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Enabling Activities for Preparation of Syria's Initial National Communication to UNFCCC

Green House Gases (GHG) Inventory for Energy Sector

July 2009

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Ministry of State for Environment Affairs (MSEA),in collaboration with United Nation Development Programm (UNDP) in Syria, and Global Environmental Facility (GEF).

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Greenhouse Gas (GHG) Inventory for Energy Sector in Syria

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This report has been approved unanimously by the technical committee, during the Technical Workshop which took place on 23.7.2009, in the Resort of Mount Hermon, Qunitra.

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Executive Summary

1. Introduction:

According to the International Energy Agency (IEA), the recent world energy consumption was doubled comparing to its consumption during the seventeenths of the last century (resulting that the CO_2 emissions grew by 55%) and expected to doubled again by the year of 2020. This accelerated energy consumption and the related expected climate change make a big challenge for the world, by mean of how we can build a harmonization between satisfaction of the development of energy demand and achieving the sustainability by protecting the environment and reducing the Greenhouse Gases GHG emissions.

This fact imposes that any adopted policy for energy supply must be complied with three indicators the economic, the social, and the environmental.

GHG emissions estimation in energy sector requires for an inventory of emissions source and sinks and calculation for GHG emissions by fuel types and consumption sectors, this estimation is the first step for evaluate the environmental damage impact and suggest the suitable steps and procedure to face this impacts and reduce the damage. Thus, the sustainable solution may change the supply system structure by implementing a new instrument and regarding to fuel types and adopted technologies to achieve the aim of GHG emissions reduction.

This study includes an inventory for GHG emissions that are caused by fuel combustion in energy sector for the period between 1994 and 2005. The study adopted the IPCC methodology for GHG emissions calculation from the sub-sectors activities and from the various fuel types as well.

2. Energy Sector in Syria

The energy sector is part of the economic activities being administrated by the office of deputy prime minister for economic affairs. The main contributors in the Syrian energy sector are ministry of oil, ministry for electricity, atomic energy commission (AECS) and the high committee for energy and resources.

The Ministry of Oil & Mineral Resources is responsible for planning and implementation of development programs related to all fossil fuels like oil and gas and all mineral resources like phosphate, marble, and granite etc.

The Ministry of Electricity is responsible for investment, tariffs, planning, and policy formulation in the power sector.

The Ministry for Irrigation is responsible for water resource management and hydro power plants. The Public Establishment of Euphrates is responsible for the three main hydropower plants of Thawra, Baath and Tishreen, all located on the Euphrates River.

3. Final Energy Consumption

The Syrian energy sector is characterized by fossil fuel dominance, absence of renewable role and exploitation of the hydro resources, low energy efficiency and very low contribution of clean fuel technologies. The total final energy consumption in 2005 amounted to 15.25 MTOE [*Ref.5*]. The transportation sector (Trans) shows the highest share with 27%, followed by house hold (HH) with 23% and industry with 19%. The consumption shares of agriculture (Ag), construction (Cons), and mining (Min) and service (Serv) amounted to 11%, 7%, 7%, 6% respectively. The final consumption by fuel type is

distributed to 72 % for the oil derivatives, 10 % natural gas, 3 % traditional fuel, and 15% for electricity.

4. Electricity Sector:

The gross electricity generation grew from about 12.2 TWh in 1991 to about 34.8 TWh 2005 registering an annual average rate of about 7.8% according to the official data of ministry of electricity. The peak load demand grew by 4.12% (comparing with an average growth of 7.8 % during the period between 2000 and 2005) from 5770 MW in 2004 to 6008 MW in 2005. The per-capita share from the electricity generation jumped from 1545 kWh in 2000 to 2000 kWh in 2005.

The distribution of produced generation by fuel types was 48% for heavy fuel oil, 45% for natural gas, and 7% for hydro.

The total installed capacity in 2005 amounted to 7160 MW distributed to 24% for Hydropower and 76% for fossil fired power plants *[Technical Statistical Report, Ministry of Electricity, Damascus, 2006]*. The sectoral electricity consumption referees to that the house hold sector had the highest share with 47%, followed by industry (33%), service sector and agriculture with 14 % and 6% respectively.

5. Primary Energy resources

This level considers all energy carriers allocated for internal consumption consisting of oil derivatives, natural gas, renewables and traditional fuel. These carriers are either consumed directly by the end consumers or used partially in the power sector for electricity generation where the new energy carrier "electricity" appears. The distribution of [1]secondary energy by fuel types between the year of 2003 and 2005 is apparent that the Syrian primary energy demand achieved an average annual growth rate of 5.3%, this demand was covered mainly by diesel followed by fuel oil and natural gas that are mainly consumed in the electricity generation, in addition to a small contribution of hydro energy.

6. GHG inventory during the period between 1994 and 2005

An inventory study for sources and sinks of GHG emissions (CO_2, CH_4 and N_2O) relating to the fuel combustion in energy uses (stationary combustions and mobile sources) in the country was made up using the IPCC methodology. The ghg emissions were distributed by main economic sectors, which include: energy industries, manufacturing and construction, transport, and others sectors (household sector, agriculture, and service). GHG emissions from fuel combustion doubled by 1.66 times jumping from about 38.24 (of which 89% is CO_2) to 58.35 Mton (95% is from CO_2 emissions) of Co_2eq[2] in between 1994 and 2005 which achieving an annual growth of about 3.9 % which is less than growth rate that achieved by the secondary energy consumption. The secondary consumption energy doubled by 1.65 times, reaching to 19.39 Mtoe comparing with 11.7 Mtoe in 1994.

The average ghg per toe reduced during this periods from 3.3 to 2.98 ton CO_2eq /toe.

The development of GHG emissions distribution in the energy sector between 1994 and 2005, is apparent that the electricity generation keep on his rank as the biggest contributor in GHG emissions with 29% in 1994 jumped to 39% in 2005, followed by transport sector (17% to 22%), and house hold sector (it's share reduced from 17% to 13%). The shares of Manufacturing and construction and mining industry declined during the inventory period from 13%, 14% respectively to 8% for each.

[1] Usually a secondary energy level is defined by conversing oil, NG to oil derivatives.
[2] Quantities of the greenhouse gases are expressed in terms of CO2-equivalence (CO_2-e), where the emission amount of each gas is converted to CO_2-e according to its Global Warming Potential (GWP) that are equals to 21 for CH_4 and 310 for N_2O [11].

1. Introduction

This analysis deals with the compilation, calculation and evaluation of greenhouse gases (GHG) inventory of the energy sector in the Syrian Arab Republic according to the rules and guidelines issued by the International Panel of Climate Change (IPCC). The outcomes of this analysis will be included in the GHG inventory which will be included in the Initial National Communication (INC) of the Syrian Arab Republic to be submitted to the Conference of the Parties COP.

The procedure applied to calculate GHG emissions refers to the methodology developed by IPCC-NGGIP laid down in 1996 Guidelines or 2006 Guidelines (Vol 1 & Vol 2). The calculation considers 1994 as base year and cover the following period up to 2006.

The GHG sources comprise the combustion processes of energy sector, non-combustion processes of industrial processes, agriculture, waste management, forestry and others.

The present energy conversion technologies rely mainly upon combustion of fossil fuels. During combustion the carbon and hydrogen of the fossil fuels are converted mainly into carbon dioxide (CO_2) and water (H_2O), releasing the chemical energy in the fuel as heat. This heat is generally either used directly or used often to generate electricity or motive energy. Thus, this sector includes two main combustion-related activities, namely Stationary combustion and Transportation.

Stationary combustion is responsible for about 70% of the greenhouse gas emissions from the energy sector[3]. Practically stationary combustion comprises all energy consuming activity except transportation sector (in addition to petrochemical and fertilizer industry). About half of the emissions of the stationary combustion are associated to combustion in energy industries mainly power plants and refineries. Mobile combustion (road and other traffic) causes about 25% of the emissions in the energy sector [*IPCC Guidelines for National Greenhouse Gas Inventories, 2006*]. Hence, the activities responsible for GHG emission in the energy sector can be classified according to following source categories:

- Energy industries comprising extractions, production and conversion of energy including electricity generation and petroleum refineries;
- Manufacturing industries and construction: include activities like iron and steel production, chemical manufacturing, pulp, paper, food industries, beverages and tobacco, et
- Other sectors comprising commercial and residential,
- Transportation.

This analysis will focus on the calculation of GHG emissions of the energy sector covering the period 1994-2006. The calculation is based on accounting the GHG sources at primary, secondary and final level of energy and according to the type of consumed fuel [*IPCC Guideline 2006*]. The sources of data used in this analysis are official national energy balances and data related to Syrian energy sector available by Ministry of Oil and Ministry of Electricity [*Final Energy Balance for the year 2005 Technical Statistical Report 2006.*], central bureau for statistics [*Statistical Abstract 2007*], national committee for energy studies [*analyzing the evolution of final energy demand in Syria for 2005 2030*], scientific reports issued by the atomic energy commission of Syria [*see ref. 6, 7, 8*] and further references and reports issued by international institutions [*see ref. 9, 10, 11, 12*].

[3] 2006 IPCC Guidelines for National Greenhouse Inventories.

2. Overview of Syrian Energy Sector

The energy sector is part of the economic activities being administrated by the office of deputy prime minister for economic affairs. The main contributors in the Syrian energy sector are ministry of oil, ministry for electricity, atomic energy commission (AECS) and the high committee for energy and resources (Figure 1).

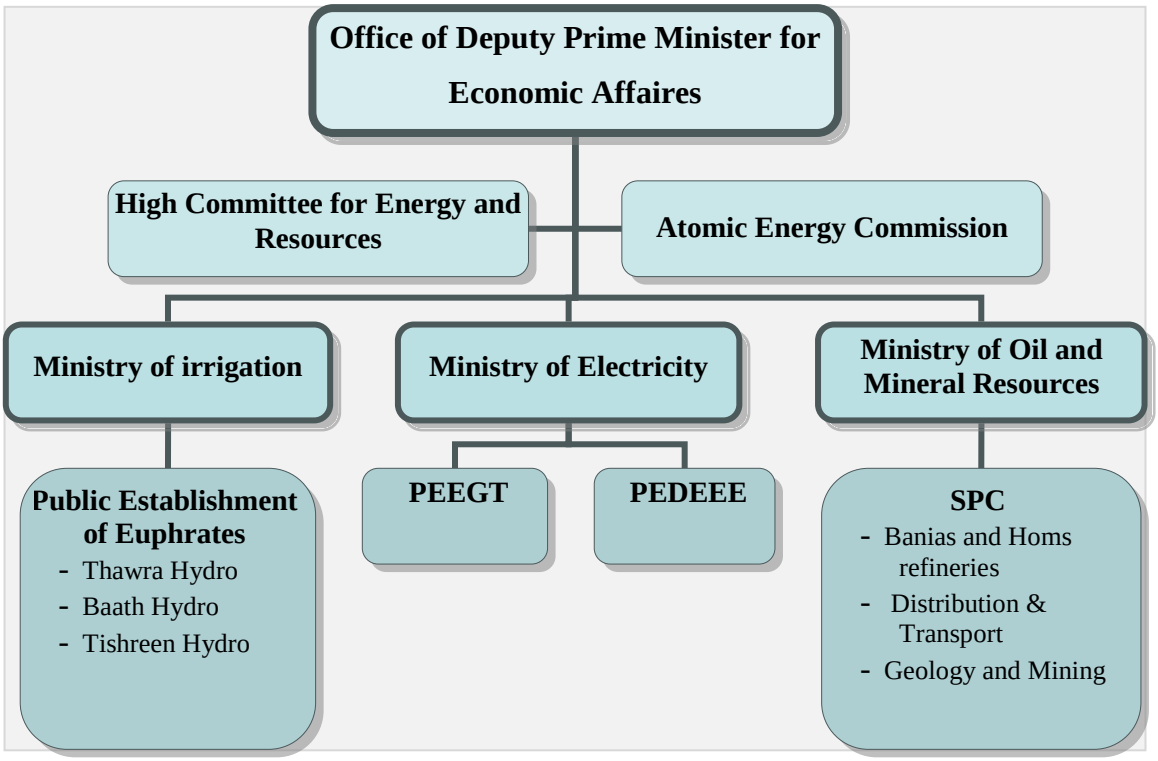

Figure 1. Institutional Organization of Energy Sectors in Syria.

The Ministry of Oil & Mineral Resources is responsible for planning and implementation of development programs related to all fossil fuels like oil and gas and all mineral resources like phosphate, marble, and granite etc. Syrian Petroleum Company (SPC) is responsible for production, transport and distribution of oil and gas. Oil products are extracted in two refineries located at Banias and Homs. The current total daily production of both refineries amounts to about 242 thousand barrel.

The Ministry of Electricity is responsible for investment, tariffs, planning, and policy formulation in the power sector. The power system is managed by the Public Establishment for Electricity (PEE), which is separated into PEEGT (Generation and Transmission), and PEDEEE (Distribution and Exploitation of Electrical Energy). PEEGT is responsible for transmission including the 400-kV and 230-kV levels, while PEDEEE supervises the 66-kV, 20-kV, and 0.4-kV levels. As a result, PEEGT has 230-kV customers, that is, large industries and irrigation. All other customers are under the responsibility of PEDEEE. Recently a new national energy research centre (NERC) has been established at the ministry for electricity. It should deal with energy survey, energy conservation and supporting the development of renewables.

The Ministry for Irrigation is responsible for water resource management and hydro power plants. The Public Establishment of Euphrates is responsible for the three main hydropower plants of Thawra, Baath and Tishreen, all located on the Euphrates River.

2.1. Main Features of National Energy Policies

The overall target of Syrian energy policy aims at ensuring supply security by providing energy services to all segments of society at cost effective and affordable prices appropriate to Syrian economic conditions. To accomplish this goal Syrian energy policy is faced with three challenges, namely expanding the gas market, sustaining the oil production and developing country's power capacity [4]. To manage these challenges following general implementation measures are considered:

- Reducing the technical losses and illegal consumption,
- Improvement of energy efficiency,
- Encouraging the use of renewables,
- Establishing costing oriented price policy,
- Saving oil and substituting it by gas,
- Attracting foreign investment in oil, gas and power sectors.

A key challenge for the Syrian natural gas (NG) industry is logistical, with natural gas reserves located mainly in north-eastern Syria, while population is centred in western and southern Syria. SPC currently is working to increase Syria's gas production through several projects aiming at expanding and developing the NG network.

The electricity production policy aims at substituting oil by natural gas in the existing power plants and building new natural gas fired power plants (at present 90% of generated electricity is thermal origin, from which 44% is gas origin). The Government is in process to relax state monopoly over power sector. There are many efforts to reinforce the transmission and distribution of networks, and to improve the quality of customer services.

2.2. Current Energy Sources and Use

According to international statistics the Syrian energy system is characterized by low per capita energy consumption. Table 1 shows selected indicators of energy sector of Syria compared with the world average and other regions for the year 2005. The primary energy consumption per capita in Syria was about 1.0 toe (ton of oil equivalent) compared to 1.77 toe of the world average and 1.4 toe of the Arab world [*see ref. 10,12 13*]. Annual Final electricity consumption per capita arrived about 1367 kWh compared to 2881 kWh and 2516 kWh in the Arab world and worldwide respectively. The CO_2 emission per capita was at the same level of world average.

Table 1. Selected Energy Indicators for the year 2005

	Primary Energy (toe/capita)	**Final Electricity Consumption (kWh/capita)**	**CO_2-Emission (tCO_2/toe)**	**CO_2-Emission (tCO_2/capita)**
Syria	0.99	1367	2.59	**2.57**
Arab World	1.4	2881	2.47	**6.51**
Asia	0.63	617	1.94	**1.22**
Africa	0.67	547	1.39	**0.93**
World	1.77	2516	2.37	**2.57**

[4] A. Hainoun, M. K. Seif-Eldin, A. Alkhatib, S. Almoustafa, 2004. Analysis of Energy and Electricity Demand Projection and Identifying the Optimal Expansion Strategy of Electric Generation System in Syria (Covering the period 1999-2030), AECS-NE/FRSR 316

2.3. Final Energy Consumption

The Syrian energy sector is characterized by fossil fuel dominance, absence of renewable role and exploitation of the hydro resources, low energy efficiency and very low contribution of clean fuel technologies. Figure 2 shows the distribution of final energy demand (including and electricity) by sector of consumption [*ref.6*].

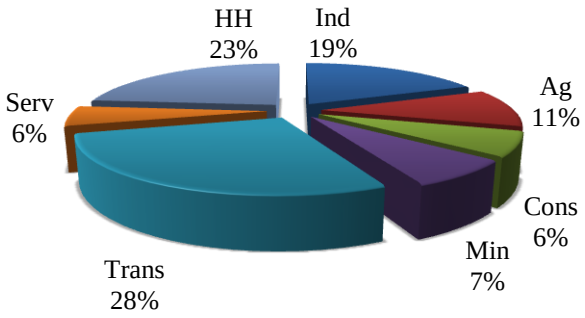

Figure 2. Final Energy Consumption by Sector for the Year 2005.

The total final energy consumption amounted to 15.25 MTOE [*ref.5*]. The transportation sector (Trans) shows the highest share with 27%, followed by house hold (HH) with 23% and industry with 19%. The consumption shares of agriculture (Ag), construction (Cons), and mining (Min) and service (Serv) amounted to 11%, 7%, 7%, 6% respectively. The final consumption by fuel type is distributed to 72 % for the oil derivatives, 10 % natural gas, 3 % traditional fuel, and 15% for electricity.

2.4. Electricity Generation

The socio-economic and technological development in the country registered an continuous increase in electricity demand. Thus, the gross electricity generation grew from about 25217 GWh in 2000 to about 38642 GWh 2007 registering an annual average rate of about 6.3% during the period 2000-2007 (Figure 3).

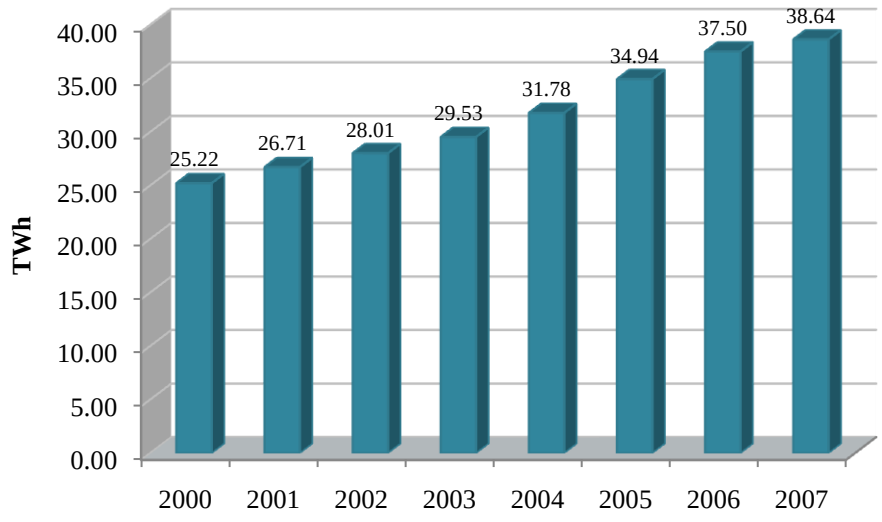

Figure 3. Development of Gross Electricity Generation 2000-2007 (TWh)

During the same period the peak load demand grew from 3878 MW to 7000 MW showing an average annual growth rate of about 8.8% (Figure 4). To cover this high peak load increase the installed capacity was expanded with adequate capacity from 6070 MW to 6480 MW during the period 2000-2005 [*ref.3,13*]. However, due to technical and structural difficulties the available installed capacity during the years 2006 and 2007 was not adequate to cover the peak demand resulting in deficit of about -750 MW in the Syrian power generation. This deficit was partially compensated through electricity import from neighbouring countries.

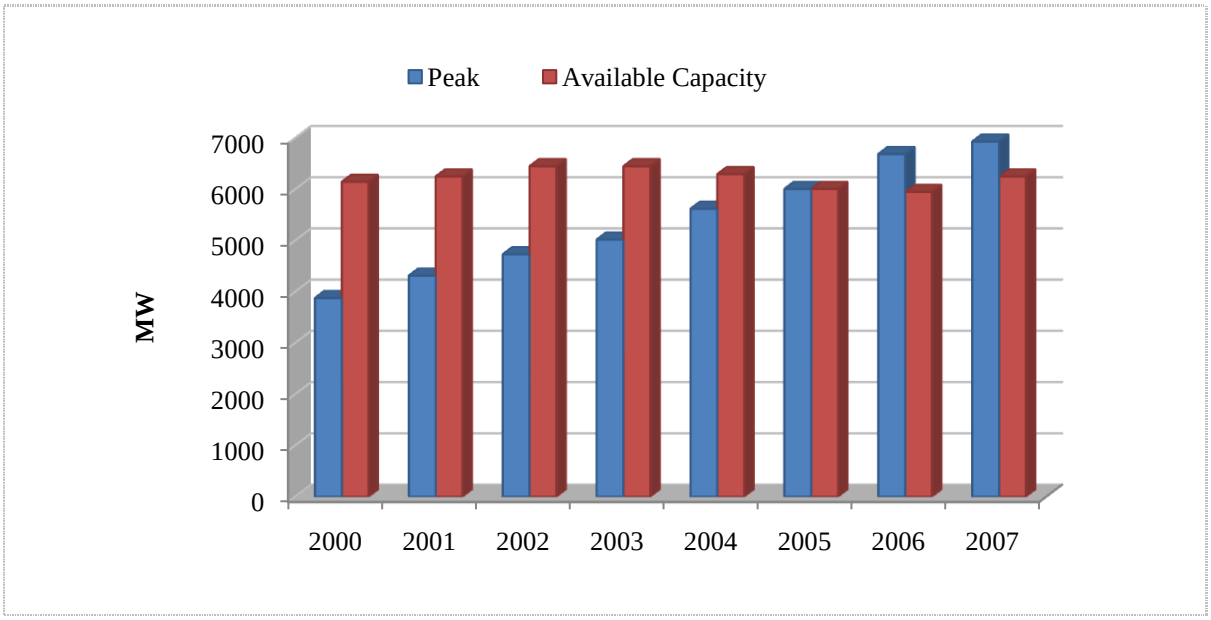

Figure 4. Development Peak Load and Available Installed Capacity 2000-2007

Figure 5 presents the structure of the Syrian electricity generation by generation type in the year 2005. The total installed capacity amounted to 7160 MW whereas the available installed capacity was 6008 MW distributed to 24% for Hydropower and 76% for fossil fired power plants [*ref.3*]. The total gross electricity generation in 2005 amounted to 34.9 TWh, whereas the total final consumption arrived to 26.81 TWh making only about 76.82 % of the total electricity generation. The sectoral electricity consumption is shown in figure 6. The house hold sector had the highest share with 47%, followed by industry (31%), service sector and agriculture with 14 % and 6% respectively, while the remaining 3% went to mining, construction and pipeline transportation.

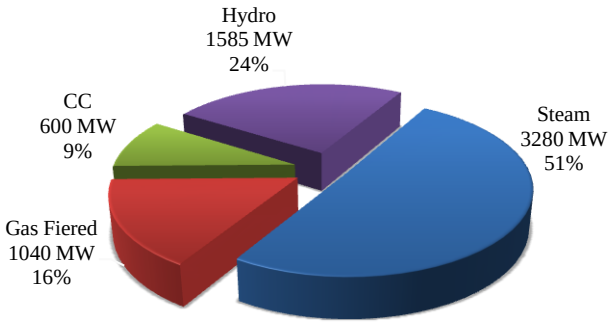

Figure 5. Total Installed Capacity by Generation Type for 2005

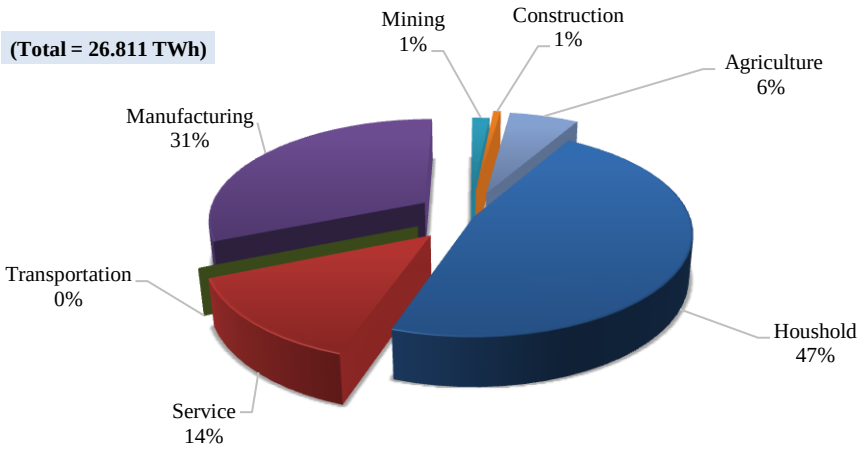

Figure 6. Distribution of Electricity by Consumption Sector for 2005.

2.5. Primary Energy Supply and Energy Sources

This level considers all energy carriers allocated for internal consumption consisting of oil derivatives, natural gas, renewables and traditional fuel. These carriers are either consumed directly by the end consumers or used partially in the power sector for electricity generation where the new energy carrier "electricity" appears. Figure 7 shows that the Syrian primary energy demand increased from 8.3 Mtoe to 22.9 Mtoe during the period 2003-2007 registering an average annual growth rate of 5.7%. The development structure indicates also that Syrian primary energy supply based mainly on oil and natural gas with small share of hydro energy.

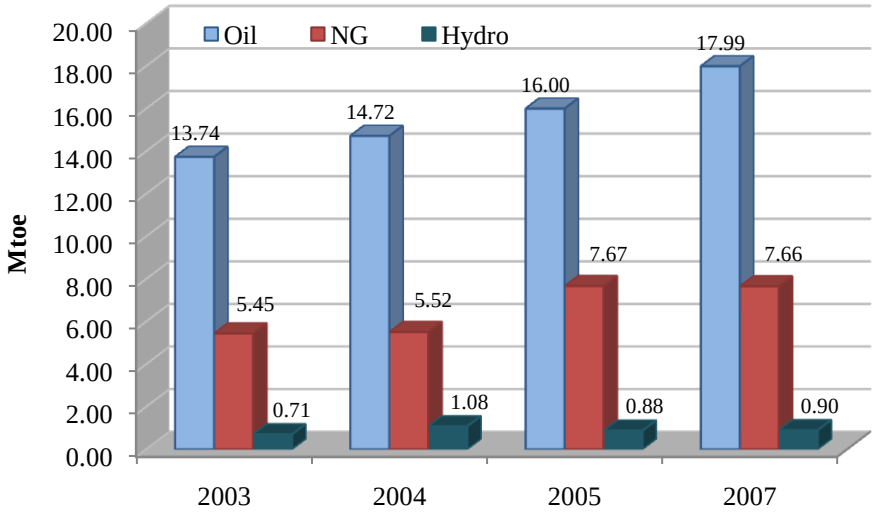

Figure 7. Development of Syrian Primary Energy Supply

The distribution of [5]secondary energy by fuel types is presented in Table 2. It is apparent that diesel occupied the main share followed by fuel oil and natural gas that are mainly consumed in the electricity generation. The share of hydro energy in the total primary supply decreased from 3% to almost 2.4%.

[5] Usually a secondary energy level is defined by conversing oil, NG to oil derivatives.

Table 2. Distribution of primary energy by fuel type for the period 2003-2005

	2003	2004	2005
Diesel	32.3%	32.2%	33.0%
Gasoline	6.9%	6.8%	6.9%
Fuel Oil	23.2%	25.3%	24.7%
LPNG	4.4%	4.4%	4.5%
NG	23.1%	22.1%	21.6%
Asphalt	3.7%	3.6%	3.6%
Heavy products	2.3%	2.2%	2.2%
Hydro power	3.1%	2.5%	2.4%
Traditional	1.0%	1.0%	1.0%
Total Annual (Mtoe)	18.13	19.00	19.41

The distribution of primary energy by type of application is presented by Figure 8. Thus, the secondary energy has been devoted to cover thermal, motive and non-energy application in addition to electricity generation. During the study period the share of thermal application in the total primary supply amounted to around 34.5%, for electricity generation 35%, for motive energy between 23% and for non-energy application (including Asphalt and heavy products like coke) about 7.5%.

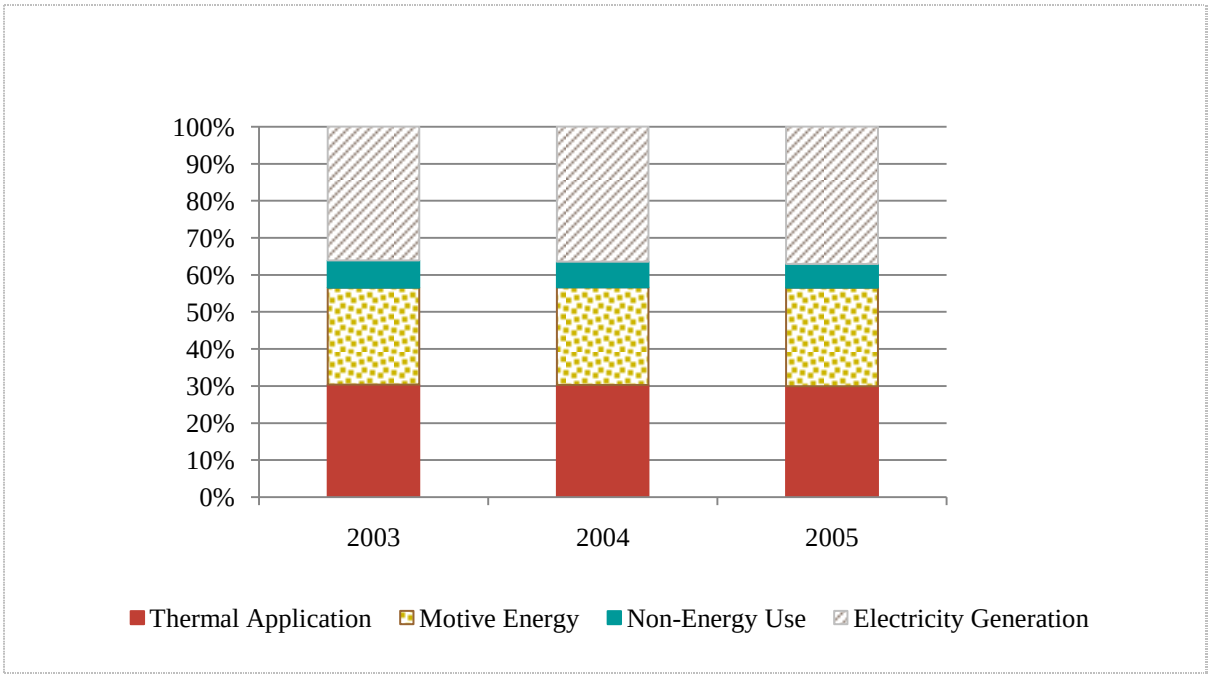

Figure 8. Distribution of primary energy by type of consumption.

3. Calculation of GHG Emissions for 2005

Determining the full implications of the greenhouse gas emissions of an energy system, using the IPCC Bottom-up methodology, requires examination of every phase of the entire energy chain, from the supply side of the system (i.e., resources extraction, refineries, electric power plants) to the demand side (i.e., industrial plants, residential and commercial units). A demonstration for the used methodology in the calculation can be summarized in the following:

3.1. Estimation Steps

Following the UNFCCC methodology, the estimation process for CO_2 emissions can be divided into six steps which are summarized as following:

3.1.1. Description of National Energy Consumption

This includes detailed specification of recent national energy consumption profile by fuel type and final consumption. In case of Syria the fuel types are limited to oil derivatives and natural gas as presented above. The sectors of consumption comprise electricity generation, oil extraction and refinery, industry and construction, agriculture, transportation, household and service. The data sources are:

- Syrian Annual Energy Balance 2005,
- Technical Statistical Report, Ministry of Electricity 2006.
- Gas Movement in the Country during 2005 Ministry of Oil and Minerals resources,
- IEA statistics, www.iea.org,
- Annual Statistical Reports (2004, 2005, 2006) for OAPEC, Kuwait, OAPEC, 2005-2008,
- Economic Arab Report, Arab Monitory Fund, 2007,
- Annual Statistical Reports of AUPTDE, 2007

3.1.2. Specification of Fuel Types Characteristics:

Including the heat content factor that is necessary for conversion of fuel data to an energy unit. In addition to the carbon content factor[6] for each fossil fuel type (product)

3.1.3. Calculation of Emission Factors

Emission factor must be calculated for each fuel type. It is strongly recommended to use the country specific emission factors. In this concern the following equation can be used:

$$\mathbf{EF = CC / CV * (44/12)}$$

Where,

EF = Emission factor (ton ghg / ton fuel)
CV = Heat content of fuel consumed (GJ /ton)
CC = Carbon content of fuel on a mass basis (%)
(44/12) = The ratio of the molecular weight of CO_2 to that of carbon

However IPCC Guideline emission factors were used, whenever the emission factor were not calculated.

[6]The carbon content of a fuel is an inherent chemical property (i.e. mass of carbon atoms relative to total mass of the fuel). The carbon content of crude oil is often measured in degrees using the API (American Petroleum Institute) gravity scale. Using an estimate of world average API gravity of 32.5 +/–2 degrees, the global average carbon composition of crude oil would be about 85 +/–1 per cent. (CGE GHG Inventory Handbool (NAI) Enery Sector – Fuel Combustion)

3.1.4. Subtraction of The Amount of Carbon Stored in Products:

(e.g. non-energy uses) like asphalt and bitumen for road construction, and some natural gas uses in fertilize industry.

The basic equation for estimating the amount of carbon stored in products is given below:

Total Carbon Stored (Gg C) =
Non-Energy Use (10^3 t)
x Conversion Factor (TJ/10^3 t)
x Emission Factor (t C/TJ)
x Fraction Carbon Stored
x 10^{-3}

3.1.5. Multiplication by an Oxidation Factor:

This is necessary to account for the small amount of un-oxidized carbon that is left in ash or soot.

When national oxidation factors are not available, the ultimate option is to use the IPCC default factors (0.99 for oil NG, oil and oil products)

3.1.6. CO_2 Emission:

In order to calculate CO_2 emissions using fuel consumption and emission factor data,

Emissions Fuel = Actual Fuel Consumption (GJ) • Emission Factor GHG Fuel (kg/GJ) * Fox (%)

Fox = Oxidation factor to account for fraction of carbon in fuel that remains as soot or ash

Table 3. Heat Contents and Carbon Emission Factors for Syrian Fuel Types

Fuel	Heat / Calorific Value (Gj/kg)	Carbon emission factor (kg/Gj)	IPCC default Values [11]
Syrian HF	0.0402	21.00	21.1
Diesel	0.04	19	20.2
Gasoline	0.04480	18	18.9
Jet kerosene	0.04459	18.5	19.5
Kerosene	0.04375	19	19.6
Crude oil	0.04187	21.50	20
Asphalt	0.04019	20	20.9
Coke	0.03475	28.20	27.5
Wood	0.00837	26.3	26
NG (Gj/CubM)	0.037679	18.5	17.2
LPG	0.0473086	15.85	15.3

While other GHG emissions are calculated using the following equations:

- CH_4 emissions:
  CH_4 emissions = fuel quantity * emission factor
- N_2O emissions:
  N_2O emissions = fuel quantity * emission factor

CH_4 and N_2O emissions factors are presented in Annex 3

3.2. Inventory Study for GHG Emissions from Energy Sector in 2005

The present energy conversion technologies rely mainly upon combustion of fossil fuels. During combustion the carbon and hydrogen of the fossil fuels are converted mainly into carbon dioxide (CO_2) and water (H_2O), releasing the chemical energy in the fuel as heat. This heat is generally either used directly or used often to generate electricity or motive energy. Thus, this sector includes two main combustion-related activities, namely stationary combustion and transportation.

Stationary Combustion

comprises practically all energy consuming activity except transportation making about 75% of GHG from the energy sector [*ref.1*] About half of the emissions of the stationary combustion are associated to combustion in energy industries mainly power plants and refineries. Hence, the activities responsible for GHG emission in the energy sector can be classified according to following source categories:

- Energy industries comprising extractions, production and conversion of energy including electricity generation and petroleum refineries;
- Manufacturing industries and construction: include activities like iron and steel production, chemical manufacturing, pulp, paper, food industries, beverages and tobacco, etc…
- Other sectors comprising commercial and residential,

Mobile combustion:

is limited to the transportation sector which contributes to about 25% of GHG emission in the energy sector.

There are two methods provided in the Revised 1996 IPCC Guidelines for estimating CO_2 from fuel combustion: the Reference Approach (RA) and the Sectoral Approach (SA). The Sectoral Approach methods provide more detailed results for those countries whose energy consumption data are collected at a detailed level. While Reference Approach provides only aggregate estimates of emissions by fuel type distinguishing between primary and secondary fuels, whereas the Sectoral Approach allocates these emissions by source category.

3.2.1. Calculating the CO2 Emissions Using Reference Approach (RA)

The Reference Approach estimates only CO_2 emissions from fuel combustion. It can be performed quickly provided that the basic energy balance sheet for a country is available.

The Reference Approach provides a potentially useful way of cross-checking emission estimates of CO_2 with the Sectoral Approach and thus helps identify inconsistencies or mistakes.

Table 4 presents the methodological approach applied for calculating the annual GHG emission of the energy sector in 2005. Using the Sectoral Approach consumption and the specific emission factors of Syrian fuels the GHG emission is calculated according to IPCC guidelines where the resulting emissions are classified by fuel types.

Table 4. CO_2 Emission According to IPCC Reference Approach in 2005

			A	B	C	D	E	F
			Production	Imports	Exports	International Bunkers	Stock Change	Apparent Consumption
Fuel Type			NG(10^3cubm) Kton (others)					F=(A+B -C-D-E)
Liquid Fossil	Primary Fuels	Crude Oil						
		Orimulsion						
		Natural Gas Liquids						
	Secondary Fuels	Gasoline	1278.08	1370.08	184.52		1253.22	1210.42
		Jet Kerosene	150.00	0.00	56.00		6.52	87.48
		Other Kerosene	119.32	0.00	72.12		-19.65	66.85
		Shale Oil						0.00
		Gas / Diesel Oil	3676.81	3420.00	8.93		28.65	6563.24
		Residual Fuel Oil	4358.00	1386.97	3.62		400.28	5341.07
		LPG	554.64	211.00	7.60		0.00	758.04
		Ethane						0.00
		Naphtha						0.00
		Bitumen						0.00
		Lubricants	0.00	1.38	0.00		-20936.01	20937.38
		Petroleum Coke	172.18	0.00	413.09		-382.24	141.33
		Refinery Feedstocks	148.00	0.00	0.00		0.00	148.00
		Other Oil (heavy products)	608.00	105.00	0.00	0.00	0.00	713.00
Liquid Fossil Totals			11065.04	6494.42	745.87	0.00	19649.23	36462.81
Solid Fossil	Primary Fuels	Anthracite						
		Coking Coal						
		Other Bit. Coal						
		Sub-bit. Coal						
		Lignite						
		Oil Shale						
		Peat						
	Secondary Fuels	BKB & Patent Fuel						
		Coke Oven/Gas Coke						
Solid Fuel Totals								
Gaseous Fossil	Natural Gas (Dry)	Gaseous Fossil	8052769.00					8052769.00
Total								
Biomass total								
		Solid						
		Liquid						
		Gas						

Continue Table 4

			G	H	I	J	K
			Conversion Factor	Apparent Consumption	Carbon Emission factor	Carbon Content	Carbon Content
Fuel Type			(Tj/Unit)	(TJ)	(t C/TJ)	(t C)	(Gg C)
				H=(FxG)		J=(HxI)	K=(J/1000)
Liquid Fossil	Primary Fuels	Crude Oil					
		Orimulsion					
		Natural Gas Liquids					
	Secondary Fuels	Gasoline	44.80	54,222.68	17.851	968,335.20	968.34
		Jet Kerosene	44.59	3,900.41	17.941	69,982.40	69.98
		Other Kerosene	43.75	2,924.83	18.29	53,482.66	53.48
		Shale Oil		0.00		0.00	0.00
		Gas / Diesel Oil	42.70	280,271.92	18.731	5,250,588.00	5,250.59
		Residual Fuel Oil	40.19	214,664.95	20.901	4,486,500.48	4,486.50
		LPG	47.31	35,861.94	15.851	568,532.25	568.53
		Ethane					
		Naphtha					
		Bitumen					
		Lubricants					
		Petroleum Coke	34.75	4,911.01	28.2	138,490.49	138.49
		Refinery Feedstocks (ref-gas)	47.31	7,001.67	15.851	111,000.00	111.00
		Other Oil (heavy products)	40.191	28,656.44	19.91	570,400.00	570.40
Liquid Fossil Totals				632,415.85		12,217,311.49	12,217.31
Solid Fossil	Primary Fuels	Anthracite					
		Coking Coal					
		Other Bit. Coal					
		Sub-bit. Coal					
		Lignite					
		Oil Shale					
		Peat					
	Secondary Fuels	BKB & Patent Fuel					
		Coke Oven/Gas Coke					
Solid Fuel Totals							
Gaseous Fossil	Natural Gas (Dry)	Gaseous Fossil	0.0376794	303,423.50	18.57779052	5,636,938.30	5,636.94
Total				935,839.35		17,854,249.79	17,854.25
Biomass total							
		Solid Biomass					
		Liquid Biomass					
		Gas Biomass					

Continue Table 4

			L	M	N	O	P
			Carbon Stored	Net Carbon Emissions	Fraction of carbon Oxidised	Actual Carbon Emissions	Actual CO_2 Emissions
Fuel Type			(Gg C)	(Gg C)		(Gg C)	(Gg CO2)
				M=(K-L)		O=(MxN)	P=(Ox[44/12])
Liquid Fossil	Primary Fuels	Crude Oil					
		Orimulsion					
		Natural Gas Liquids					
	Secondary Fuels	Gasoline	0	968.34	0.99	958.65	3,515.06
		Jet Kerosene	0	69.98	0.99	69.28	254.04
		Other Kerosene	0	53.48	0.99	52.95	194.14
		Shale Oil	0	0.00	0.99	0.00	0.00
		Gas / Diesel Oil	0.00	5,250.59	0.99	5,198.08	19,059.63
		Residual Fuel Oil		4,486.50	0.99	4,441.64	16,286.00
		LPG	0.00	568.53	0.99	562.85	2,063.77
		Ethane	0.00	5,250.59	0.99	5,198.08	19,059.63
		Naphtha		4,486.50	0.99	4,441.64	16,286.00
		Bitumen	0.00	568.53	0.99	562.85	2,063.77
		Lubricants	0.00	0.00	0.99	0.00	0.00
		Petroleum Coke	13.84904913	124.64	0.98	122.15	447.88
		Refinery Feedstocks (ref-gas)		111.00	0.99	109.89	402.93
		Other Oil (heavy products)	570.4	0.00	0.98	0.00	0.00
Liquid Fossil Totals			584.25	11,633.06	16.81	11,515.49	42,223.45
Solid Fossil	Primary Fuels	Anthracite					
		Coking Coal					
		Other Bit. Coal					
		Sub-bit. Coal					
		Lignite					
		Oil Shale					
		Peat					
	Secondary Fuels	BKB & Patent Fuel					
		Coke Oven/Gas Coke					
Solid Fuel Totals							
Gaseous Fossil	Natural Gas (Dry)	Gaseous Fossil	1,955.17	3,681.77	0.99	3,644.95	13,364.82
Total			2,539.42	15,314.83	0.99	15,160.44	55,588.27
Biomass total							
		Solid Biomass					
		Liquid Biomass					
		Gas Biomass					

Figure 9 summarizes the results of reference approach , and according to the these results CO_2 emissions mounted about 55.58 Mton in 2005, distributed by 34%, 29%, 24% from diesel, fuel oil, and natural gas respectively, and by 6%, 4% for gasoline and LPG while the contribution of petroleum coke , refinery gas, and kerosene didn't exceed 1% for each one.

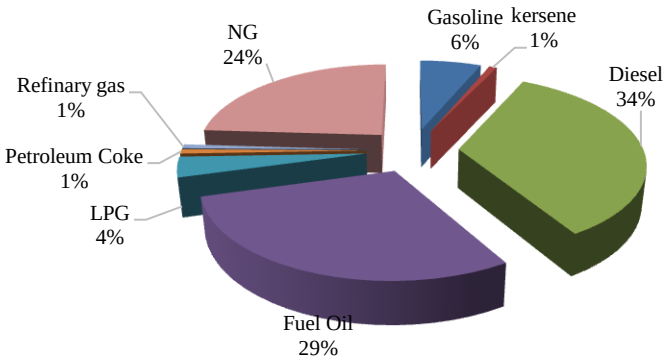

Figure 9. CO2 Emission from Energy Sector Using RA by Fuel Types 2005

3.2.2. Calculating the CO_2 Emissions using sectoral Approach

The sectoral approach assesses CO_2 and non-CO_2 emissions due to combustion of energy by estimating emissions split throughout the economy. Sectors to be considered are:

- Energy sector (public electricity and mining industry)
- Manufacturing Industries and Construction
- Transport (including Pipeline Transport)
- Other Sectors (Commercial/Institutional, Residential, griculture/Forestry/Fisheries)

The sectoral approach provides a valuable way for cross-checking emission estimates of CO_2, with the reference approach.

based on sectoral approach methodology the total GHG emissions mounted about 58.3 Mton of CO_2eq[7], off which more than 95% belongs to CO_2 emission while the remaining comes from CH_4 (4.4%) and N_2O (0.6%)

⇒ **CO_2 emissions**

Table 5 presents the methodological approach applied for calculating the annual GHG emission of the energy sector in 2005. Using the Sectoral Approach consumption and the specific emission factors of Syrian fuels the GHG emission is calculated according to IPCC guidelines where the resulting emissions are classified by source of origin. Figure 10 presents the distribution of emission shares by energy sub-sector. Thus, the CO_2 emission amounted to about 55.5 million ton.

[7] The CH4, N2o emissions are expressed using the equivalent GWP (Global Worming Potential) values of 21 for CH4 and 310 for N2O [11].

The relative distribution indicates that this amount results mainly from the energy industry with about 48% (40% for electricity generation and 8% for refineries), followed by transportation sector with 22%, house hold sector with 12%, industry and constructing with 8%, agriculture 8% and service sector 2%.

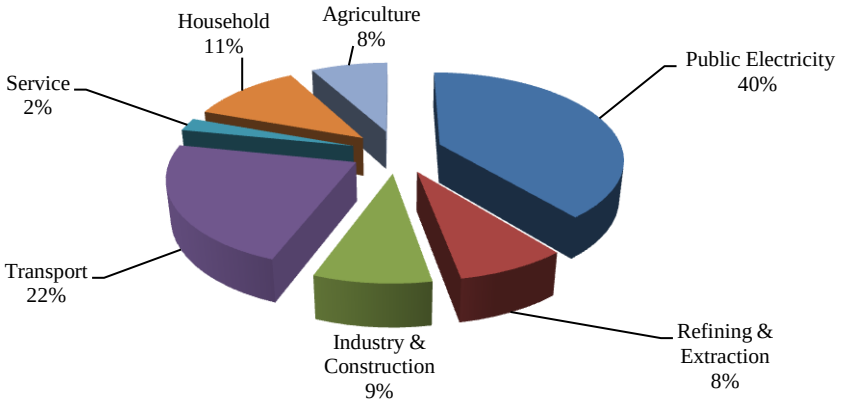

Figure 10. Distribution of GHG Emission for The Energy Sector in 2005.

Table 5. Primary Energy and GHG Emission by Emission Source in 2005.

	Energy Consumption (Mtoe)	CO_2 emissions (Mt)	CO2 per toe (ton)	CH_4 (kton)	N_2O (kton)
A-Fuel Combustion (Sectoral Approach)	19.59	55.52	2.83	16.89	0.942
1-Energy Industries	8.78	26.16	2.98	1.946	0.369
- **Public Electricity**	6.90	21.70	3.14	0.620	0.110
- **Refining & Extraction**	1.88	4.46	2.38	1.326	0.259
2-Manufacturing Industry & Construction	1.57	4.76	3.04	0.060	0.081
3-Transport	4.44	12.46	2.81	1.722	0.139
4-Other Sectors	4.81	12.15	2.52	12.930	0.354
- **Service (Ser)**	0.472	1.32	2.79	0.416	0.025
- **Household (HH)**	2.62	6.38	2.44	8.281	0.208
- **Agriculture**	1.7142	4.45	2.59	4.233	0.120
B- Fugitive				104.76	
Grand Total of Energy Sector (Mt of CO_2 eq)		**58.05**			

As shown in table 6-A, the CO_2 emissions values in fro RA is greater than this from SA by 73kton. This difference is very small and (less than 0.14%) and can be justified by the fact that there is an interconnection between the diesel uses in household sector and transport sector.

Detailed standard tables results for GHG emissions by fuel types and sectors are in Annex 2,3.

Table 6-A : A brief Comparing Between Results of RA and SA in 2005

SHORT SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (Gg)				
GREENHOUSE GAS SOURCE AND SINK CATEGORIES		CO2	CH4	N2O
Total National Emissions and Removals			121.42	0.900
Energy	Reference Approach	55,59	NA	NA
	Sectoral Approach	55,52	121.42	0.900
A Fuel Combustion		55,515	16.659	0.900
B Fugitive Emissions from Fuels		0	104.76	

3.2.3. Non CO_2 Emissions (CH_4 ،N_2O)

For the other non- Co_2 emissions (CH4, N_2o), their emissions mounted about 0.647 Mton of CO_2eq (without the fugitives), of which about 55% comes from CH_4 and 45% from N_2O.

The aggregative CH_4 emissions with fugitives mounted about 2.55 Mton of CO_2eq , fugitives shared more than 86% (about 2.2 Mton of CO_2eq) of this amount and more than 78% of total non-CO_2 emissions (figure 11).

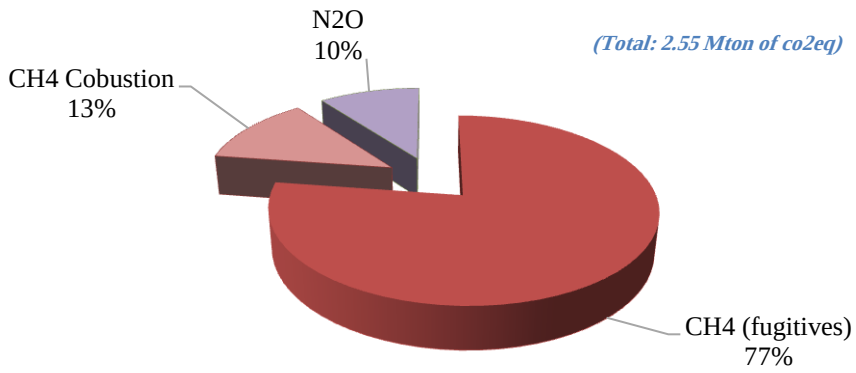

Figure 11. Share of Non-CO2 GHG Emissions in 2005

Figure 12 present the sectoral distribution for CH_4, N_2O emissions from fuel combustion. The greatest share for CH_4 comes from households sector with 49% following by agriculture, energy sector, and transport with 25%, 11.5%, 10.2% respectively, while the contribution of the service and industry were 2.5%m 1.75 respectively. For N_2O emissions, results indicate that the energy sector was the main resource for this emission with 41% followed by households, and transport with 235, 15.4% respectively, agriculture shared by 13.4% while the industry and service shared by 4.3% and 2.8% respectively.

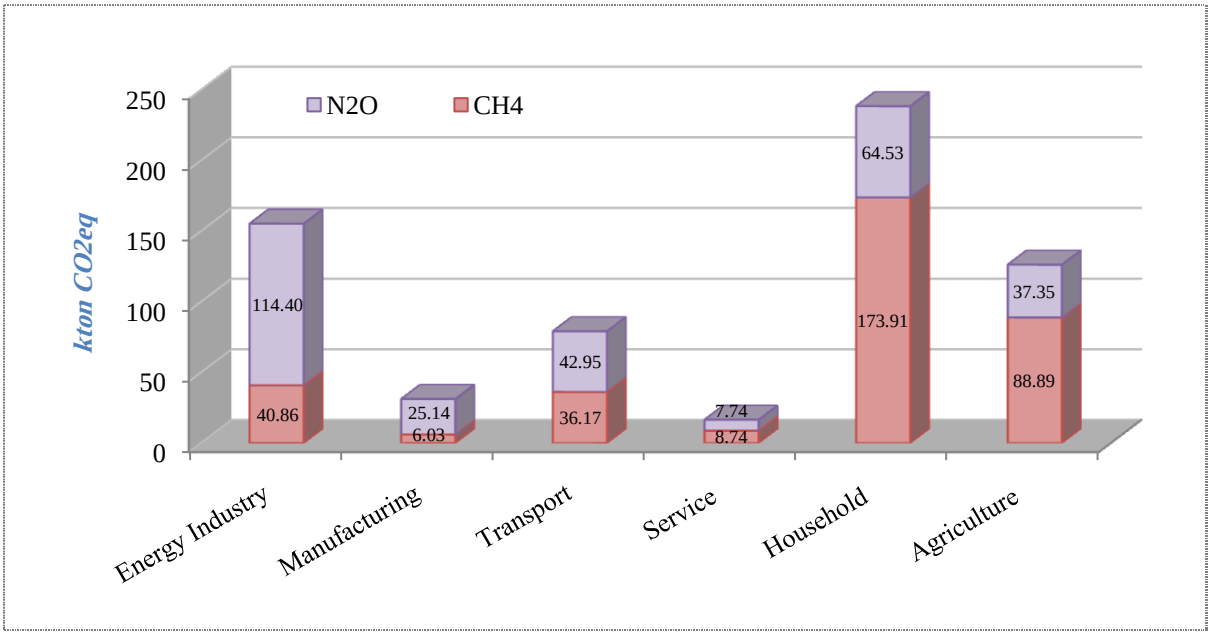

Figure 12. CH4, N2O Emissions by Sectors in 2005.

In general CO_2 emissions depends on the fuel characteristics and heat content, while CH_4, N_2O emissions are determined mainly by the combustion process and its boundary conditions (like combustion technology, apparatus efficiency, post-combustion controls,…etc) in addition to the gas contents in the fuel. For this reason the highest non-CO_2 emissions come from residential application like small stoves, open burning.

3.2.4. Fugitives Emissions

According to the IPCC guidelines, fugitive emissions are reported separately. Following Table 6 fugitives emissions account about 88% of the total CH_4 emissions with almost 105 kton (about 2200 kton of CO_2-equevelent) while the remaining 12% comes from the fuel combustion activities. Table 6-B presents detailed description of emission calculation of fugitives.

Annex 1 and 2 include the detailed calculations for the GHG emissions according to the IPCC methodology

Table 6-B. Emissions of Fugitives and Flaring

SOURCE AND SINK CATEGORIES	ACTIVITY DATA		EMISSION ESTIMATES	AGGREGATE EMISSION FACTORS
	Fuel Quantity		CH4	CH4
1 B2 Fugitives	GJ		Kton	kton per Gj of the fuel
A- Oil				
i Exploration	(no. of wells drilled)	NA	NA	7.97E-07
ii Production of Crude Oil	(production)	8.97E+08	32.50	3.62E-08
iii Transport of Crude Oil	(Qnty. loaded on tankers)	5.29E+08	69.06	1.30E-07
B- Natural Gas	M Cubm		Kton	Gg per M cubm of NG
1- Production/Processing	(production)	8.05E+03	3.06	3.80E-04
2-Transmission/Distribution	((consumption)	7.08E+03	0.12	1.66E-05
1B2 c Venting and Flaring	GJ		Kton	Kg/Gj
total flaring gas	**(production)**	**1.58E+07**	**0.02**	**1.11E-03**

4. Results of the Inventory Study for the Period between 1994 and 2005

In view of vulnerability of energy sector to climate change resulting form the increase of GHG emission, an inventory study for sources and sinks of GHG emissions (CO_2, CH_4 and N_2O) relating to the energy uses (stationary combustions and mobile sources) in the country was made up using the IPCC methodology.

Activity data that is used for calculation of green house gases from this sector are those reported in national energy balances for the year 1994, 1995, 1996, 1998, 1999, and 2005.

The balances of 1995 to 1999 were prepared by the ministry of oil and mineral fortune. However, the others were prepared by the energy group of Atomic Energy Commission of Syria (AECS).

For the years between 2000 and 2004, only CO_2 emissions were calculated according the reference approach (RA), depending on the consumed natural gas and petroleum derivatives quantities, which are adopted from the OAPEC (Organization of Arab Petroleum Exporting Countries) annual statistical report for year 2005 , as there are now official energy balance for any of these years.

Emission factors for CO_2 was calculated using the specific data for national fuel types that were reported previously, while emission factors for CH4 and N2O were obtained from IPCC guidelines based on the GCV[8]

The outcome of this work is summarised in the following tables and figures.

4.1. Development of the GHG Emissions Between 1994 and 2005

The energy sector is the largest contributor to greenhouse gas emissions in Syria. This is mainly because Syria is highly dependent on fossil fuels, namely oil and natural gas; thus carbon dioxide is the main GHG emitted.

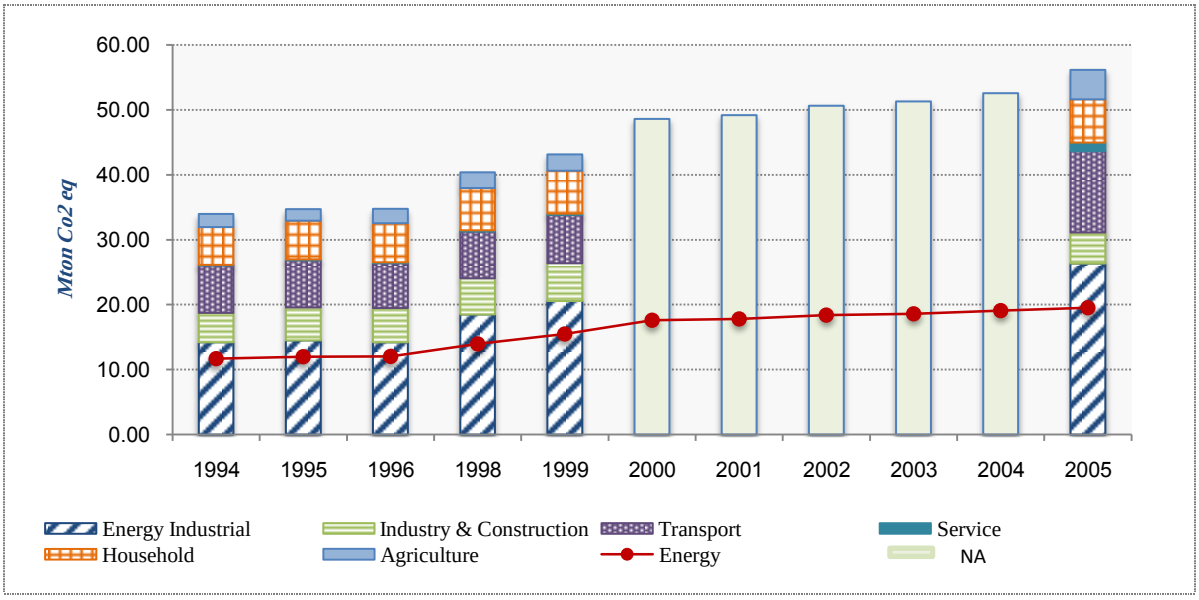

Figure 13[9]**.** Development of GHG Emissions and from Fuel Combustion Between 1994 and 2005[10]

[8] Net calorific values (NCVs) measure the quantity of heat liberated by the complete combustion of a unit volume or mass of a fuel, assuming that the water resulting from combustion remains as a vapor, and the heat of the vapor is not recovered. Gross calorific values (GCVs), in contrast, are estimated assuming that this water vapor is completely condensed and the heat is recovered, and are therefore slightly larger. However , GCV= NCV/0.95.

Figure 13 presents the GHG emissions development in the energy sector between 1994 and 2005 combined with the secondary energy consumed for combustion process. While the development of the individual sectoral emissions for some sample years are shown in table 7.

Results indicate that GHG emissions from fuel combustion doubled by 1.66 times jumping from about 38.24 to 58.35 Mton of Co_2eq in between 1994 and 2005 which equal to annual growth of about 3.92 % which is less than growth rate that achieved by the secondary energy consumption.

The secondary consumption energy doubled by 1.65 times, reaching to 19.39 Mtoe comparing with 11.7 Mtoe in 1994.

The average GHG per toe reduced during this period from 3.3 to 2.98 ton CO_2eq /toe.

Table 7. Development of GHG Emission for the Period 1994-2005 Distributed by Sub-Sector (MtCO2eq)

	1994	1995	1996	1998	1999	2005
Fuel Combustion (Sectoral Approach)	33.94	34.69	34.75	40.41	43.14	56.15
1 Energy Industries	14.20	14.48	14.23	18.51	20.57	26.31
a Public Electricity	9.54	9.61	9.36	13.94	16.63	21.75
b Refining & Extraction	4.66	4.87	4.87	4.56	3.94	4.57
2 Industry & Construction	4.56	5.08	5.24	5.56	5.80	4.79
3 Transport	7.26	7.27	6.92	7.18	7.44	12.54
4 Other Sectors	7.92	7.85	8.36	9.15	9.33	12.51
a Service (Ser)	0.12	0.15	0.13	0.20	0.20	1.33
b Household (HH)	5.79	5.93	6.00	6.50	6.62	6.62
c Agriculture (Agr)	2.02	1.77	2.23	2.45	2.51	4.56
Fugitives (kton of CH4)	204.49	224.47	205.43	201.95	202.89	104.76
Total (CO_2 eq)	**38.24**	**39.41**	**39.07**	**44.65**	**47.40**	**58.35**

4.2. The Sectoral Emissions

Figures 14 and 15 show the distribution of GHG emissions in energy sectors for 1994 and 2005.

With share of 42% (29% for electricity generation and 14% for refining & extraction) of the total emissions from fuel combustion activities, energy industries (electricity generation and refining & extraction) were the largest source for ghg emissions in 1994. keep on this

[9] For the years from 2000 to 2004 only the CO2 emissions are estimated using the reference approach as the available data was for the oil products consumption.

[10] Quantities of the greenhouse gases are expressed in terms of CO2-equivalence (CO2-e), where the emission amount of each gas is converted to CO2-e according to its Global Warming Potential (GWP) that are equals to 21 for CH4 and 310 for N2O [11].

rank but with a higher share, of 48% (39% for electricity, 9% refining and extraction) in 2005.

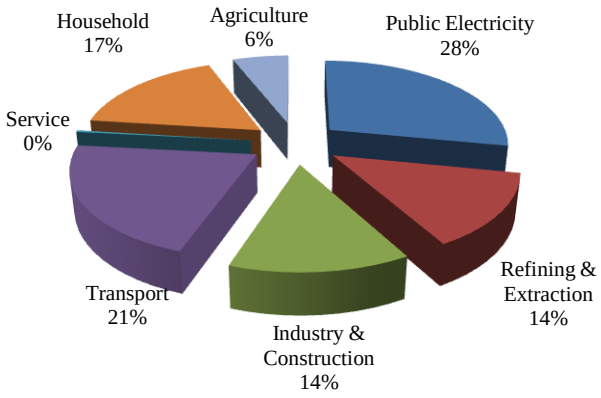

Figure 14: GHG emissions distribution in 1994 in energy sector by sub sectors

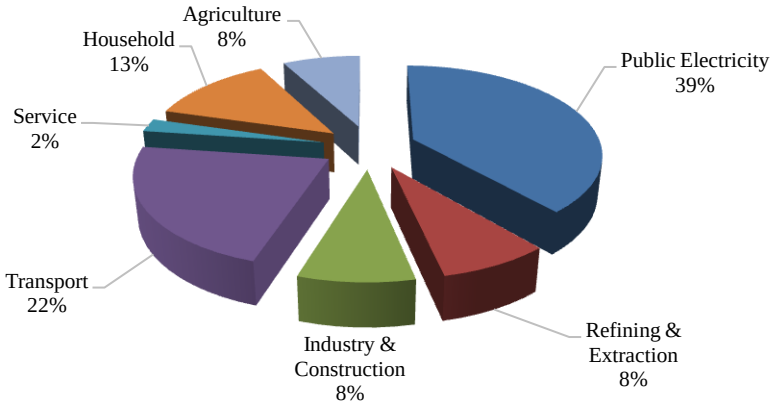

Figure 15. GHG Emissions Distribution in 2005 in Energy Sector by Sub-Sectors

This result is logical because of the high energy intensity of combustion processes in this sector that consumed about 45% of the total available primary energy in 2005.

Because of the big development in the vehicles numbers during this period, Transport came second and shared by 12.5% comparing with 7.9% in 1994

Household sector contribution grew from 5.8 to 7.11% during the same period while the industry and construction sector almost have the same share (4.56 an 4.66) % in the two year respectively, which reflect the affect of using modern and new machines in this sector.

Service and agriculture shares grew from 0.12%, 2% in 1994 to about 1.32% and 4.4 % in 2005 respectively.

4.3. Fugitives

The Fugitive energy sector is a sub-sector of the Energy sector. It covers emissions of greenhouse gases that are associated with the production, processing, transport, storage, transmission and distribution of fossil fuels such as black coal, oil and natural gas. The Fugitive sector does not include emissions arising from the combustion of fuel for energy purposes, which is accounted for in the Stationary Energy sector. Nor does the Fugitive

energy sector include emissions from the decomposition of organic waste in landfills, as these emissions are accounted for in the waste sector.

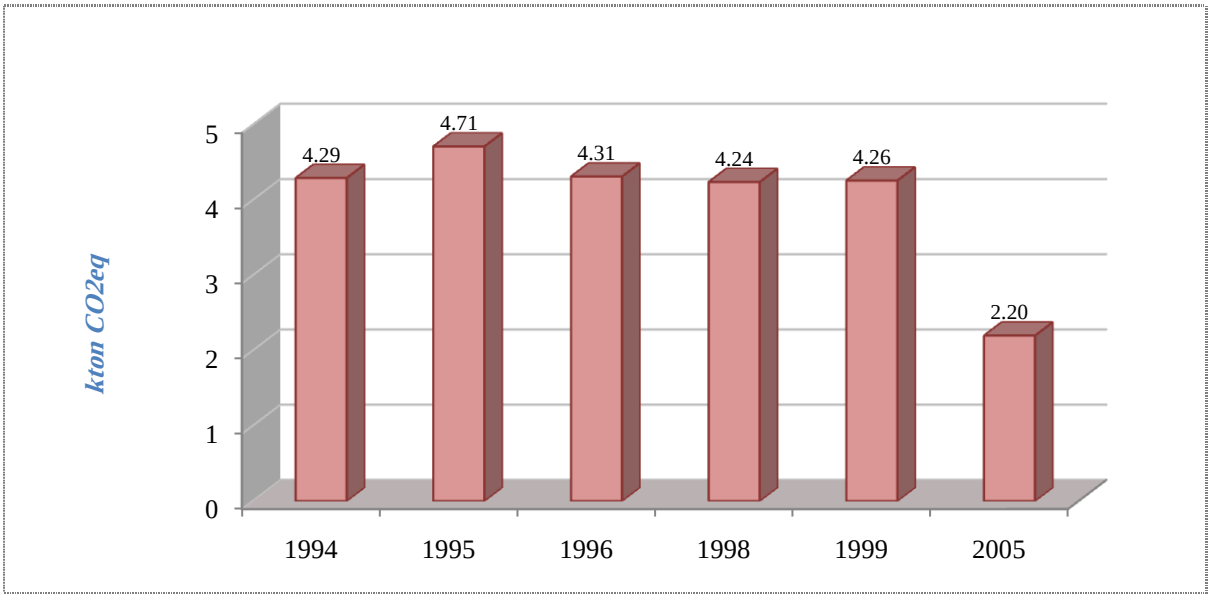

Figure 16. Development of Fugitives CH4 Emissions Between1994 and 2005

Comparing with 1994, when fugitives emissions of CH_4 mounted 4.3 kton of CO_2eq (204 kton) and shared by almost 86% of the total CH_4 emissions from the energy sector, figure 16 refers to a dramatic declining in these emissions in 2005 when it's share became about 88% and the quantities dropped to 2.2 kton of CO_2eq (104.7 kton). This declining can be justified because of the noticeable decreasing in the crude oil production and re inject the combined gas to in the wells to enhance their recovery.

More detailed data about the emissions development in individual years is presented in annex 3 and will demonstrate in the following:

4.4. Energy Industry

GHG emissions doubled by about 1.85 times between 1994 and 2005 with an annual growth of about 5.3%.

With an annual growth of 5.7% Energy sector consumed about 8.8 Mtoe in 2005 comparing with 4.8 Mtoe in 1994. thus, GHG emissions mounted about 26.31ton CO_2eq comparing with 14.2 Mton of CO_2Eq during the same years respectively.

Table 8. Development of GHG Emission for the Period 1994- 2005

	1994	1995	1996	1998	1999	2005
GHG (MtCO2eq)	14.20	14.48	14.23	18.51	20.57	**26.31**
Energy (Mtoe)	4.77	4.88	4.83	6.27	6.92	**8.78**

As result, CO_2 per kWh had decreased slightly from 641 to 622 g during the same period as presented in figure 17. The observed variation results from the changing shares of NG and fuel oil in the generation process. Higher NG share relates to lower CO_2 emission.

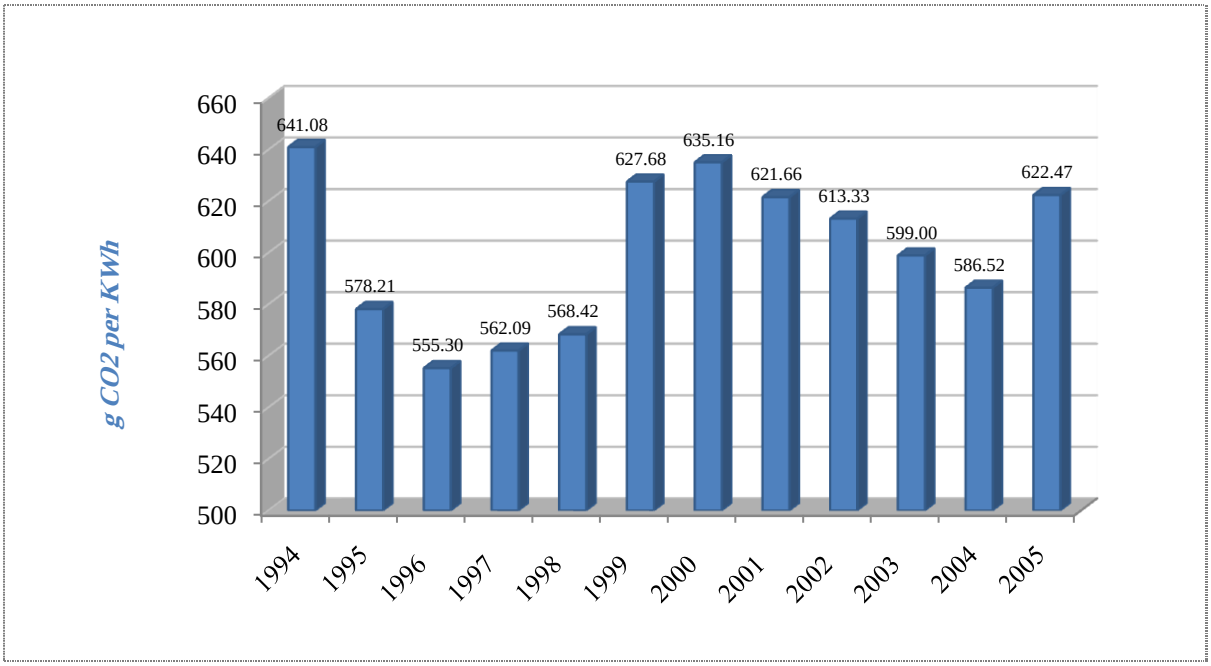

Figure 17: Development of CO_2eq-Emission per kWh of Generated Electricity for the period 1996-2005.

4.5. Manufacturing& Construction

The total consumed energy grew during nineteenths of the last century and reach about 5.8Mtoe in 1999 comparing with 4.55 Mtoe in 1994. However it became to decreasing in the last nine years owing to the high penetration for the electric machines and full controlled factories. As a result the consumed energy was about 1.57 Mtoe in 2005

GHG emissions follow the same trace and the 2005 emissions was almost the same comparing with 1994 (4.66, 4.77 Mt respectively).

Table 9. Development of GHG Emission and Consumed Energy for the period 1994- 2005

	1994	1995	1996	1998	1999	2005
GHG (MtCO2eq)	4.55	5.08	5.24	5.56	5.80	**4.77**
Energy (Mtoe)	1.50	1.69	1.74	1.86	1.94	**1.57**

4.6. Transport Sector:

Transport sector in Syria depend on the road transport whether for passenger or goods transportation.

Transportation sector had a great development the last two decades. this development reflects mainly in the increasing of the vehicles from 520000 in 1996 to 140357 in 2005.

Transport sector consumption was about 4.44 Ktoe comparing with 2.58 Mtoe in 1994 achieving an annual growth rate of about 5%. While the GHG emissions grew by the same rate from 7.3 to 12.5 Mt CO_2eq during the same period.

Table 10. Development the Energy Consumption and Related GHG Emissions during 1994 2005

	1994	1995	1996	1998	1999	2005
Consumption Mtoe	2.58	2.59	2.46	2.55	2.64	**4.44**
Emissions Mt Co_2eq	7.26	7.27	6.92	7.18	7.44	**12.54**

4.7. Household Sector

This sector characterizes by the high interference in energy end use types as these end uses are affected by a lot of socio-economic and weather factors. However. The energy uses in HH sector distributes in tow the activities of cocking, space and water heating. While the consumed fuel types include diesel, LPG, in addition to the biomass (wood and wood waste)

The total energy consumption achieved an annual growth rate of 1.96% in the period between 1994 and 2005, and mounted about 2.62 , 2.12 Mtoe respectively.

Table 11. Development the Eenergy Consumption and Related GHG Emissions during 1994 2005

	1994	1995	1996	1998	1999	2005
Consumption Mtoe	2.12	2.17	2.20	2.38	2.43	**2.62**
Emissions Mt Co_2eq	5.79	5.93	6.00	6.50	6.62	**6.62**

The GHG emissions grew by 1.23% annually, and mounted about 6.62 MtCO_2eq in 2005 comparing with 5.8 MtCO_2eq in 1994.

4.8. Agriculture and Service Sectors

These two sub sectors achieved the highest annual growth rate in GHG emissions with 7.7% for agriculture and almost 24.8% for service during the considered period.

Total energy consumed in this agriculture sector grew from 0.69 Mtoe in 1994 to 1.7 Mtoe in 2005, resulting that the GHG emissions nearly doubled and jumped to 4.6 MtCO_2eq in 2005 comparing with 2.02 MtCO_2eq in 1994.

Table 12. Development the Energy Consumption and Related GHG Emissions in Agriculture & Service Subsectors.

		1994	1995	1996	1998	1999	2005
Agriculture	Consumption (Mtoe)	0.69	0.62	0.77	0.84	0.86	**1.71**
	Emissions Mt CO_2eq	2.02	1.77	2.23	2.45	2.51	**4.56**
Service	Consumption (ktoe)	0.0404	0.053	0.046	0.071	0.068	**0.472**
	Emissions Mt CO_2eq	0.116	0.152	0.131	0.205	0.195	**1.331**

While, in service sector, and since the consumed energy grew from 40 ktoe in 1994 to 472 ktoe in 2005, GHG emissions jumped from less than 116 KtCo_2eq to 1.33 ktCO_2eq in the same years respectively.

Annexes

Annex 1. Sectoral Report for National GHG Inventories for Energy

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 (Gg)	CH_4 (Gg)	N_2O (Gg)
Total Energy	55,503	121.64	0.942
A. Fuel Combustion Activities (Sectoral Approach)	55,503	16.89	0.942
1. Energy Industries	26,159	1.95	0.37
a. Public Electricity	21,700	0.62	0.11
b. Petroleum Refining	4,459	1.33	0.26
2. Manufacturing and Construction	4,756	0.287	0.081
a. Iron and Steel			
b. Non-Ferrous Metals			
c. Chemicals			
d. Pulp, Paper and Print			
e. Food Processing, Beverages and Tobacco			
f. Other (please specify)			
3. Transport	12,457	1.7225	0.1386
a. Civil Aviation	383.52	0.006	0.024
b. Road Transportation	11,917.29	0.000	0.000
c. Railways	133.22	1.695	0.112
d. Navigation	11.33	0.020	0.002
e. Other (Pipeline Transport)	11.6	0.0015	0.0002
4. Other Sectors	12,132	12.930	0.354
a Commercial/Institutional	1,315	0.416	0.025
b Residential	6,381	8.281	0.208
c Agriculture/Forestry/Fishing	4,437	4.233	0.120
B Fugitive Emissions from Fuels	0	104.8	0
1. Solid Fuels	0	0	0
a Coal Mining	---	--	--
b Solid Fuel Transformation	---	--	--
c Other (please specify)	---	--	--
2. Oil and Natural Gas	0	104.8	0
a Oil		101.6	
b Natural Gas		3.2	
c Venting and Flaring		0.0178	
Memo Items (1)			
International Bunkers	---	--	--
Aviation	---	--	--
Marine	---	--	--
CO_2 Emissions from Biomass	1,035		

Annex 2 Details of GHG emissions for relevant sectors that are included in the Energy Sectors are in the following tables:

SOURCE AND SINK CATEGORIES	A	B			C		
	Consumption	Emissions			Emission Factors		
	TJ	kton			(Ton polluant/TJ) B/C*1000		
Fuel Consumbtion Activities		CO2	CH4	N2O	CO2	CH4	N2O
1 Energy Industries	367399.27	26158.59	1.95	0.37	71.20	0.074	1.00E-03
2 Industries and Construction	65570.23	4755.72	0.29	0.08	72.53	0.060	1.24E-03
3 Transport	185922.93	12468.59	1.72	0.14	67.06	0.138	7.45E-04
4 Other Sectors	201169.33	12132.02	12.93	0.35	60.31	1.066	1.76E-03
a Commercial/Institutional	19757.19	1314.71	0.42	0.02	66.54	0.316	1.26E-03
b Residential	109645.52	6380.69	8.28	0.21	58.19	1.298	1.90E-03
c Agriculture	71766.63	4436.62	4.23	0.12	61.82	0.954	1.68E-03

Fugitives and Flaring Emissions

SOURCE AND SINK CATEGORIES	ACTIVITY DATA		EMISSION ESTIMATES			AGGREGATED EMISSION FACTORS (1)		
	Fuel Quantity		CH_4	CO_2	N_2O	CH_4	CO_2	N_2O
1 B2 Fugitives	GJ(Mcubm)		Kton	Kton	Kton			
A- Oil							kton per Gj of the fuel	
i Exploration	(no. of wells drilled)	NA				7.97E-07	2.42E-06	ND
ii Production of Crude Oil	(production)	8.97E+08	32.50	2.38		3.62E-08	2.66E-09	na
iii Transport of Crude Oil	(Qnty. loaded on tankers)	5.29E+08	69.06	6.27		1.30E-07	1.18E-08	na
B- Natural Gas						Gg per 10^6 cubm of the fuel		
i Production/Processing	(production)	8.05E+03	3.06	1.13		3.80E-04	1.40E-04	NA
ii Transmission/Distribution	(consumption)	7.08E+03	0.12	0.00		1.66E-05	8.80E-08	nd
1B2 c Venting and Flaring		GJ				Kg/Gj(3)	Kg/Gj	Kg/Gj
Total Flaring Gas	**(production)**	**1.58E+07**	**0.02**	**294.41**	**0.00**	**1.11E-03**	**18.6**	**1.11E-04**

Sectoral Emissions

<u>Energy Industry:</u> Fuel Combustion Activities - Detailed Fuel Type Based Calculation

SOURCE AND SINK CATEGORIES	Activity Data (A)	Emission Estimates (B)			Aggregated Emission Factor		
	Consumption	Emissions					
	TJ				B/C		
		CO_2 (kton)	CH_4 (ton)	N_2O (ton)	CO_2 (ton/TJ)	CH_4(ton/Tj)	N_2O(ton/Tj)
Kerosene	3.208	0.211	0.030	0.006	65.707	9.45E-03	1.89E-03
Diesel	5710.397	388.330	53.971	10.801	68.004	9.45E-03	1.89E-03
Fuel Oil	171712.728	13027.338	1622.922	324.790	75.867	9.45E-03	1.89E-03
Refinery Gas	6933.545	399.010	65.532	13.115	57.548	9.45E-03	1.89E-03
Natural gas	183039.394	12343.697	203.174	20.336	67.437	1.11E-03	1.11E-04
Total	**367399.272**	**26158.586**	**1945.629**	**369.047**	**71.199**	**5.30E-03**	**1.00E-03**

Manufacturing& Construction: Fuel Combustion Activities- Detailed fuel type Based Calculation

SOURCE AND SINK CATEGORIES	Activity Data (A)	emission Estimates (B)			Aggregated Emission Factor		
	Consumption	Emissions					
	TJ				B/C		
		CO_2 (kton)	CH_4 (ton)	N_2O (ton)	CO_2 (ton/TJ)	CH_4(ton/Tj)	N_2O(ton/Tj)
Gasoline (Caz)	0.00	0.000	0.000	0.0	-	-	-
Gas/Diesel Oil	18,583.30	1,263.74	82.178	24.7	68.00	4.42E-03	1.33E-03
Residual Fuel Oil	38,719.11	2,951.56	171.221	51.5	76.23	4.42E-03	1.33E-03
LPG	3,336.72	192.02	14.755	4.4	57.55	4.42E-03	1.33E-03
Petroleum Coke	606.19	57.67	0.000	0.00	95.14	0.00E+00	0.00E+00
Refinery Gas	0.00	0.00	0.000	0.0	-	-	-
Natural gas	3,448.27	232.54	19.17	0.38	67.44	5.56E-03	1.11E-04
Total	**64,693.59**	**4,697.53**	**287.33**	**81.08**	**72.61**	**4.44E-03**	**1.25E-03**

Transportation : Fuel Combustion Activities - Detailed fuel type Based Calculation

SOURCE AND SINK CATEGORIES		Activity Data (A)	Emission Estimates (B)			Aggregated Emission Factor		
		Consumption	Emissions					
		TJ				B/C		
			CO2 (kton)	CH4 (ton)	N2O (ton)	CO2 (Kton/TJ)	CH4 (ton/Tj)	N2O (ton/Tj)
Domestic Aviation		5888.41	383.52	6.20	23.554	65.131	1.1E-03	4.0E-03
Road Transport	Gasoline	3485.17	1075.23	33.977	64.826	2.0E-02	6.3E-04	6.3E-04
	Diesel	8443.74	619.97	78.364	68.004	5.0E-03	6.3E-04	6.3E-04
Rail Transport		1959.04	133.22	19.59	2.476	68.004	1.0E-02	1.3E-03
National Navigation		148.63	11.33	1.49	0.188	76.228	1.0E-02	1.3E-03
Total		**185922.93**	**12456.98**	**1722.48**	**138.560**	**67.001**	**9.3E-03**	**7.5E-04**

Other Sectors: Fuel Combustion Activities- Detailed fuel type Based Calculation

SOURCE AND SINK CATEGORIES	Activity Data (A)	Emission Estimates (B)			Aggregated Emission Factor		
	Consumption	Emissions					
	TJ				B/C		
		CO_2 (kton)	CH_4 (ton)	N_2O (ton)	CO_2 (ton/TJ)	CH_4 (ton/Tj)	N_2O (ton/Tj)
Commercial/Institutional	19757.186	1314.712	416.086	24.973	66.543	0.021	1.26E-03
Residential	109645.519	6913.598	8281.471	208.151	63.054	0.076	1.90E-03
Agriculture / Forestry /	71766.628	4938.276	4232.743	120.494	68.810	0.059	1.68E-03

TABLE 1.A(a) SECTORAL BACKGROUND DATA FOR ENERGY SYRIA
Fuel Combustion Activities- Sectoral Approach 2005

(Sheet 1 of 3)

GREENHOOUSE GAS SOURCE AND SINK GATEGORIES	AGGREGATE ACTIVITY DATA	IMPLIED EMISSION FACTORS			EMISSIONS		
	Consumption (TJ)	CO_2 (T/TJ)	CH_4	N_2O	CO_2	CH_4	N_2O
		t/TJ	kg/TJ			Gg	
1.A.FUEL CONSUMPTION	819890.94	68.06	2.03E-02	6.50E-04	55802.4	16.68	0.53
Liquid Fuel	611536.73	67.62	1.12E-02	1.87E-05	41349.2	6.87	0.01
Solid Fuel	4911.01	109.53	2.60E-01	4.22E-03	537.9	1.28	0.02
Gaseous Fuel	186487.66	66.19	1.19E-03	2.06E-03	12343.7	0.22	0.38
Biomass	16955.542	61.016	4.90E-01	6.91E-03	1034.6	8.31	0.12
1.A.1.Energy Industries	367399.27				26158.59	0.7854	0.1369
Liquid Fuel	184359.88	74.93	3.16E-03	6.32E-04	13814.89	0.5822	0.1165
Solid Fuel	0.00				0.00		
Gaseous Fuel	183039.39	67.44	1.11E-03	1.11E-04	12343.70	0.2032	0.0203
Biomass	0.00						
a. Public Electricity and Heating Production	290371.12	74.73	2.14E-03	4.03E-04	21700.00	0.6200	0.1171
Liquid Fuel	162815.20	80.45	2.94E-03	6.32E-04	13097.96	0.4784	0.1029
Solid Fuel							
Gaseous Fuel	127555.92	67.44	1.11E-03	1.11E-04	8602.04	0.1416	0.0142
Biomass							
b. Petroleum Refinery	77028.15				4458.59	0.1654	0.0269
Liquid Fuel	21544.68	33.28	4.82E-03	9.60E-04	716.93	0.1038	0.0207
Solid Fuel							
Gaseous Fuel	55483.47	67.44	1.11E-03	1.11E-04	3741.66	0.0616	0.0062
Biomass							

TABLE 1.A(a) SECTORAL BACKGROUND DATA FOR ENERGY SYRIA

Fuel Combustion Activities- Sectoral Approach 2005

(Sheet 2 of 3)

GREENHOOUSE GAS SOURCE AND SINK GATEGORIES	AGGREGATE ACTIVITY DATA	IMPLIED EMISSION FACTORS			EMISSIONS		
	Consumption (TJ)	CO_2 (T/TJ)	CH_4	Consumption (TJ)	CO_2 (T/TJ)	CH_4	Consumption (TJ)
		t/TJ		kg/TJ			
1.A.2.Mnufacturing Industries and Construction	65570.23	62.760	2.02E-03	5.24E-04	4115.19	0.132	0.034
Liquid Fuel	61515.77	63.116	1.84E-03	5.53E-04	3882.65	0.113	0.034
Solid Fuel	606.19						
Gaseous Fuel	3448.27	67.437	5.56E-03	1.11E-04	232.54	0.019	0.000
Biomass							
1.A.3.Transport	185752.11						
Liquid Fuel	185752.11	67.000	9.20E-03	6.75E-04	12445.36	1.709	0.125
Solid Fuel							
Gaseous Fuel							
Biomass							

TABLE 1.A(a) SECTORAL BACKGROUND DATA FOR ENERGY SYRIA
Fuel Combustion Activities- Sectoral Approach 2005

(Sheet 3 of 3)

GREENHOOUSE GAS SOURCE AND SINK GATEGORIES	AGGREGATE ACTIVITY DATA	IMPLIED EMISSION FACTORS			EMISSIONS		
	Consumption (TJ)	CO_2 (T/TJ)	CH_4	N_2O	CO_2	CH_4	N_2O
		t/TJ	kg/TJ			Gg	
1.A.4.Other Sectors	201169.33				13166.59	10.600	0.294
Liquid Fuel	179908.97	65.737	5.18E-03	9.49E-04	11826.65	0.933	0.171
Solid Fuel	4304.82	70.939	3.16E-01	1.47E-03	305.38	1.359	0.006
Gaseous Fuel	0.00						
Biomass	16955.54	61.016	4.90E-01	6.91E-03	1034.56	8.308	0.117
a. Commercial / Institutional	19757.19						
Liquid Fuel	19757.19	66.543	1.05E-02	6.32E-04	1314.71	0.208	0.012
Solid Fuel							
Gaseous Fuel							
Biomass							
b. Residential	109645.52						
Liquid Fuel	99401.93	64.191	4.19E-03	1.26E-03	6380.69	0.416	0.126
Solid Fuel							
Gaseous Fuel	0.00						
Biomass	10243.59	52.023	6.04E-01	8.05E-03	532.90	6.188	0.083
a. Agriculture/Forestry/Fishing	71766.63						
Liquid Fuel	60749.85	68.004	5.08E-03	5.37E-04	4131.24	0.309	0.033
Solid Fuel	4304.82	70.939	3.16E-01	1.47E-03	305.38	1.359	0.006
Gaseous Fuel	0.00						
Biomass	6711.96	48.973	2.07E-01	3.38E-03	501.66	2.120	0.035

Annex 3. Default emission factors for CH_4 by major technology and fuel types as presented in the Revised 1996 IPCC Guidelines based on NCVs[11]

TABLE 1-7
CH_4 DEFAULT (UNCONTROLLED) EMISSION FACTORS (IN KG/TJ)

			Coal(a)	Natural Gas	Oil	Wood/ Wood Waste	Charcoal	Other Biomass and Wastes(c)
Energy Industries			1	1	3	30(b)	200(b)	30
Manufacturing Industries and Construction			10	5	2	30	200	30
Transport	Aviation(d)				0.5			
	Road			50	Gasoline 20(e)	Diesel 5		
	Railways		10		5			
	Navigation		10		5			
Other Sectors	Commercial/Institutional		10	5	10	300	200	300
	Residential		300	5	10	300	200	300
	Agriculture/ Forestry/ Fishing	Stationary	300	5	10	300	200	300
		Mobile		5	5			

Note: These factors are considered as the best available global default factors to date.

(a) The emission factors for brown coal may be several times higher than those for hard coal.

(b) These factors are for fuel combustion in the energy industries. For charcoal production, please refer to Table 1-14, Default Non-CO_2 Emission Factors for Charcoal Production.

(c) Includes dung and agricultural, municipal and industrial wastes.

(d) In the cruise mode CH_4 emissions are assumed to be negligible (Wiesen et al., 1994). For LTO cycles only (i.e., below an altitude of 914 metres (3000 ft.)) the emission factor is 5 kg/TJ (10% of total VOC factor) (Olivier, 1991). Since globally about 10% of the total fuel is consumed in LTO cycles (Olivier, 1995), the resulting fleet averaged factor is 0.5 kg/TJ.

(e) Emission factors for 2-stroke engines may be three times higher than those for 4-stroke engines.

11 Net calorific values (NCVs) measure the quantity of heat liberated by the complete combustion of a unit volume or mass of a fuel, assuming that the water resulting from combustion remains as a vapor, and the heat of the vapor is not recovered. Gross calorific values (GCVs), in contrast, are estimated assuming that this water vapor is completely condensed and the heat is recovered, and are therefore slightly larger. Default data in the Revised 1996 IPCC Guidelines are based on NCVs.

Default emission factors for $N2O_4$ by major technology and fuel types as presented in the Revised 1996 IPCC Guidelines based on NCVs

TABLE 1-8
N_2O DEFAULT (UNCONTROLLED) EMISSION FACTORS (IN KG/TJ)

			Coal[a]	Natural Gas	Oil	Wood/ Wood Waste	Charcoal	Other Biomass and Wastes[c]
Energy Industries			1.4	0.1	0.6	4[b]	4[b]	4
Manufacturing Industries and Construction			1.4	0.1	0.6	4	4	4
Transport	Aviation				2			
	Road			0.1	Gasoline 0.6[d] / Diesel 0.6			
	Railways		1.4		0.6			
	Navigation		1.4		0.6			
Other Sectors	Commercial/Institutional		1.4	0.1	0.6	4	1	4
	Residential		1.4	0.1	0.6	4	1	4
	Agriculture/ Forestry/ Fishing	Stationary	1.4	0.1	0.6	4	1	4
		Mobile		0.1	0.6			

Note: These factors are considered as the best available global default factors to date.

(a) Brown coals may produce less N_2O than bituminous coals; some measurements have shown that N_2O emissions by hard coal combustion in power plants may be negligible. N_2O emissions from FBC are generally about 10 times higher than from boilers.

(b) These factors are for fuel combustion in the energy industries. For charcoal production, please refer to Table 1-14, Default Non-CO_2 Emission Factors for Charcoal Production.

(c) Includes dung and agricultural, municipal and industrial wastes.

(d) When there is a significant number of cars with 3-way catalysts in the country, road transport emission factors should be increased accordingly. Emission factors for 2-stroke engines may be three times higher than those for 4-stroke engines.

Source: IPCC Reference Manual – Volume 3, table 1-8, p. 1.36

Annex 4. Yearly GHG emissions between 1994 and 2005

	1994			1995		
	CO_2 (Mt)	CH= (kton)	N_2O (kton)	CO_2 (Mt)	CH_4 (kton)	N_2O (kton)
1 Energy	33.769	208.63	0.27	34.55	227.247	0.261
Fuel Combustion (Sectoral Approach)	33.769	4.14	0.27	34.55	2.777	0.261
1 Energy Industries	14.172	0.41	0.07	14.45	0.400	0.067
a Public Electricity	9.516	0.30	0.06	9.59	0.286	0.052
b Refining & Extraction	4.657	0.11	0.01	4.87	0.114	0.015
2 Industry & Construction	4.537	0.29	0.04	5.06	0.250	0.039
3 Transport	7.218	1.01	0.08	7.23	1.016	0.080
4 Other Sectors	7.842	2.43	0.08	7.81	1.110	0.075
a Service (Ser)	0.115	0.02	0.00	0.15	0.024	0.001
b Household (HH)	5.750	0.93	0.06	5.90	0.957	0.057
c Agriculture (Agr)	1.977	1.48	0.02	1.76	0.130	0.016
Fugitives		204.49			224.470	

	1996			1998		
	CO2 (Mt)	CH4 (kton)	N2O (kton)	CO2 (Mt)	CH4 (kton)	N2O (kton)
1 Energy	34.59	209.429	0.256	40.23	206.361	0.288
Fuel Combustion (Sectoral Approach)	34.59	4.085	0.256	40.23	4.414	0.288
1 Energy Industries	14.20	0.373	0.060	18.47	0.492	0.080
a Public Electricity	9.34	0.249	0.043	13.92	0.354	0.059
b Refining & Extraction	4.86	0.124	0.018	4.55	0.138	0.021
2 Industry & Construction	5.23	0.215	0.036	5.55	0.284	0.042
3 Transport	6.88	1.009	0.077	7.14	1.043	0.075
4 Other Sectors	8.28	2.488	0.083	9.07	2.596	0.091
a Service (Ser)	0.13	0.020	0.001	0.20	0.031	0.002
b Household (HH)	5.96	0.969	0.058	6.46	1.050	0.063
c Agriculture (Agr)	2.20	1.498	0.024	2.41	1.514	0.026
Fugitives		205.429			201.948	

	1999			2005		
	CO2 (Mt)	CH4 (kton)	N2O (kton)	CO2 (Mt)	CH4 (kton)	N2O (kton)
1 Energy	42.95	207.346	0.313	55.50	121.643	0.942
Fuel Combustion (Sectoral Approach)	42.95	4.461	0.313	55.50	16.886	0.942
1 Energy Industries	20.52	0.573	0.096	26.16	1.946	0.369
a Public Electricity	16.59	0.441	0.075	21.70	0.620	0.110
b Refining & Extraction	3.93	0.132	0.021	4.46	1.326	0.259
2 Industry & Construction	5.78	0.223	0.043	4.76	0.287	0.081
3 Transport	7.40	1.045	0.080	12.46	1.722	0.139
4 Other Sectors	9.25	2.620	0.093	12.13	12.930	0.354
a Service (Ser)	0.19	0.030	0.002	1.31	0.416	0.025
b Household (HH)	6.58	1.071	0.064	6.38	8.281	0.208
c Agriculture (Agr)	2.47	1.519	0.027	4.44	4.233	0.120
Fugitives		202.885			104.757	

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