplied in South Africa. The sector can be divided into mining, iron and steel, chemicals, non-ferrous metals, non-metallic minerals, pulp and paper, food and tobacco and other productions (includes manufacturing, construction, textiles, wood products etc.).

Questions

The table below gives a summary of the consumption of sub bituminous coal for the different sectors in the manufacturing industry and construction. Using the information provided below answer the following questions:

a) Convert the consumption of the coal fuel from mass units to energy units (refer to IPCC guidelines)

b) Estimate the GHG emissions from coal for each subsector

c) Calculate the CO_2 equivalence for the GHG emissions calculated.

Table 2 Consumption of sub bituminous coal for the period 2000-2009

Sub Bituminous Coal (Tons)										
Summary	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Pulp and Paper	2967	3096	3,237	2511	2251	2,322	3,121	3,121	3,121	2,323
Iron and Steel	18033	210,281	207,535	211613	229996	228,656	216,593	219,840	219,840	163,680
Machinery	789	824	865	2,334	1917	2,127	7,869	30,272	2,329	1,733
Mining and Quarrying	67609	68241	67,830	69819	72070	91,143	88,225	89,181	95,073	70,786
Non-Metal Minerals	39,371	36,066	35,747	50813	59,448	65,441	35,486	47,468	47,468	35,341
Non-specified industry	123,940	98,004	122,467	147572	188,822	220,687	178,985	107,862	143,122	106,560
Chemical Industry	265,496	201,141	149,506	144544	118,406	105,517	111,332	112,649	109,252	81,342
Food and Tobacco	1251	1305	1368	1116	924	1,046	1,397	1,397	1,397	1,039

Liquid Fuels

South African Fuel Market

South Africa consumed approximately 11.3-billion litres of petrol and 9.1-billion litres of diesel during 2009, showing a 2.2% increase in petrol and a 6.6% decrease in diesel from the previous year. During 2008 there was a 4.2% decrease in petrol consumption and a 0.1% increase in diesel consumption from 2007.

Refining

South Africa has very limited oil reserves and about 95% of its crude oil requirements are met by imports from the Middle East and Africa (Source: South Africa Yearbook 2008/091). Refined petroleum products such as petrol, diesel, fuel oil, paraffin, jet fuel and LPG re produced by the following methods:

- crude oil refining;
- coal to liquid fuels and gas to liquid fuels; and
- Natural gas to liquid fuels.

Distribution

Petroleum products are moved from refineries by pipelines, rail, sea and road to approximately 200 depots, 4 600 service stations and 100 000 direct consumers who are mostly farmers.

Wholesaling

The majors in the South African oil industry are BP Southern Africa, Chevron South Africa, Engen Petroleum, PetroSA, Sasol Oil, Shell South Africa and Total South Africa. They operate storage terminals and distribution facilities throughout South Africa.

Retailing

There are approximately 4 600 service stations (forecourts, company owned and dealer owned) in South Africa.

Questions

Using on the information provided below answer the following questions:

a) Convert the consumption of the liquid fuels from mass units to energy units (refer to IPCC guidelines)

b) Determine the subsector shares of each of the liquid fuels referring to the graphs provided below.

c) Estimate the GHG emissions from liquid fuels for each subsector

d) Calculate the CO_2 equivalence for the GHG emissions calculated.

e) Will the international bunker fuels be reported separately or in the national emission totals? Explain.

The consumption of liquid fuels for the period 2000 to 2009 is summarized in the tables below.

Table 3 Consumption of liquid fuels in Litres

Kilolitres							
Year	Petrol	Diesel	Jet Fuel	Paraffin	Fuel Oil	Bitumen	LPG
2000	10396000	6254000	2020000	857000	555000	219000	567000
2001	10340000	6488000	1924000	786000	555000	242000	599000
2002	10335000	6831000	1967000	745000	536000	267000	586000
2003	10667000	7263000	2099000	769000	528000	272000	558000
2004	10984564	7678607	2075737	797381	569215	276578	563199
2005	11165000	8115000	2180000	761000	489000	305000	550000
2006	11279000	8708000	2269000	738000	476000	314000	605000
2007	11558000	9757000	2392000	697000	470000	334000	635000
2008	11069000	9762000	2376000	532000	555000	323960	613000
2009	11313000	9116000	2186000	545000	593000	329431	548000

Subsector Shares of Liquid Fuels

The graphs below give a summary of the subsector shares of the liquid fuels.

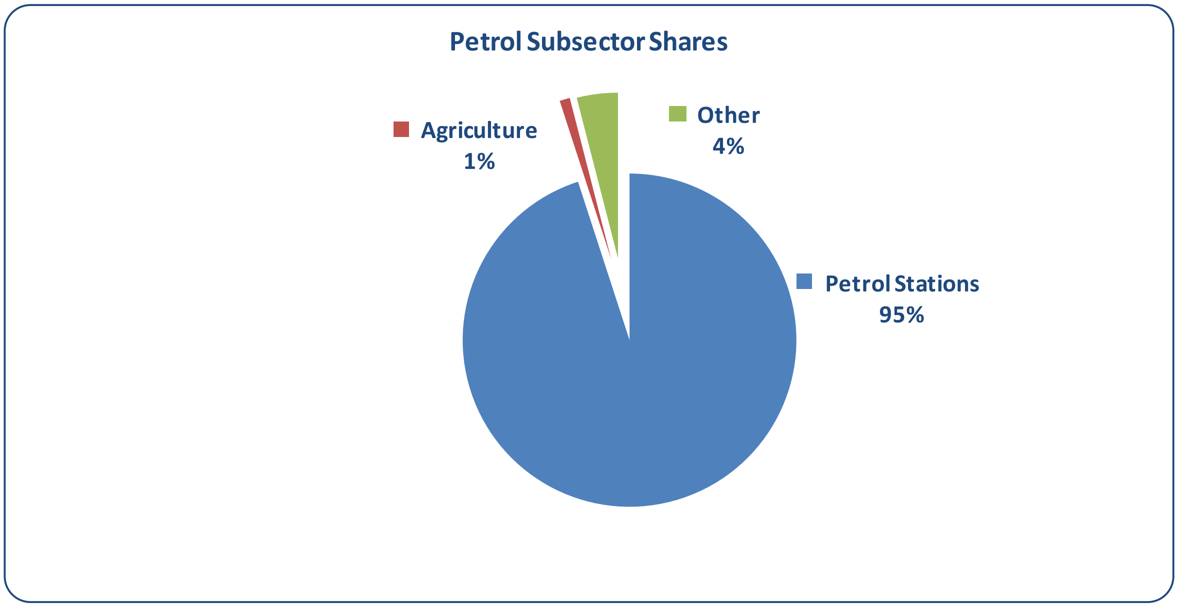

Figure 1 Petrol subsector shares

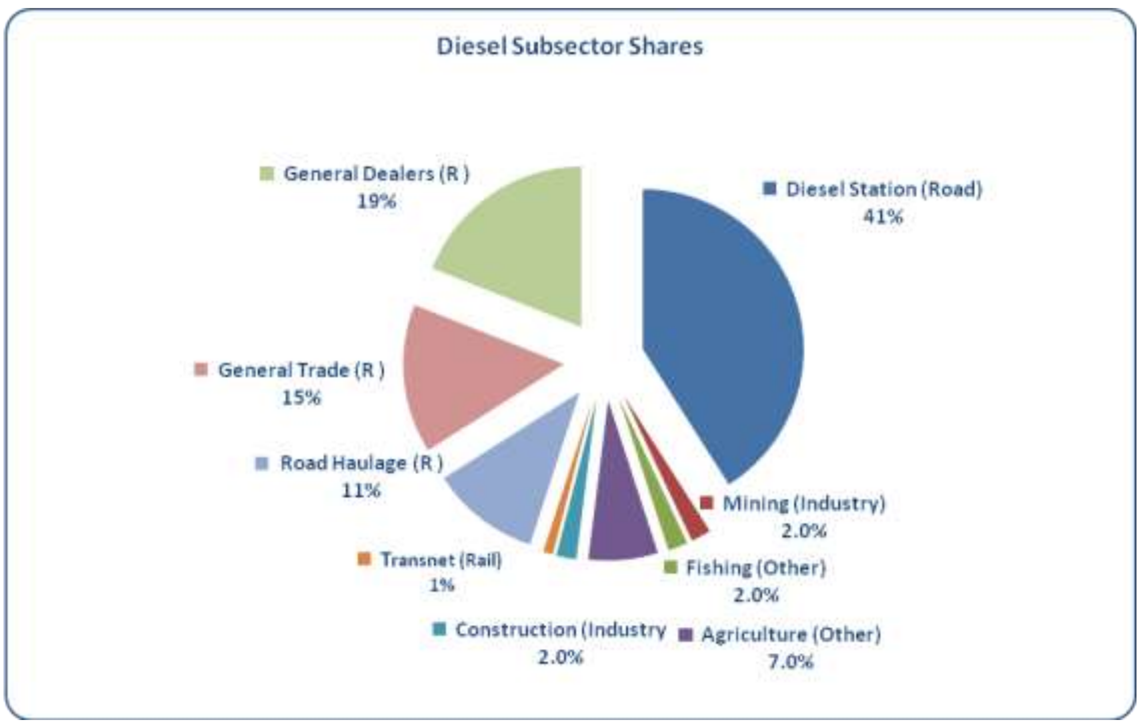

Figure 2 Diesel subsector shares

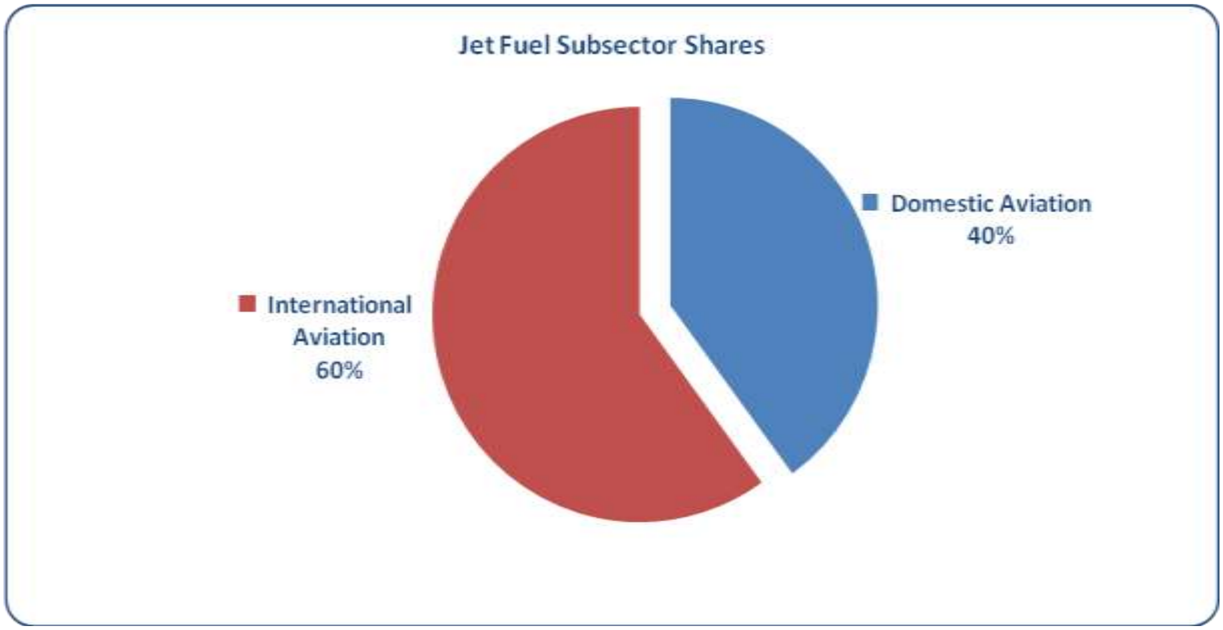

Figure 3 Jet Fuel subsector shares

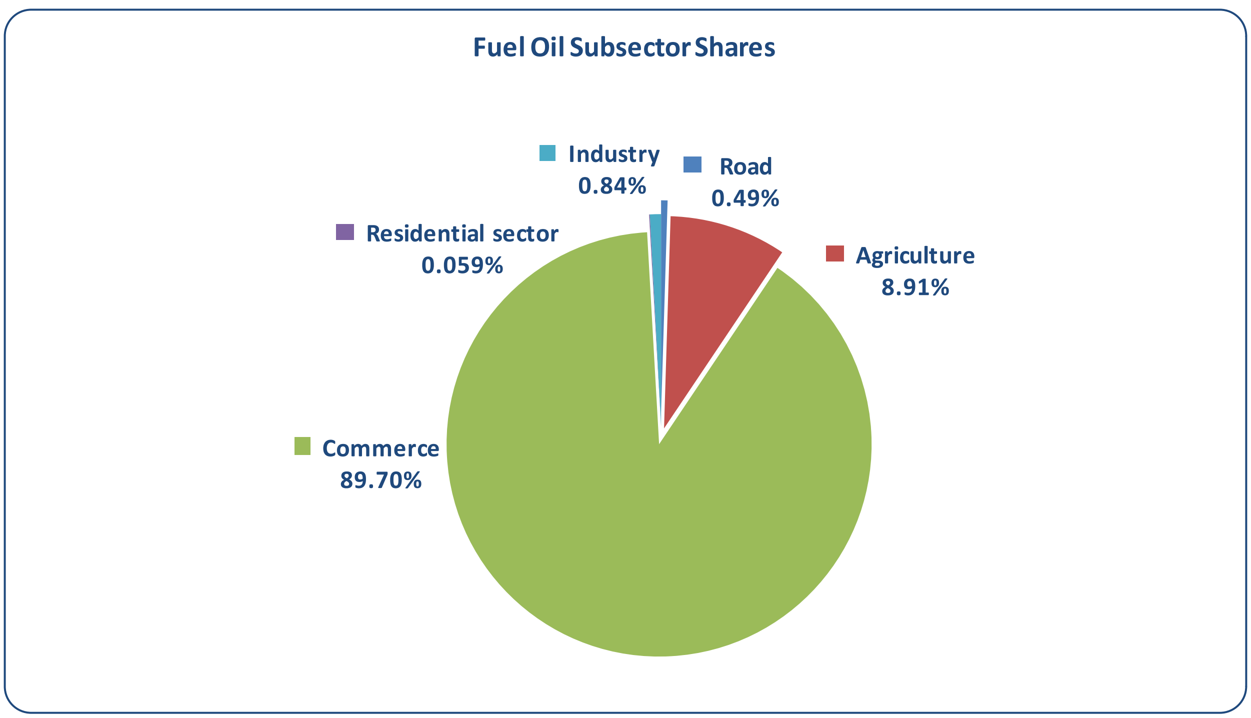

Figure 4 Fuel Oil subsector shares

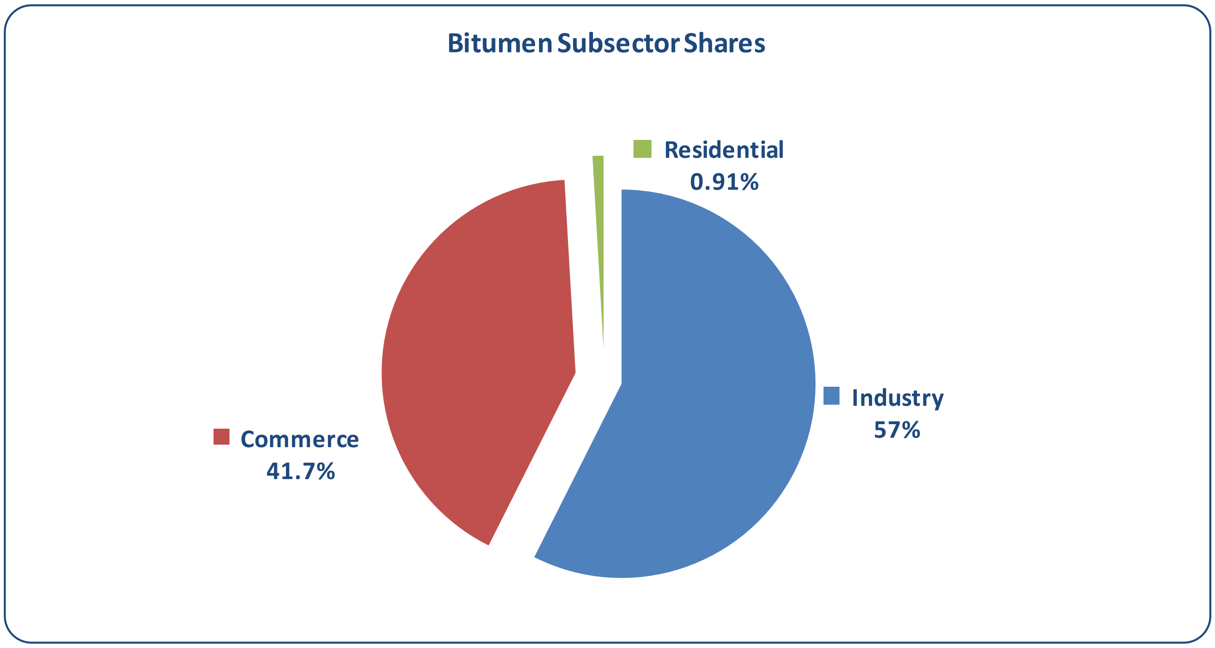

Figure 5 Bitumen subsector shares

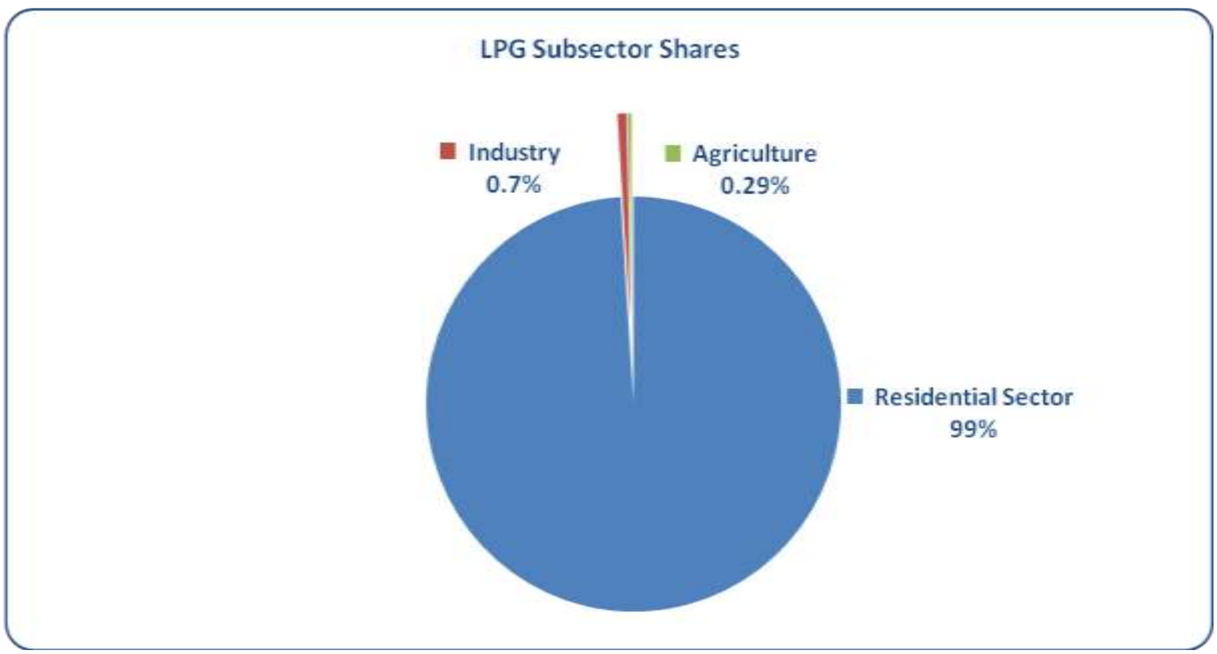

Figure 6 LPG subsector shares

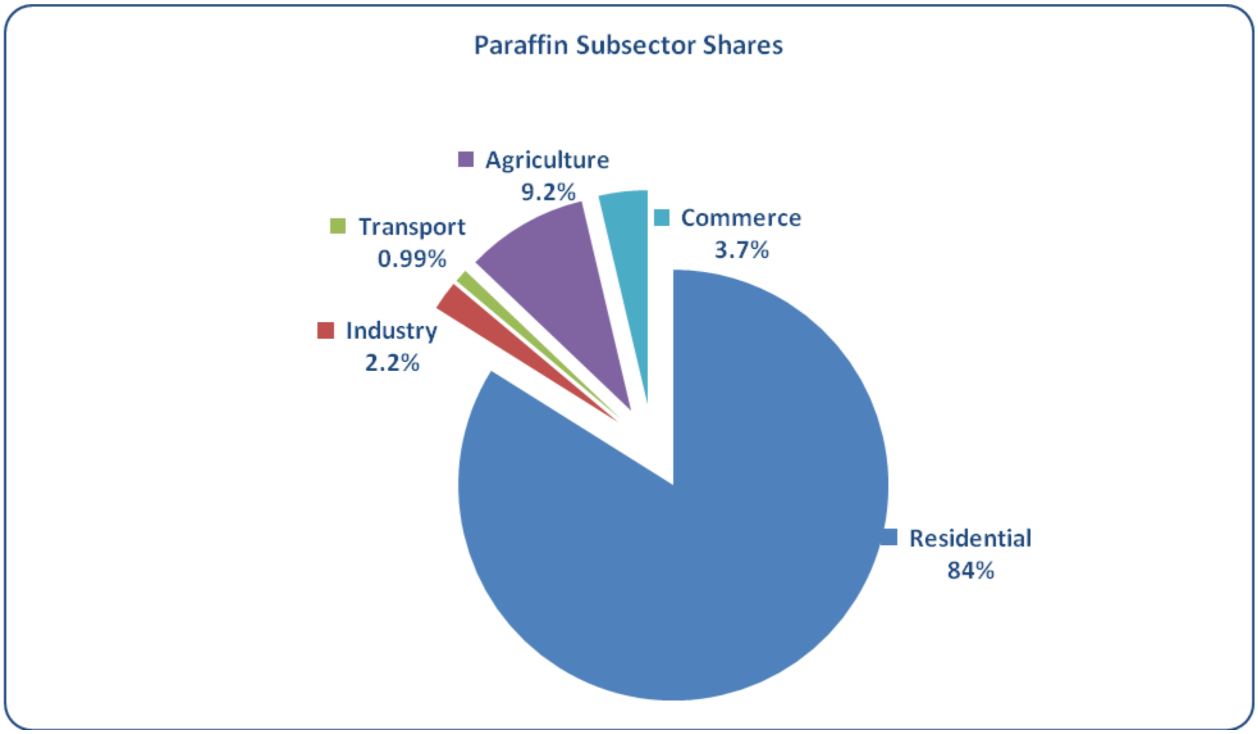

Figure 7 Paraffin subsector shares

Reference approach

The Reference Approach is a top-down approach, using a country's energy supply data to calculate the emissions of CO2 from combustion of mainly fossil fuels. The Reference Approach is a straightforward method that can be applied on the basis of relatively easily available energy supply statistic.

Questions

You are provided with energy balance for the period 2000 to 2009, using the reference approach estimate the following:

a) Estimate the CO2 emissions associated with the combustion of fuels in South Africa

b) Can you use the reference approach to calculate CH_4 and N_2O emissions? Explain.

c) Can you add biomass combustion related CO_2 emissions to the sectoral or reference approach? Explain

d) Can you use the reference approach to estimate CO_2 emissions related to biomass combustion? Explain

Fugitive Emissions

Fugitive emissions cover emissions of greenhouse gases associated with the production, processing, storage, transmission and distribution of fossil fuels such as coal, oil and natural gas. The sector also includes emissions from decommissioned (abandoned)

Fugitive Emissions (Coal mining)

Fugitive emissions refer to the intentional and unintentional releases of greenhouse gases that occur during the extraction, processing and delivery of fossil fuels to the point of final use. Methane is the most important emission sourced from solid fuels fugitive emissions.

For solid fuels, venting and disposal of coal-bed methane is the primary source of fugitive emissions. Most of these emissions occur at the mine with some residual emissions occurring from post-mining handling/processing activities.

The specific emission rates from coal mining depend primarily on the relative contribution of surface and underground mining to a Party's total coal production. Specific emissions are greater for underground mining and tend to increase with the depth of the mine. The emissions from coal handling are related to the type of mine from which the coal was produced. Emissions from coal mines may continue after the mines have stopped producing coal.

Question:

The table below gives the total coal mined in South Africa for the period 2000 to 2009. For the nine year period it has been estimated that 60% of the coal was mined underground and the remaining 40% was mined through underground mining.

Using the information provided calculate the following:

a) Calculate the amount of coal mined in open cast and underground mining methods

b) Calculate the CH_4 and N_2O related to fugitive emissions from underground and open-cast mining.

c) Calculate the CO_2 related to fugitive emissions from underground and open-cast mining.

d) Why is the type of mine important in the estimation of fugitive emissions from mining activities?

Period	Total coal mined (tons)
2000	287,604,446
2001	285,798,822
2002	281,674,627
2003	304,184,274
2004	311,216,790
2005	313,284,202
2006	313,084,952
2007	316,708,897
2008	322,523,475
2009	319,948,849

Fugitive Emissions (Oil and Natural Gas systems)

Specific fugitive emission rates from oil and natural gas systems may vary greatly according to:

- the type of oil or natural gas being produced, processed or handled (e.g., conventional crude oil, heavy oil, crude bitumen, dry gas, sour gas, associated gas);
- the stage of the system;
- the type and age of facility;
- operating, maintenance, and design practices; as well as

- Local regulatory requirements and enforcement.

The primary types of fugitive emission sources at oil and gas facilities are the following:

- fugitive equipment leaks;
- process venting and flaring;
- evaporation losses (i.e., from product storage and handling, particularly where flashing losses occur); and
- Accidental releases or equipment failures.

The diagram below gives an overview of the oil and natural gas system.

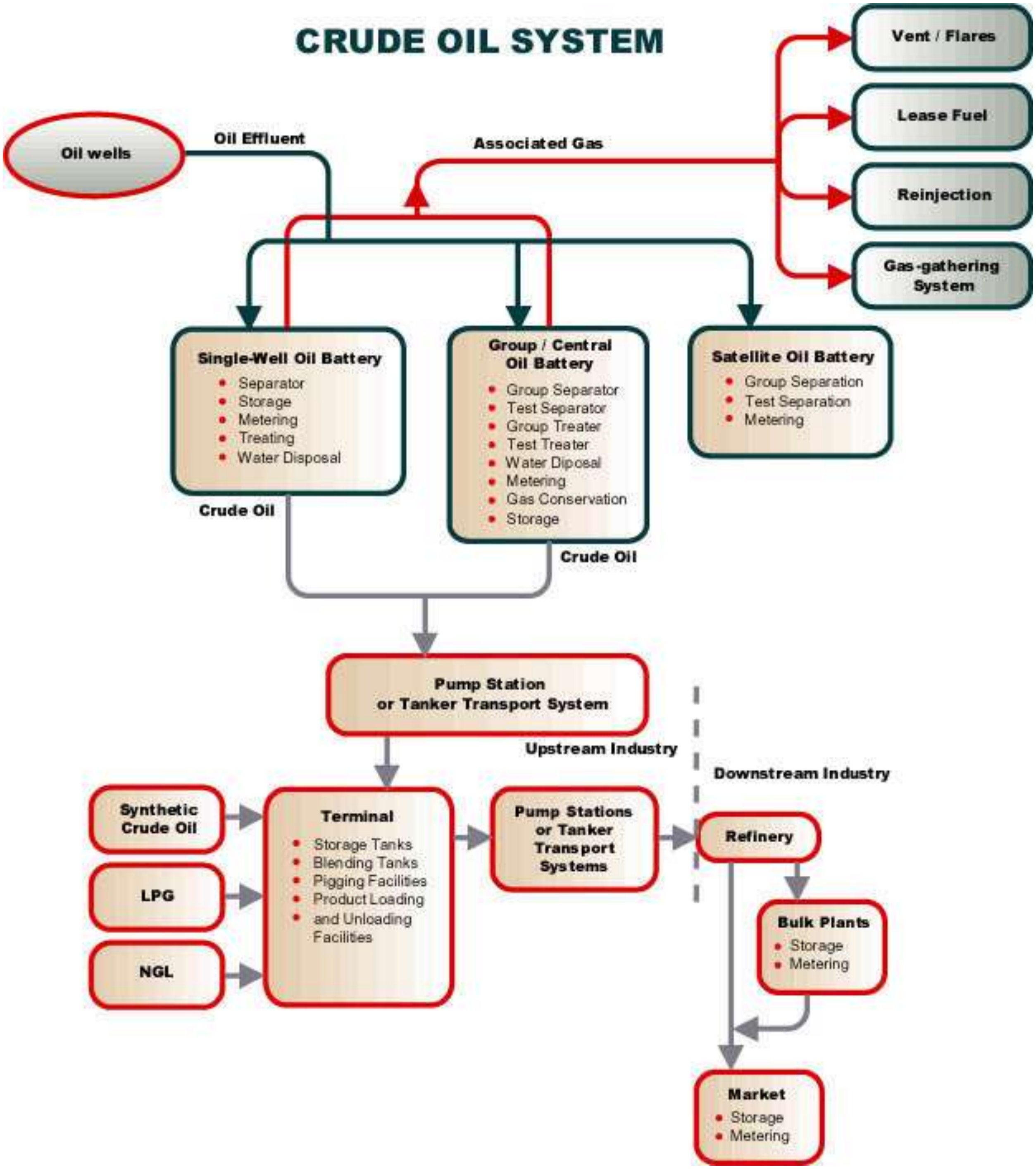

Figure 8 Example of a crude oil system

Questions:

a) In the year 2009, it was estimated that South Africa has a crude oil pipeline system of 6500 m3 in length. In the year 2009 three wells were drilled which produced a total of 3000m3, furthermore in the same period 1000m3 of oil well was serviced and a total of 3000m3 of the oil was refined.

   i. Estimate the CH4 emission associated with well drilling activities for the period

   ii. Estimate the CH4 emission associated with well servicing activities

   iii. Estimate the CH4 emissions associated with oil refining activities

b) In the year 2009, Engen Oil Company produced 65000 m3 of oil was and distributed it through different modes of transportation; 60% of the total was transported through pipelines; 20% was transported through tanker trucks and the remaining 20% through tanker ships.

   i. Calculate the GHG emissions associated with the transportation of oil using the three different modes of transportation

c) South Africa has a natural gas distribution company that has a pipeline of 10000 km long, 4000 km of the pipeline is made of protected steel mains and 6000km of the pipeline is made of plastic service pipeline. The natural gas delivered has an annual average methane content of 96.5% and the average leak rate is approximately 0.479 kg/h. For the year 2009, 9000m3 of natural gas was produced, 60% was stored on site and the remaining 40% was distributed to various sectors. 20% of the natural gas stored on site was processed.

   i. Calculate the fugitive emissions associated with the production of Natural gas

   ii. Estimate the fugitive emissions associated the natural gas processing

iii. Calculate the fugitive emissions associated with the distribution of the natural gas (40% of the natural gas produced)

iv. Calculate the fugitive emissions associated with the storage of the natural gas in tanks (60% of the natural gas produced).

v. Between a large and small facility which are the major contributors of fugitive emissions on both oil and natural gas systems.

Annexure A

Calorific Values for Fuels

A net Calorific value refers to the amount of heat liberated by the complete combustion, under specified conditions, of unit volume of a gas, the water produced by the combustion of the gas being assumed to remain as a vapour, the other products of combustion being referred to the standardized test conditions as applied in different countries. Hence the net calorific value is the gross calorific value less the latent heat of evaporation of the water that formed during combustion of the fuel. The table below gives a summary of the net calorific value for different fuels.

Table 4 Net Calorific Values for Fuels

Types of Fuel	Net Calorific Value for Fuels (TJ/L)
Petrol	0.0000342
Diesel	0.0000381
Jet Fuel	0.0000343
Paraffin	0.000037
Fuel Oil	0.0000416
Bitumen	0.0000402
LPG	0.0000267
Natural Gas	1

GWP Units, factors and abbreviations

Multiplication factor	Abbreviation	Prefix	Symbol
1 000 000 000 000 000	1015	Peta	P
1 000 000 000 000	1012	Tera	T
1 000 000 000	109	Giga	G
1 000 000	106	Mega	M
1 000	103	Kilo	k
100	102	Hector	h
0,1	10-1	Deci	d

0,01	10-2	Centi	c
0,001	10-3	Milli	m
0,000, 001	10-6	Micro	µ

Unit	Equivalency
1 tonne (t)	1 Megagram (Mg)
1 Kilotonne	1 Gigagram (Gg)
1 Megatonne	1 Teragram (Tg)

Table 5 Global Warming Potential of greenhouse gas gases (Source: FCCC/CP/2002/8, p.15).

Greenhouse gas	Chemical formula	1995 IPCC GWP
Carbon dioxide	CO_2	1
Methane	CH_4	23
Nitrous oxide	N_2O	296
Hydrofluorocarbons (HFCs)		
HFC-23	CHF_3	11 700
HFC-32	CH_2F_2	650
HFC-41	CH_2F	150
HFC-43	$C_5H_2F_{10}$	300
Perfluorocarbons (PFCs)		
Perfluoromethane	CF_4	6 500
Perfluoroethane	C_2F_6	9 200
Perfluoropropane	C_3F_8	7 000
Perfluorobutane	C_4F_{10}	7 000
Perfluorocyclobutane	$c\text{-}C_4F_8$	8 700
Perfluoropentane	C_5F_{12}	7 500

Greenhouse gas	Chemical formula	1995 IPCC GWP
Perfluorohexane	**C_6F_{14}**	**7 400**
Sulphur hexafluoride		
Sulphur hexafluoride	**SF_6**	**23 900**