

## Chapter 2 Current and Projected GHG Emissions and Reduction / Avoidance Potential in Egypt

### Introduction

The contribution of major sectors to the overall GHG emissions of Egypt serves as a first indicator on which sectors should be primarily targeted for identifying GHG mitigation projects.

The present chapter therefore presents and discusses the inventory (Section 2.1) and projection (Section 2.2) of the Green House Gas (GHG) emissions from different sectors in Egypt.<sup>1</sup>

As it may be assumed that today's major GHG emitters in Egypt remain largely the same as in 1990, the available inventory is the basis for identifying the sectors with a large potential for GHG emission reduction. Section 2.3 assesses the potential in the identified sectors for projects under the Clean Development Mechanism (CDM) in a bottom-up approach. Here, the cost of saved carbon and the replication potential for several project types and technologies are calculated. The project types are then aggregated to a bottom-up marginal abatement cost curve of selected projects, which presents the total saved carbon against the cost of saved carbon for each project type.

Sections 2.4 and 2.5 discuss the government policies, strategies and development plans, which may promote or impede the GHG mitigation activities in Egypt. The chapter then concludes, in Section 2.6, with the identification and justification of priority technologies and project types for CDM in Egypt.

### 2.1 Analysis of the Greenhouse Gases Inventory

#### 2.1.1 Methodology and Data Used

The first estimation of Egypt's GHG inventory<sup>2</sup> was carried out by EEAA with the technical support of VTT (a Finnish technological institute) and in co-operation with the United Nations Environment Program (UNEP). The study was a first attempt to calculate GHG inventory based on the available data at that time (1993) and since the IPCC guidelines were not yet published, the study's results could not be utilized for the purposes of this NSS.

The second attempt for estimating Egypt's GHG inventory was carried out by the Organization of Energy Conservation and Planning\* (OECF) in co-operation with the United States Country Study Program (USCSP). Following this study, two official documents were published related to climate change, those are: Initial National Communication on Climate Change, issued in June 1999 by EEAA and the National Action Plan on Climate Change, issued in August 1999 by Ministry of State for Environmental Affairs (MSEA).

The present NSS relies on the data reported in the official published documents mentioned above as well as the following documents:

- OECF, (1997), "Support for National Action Plan (SNAP) Reports".
- OECF, (1998), "Egypt National Greenhouse Gases Inventory".

<sup>1</sup> Comprehensive inventory data has been available only for the fiscal year 1990/91, while the projection figures cover the period until the fiscal year 2016/17, which represents the objective year for achieving the economic and social development plans; Ministry of Planning. (1997). "Social and economic development plans"

<sup>2</sup> EEAA, (1995), "Greenhouse Gas abatement costing study, case study of Egypt"

\* Currently known as Organization of Energy Planning (OEP)

- EEAA, (1999), “Initial National Communication on Climate Change”.
- MSEA, (1999), “National Action Plan on Climate Change”.
- OEP, (1999), “Energy in Egypt” (in Arabic).

The revised IPCC guidelines were also reviewed to make sure that the national reports complied with the Revised Version.

Since all documents rely on the data reported in the OECF 1998 study; therefore this NSS report used it as the original source of information. However, the two national documents on climate change, the National Action Plan on Climate Change and the Initial National Communication on Climate Change, were utilized as references for other necessary information.

The methodology used in the aforementioned documents to develop and report the inventory was based on the IPCC guidelines<sup>3</sup> published in 1995 and revised in 1996.

The inventory was estimated for the main three GHGs, namely CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O, and then converted to CO<sub>2</sub> equivalent by multiplying by the global warming potential for each GHG\*. The GWP used for CO<sub>2</sub> is 1, for CH<sub>4</sub> is 21, and for N<sub>2</sub>O is 310<sup>4</sup>. In Egypt, the data for other GHGs such as NO<sub>x</sub>, CO and non-methane VOCs is not available.

The inventory of GHG emissions and sinks (removals) for Egypt has been compiled for the fiscal year 1990/1991 (July 1<sup>st</sup>, 1990 – June 30, 1991). The CO<sub>2</sub> emissions from biomass burned for energy purposes are excluded from the calculations and the emissions from international bunkers are reported separately according to the IPCC guidelines.

### 2.1.2 GHG Emissions Inventory by Sector

The total GHG emissions of Egypt in 1990 were 116,708 Gg of CO<sub>2</sub> equivalent while the total GHG sinks in the land - use and forestry sector recorded 9,900 Gg of CO<sub>2</sub> equivalent. CO<sub>2</sub> is the main Greenhouse Gas in Egypt. It represented about 72% of the total GHG emissions in 1990. The second important Greenhouse Gas is CH<sub>4</sub>, which recorded 19% of the total GHG emissions and lastly N<sub>2</sub>O with 9%.<sup>5</sup>

Table 2.1, which is extracted from the OECF study<sup>6</sup> and adapted for the purpose of this CDM report, shows a summary of the national GHG inventories from the main sectors for the fiscal year 1990/1991. The “All Energy” sector shown in the table includes:

- Emissions from fossil fuel combustion for power production,
- Emissions from fossil fuel combustion in industries,
- Manufacturing industries and construction (ISIC)\*,
- Transport,
- Small combustion,
- Traditional burned biomass (excluding CO<sub>2</sub> emissions),
- Fugitive emissions from fuels.

<sup>3</sup> Available: <http://www.ipcc-nggip.iges.or.jp/public/gl/guideline/>

\* Global Warming Potentials (GWP) are an index created in The Kyoto Protocol that allows for equal comparison of the various Greenhouse Gases concerning their varying power to accelerate global warming and/or the duration of their presence in the atmosphere

<sup>4</sup> IPCC, (1996)

<sup>5</sup> OECF, (1998) P.1

<sup>6</sup> OECF, (1998) P.35

\* International Standard for Industrial Classification

Table 2.1: Summary of National Greenhouse Gas Inventories – 1990/91

	Greenhouse Gas Sources and Sinks (Gg)			
	CO <sub>2</sub> (Gg)	CH <sub>4</sub> (Gg)	N <sub>2</sub> O (Gg)	CO <sub>2</sub> Eq (Gg)
<b>Net National Emissions (emissions – removals)</b>	<b>74,559</b>	<b>1,029</b>	<b>34</b>	<b>106,708</b>
1. All Energy (Fuel Combustion + Fugitive Emissions)	74,682	206	12	82,728
2. Industrial Processes	9,777	9	1	10,276
3. Solvent and Other Product Use	-	-	-	-
4. Agriculture	-	543	21	17,913
5. Land Use Change & Forestry	-9,900	-	-	-9,900
6. Waste	-	271	-	5,691
7. Other	-	-	-	-

Source: Extracted from OECP (1998)<sup>7</sup>

CO<sub>2</sub> emissions from international bunkers were reported to be 7,184Gg<sup>8</sup>.

Figure 2.1 shows the percentage share of each Sector (and all energy sub-sectors) related to the total GHG emissions in 1990. The main emitters of GHG in Egypt are fuel combustion in the energy (22%) and industry (21%) sectors, Transport (18%) and Agriculture (15%). The energy-related emissions (“All energy”) are responsible for 71% of the total GHG emissions.

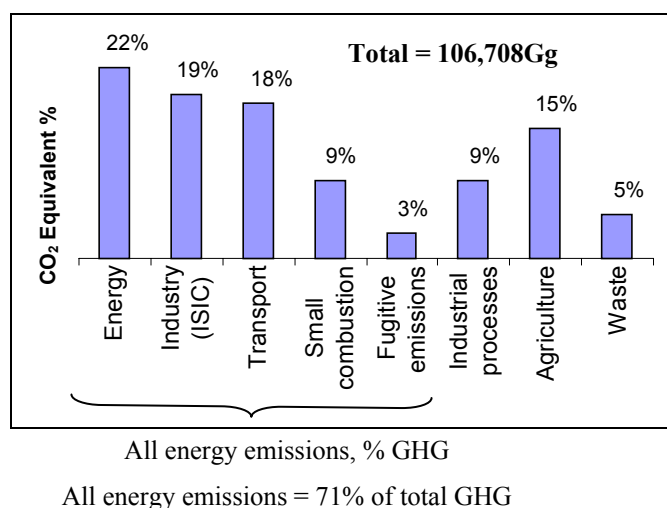


Figure 2.1: Sector Percentage Share of Net GHG Emissions, 1990/1991

Source: Extracted from OECP (1998)<sup>9</sup>

Important Notes: In the OECP report (1998), page 11, Table 2.4 titled “Greenhouse Gas Emissions 1990/1991”, the figure of Industry (ISIC) CO<sub>2</sub> emissions should be 21,342 Gg instead of 21,120 Gg as reported in the Summary Table 7A in the same OECP document.

In the same Table 4, the figure of Oil and Natural Gas fugitive emissions should be 147.56 Gg of CH<sub>4</sub> instead of 147.59 Gg as reported in the Summary Table 7A in the same OECP document.

<sup>7</sup> OECP (1998) P. 11

<sup>8</sup> OECP (1998) P.36

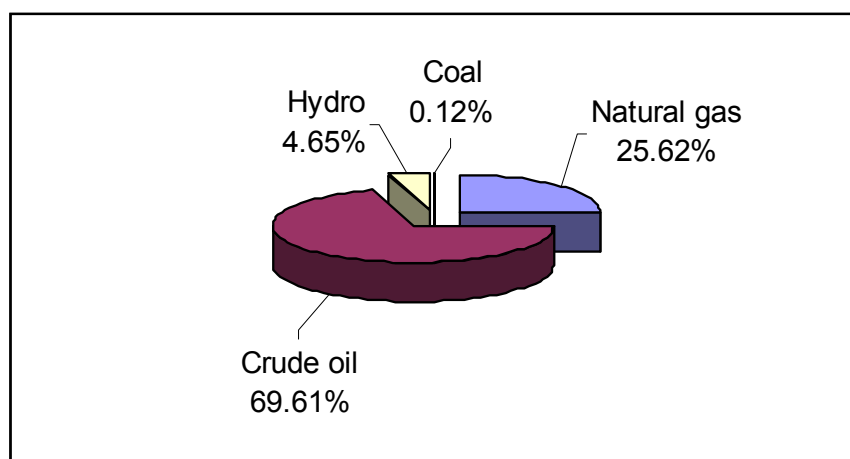
<sup>9</sup> OECP (1998) P. 11

The CO<sub>2</sub> emissions from international bunkers reported in the text of the OECD report (1998) should be 7,184 Gg instead of 7,253 Gg according to the figure in the Summary Table 7B in the same OECD document.

### 2.1.2.1 Emissions from “All Energy” Sector (fuel combustion and fugitive emissions)

The main energy sources of Egypt are oil, natural gas, and to a lesser extent hydropower (mainly generated from the high dam in Aswan). Coal, non-commercial fuels (e.g. agricultural residues, firewood, dried livestock manure etc), wind and solar energies play only a minor role as shown in Figure 2.2.

The electricity generation sector was the major consumer of fossil fuels in Egypt in 1990 (34%) followed by industry (27%), transport (23%), residential & commercial (13%), petroleum (2%) and finally agriculture (1%)<sup>10</sup>. The high dependency on petroleum as a primary energy source makes the energy production the highest contributor to the GHG emissions in Egypt (Table 2.1 and Figure 2.1).



**Figure 2.2: Primary Energy Production Pattern in Egypt**

Source: OEP (1998)<sup>11</sup>

### 2.1.2.2 Emissions from Industrial Processes

In 1990, the percentage share of the industrial sector was 18.5% of the total Egyptian GDP. The industrial base is highly diversified and activities include transport vehicles, textiles, consumer goods, electronics, pharmaceuticals, cement, iron & steel, fertilizers and aluminum industries.

Emissions from Industrial Processes include all GHG emissions that result from (chemical) processes in industry and that are not related to the combustion of fossil fuels, e.g. the production of CO<sub>2</sub> from the calcinations of limestone in the cement production. Emissions from fuel use in industry are included in Section 2.1.2.1.

Table 2.2 shows the total GHG emissions from major industries.

<sup>10</sup> MSEA, (1999), P.26

<sup>11</sup> OEP, (1999,) “Energy in Egypt” P.15

Table 2.2: GHG Emissions from Industrial Processes Sector – 1990/91\*

Industry	CO <sub>2</sub> (Gg)	CH <sub>4</sub> (Gg)	N <sub>2</sub> O (Gg)	CO <sub>2</sub> Eq (Gg)
A. Iron and steel	1318.71	7.8	-	1482.51
B. Non-ferrous Metals Aluminum production	390.94	-	-	390.94
C. Inorganic Chemicals Ammonia production Nitric acid production	143.68	1.45	0.86	174.13 266.6
D. Organic Chemicals Adipic Acid production	-	Not Available	-	Not Available
E. Non-Metallic Mineral Products Cement production Lime production	7867.3 55.9	-	-	7867.3 55.9
F. Others Carbon Black Methanol	-	0.02	-	0.042
<b>Total</b>	<b>9776.6</b>	<b>9.3</b>	<b>0.86</b>	<b>~ 10238</b>

Source: Adapted from OECF (1998)<sup>12</sup>

Egyptian emission factors were estimated for some industries, namely: iron and steel, aluminum and ammonia production. Those emission factors were extracted from case studies in relevant industrial plants. Activity data were obtained from the Ministry of Industry and the relevant holding industrial companies. The produced quantity of lime does not include the amount of lime used to produce iron & steel and cement. The type of produced cement in Egypt is mainly Portland cement and the IPCC default emission factors for CO<sub>2</sub> is used for estimating the CO<sub>2</sub> emissions from cement production<sup>13</sup>.

### 2.1.2.3 Emissions from the Agriculture Sector

In 1990/91, agriculture was the most important commodity sector in Egypt, constituting 17.6% of Egypt's GDP. The agriculture sector is the fourth largest source of GHG emissions in Egypt, 17,913 Gg of CO<sub>2</sub> equivalent and 15% of GHG emissions. This is mainly due to the methane emissions from the rice cultivation and animal manure. Rice is one of the main cereal crops in the Egyptian cropping pattern together with wheat and maize. In 1990, the total harvested area of rice was 0.43 million hectares which resulted in 189 Gg of CH<sub>4</sub> emissions<sup>14</sup>. The livestock population in Egypt is relatively small.

Table 2.3 shows the types and population of the recorded livestock in 1990.

Table 2.3: Livestock Types and Population in 1990/91

Animal	Cattle (Dairy & Non-Dairy)	Buffalo	Sheep	Goat	Camel	Horse	Mule & Ass	Swine	Poultry
Population (1000 head)	2,993	2,792	4,147	4,446	197	10	1,624	102	42

Source: Adapted from OECF<sup>15</sup>

\* The slight difference between the total sum of GHG emissions and those presented in Table 2.1 are due to rounding the figures to zero decimal places.

<sup>12</sup> OECF, (1998), P.47

<sup>13</sup> EEAA, (1999), P.52

<sup>14</sup> OECF, (1998), P.49

<sup>15</sup> OECF, (1998), P.48

As shown in Figure 2.3, the biggest source of methane emissions in this sector is the enteric fermentation, followed by the rice cultivation, manure management and lastly, field burning of agricultural residues.

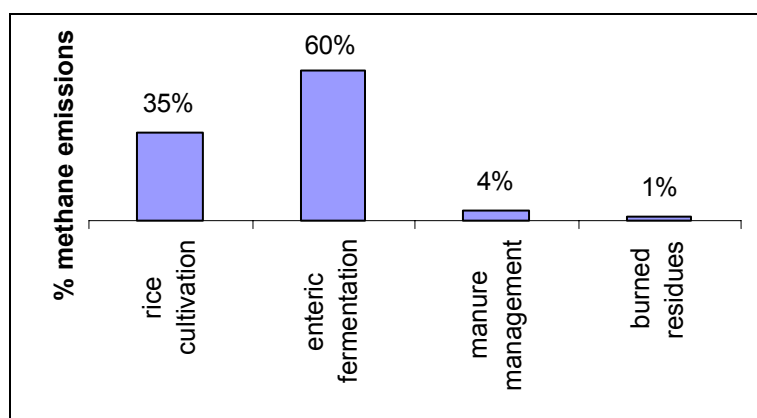


Figure 2.3: Percentage Emissions of Methane by Source – Agriculture Sector -1990  
Source: EEAA (1999)<sup>16</sup>

#### 2.1.2.4 Emissions from Land-Use, Land-Use Change and Forestry

No natural forests exist in Egypt. In 1990 the total number of planted trees was about 60 million forest trees.<sup>17</sup> The natural growth of non-forest trees existing along river Nile and in agriculture lands represented a net sink of with an amount of -9,900 Gg CO<sub>2</sub> Table 2.1 equivalent. There is no wood burnt as fuel in Egypt except agriculture residues and dung.<sup>18</sup> Recently more attention is given to establish tree plantations using treated wastewater.<sup>19</sup>

#### 2.1.2.5 Emissions from Waste Sector

This section reports the total emissions from solid waste disposal on land, wastewater, waste incineration and any other waste management activity. Methane is the main greenhouse gas emitted from this sector with an amount of approximately 271 Gg CO<sub>2</sub> equivalent (Table 2.1). It results from the anaerobic bacterial decomposition of organic matter in the landfills and open dumps and also from the treatment of industrial and domestic wastewater. It is estimated that 75% of the total municipal solid waste in Egypt is generated from urban areas. The major constituent of this waste is organic waste (60%). Municipalities and the private sector share responsibility for waste management in different governorates. In 1990, only two governorates out of twenty-six were using a landfill disposing system while the rest were using open dumps. It was assumed that the landfill disposal emits double the quantity of that emitted from open dumps. In both cases, there were no CH<sub>4</sub> recovery systems in place. The fraction for solid waste was estimated as 0.15 for landfills and 0.82 for open dumps.<sup>20</sup> As shown in Figure 2.4, the solid waste disposal represented about 97% (71.5% + 26.1%) of the total CH<sub>4</sub> emissions of the waste sector.

<sup>16</sup> EEAA, (1999), "Initial National Communication on Climate Change" P.53

<sup>17</sup> OECP, (1999) P. 53

<sup>18</sup> EEAA, (1999) P.54

<sup>19</sup> Personal interview with Ahmed Abd-Rabbo, EEAA coordinator for climate change program, TIMS, (03/07/2001)

<sup>20</sup> OECP (1998) P. 9

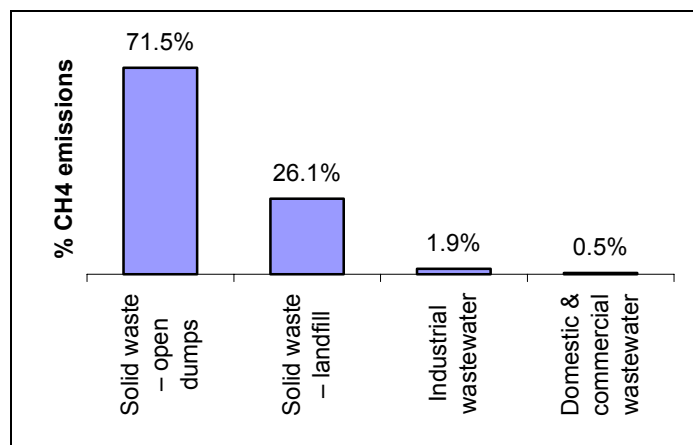


Figure 2.4: Percentage Share CH<sub>4</sub> Emissions – Waste Sector 1990/91

Source: Adapted from OECD (1998)<sup>21</sup>

As for wastewater, the national average BOD was assumed to be 0.035 Gg/year/1000 persons according to the urban population ratio. The water consumption was estimated as 270 liter/capita/day and the domestic wastewater was assumed to be the same. The methane emission factor used for domestic and commercial wastewater was 0.22. Due to lack of data, emissions from some food and beverage industries were not included in the inventory.<sup>22</sup>

#### 2.1.2.6 Emissions from Biomass

CO<sub>2</sub> emissions from biomass (agricultural residues, fruit trees, and dung) are estimated as 9,543 Gg<sup>23</sup>. This figure is excluded from the total emissions of the energy sector according to the IPCC guidelines. The CH<sub>4</sub> and N<sub>2</sub>O emissions are included in the calculations for GHG emissions of the “All Energy” sector.

#### 2.1.2.7 Emissions from International Bunkers

CO<sub>2</sub> emissions from international bunkers (aviation and marine) recorded in 1990/91 were 7,184 Gg and they are excluded from the total national GHG emissions according to the IPCC guidelines.<sup>24</sup>

### 2.1.3 Discussion

It is clear, from the previous presentation of GHG emissions from different sectors, that the electricity generation sector is the main contributor to the GHG emissions in Egypt (22%). This is mainly due to the high dependency on fossil fuels, mainly heavy oil. Increasing the share of renewable energy sources represents a big potential for reducing or maintaining the current levels of GHG emissions, given the expectations of increased demands for electricity in the future.

Due to its provision of job opportunities and significant contribution to the national economy, the Government of Egypt (GOE) has been encouraging the establishment of different types of industries. Industrial parks; and tax exemptions have encouraged local and foreign investors to establish new industries. The GHG emissions from the combustion of fossil fuels for the different industrial purposes ranked second with a percentage share of 19%. The Egyptian industry is currently not operating with the optimal energy efficiency and since it is vital for the Egyptian economy - further

<sup>21</sup> Adapted from OECD (1998) P. 55 - 58

<sup>22</sup> EEAA, (1999), P.54 -57

<sup>23</sup> OECD, (1998), P.35

<sup>24</sup> OECD, (1998), P.36

expansion foreseen - that the Egyptian industry must improve its overall energy efficiency. This will not only reduce GHG emissions but will also generate financial savings in many cases.

Due to the increase of the per capita annual income, and the growth of the overall economical activities, there has been a significant growth in the transportation sector. Per capita car ownership has increased and the establishment of new cities and expansions of the urban areas have increased the need for transportation. Since all transport facilities in Egypt use fossil fuels, the transportation sector ranked third in terms of GHG emissions (18%).

The agriculture sector is another fast growing sector as it is part of the GOE policy to narrow the gap between the demand and supply of locally grown food. There are ongoing projects for land reclamation and efforts to increase the crop yield per Feddan. The rice crop, being highly marketable and profitable for farmers, represented one of the favorable crops to grow and increase its annual yield. The GHG emissions from the agriculture sector ranked fourth among all other economic activities with a percentage of 15%.

## **2.2 Projection of GHG Emissions**

### **2.2.1 Methodology, Data Used and Economic Scenarios**

In order to develop simple projections of the development of GHG emissions in the future, constant growth factors for GHG emissions have been extracted and estimated from relevant previous studies. When a previous study estimated a GHG emission growth factor for a specific sector, its methodology is revised to check its validity and applicability for the purpose of this CDM report. In the sectors where no previous studies existed, justified assumptions are used and explained (see in the sections below).

The estimation of Egypt's GHG emission projection in previous studies was carried out for two sectors only: energy and waste. This was done partially in the Support for National Action Plan (SNAP) and the GEF building capacity project. The results were presented in the National Action Plan on Climate Change report issued by MSEA in 1999<sup>25</sup>.

For all sectors, the period chosen for estimating the GHG projection extends till the fiscal year 2016/2017, which represents the objective year for achieving the economic and social development plans<sup>26</sup>. Please note that no comprehensive inventory data and GHG projection data was available for Egypt for the recent years. Nevertheless, the resulting inventory and projections data in this section may be used to indicate the most important GHG emitting sectors that should be targeted to identify GHG mitigation measures.

### **2.2.2 Projection of Baseline Emissions by Sector**

#### **2.2.2.1 GHG Projection for the "All Energy Sector"**

An intensive effort was done by the SNAP project at OEP to estimate the GHG emission growth factor for the energy sector. The present section on energy related emissions are based on these figures. Based on the growth rates of total and sector GDP (6.6%), population (1.6%), fuel prices, and using the income and elasticity of the price previously developed at OEP, the future total and sector energy demand during the period 1990/91 – 2016/17 have been determined using Energy and Power Evaluation

<sup>25</sup> MSEA, 1999, P. 36 - 41

<sup>26</sup> Ministry of Planning, 1997, "Social and Economic Development Plans"

Program (ENPEP). The total energy consumption was estimated to increase from 1156 PJ in 1990/91 to 4177 PJ in 2016/17. The total CO<sub>2</sub> emissions are expected to increase from about 75 million tons in 1990/91 to 261 million tons in 2016/17 with annual growth rate of 4.9%. While the power generation (electricity) sub-sector was the major contributor to CO<sub>2</sub> emissions (32% of the “All Energy” sector CO<sub>2</sub> emissions) in 1990/91, it is expected that the industry sub-sector will become the major contributor to CO<sub>2</sub> emissions with a share of 49%, followed by power generation, (29%) and transport (14%)<sup>27</sup>.

#### 2.2.2.2 GHG Projection for the Industrial Processes Sector

It is the GOE policy to encourage establishment of new industries. Industrial parks are being established nationwide with many economic incentives. The industry’s share in the country’s GDP has increased in the last few years. The actual average annual growth rate for the industrial sector reached 4.76% in 1991-1995<sup>28</sup>.

#### 2.2.2.3 Emissions from the Agriculture Sector

The rice crop yield has increased from 3448 million tons in 1991/92 to 4452 million tons in 1998/99 with a percentage increase of about 4% annually<sup>29</sup>. It is assumed that this growth rate will continue at the same rate in the future five-year development plans until 2016/2017. This growth rate will be used to estimate the GHG projection from the agriculture sector.

#### 2.2.2.4 Emissions from Land - Use, Land - Use Change & Forestry

Since no previous projection studies in Egypt have been made on the GHG emissions from land use, land use change & forestry, this part will be discussed in detail in Annex 2.3 to this chapter.

#### 2.2.2.5 Emissions from the Waste Sector

The Egyptian population was assumed to increase by an average growth rate of about 1.6% during the study period 1990/1991 – 2016/2017<sup>30</sup>. This figure is used to estimate the GHG emissions projection.

#### 2.2.2.6 Projection of Total Emissions

Table 2.4 shows the calculation of GHG emissions using the estimated growth rate for each sector.

Table 2.4: GHG Projection for all Sectors (in 1000 Gg of CO<sub>2</sub> eq)

	Energy	Industrial Processes	Agriculture	Waste	Land-Use & Forestry	Total CO <sub>2</sub> eq
1990/1991	82.73	10.28	17.91	5.69	-9.900	106.71
1996/1997	110.23	13.58	22.67	6.26	NA	151.46
2001/2002	140.02	17.14	27.58	6.78	NA	188.73
2006/2007	177.85	21.62	33.55	7.34	NA	235.56
2011/2012	225.91	27.29	40.82	7.94	NA	294.46
2016/2017	286.96	34.43	49.66	8.60	NA	368.61
<b>Growth Rate</b>	<b>4.90%</b>	<b>4.76%</b>	<b>4%</b>	<b>1.6%</b>	<b>Not Available</b>	<b>Not Applicable</b>

<sup>27</sup> MSEA, (1999) P.35 - 39

<sup>28</sup> MSEA, (1999) P.4

<sup>29</sup> Egypt’s State Information Service, “Eighteen years of achievements”. Available: <http://www.sis.gov.eg/public/18years/html/frame.htm>

<sup>30</sup> MSEA, (1999), P. 36

Figure 2.5 shows the GHG projection for all sectors (except land-use and forestry). On the basis of these rough assumptions for all sectors, the total GHG emissions of Egypt are expected to raise to 345% above 1990 levels until 2017, a projected increase typical for developing countries. The all energy sector is expected to remain by far the major source for GHG emissions in the future and to increase its share with the highest growth rate. Efforts should be done to meet Egypt's need of energy and meanwhile reduce the GHG emissions. Another high growth of GHG emissions is expected in the agriculture sector due to the expansion in land reclamation and the ongoing need to meet the demand on essential crops for the growing population.

Please note that uncertainties in such projections are assumed to be very high and that the results should be interpreted with caution.

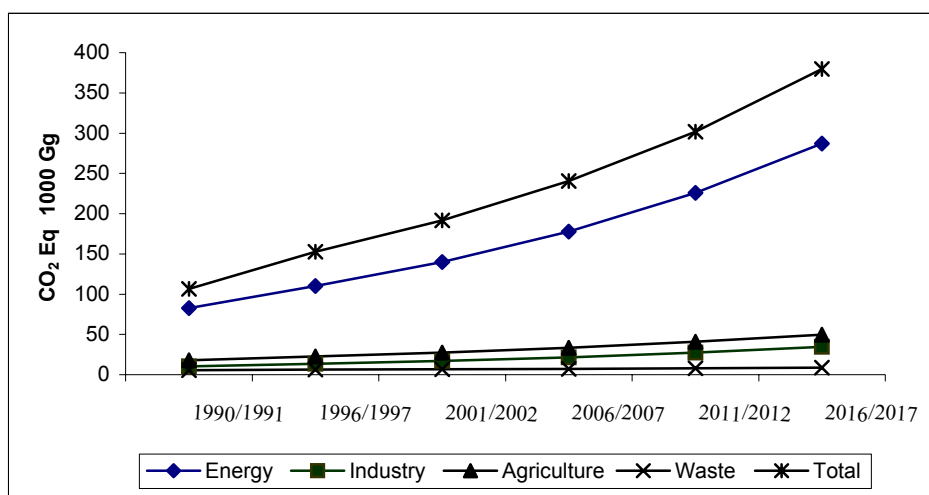


Figure 2.5: GHG Projection from All Sectors

### 2.3 GHG Reduction/Avoidance Potential

This section provides an overview of project types, which if implemented on a national scale, can significantly reduce Egypt's total GHG emissions. The proposed projects are mainly in the energy sector (including transportation) since it is the major current and future contributor to the GHG emissions in Egypt as discussed in the previous sections. The purpose of this section is to assess the potential for reduction/avoidance of GHG emissions through various technology options in different sectors.

#### 2.3.1 Methodology and Data Used

Different project types were investigated for GHG reduction potential. In this chapter, the project types are presented with an overall view of the reduction potential depending on the replication potential of specific projects within the same project type. The replication potential is based on the technical feasibility of the proposed technology and the capacity to implement a number of specific projects of the same project type repeatedly until the year 2010.

The overall GHG emission reduction is then calculated in a bottom-up, or project-based, approach together with the calculation of the average cost of saved carbon. The bottom-up model focuses on individual processes such as end-use energy consumption, which do not have to assume market equilibrium, thus intervention in the market place may be achieved at a negative cost.

A previous study conducted by UNEP used another approach to calculate the marginal abatement cost; that is the top-down model. The top-down analytical method assumes

a macroeconomic perspective, wherein mitigation costs are defined in terms of losses in economic output, income and GDP. A key assumption underlying many top-down analyses is that the baseline scenario represents the economy in equilibrium, with all factors of production employed efficiently given prevailing prices. Thus mitigation options are interpreted to cause deviations from an equilibrium situation, which results in positive costs to the economy.

There is currently no modeling framework available in Egypt to complement the bottom-up model with the top-down one. Usually the bottom-up project-based approach results in higher costs than the top-down approach, because the project level data reflects barriers that are not represented in the idealized models. Also, the identified list of CDM projects should not be regarded as comprehensive, as only project types with sufficient data availability have been considered.

Therefore the present Marginal Abatement Cost of selected project types gives a rather conservative picture of the possible CDM market in Egypt. The description in this chapter follows a financial analysis of the projects, using the prices of fuel and power for the user, not an economic analysis using international prices. With this, prices also reflect barriers to CDM that result from subsidies for fossil fuels. The costs related to the submission, validation, verification and certification of CDM projects (transaction costs) have not been included. Details on data and methods for cost and emission calculations and baseline setting are presented in Chapter 6.

Calculating the GHG reductions in a bottom-up approach was based on:

- Definition of the project type.
- Definition of the baseline (business as usual case).
- Estimating the cost for the proposed project type.
- Estimating the lifetime of the typical project.
- Calculating the total CO<sub>2</sub> emission reduction with respect to the baseline.
- Calculating the incremental cost per ton of carbon saved or sequestered in typical projects.

In order to estimate the replication potential for each project type, experts in the relevant fields were consulted and documented sources were reviewed. For the renewable energy and transportation project types, national studies were consulted.

For the energy efficiency project types, a comprehensive study<sup>31</sup> was conducted by the ECEP project to calculate the replication potential for each energy efficiency technology. The market size, practical replication and total saved carbon were obtained from this study. The replication potential used in this report in the energy sector adopts the conservative scenario, which estimates that 21% of the total market size will respond and actively participate in the energy efficiency programs.

It is worth noting that in energy efficiency project types considered, the reduction of CO<sub>2</sub> emissions is usually accompanied by financial benefits, and the projects generate financial profits. This is mainly due to the significant reduction in the fuel related operation costs. However, the implementation of energy efficiency projects may be hindered by other barriers, such as very lengthy payback periods, lack of financing, import taxes, lack of technical know-how etc.

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<sup>31</sup> ECEP/USAID, (1998), "The replication potential of ECEP applications: An assessment of national energy, economic, and environmental benefits"

### 2.3.2 Reduction / Avoidance Potential in Different Sectors

In this section, a number of possible CDM project types are briefly described followed by Table 2.5, which summarizes the estimated potential quantity of Ton Carbon reduced and the average cost of saved carbon. Potential for replication is also presented in this table. In Chapter 6, specific projects are extracted from each project type and described and analyzed separately in detail.

#### 2.3.2.1 Renewable Energy Applications in Electricity Generation

a. Electricity Generation by Wind Farms	The potential of wind energy in Egypt was estimated as a result of the national wind resource assessment program based upon 44 measuring stations, which proved the abundant wind energy potential of 100,000 MW at the Western coast of the Suez Gulf, the Northern Coast of Egypt, South Sinai and East Oweinat. Egypt aims to increase the installed capacity of the wind power to reach 600 MW by the year 2010. The Government of Egypt (GOE) plans to finance 300 MW and the remaining 300 MW are expected to be installed by the private sector based on the BOOT system. The capacity range of wind farms could start from 5 MW, 60, 100, 150, and 200 MW for each wind farm. According to the current plans for establishing new fossil fueled power plants, the Business As Usual scenario indicates that the highest share of energy generation will be mainly from steam turbine power plants with a share of 42.6% of the total planned capacity, which represents a technical potential for establishing ten – 60 MW wind farms by the year 2010.
b. Electricity Generation by Integrated Solar Thermal / Combined Cycle System -ISCCS	In 1995, both NREA and EEA completed an assessment and identification study for the hybrid solar thermal electricity generation potentials which concluded that: <ul style="list-style-type: none"> <li>• High potential exists for national grid connected system. Priority is given to the areas having higher solar radiation intensity and access to both electrical grids and natural gas networks</li> <li>• The integrated hybrid solar combined cycle system using parabolic trough solar technology is the most appropriate system to be applied in Egypt.</li> </ul> The program of ISCCS for Egypt consists of three power plants; the first is of 130 MW capacity and is currently in the phase of preparing the technical documents for the request for proposals (RFP), the second and third plants are of 300 MW capacity each and they can be implemented through the CDM project. It is estimated that 2 x 300 MW plants can be established by the year 2010.

#### 2.3.2.2 Other Renewable Energy Applications

Given the high values of irradiation in Egypt, solar energy can be utilized as a promising clean energy source; especially in the new remote communities, which are currently being established.

a. Solar Photo Voltaic water pumping	The use of photovoltaic for water pumping and other uses in remote villages and new reclaimed lands is another application of renewable energy. A good example is the PV-powered pumping station system with a capacity of 14 kW in Wadi El Natroun. Another example is the portable PV water-pumping unit at West Nobareya with a capacity of 2.2 kW. There are 500,000 Feddan of new reclaimed lands in the South of Egypt, which can be partially irrigated using PV-powered pumping systems. To estimate the technical replication potential for this project type, it is assumed that out of the new reclaimed lands (approximately 500,000 Feddan), 20% can be irrigated by the proposed system (approximately 100,000 Feddan). This results in a technical replication potential of 1000 systems (given that a system can cover 100 Feddan). To estimate the replication potential until the year 2010, it is assumed that 60% of the technical potential can be achieved (approximately 600 systems to cover 60,000 Feddan). However the economic feasibility of such PV pumping systems should be carefully considered case by case.
b. Solar food-dehydration	Solar energy can be utilized for the production of hot air or steam for the purpose of drying food crops, especially vegetables and fruits. The best application for this project type is in the new reclaimed lands in the high irradiation areas such as in Toushka, South of Egypt. It is estimated that 200,000 ton of crops can be dried annually using this technology.

### 2.3.2.3 Transportation Projects

As discussed in Section 2.1, transportation is an important and increasing source of GHGs in Egypt. Transport is therefore an important target of CDM measures.

a. Railway Electrification Projects	Electrification of railway systems should concentrate on routes with high traffic density. In Egypt there are three major routes, all connected to Cairo. The first one to Alexandria (about 208 km) gives the highest density for passengers and freight. The second line is to Ismailia and Port Said (on the Suez Canal about 230 km) and it comes as the second railway line as concerns density. However, because of the potential for new development in Sinai and Suez Canal region, this route can attract more users if upgraded. The possibility of electrifying a third railway line - when applicable - would be applied to the route to Upper Egypt, from Cairo up to Aswan. However, the possibility of electrifying this route is less likely due to its length (about 900 km), which will make it very expensive especially when it is newly constructed as double track. Switching to electricity for power generation in railways, in addition to the increase in passenger capacity will contribute to air emission reduction because of more efficient use of fuel and attraction of passengers from other polluting modes such as aeroplanes and cars. The total kilometers that are technically feasible to be electrified until the year 2010 are estimated to be 438 km which basically means the electrification of 2 lines, Cairo-Alexandria, and Cairo-Port Said.
b. Mass Transit Underground System	As discussed, transportation is one of the major sources of GHG emissions in Egypt. Emissions from transport depend on the choice of the modes of transportation such as private cars, public and private group transportation facilities, etc. The Mass transit underground system is one of the key solutions proposed to shift the mode of transportation from private and public surface facilities to an underground electrified transit system. This is expected to lead to significant reduction of air emissions, especially GHG. It is estimated that 55 km of underground metro tunnels can be established until the year 2010.
c. Waterway Transportation	The share of waterway transportation in the freight transport is very minor when considering the length of the River Nile and its navigable branches in Egypt. There are some bottlenecks that need to be upgraded in order to make the freight waterway transportation performance higher and attract more users. Upgrading the system can be done by defining the navigation routes with lighted buoys and lanterns, making the necessary dredging in shallow areas as well as solving the locks problems. These improvements may raise the share of the waterway transportation from 2 % to 10 % or more. This share will consequently mean a reduction in the road transport share, which is about 90 % now. This means less number of trucks will be on the road and consequently less emission. The technical potential for this project type is approximately 150 million tons of cargo.
d. Fuel Switching	This project can be applied, on a large scale, to the public transport buses such as in Cairo and Alexandria. Approximately 200 buses are replaced every year by the Cairo Transport Authority. Using natural gas instead of diesel or gas oil will reduce the air emission. There are 57 stations for supply and conversion vehicle, buses & taxis, on the hand, selling price of CNG is 0.45 LE/M <sup>3</sup> as a result one cubic meter of CNG which is equal to liter of a gasoline costs less than half the price of a liter gasoline depends on kilometers driven and the entire conversion cost can be recovered in less than two years and continue to save more than 50% on fuel cost over the remaining life of the vehicle. The Greater Cairo Bus Company fleet is composed of 3200 buses. It is estimated that 100 bus engines can be converted every year until the year 2010, which amounts to approximately 800 converted bus engines

### 2.3.2.4 Energy Efficiency

a. Energy Saving Process	<p>The anticipated energy saving due to the implementation of a nation-wide fuel to air ratio control program was estimated at 13%. Cost Benefit Analysis was conducted for burners in the range between 2 MW and 22 MW. Based on a detailed analysis<sup>32</sup> conducted during the ECEP project, it was estimated that in order to achieve the 13% annual energy saving, an investment of US\$ 111 million is required.</p> <p>Another combustion control program is to establish 40 tune-up centers distributed over the industrial locations and parks in Egypt. Based on past experience with boilers and furnaces tune up activities, a national tune up program is proposed as a CDM. The related fuel savings for boilers are about 7% while those for furnaces are about 3%. It is estimated that 75% of the total installed boiler capacity and 60% of the total installed furnace capacity will benefit from this program.</p>
b. Waste Heat Recovery	<p>Eight technology options are proposed under WHR: regenerative burners, metallic recuperators, economizers, water treatment facilities, boiler feed water pre-heater systems, boiler combustion air preheating, feeding material preheating systems, and waste heat boilers. The WHR projects are expected to give maximum results on implementing projects related to switching liquid fuel (light and heavy oil) to natural gas.</p>
c. Cogeneration	<p>Combined heat and power generation, or cogeneration, offers a very high potential for energy saving hence substantial reduction in GHG emissions. The results from the replication survey, conducted by the ECEP project, indicated that many end-users require the simultaneous use of both electricity and thermal energy. Energy saving from cogeneration is generated by meeting the electricity <i>and</i> steam demand on-site through the use of a single fuel source. The on-site generation of power saves additional energy by eliminating losses involved in the transmission and distribution of electricity. Cogeneration can be implemented in different sectors with different market sizes.</p>
d. Fuel Switching in Industry	<p>Energy saving from converting old oil-fired ovens, heaters and dryers to natural gas is due to improved fuel combustion (gas mixes with air more efficiently than in old oil burners) and high efficiency of new burners. Together with the lower carbon content of natural gas (ton C emitted per GJ), this leads to a reduction of GHG emissions. The potential for switching to natural gas in different sectors is limited by the availability of gas networks and accessibility. However, the study conducted by the ECEP project estimated that switching from fuel to Natural Gas in the food industry can result in saving a total of 97,608 Ton Carbon.</p>

### 2.3.2.5 Solid Waste Management

a. Methane Recovery from Sanitary Landfill	<p>The Egyptian Environmental Affairs Agency, EEAA, in cooperation with different governorates, is preparing some sites to be used as proper sanitary landfills. Different technologies can be applied to utilize the methane gas resulting from municipal solid wastes. It is proposed that a methane gas collection and utilization system be established in landfills. The collected methane gas will be utilized as an energy source, which is expected to reduce the overall amount of GHG emissions from landfills. Another project area is the in-vessel digestion of organic wastes, from the food industry for example.</p> <p>The main advantage of biogas technology, from the point of view of GHG emission reduction, is: CO<sub>2</sub> neutrality, avoidance of uncontrolled methane emissions (with a high global warming potential) and energy efficiency. However the production of high value organic fertilizers and improving both health and environment conditions are additional very important advantages. There are about 5.6 million tons of municipal solid wastes that are generated annually in urban areas. With a total efficiency of about 60% and assuming that 25 % of the wastes can be utilized for methane gas production until 2010, the technical replication potential is estimated to be 840,000 tons of waste.</p>
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<sup>32</sup> ECEP/USAID, (1998), "The replication potential of ECEP applications: An assessment of national energy, economic, and environmental benefits".

b. Utilizing Organic Waste as Animal Fodder	In the food industry sector, organic waste constitutes the highest percentage of the total solid waste generated. Simple technology can be used to convert this organic waste into animal fodder, thus eliminating a fair share of GHG emissions from dumped organic waste. It is estimated that 10 modules can be established to convert organic wastes, from the food industry, into animal fodder.
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### 2.3.2.6 Land - Use, Land - Use Change and Forestry

A. Tree Plantation for Protecting New Cities	Establishing wood lots and shelterbelts around most of the new important industrial cities to protect it in addition to wood production and greening of the area.
B. Tree Plantation for Protecting Irrigation and Drainage Canals	Establishing windbreaks along the main irrigation and drainage canal to protect it in addition to wood production and greening of the area.
C. Tree Plantations for Protecting Stabilization of Coastal Sand Dunes	Fixing sand dunes in the vicinity of farmlands, roads, settlements, industrial complexes and valuable installations and providing wood and fodder.
D. Tree Plantations for Protecting Roads	Planting 2 rows windbreaks along both sides for protecting of the International Sahelian highway from Rosetta to Damietta using both fresh and/or agricultural wastewaters.

Table 2.5: Summary of Proposed CDM Project Types

Project Type	Average Marginal Incremental Abatement Cost US\$/Ton C <sup>33</sup>	Unit of Calculation (Specific Ton C Reduction)	Replication Potential Until 2010	Total Carbon Saved / Sequestered Per Year (Ton C) <sup>34</sup>	Number of Projects
<b>Renewable Energy</b>					
1. Electricity generation by wind farms.	30	40,138 Ton C / 60 MW	600 MW	401,380	2 x 300MW
2. Electricity generation by Integrated Solar Thermal System	65	80,910 Ton C / 300 MW	600 MW	161,820	2 x 300MW
3. Other solar energy applications (Solar PV pumping)	2100	80 Ton C / 100 Feddan	60,000 Feddan	48,000	2 x 30,000 Feddan
4. Solar food-dehydration	156	1690 Ton C / 200,000 Tons Dried	2000,000 Tons	16,900	
<b>Transportation</b>					
5. Railway electrification	1600	21,073 Ton C / 208 km	438 km	44,375	3
6. Underground mass transit system	3169	11,579 Ton C / 22 km	55 km	28,948	3
7. Waterway transportation	97	Ton C / Ton cargo	150 x 10 <sup>6</sup> ton	32,000	1
8. Fuel Switching to Compressed Natural Gas	-300	2,580 Ton C / 100 CNG-Engine	800 Bus Engines	20,640	1

<sup>33</sup> The average marginal incremental abatement cost is given in US\$ per ton of Carbon saved or sequestered. To convert the values to cost per ton of carbon dioxide (CO<sub>2</sub>), divide by 3.66 (e.g. 30 US\$/tC = 8.18 US\$/tCO<sub>2</sub>).

<sup>34</sup> The amount of annually saved or sequestered GHG is given in ton of carbon. To convert the values to tons of carbon dioxide (CO<sub>2</sub>), multiply by 3.66 (e.g. 400,000tC = 1.46 million tCO<sub>2</sub>).

Table 2.5: Summary of Proposed CDM Project Types (Cont.)

Project Type	Average Marginal Incremental Abatement Cost US\$/Ton C	Unit of Calculation (Specific Ton C Reduction)	Replication Potential Until 2010	Total Carbon Saved / Sequestered Per Year (Ton C)	Number of Projects
<b>Energy Efficiency – Cogeneration *</b>					
9. Food and beverage	-220	Ton C / TOE	11,340 (TOE)	73,496	
10. Textile	-380	Ton C / TOE	84,000 (TOE)	544,414	
11. Metals	-160	Ton C / TOE	47,250 (TOE)	306,233	
12. Hotels	-45	Ton C / TOE	23,520 (TOE)	152,436	
13. Building	-90	Ton C / TOE	42,420 (TOE)	274,929	
14. Chemicals	-260	Ton C / TOE	54,600 (TOE)	353,869	
<b>Energy Efficiency – Waste heat recovery *</b>					
15. Food & Beverage	-80	Ton C / TOE	3,066 (TOE)	13,649	
16. Textile	-80	Ton C / TOE	13,083 (TOE)	58,240	
17. Metals	-80	Ton C / TOE	8,652 (TOE)	38,515	
18. Chemicals	-80	Ton C / TOE	22,764 (TOE)	101,336	
<b>Energy Efficiency – Control systems and energy saving equipment *</b>					
19. Food & Beverage	-80	Ton C / TOE	8547 (TOE)	37,085	
20. Textile	-80	Ton C / TOE	12747 (TOE)	55,309	
21. Metals	-80	Ton C / TOE	1890 (TOE)	8,201	
22. Hotels	-80	Ton C / TOE	1512 (TOE)	6,560	
23. Chemicals	-80	Ton C / TOE	23772 (TOE)	103,145	
24. Buildings	-80	Ton C / TOE	252 (TOE)	1,093	
<b>Fuel Switching to Natural Gas – in Industry</b>					
25. Food	-21	Ton C / TOE	101,700 (TOE)	97,608	
<b>Waste Management</b>					
26. Methane recovery from Municipal solid waste landfills	0	30,000 Ton C / 125,000 Ton waste processed	840,000 Ton Waste	201,600	1
27. Organic food waste management	0	37,336 Ton C / module	10 modules	37,336	1
<b>Land Use, Land Use Change and Forestry</b>					
28. Casuarina and sissoo plantations around new cities	12.29	39000 tC on 500 ha	3100 ha	240,000	
29. Acacia stenophylla plantations around new cities.	32.62	5000 tC on 100 ha	4800 ha	240,000	
30. Planting along irrigation and drainage canals	14.11	5628 tC on 70 ha	12000 ha	967,900	
31. Coastal sand dune fixation	7.11	10200 tC on 1000 ha	10000 ha	101,870	
32. Planting of roads and highways	17.71	9429 tC on 70 ha	8350 ha	1,123,650	

\* Extracted from ECEP study

### 2.3.3 Cumulated GHG Reduction Potential

Table 2.6 presents the GHG emission reduction potential, which can be achieved by implementing specific projects of different technologies on a wide scale using the replication potential estimated in the previous section. The table is sorted based on the cost of saved carbon. The Marginal Abatement Cost Curve for selected projects in

Egypt is graphically represented in Figure 2.6 representing the cost of saved carbon in US\$ against the cumulated saved carbon in Ton C.

Please note that this estimated CDM potential in Egypt is based on a limited list of projects that have been proposed for implementation and for which data was available. Also, the replication potentials are restricted to specific applications proposed by the project proponents and based not on a comprehensive assessment of the fields of application. Therefore, the presented potential serves mainly to illustrate interesting options for CDM in the country; it may be assumed that the actual potential for CDM projects in Egypt is higher.

**Table 2.6: Summary of Technologies, Saved Carbon and Cost of Saved Carbon**

	Area of Application	Technology	CSC (US\$/ton C)	Ton C Saved
1	Textile	Cogeneration	-380	544,414
2	Fuel switching in transportation	Fuel switching	-300	20,640
3	Chemicals	Cogeneration	-260	353,869
4	Food and beverage	Cogeneration	-220	73,496
5	Metals	Cogeneration	-160	306,233
6	Building	Cogeneration	-90	274,929
7	Buildings	Combustion Control	-80	1,093
8	Hotels	Combustion Control	-80	6560
9	Metals	Combustion Control	-80	8201
10	Food & Beverage	Waste Heat Recovery	-80	13,649
11	Food & Beverage	Combustion Control	-80	37085
12	Metals	Waste Heat Recovery	-80	38,515
13	Textile	Combustion Control	-80	55309
14	Textile	Waste Heat Recovery	-80	58,240
15	Chemicals	Waste Heat Recovery	-80	101,336
16	Chemicals	Combustion Control	-80	103,145
17	Hotels	Cogeneration	-45	152,436
18	Fuel switching in industry	Fuel switching	-21	97,608
19	Organic waste management	Waste Management	0	37,336
20	Methane recovery from Municipal solid waste	Solid Waste Management	0	310,600
21	Coastal sand dune fixation	LULUCF	7.11	101,870
22	Casuarina and sissou plantations around new cities.	LULUCF	12.29	240,000
23	Planting along irrigation and drainage canals	LULUCF	14.11	967,900
24	Planting of roads and highways	LULUCF	17.71	1,123,650
25	Renewable energy for electricity generation (wind farms)	Renewable Energy	30	401,380
26	Acacia stenophylla plantations around new cities.	LULUCF	32.62	240,000
27	Integrated solar thermal Combined Cycle system	Other Renewable Energy	65	161,820
28	Waterway transportation	Transportation	97	32,000
29	Railway electrification	Transportation	1600	44,375
30	Solar pumps	Renewable Energy	2141	48,000
31	Underground mass transit system	Transportation	3169	28,948

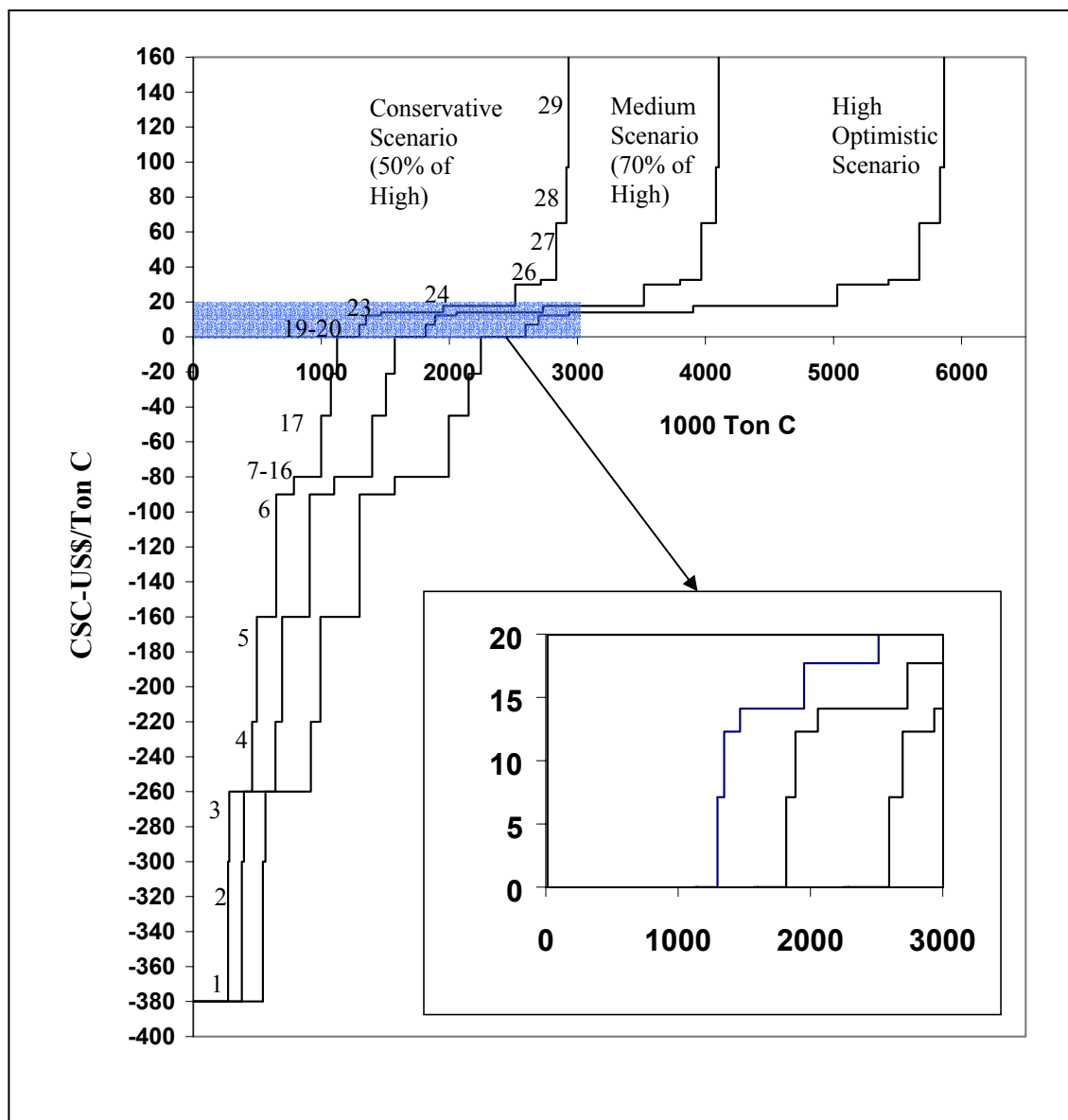


Figure 2.6: Egypt's Marginal Abatement Cost Curve with Three Scenarios

### 2.3.4 Discussion

Three scenarios are presented in the marginal abatement curve, optimistic, medium and conservative. The optimistic scenario assumes that all policies and economic conditions are in favor of the CDM projects and this is reflected in the assumed replication potential for each technology. For a medium scenario, it was assumed that, due to a few barriers, the replication potential would be less and consequently the potential for GHG reduction would be less. The medium scenario assumes 70% of the GHG reduction in the optimistic scenario. The third scenario, conservative, assumes high political and economical barriers, which would result in only 50% of the expected GHG reduction in the optimistic scenario.

It is clear from Figure 2.6 and Table of Marginal Abatement Cost of selected projects above, that significant emission reduction can be achieved through the implementation of CDM projects in the areas proposed. A large fraction of the proposed project types are 'no-regret' options, with no or negative cost of saved carbon. Assuming an

international market price of US\$ 31 per ton of C (8.5 US\$/tCO<sub>2</sub>; see market analysis below), the ultimate GHG reduction expected by the year 2010 (if all the selected projects are implemented under an optimistic scenario) can reach about 3 million Tons of Carbon (11 MtCO<sub>2</sub>; about 3% of the overall GHG inventory of Egypt).

Please note that this estimate of the CDM potential in Egypt is based on a limited list of projects that have been proposed for implementation and for which data was available. Also, the replication potentials are restricted to specific applications proposed by the project proponents and not on a comprehensive assessment of the fields of application. Therefore, the presented potential serves mainly for illustrative purposes, and the actual total potential for CDM projects in Egypt is significantly higher.

The Energy Efficiency technologies (combustion control, cogeneration, waste heat recovery and fuel switching) show the highest priority in terms of the “no regret scenario” where the cost of saved carbon is negative, which means that the GHG reduction is accompanied by direct financial savings. Previous studies (such as SNAP, 1997 and ECEP, 1998) also support the current results. Implementing the energy efficiency in different sectors in Egypt may result in GHG reduction of about 1 to 2 million Ton C under the conservative and optimistic scenarios respectively.

In addition to the energy efficiency technologies, the current study supports investing in the waste management sector to produce methane gas as an alternative energy source and utilizing the organic waste from the food industry to produce animal fodder. The waste management sector represents a national priority, as declared by the Ministry of State for Environmental Affairs, therefore any investment in that sector will gain government support and match with the current environmental strategies regarding solid waste management.

Implementation of projects in the area of renewable energy, such as wind energy and solar energy will result in a significant boost in GHG reduction, with a considerably low cost of saved carbon (about US\$ 30 per ton carbon (8 US\$/tCO<sub>2</sub>) for wind farms).

The creation of new communities in the Southern part of Egypt, with agriculture as the main economic activity, is an opportunity for the Government to encourage sustainable development of those communities. The remoteness of those new communities from the national electricity grid and old cities also provides more incentives to invest in new and cleaner technologies such as solar pumps.

The proposed transportation projects may have lower priority than other projects due to the high investment cost of these project types and the high incremental cost, however, they should be considered when making strategic decisions because of other benefits (social and environmental).

It is worth mentioning here that it is not possible to compare the results of the current marginal abatement cost curve with previous studies, such as the UNEP, 1994 study, due to the different model used in that study and the difference in the economic conditions between the time the UNEP study was conducted and the current study. The UNEP study followed a top-down approach looking at the macroeconomics of the country, while this study follows a bottom-up approach focusing on specific projects with fairly detailed financial analysis. However, in the UNEP study, the sectors covered were mainly in energy efficiency, transportation and electricity generation. The CSC showed negative values for energy efficiency projects (same as the current study).

## **2.4 Impact of Changes in Policy on Reduction/Avoidance Potential**

### **2.4.1 Policies**

Government policies can encourage or impede the implementation of GHG reduction/avoidance projects. This section discusses the policies, which may influence the identified CDM projects in different sectors in view of the limitations or encouragement they can provide.

#### **2.4.1.1 Customs Policies**

The Custom Authority operating under the Ministry of Finance regulates the importation of devices or goods or commodities, the same applies to any energy efficiency/clean technology devices. In general, all equipment are first classified according to their function. Then, the level of their energy consumption or demand level may be used to further categorize the equipment into sub-categories. The level of demand or energy consumption is usually used to compare the imported devices with other similar ones that may or may not be manufactured locally. Based on this comparison, the custom tariff rates are partly selected from the charts of custom tariffs.

Similar devices, in terms of function, product, or output, have the same level of custom rates. An example of that is a 36 watts fluorescent lamp as compared to a 40 watt one with the same light output level; both are exposed to the same (60%) custom duties disregarding the efficiency issue.<sup>35</sup> Other examples of that are the drives, which are mainly classified according to their rated capacity (demand level), without indication to their efficiency. In some other cases energy efficiency devices are exposed to lower custom duties. An example of that is compact fluorescent lamps (30% custom duties) as compared to classical fluorescent lamps or filament lamps (60% custom duties). However, it is worth mentioning that in a number of cases, imports, which do not have similar local manufactured products, are generally exposed to lower custom duties. This means that the lower rate on the compact fluorescent lamp is mainly because they are not locally manufactured.

As a means of encouraging new investment in development projects, customs are reduced on capital equipment. Most of the new equipment are of higher efficiency and are much cleaner than old technologies.

To conclude, the current customs policy does not provide enough incentives to promote technologies, which reduce or avoid GHG emissions.

There is a probability that customs, in general, will be reduced after the full implementation of the GATT agreement. In addition, it is expected that the Government of Egypt will continue to encourage investment in development projects, which means lower taxes on new efficient capital equipment. Also, considering the different custom duties and tax exemptions, for both imported and locally manufactured renewable energy equipment, will have a positive impact. Those positive changes of custom policies, if realized, are expected to speed up the GHG reduction process.

#### **2.4.1.2 General Energy Policy**

The energy policies for Egypt during many years have been focusing on the following:

- Enhancement of energy use efficiency and energy conservation.
- Promotion of renewable energy utilization.
- Participation of the private sector in the development plans of the energy sector

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<sup>35</sup> Chapter 85 of the item 85-31 of the custom tariff manual

- Enhancement of natural gas utilization.
- Adjustment of energy pricing and removal of subsidies.

One of the major objectives, for which these policies have been considered, is to address some of the national concerns and priorities, among which are expanding the life expectancy of conventional energy resources, diversification of energy supply mix and having a significant impact on limiting future growth in Greenhouse Gas emissions.

A number of policies are adopted with different objectives and have the potential to reduce GHG emissions. These policies include but are not limited to:

On the supply side:

- Maximizing the utilization of all hydropower resources, through electrification of suitable barrages on the river Nile and its branches.
- Maximizing the use of Natural gas for electric energy production.
- Promoting the electric energy production through utilizing renewable energy.
- Electric interconnection with neighboring countries towards the east and west.
- Permitting Independent Power Producers.
- Environment protection by adopting suitable measures in electricity generation, transmission and distribution.

On the demand (end user, load) side:

- Promoting energy efficiency concepts and assist in carrying on demonstration projects
- Promoting and conducting public awareness campaigns on the economic and environmental benefits of energy efficiency.
- Examining appropriate policy and market mechanisms to enhance demand for energy efficiency by considering, for example, options such as:
  - Energy pricing.
  - Customs.
  - Tax incentives.
  - Substitution of natural gas for liquid fuels.
  - Equipment labeling.
  - Certification of service providers.
  - Participation with a number of national organizations to formulate a National Energy Efficiency Strategy.
  - Organizing appropriate training and public awareness programs to implement the strategy.
- Establishing mechanisms to monitor and, as necessary, update the National Energy Efficiency Strategy.

#### **2.4.1.3 Electricity Pricing Policy**

The current policy of the government is to bring the local energy prices to the international market prices. The electricity sector is working toward this target. The general features of the current electricity rates for end users is as follows:

- For a wide range of industrial users electricity rates are near the real long run marginal cost (LRMC).
- For few strategic industries it is still lower than the LRMC value.
- For governmental users it is higher than the LRMC. In this way, the government is subsidizing the electricity prices for low-income users and other national activities, which need support such as agriculture projects.

- For commercial users it is higher than the LRMC, this is also classified as cross subsidy pricing mechanism.
- For most of the residential users (over 85%) the average electricity rates are below the LRMC, while for the rest the average electricity rate is higher than the LRMC, also for cross subsidy activities.

The developments of energy prices over a number of years (1980-97) indicate low prices for fuel and electricity especially during the early 1980s. Furthermore, industrial and agriculture users had for some time decreasing electric tariff structures, over the period of May 1990 to July 1993, in order to promote the use of electricity in production and help in improving the GDP. This in a way gave the signal for some industrial and large buildings (hotels, hospitals) end users to consume energy inefficiently instead of utilizing it at a better energy intensity rate. This concept of low energy prices and high subsidy from the government has changed towards values that are nearer to the market values in the 1990s discussed above. A detailed discussion of the current electricity tariffs in Egypt is given in the annex to Chapter 2.

#### **2.4.1.4 Fuel Pricing Policy**

As for fuel pricing policy, the government sets the price for selling all types of fuels. Fuels are heavily subsidized by typically over 50% in Egypt (for a comparison with international market prices see Table 6.2 in Chapter 6). Also, there is a price differentiation policy to encourage the use of cleaner fuels. For instance, natural gas (cleaner fuels) is sold approximately at 0.09 US\$/M<sup>3</sup>. Petrol with higher octane is sold at a higher price (0.2 US\$/liter) than that of lower octane (0.18 US\$/liter).

Petrol with higher octane is sold at a higher price (0.26 US\$/liter) than that of lower octane (0.23 US\$/m<sup>3</sup>). Diesel fuel is subsidized due to socio-economic reasons mainly relevant to transportation. This subsidy of fuels encourages the inefficient use of fuel in transportation as well as in industry, increases emissions of air pollutants and GHG. Also the high level of fuel subsidies makes energy efficiency projects much less attractive, because fuel savings do not result in an adequate reduction of fuel costs.

The current prices of fuels are as follows:

- Light fuel used for transportation, water pumping engines, lighting and water heating is 0.08 US\$/liter, which is considered a valuable subsidy to the poor.
- Heavy fuel oil, used in boilers and industrial furnaces, is also subsidized. The current price is 94.8 US\$/ton. However, due to environmental emission, its use is gradually restricted and controlled by Law No. 4 (1994).

The fuel pricing policy cannot be easily changed due to its impacts on a wide range of population who might face higher costs of living upon subsidy removal or reduction. However, the GOE is adopting the market economy policies by which subsidies should be completely removed or reduced to be minimal. The economic reform program is expected to continue in the coming years and subsidies on fuels (mainly diesel) might be considered for reduction.

In this case, the change in the fuel pricing policy will have a positive impact on the reduction potential of GHG, because fuel saving projects will become more profitable with higher fuel prices.

#### **2.4.1.5 Policy Regarding Expansion in Using Natural Gas**

With the discovery of huge reserves of natural gas, the GOE adopted a policy to use natural gas in different sectors instead of oil. The main purpose is to utilize the abundant resources of natural gas and to export the crude oil to the international markets.

The country is expanding the infrastructure for supplying natural gas to major consumers, such as power plants, major industrial facilities and households as well. There are also incentive programs to promote the converting of vehicles to run on natural gas. Soft loans are granted for vehicle owners who wish to convert the engines to run on natural gas. Currently, there are 36,000 vehicles, including taxis that have been converted to run on CNG. By the year 2001, fifty municipal buses will be placed in the commercial services in Cairo. There are 57 CNG fuel stations are either under construction or actual operation to convert private cars to run on CNG.

The use of natural gas as cleaner fuel is positively affecting the efforts to reduce GHG emissions. All signs indicate that this policy of using natural gas will not change in the near future. However, the lack of capital investment is slowing down the process of switching to Natural Gas in industrial and transportation sectors. The CDM project can be a catalyst to speed-up the process and maintain and enhance the demonstrated achievements in this field.

#### **2.4.1.6 Financing Policy**

Although it can't be stated that the banking system in Egypt (the main financier of development projects) has an announced policy against financing environmentally sound projects, it is also true that there is no policy that gives preference to CDM or "green" projects. The concepts of environmental accounting and green loans are missing. The absence of such a policy and the non-availability of loans represent one of the major barriers to the implementation of projects which might have high environmental benefits (e.g. high GHG emission reduction potential) and low direct economic benefit.

There are current efforts to introduce green loans and environmental accounting concepts in the banking system. Green funds (such as the Environmental Protection Fund at the EEAA) represent a start in that direction which might set an example to commercial banks. The inter-banking working group is another institution to promote development of green funds.

The change in the financing policy towards acceptance of environmental projects in general will have great positive impacts on the reduction potential of GHG emissions.

#### **2.4.2 Limitations**

Even though the level of energy awareness is increasing in the residential, industrial and commercial sectors, a number of constraints are facing energy efficiency related activities in these sectors among which are:

**Limited technical knowledge** in some cases at the end user level, on how to identify inefficient energy consumption locations and/or operations needs energy audits, as well as identifying technically and financially attractive ways to overcome such energy inefficiencies. Overcoming this barrier will encourage these end users to invest in energy saving projects in a number of ways as they invest in new production lines in the industrial sector or new service activities in the residential and commercial sectors.

**Limited confidence** in the financial feasibilities of energy efficiency applications, to be overcome by extensive and directed promotion activities are needed for successfully implementing energy efficiency projects in other similar locations; especially if it is conducted in Egypt.

**Financial barriers**, where in many cases the traditional financing mechanisms through financial bodies, such as banks, are blocked also due to the lack of confidence and limited technical knowledge at the financing bodies or due to the lack of financing policies as discussed previously.

**Customs duties and other taxes** associated with importing energy efficiency related equipment as discussed previously.

**Limited technical experience:** In some cases the industrial or commercial institutions do have limited technical human capabilities as concerns energy efficiency. This is due to the fact that most of the staff is employed with emphasis on production needs.

**Availability of standards for energy efficient equipment:** as well as the availability of energy consumption rates for devices, processes and activities.

**Availability of energy efficient equipment:** This presents an obstacle in some cases, because obtaining such equipment from other countries is sometimes a lengthy and expensive process.

## **2.5 Governmental Strategies and Development Plans for the Future**

### **2.5.1 National Energy Strategy**

The National Energy Strategy aims at saving up to 10 % by the year 2010 in both supply (oil and gas, electricity sub-sectors), and demand sides (industrial, commercial, domestic and transport sub-sectors). Since the electrical power generation projects require tremendous investments, the Government of Egypt has adopted the BOOT<sup>36</sup> concept as one of the important schemes for future Power Generation projects by enabling the private sector and foreign investors to participate in this field of Electrical Power Generation. Therefore, the electricity sector is now following an economical policy aiming at running the public sector on commercial basis that will enable self financing future plans as well as allowing the private sector and joint venture companies to participate in building and operating new power plants through the BOOT concept. A number of strategies are adopted within the sector's policy to promote foreign investment, which includes financing the future power generation projects through a mix of "On Balance Sheet Finance" and "Project Finance". In fact the selection of the BOOT scheme as one of the "Project Finance" options is the result of a thorough evaluation, and is one of the best approaches for EEC to meet its commitments.

Promotion of electric power interconnection of the national grid with neighboring countries is also one of the main strategies. This is due to the technical advantages, higher reliability, less installed local generation capacity, less capital investment, as well as operational and maintenance costs in addition to the economic benefits from energy trading. Through Egypt it would be possible to interconnect Africa to Asia and Europe. This can be achieved through electrical interconnection projects, which are now under execution with neighboring countries. Towards the east, this will be done through the

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<sup>36</sup> BOOT is a system, implemented by the GOE, which encourages the private sector to Build, Own, Operate then Transfer the establishment to the ownership of the Government after a period of contracted time. This system relieves the burden of securing initial investment from the government and has proven to increase the operating efficiency of the utilities.

five countries electrical interconnection project (Egypt, Iraq, Jordan, Syria and Turkey). Toward the west, this will be done through the seven countries electrical interconnection project (Egypt, Libya, Tunisia, Algeria, Morocco, Spain and Italy). This strategy enables Egypt to meet part of its demands without the need to build new power plants or at least decrease the current needs for investing in huge power stations. The benefit of this strategy to mitigate climate change depends on the amount of GHG emitted abroad for the production of the imported electricity.

### 2.5.2 New and Renewable Energy Sources

The increasing demand for electrical power in Egypt is expected to continue in the future due to population and economic growth. Egypt's development plans will require about 52.1 to 96.9 million TOE of primary energy annually by the year 2017. Egypt is therefore seeking to diversify and alter its current mix of energy sources with renewable such as wind and solar energy. The GOE has launched a program to apply renewable energy technologies basically through the NREA. The strategies foresee developing renewable energy sources utilization to satisfy about 3% of the electric energy demand by the year 2010, basically from wind and solar energy, along with additional contribution of other renewable energy applications such as solar water heating, in both domestic and industrial sectors, water pumping and desalination by wind and solar energy, PV rural electrification and different biomes/biogases applications<sup>37</sup>.

Current new and renewable energy programs and projects in Egypt are based on the availability of donor funding. Future strategy allows for private sector participation including implementation of BOOT projects. Institutional building, strengthening and financing schemes are key areas for improvement and development. Opportunities for large-scale implementation of renewable energy that have a major impact on the sector, e.g. large commercial wind farms and solar thermal power generation, could be exploited through partnerships of government, private sector and donors. CDM projects can play an important role in this area. Further details on the national strategy in renewable energy are given in the annex to Chapter 2.

### 2.5.3 Transportation

The electrification of the mass transit system is considered a governmental policy in its economic and social planning for the spatial development. This will raise the capacity of the system as well as provide an environmentally friendly mode of transport. The GOE in its national strategy stated that this policy should concentrate on the urban transport for crowded cities such as Cairo and Alexandria for the use of this rapid transit system (electric metro). In addition, it can switch part of the inter-city railway system to use electricity as a power source instead of the diesel fuel especially in those routes with high densities.<sup>38</sup> Among the development plans in the transport sector, is the integrated system for the zero or reduced emission fuel cell bus operation in Cairo project. The project addresses energy efficiency and energy conservation issues in Egypt. The overall objective of the project is to contribute to the long-term reduction of the cost if an integrated and optimized fuel cell based system is used.

Another project in the transport sector is retrofitting two stroke engines. The objective of this project is to reduce emissions from motorcycles equipped with two stroke engines through a phased program of retrofitting. This project is still under study and evaluation.

<sup>37</sup> NREA (1999) "National Plan for Renewable Energies"

<sup>38</sup> Ministry of Planning (1997) "Economic and social planning for spatial development"

#### 2.5.4 Waste

One of the development plans in the waste sector is to expand the establishment of sanitary landfills. Recognizing the impacts of CH<sub>4</sub> emissions from landfills, the EEAA is implementing a project to utilize the methane gas emissions under a project titled “Reduction of Methane Emissions to the atmosphere through Commercial Utilization of Landfill Methane in Egypt”.

The project is being developed to promote the energy and economic benefits of commercial landfill methane recovery commensurate with solid waste management in Egypt. The major objective of the project is to develop an initial successful demonstration of commercial landfill methane recovery from an existing disposal site in Greater Cairo.

#### 2.6 Conclusions

Egypt’s main GHG emissions result from the primary energy use for electricity production, industrial production and transport.

According to the estimated growth rates of each economic sector, the energy sector would remain in first place as the major contributor to the GHG emissions. Energy for electricity production, industry and transport remain the major sub-sectors responsible for GHG emissions until 2017.

The selected types of CDM projects in Egypt have the potential to reduce GHG emissions by approximately 1.5 - 3 million tons of Carbon equivalent (5-11 MtCO<sub>2</sub>eq) under different scenarios until 2010.

Energy efficiency technologies have negative marginal abatement costs, which indicates financial benefits and therefore they may be ranked high on the implementation agenda. Solid waste management comes with a very low abatement cost (approximately \$0 per ton C) and is considered to be the most attractive to implement given the national priorities regarding environmental issues.

Investment in renewable energy has also shown attractiveness in terms of low abatement costs. Solar pumps to be used in new communities may provide one of the opportunities to reach sustainable development in those new lands, although costs per emission reduction are very high. Wind energy is seen as a high priority option due to encouraging national energy policies and low marginal abatement cost.

The GOE strategies and policies are promoting projects which serve its economic development plans. National strategies regarding removal of subsidies on fuel and electricity, the promotion of renewable energy, the expansion of the natural gas availability and the promotion of sanitary waste disposal will improve the conditions for CDM projects in Egypt. On the other hand, customs policy and financing policies still leave room for improvements of the conditions for CDM projects. In general, the proposed CDM projects match the national policies and strategies for sustainable development as well as Egypt’s ongoing economic development plans.

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