International Journal of Earth, Energy and Environmental Sciences
ISSN: 2517-942X
Vol:3, No:6, 2009

Strategies and Compromises: Towards an Integrated Energy and Climate Policy for Egypt

S.T. El Sheltawy, A. A. Refaat

***Abstract*—**Until recently, energy security and climate change were considered separate issues to be dealt with by policymakers. The two issues are now converging, challenging the security and climate communities to develop a better understanding of how to deal with both issues simultaneously. Although Egypt is not a major contributor to the world's total GHG emissions, it is particularly vulnerable to the potential effects of global climate change such as rising sea levels and changed patterns of rainfall in the Nile Basin. Climate change is a major threat to sustainable growth and development in Egypt, and the achievement of the Millennium Development Goals. Egypt's capacity to respond to the challenges of climate instability will be expanded by improving overall resilience, integrating climate change goals into sustainable development strategies, increasing the use of modern energy systems with reduced carbon intensity, and strengthening international initiatives. This study seeks to establish a framework for considering the complex and evolving links between energy security and climate change, applicable to Egypt.

***Keywords*—**climate change, climate policy, cnergy policy, energy security, sustainable development
.

I. Introduction

DEVELOPING countries, including Egypt, are facing a daunting challenge in meeting the energy needs of a growing and developing population while mitigating the impacts of global climate change and adapting to its anticipated vulnerabilities.

An overwhelming body of scientific evidence indicates that the Earth's climate is rapidly changing, predominantly as a result of increases in greenhouse gases (GHGs). Global atmospheric concentrations of carbon dioxide, methane and nitrous oxide have increased markedly as a result of human activities. The global increases in carbon dioxide concentration are due primarily to fossil fuel use and, to a lesser extent, land use change, while those of methane and nitrous oxide are primarily due to agriculture. Carbon dioxide is the most important anthropogenic greenhouse gas. The global atmospheric concentration of carbon dioxide has increased from a pre-industrial value of about 280 ppm to about 380 ppm in 2005 and rising at around 2.3 ppm per year [1].

S. T. El Sheltawy is a professor at the Department of Chemical Engineering, Faculty of Engineering, Cairo University (phone: +20106044605; e-mail: chakinaz@hotmail.com).

A. A. Refaat is a teaching assistant at the Department of Chemical Engineering, Faculty of Engineering, Cairo University (e-mail: aarefaat@hotmail.com).

With 1.1% of the world's population, Egypt accounts for 0.5% of global emissions - an average of 2.3 tonnes of CO_2 per person. Nevertheless, Egypt has been identified in most climate change international reports as one of the countries highly vulnerable to climate change impacts [2].

Under the strictest terms, energy security is defined as the availability of reliable and affordable energy supplies in adequate quantities to satisfy demand and maintain economic growth. More comprehensively, it also includes notions of geopolitics, sustainability, and social acceptability. Energy insecurity stems from the impact on welfare of either the physical unavailability of energy, or from prices that are not competitive or overly volatile [3]. Whether energy insecurity stems from price or physical availability concerns, however, depends on the nature and effectiveness of price-volume linkages in the market.

Energy security concerns vary by country depending on resource endowment, population distribution, economic makeup, and a number of other factors. Concern over energy security grows deeper as energy demand increases, prices continue to rise, and the ability to bring new supplies to market is called into question. Governments have to determine energy policy objectives based on best available information and implement measures deemed most suited to achieve them given existing political and economic constraints. In this context, interactions between different policy objectives may be significant and should be assessed carefully.

Policymakers often think of energy security in terms of oil supply disruptions and energy price volatility, which can wreak havoc on economic growth and create significant international tension. However, policymakers must consider the links between fuel choices, energy demand, infrastructure needs (both existing and future), investment requirements, and the environmental impacts of energy use. There are several kinds of government actions addressing energy security. Policies addressing concerns linked to resource concentration may have the most significant implications for climate change mitigation and vice versa: both policies are likely to affect fuel and associated technological choices. Regulatory misjudgments can have economic consequences of great magnitude due to the nature of energy as a commodity: energy markets are among the most capital intensive, lead times for planning and construction are long, while energy itself is the primary feedstock of many productive activities.

Until recently, energy security and climate change were considered separate issues to be dealt with by policymakers. The two issues are now converging, challenging the security and climate communities to develop a better understanding of how to deal with both issues simultaneously. A workable strategy must be concerned not just with how to design a future in which climate change and energy security concerns are met, but also with the pathway to get there. The evolving and interconnected nature of energy security and climate change requires addressing the following categories on shaping the framework for an integrated energy and climate policy, applicable to Egypt:

- Climate Change Challenges.
- Energy Security Challenges.

II. Climate Change Challenges

A. *Egypt Environmental Outlook*

1) *Carbon Dioxide Emissions Indicator*

Carbon dioxide emission trends are commonly used as a tool to assess efforts to mitigate climate change [4]. As previously mentioned, Egypt accounts for 0.5% of global emissions - an average of 2.3 tonnes of CO_2 per person - nevertheless, Egypt has been identified in most climate change international reports as one of the countries highly vulnerable to climate change impacts [2] (Table I).

2) *Major Environmental Challenges*

TABLE I
Egypt Carbon Dioxide Emissions Indicator (2006)

Parameter	Unit	Amount
Population	million	74.17
GDP	billion 2000$	127.85
GDP (PPP - Purchasing Power Parity)	billion 2000$	303.93
TPES (Total Primary Energy Supply)	mtoe	62.50
Energy-Related Carbon Dioxide Emissions	million metric tons	152.74
CO_2/Pop	t CO_2/capita	2.06
CO_2/GDP	kg CO_2/2000$	1.19
CO_2/GDP (PPP) [Carbon Dioxide Intensity]	kg CO_2/2000$ PPP	0.50
CO_2/TPES	t CO_2/toe	2.44

Source: Adapted from IEA, 2008 [4].
(N.B. In 2007, the total population reached 76.9 millions, the GDP remained at 27.9 billion, and the GDP (PPP) as share (%) of world total was 0.63 [6]).

According to the new international environmental performance index (EPI), which evaluates environmental stress and ecosystem vitality in each country, Egypt scored 76.3 out of 100 in 2008 and ranked 71st worldwide and 5th African [5]. The EPI is a composite index based on twenty-five indicators in six policy categories: Environmental Health, Air Quality, Water Resources, Biodiversity and Habitat, Productive Natural Resources, and Climate Change. It uses a proximity-to-target methodology. Looking at the components of the EPI, it is apparent that Egypt faces serious challenges in urban air quality, waste management, preserving water quality and protecting coastal areas.

B. *Climate Change Impacts and Vulnerabilities*

Climate change can be viewed as ‘catastrophic’, ‘rapid’, ‘urgent’, ‘irreversible’, ‘chaotic’, and ‘worse than previously thought’ [7]. Without more ambitious policies, increasing pressures on the environment could cause irreversible damage within the next few decades [8].

Climate change is likely to impact more severely on the poorer people of the world, because their natural-resource dependency is high, because they are closer to the biophysical and experience limits of climate, and because their adaptive capacity is lower. A Gini coefficient for climate change impacts, showed that the distribution of impacts is very skewed in the near future and will deteriorate for more than a century before becoming more egalitarian [9].

While any warming may have consequences, many scientists believe global warming must be limited to no more than two degrees Celsius above current levels to avoid the worst impacts of climate change. As indicated in Fig. 1, two degrees is not a guaranteed “safe” amount of warming; even at this level of change, serious impacts are predicted. However, it is often considered the maximum amount that the climate system can withstand before tipping points are reached that could rapidly accelerate the rate of warming and increase the risk of serious danger [1].

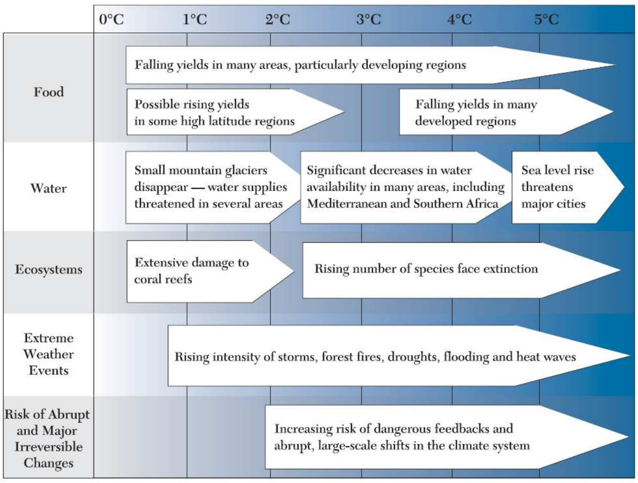

Fig. 1 Projected impacts of climate change
Source: (Stern, N. “The Economics of Climate Change”. Presentation to the Convention Dialogue, Nairobi, Kenya, 2006).

As identified in the Initial National Communication (INC) report to the United Nations Framework Convention on Climate Change (UNFCCC), UNDP Global Human Development Report 2008 [10] and the IPCC Fourth Report [1], Egypt proves to be highly vulnerable to climate change impacts that may jeopardize Egypt’s development gains.

Egypt’s most vulnerable sectors to climate change are i) coastal zones, ii) water resources, and iii) agriculture. Global temperature rise will result in a significant loss of the highly populated agricultural lands in the Nile delta as well as many parts of Egypt's northern Mediterranean coast. The Nile catchments areas are also subject to climate change negative impacts which would affect the already limited surface water resources in Egypt. Food production could be also adversely affected in an area suffering from nutrition deficiency [11].

(a) Coastal Zones:

For Egypt, the consequences of sea-level rise (SLR), are potentially catastrophic [12]. According to the United Nations estimates, 0.5 m Sea Level Rise (SLR) would lead to the permanent submersion of 1,800 km^2 of cropland in low land of the Nile Delta, and accelerate trend of desertification in the form of increased soil salinity in the remaining land. This could lead to economic losses in excess of US$35 billion and the displacement of 2 million people. A one-meter rise in sea level could possibly displace six million people and flood 4,500 km^2 of farmland (fig. 2) [11]. This poses a serious threat to livelihood security and has a tendency to reverse progress in human development [2].

The same threats are also confirmed by a World Bank Policy Research Working Paper which has been issued in February 2007 [14] and Global Monitoring Report issued 2008 [13] in which a comparative analysis covering 84 developing countries was conducted and concluded that severe impacts are limited to a relatively small number of countries among which is Egypt.

Egypt's population would be most severely impacted by SLR. With a 1m SLR, approximately 10% of Egypt's population would be impacted. Most of this impact takes place in the Nile Delta; it reaches 20% with a 5m SLR. The Egyptian GDP would also be significantly impacted due to severe disruption of the agricultural sector. Even with a 1m SLR, approximately 12.5% of the Egyptian agricultural sector would be impacted; this percentage reaches 35% with a 5m SLR [13]. Cost of adaptation to sea level rise could amount to at least 5–10% GDP [14].

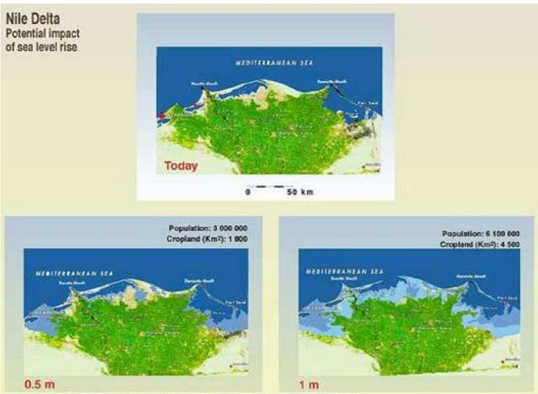

Fig. 2 Potential Impact of Sea Level Rise on Nile Delta
Source: UNEP/GRID – Arendal Maps and Graphics Library

(b) Water Resources:

Egypt is facing critical water resource challenges. Underscoring the difficulty of meeting an increasing water demand in a context of insufficiency, rarefaction, if not overexploitation, of water resources (likely to be exacerbated under the effect of climate change), as well as of alarming deterioration of water quality [15]. Water scarcity is a major challenge for the already closed basin. The challenge is further exacerbated by incidence of climate variability and natural shocks such as droughts and floods leading to greater scarcity in the future [16]. The Nile basin is shared by 10 countries, of which Egypt is last in line. Almost all of the total flow in Egypt originates outside its borders and no water-sharing agreement exists between Egypt and Ethiopia, where some 55% of the Nile's flow originates [17]. The national security of Egypt which is based on the waters of the Nile is in the hands of other countries. This gave the "water wars" debate a stronger impetus. For a country like Egypt the dependency is extremely high, because the country receives hardly any precipitation and thus mostly depends on the inflowing Nile water [18].

A major challenge is to close the rapidly increasing gap between the limited water availability and the escalating demand for water from various economic sectors. The rate of water utilization has already reached its maximum for Egypt, and climate change will exacerbate this vulnerability [19]. Agriculture consumes about 85% of the annual total water resource and plays a significant role in the Egyptian national economy, contributing about 20% of GDP. More than 70% of the cultivated area depends on low-efficiency surface irrigation systems, which cause high water losses, a decline in land productivity, water logging and salinity problems. Moreover, unsustainable agricultural practices and improper irrigation management affect the quality of the country's water resources [19].

With climate change, an array of serious threats is apparent:

- Temperature rises will be likely to reduce the productivity of major crops and increase their water requirements, thereby directly decreasing crop water-use efficiency [20].
- There will probably be a general increase in irrigation demand.
- There will also be a high degree of uncertainty about the flow of the Nile. Several models suggest a decrease in river flow, with nine climate scenario impacts ranging from no change to more than 75% reduction in flows by 2100 [21].
- Based on SRES scenarios (IPCC Special Report on Emissions Scenarios), Egypt will be likely to experience an increase in water stress, with a projected decline in precipitation and a projected population of between 115 and 179 million by 2050. This will increase water stress in all sectors [21].

(c) Agriculture and food security:

Agricultural production in Egypt is projected to be severely compromised by climate variability and change. The combined effect of temperature increasing, SLR, water shortage and other environmental conditions could be a general reason of agriculture-system failure in many regions in Egypt [2].

Temperature rises will be likely to reduce the yield of the major crops and increase their water requirements. Climate change could decrease the national production of rice by 11% and soybeans by 28% by the year of 2050, compared with their production under current conditions [22].

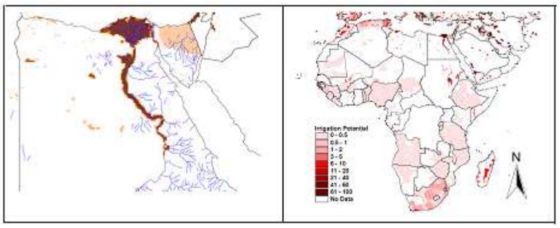

Fig. 3 Potential Irrigated Area in the Nile Delta
Source: The World Bank, 2007 [23].

C. Climate Change Mitigation Measures

Mitigating climate change cannot be successful without a radical change in the way we produce, transform and use energy. Energy-related greenhouse gas emissions, which are predominantly in the form of CO_2, can ultimately be reduced through one, or a combination, of the following approaches:

Improving energy efficiency:

Energy efficiency gains can deliver environmental benefits by reducing greenhouse gas emissions and local air pollution [5]. Technological improvements can increase the efficiency of power plants, energy-using equipment such as appliances, cars, lighting equipment, as well as buildings. In addition, behavioral change towards more economical utilization can also contribute in reducing overall energy use.

Switching to less carbon-intensive fossil fuels:

The type of fossil fuel used defines the resulting level of emissions. Coal is the most carbon-intensive fuel with a carbon emission factor of about 26 tC/TJ, while crude oil has a carbon emission factor of about 20 tC/TJ, and natural gas 15 tC/TJ [3]. Switching to less carbon intensive fuels therefore reduces the level of emission per unit of energy generated.

Switching to emission-free energy sources:

Greenhouse gas emissions related to nuclear and renewable energy sources, such as wind and solar power, are negligible. Switching from fossil-based fuels to emission-free energy sources therefore leads to a reduction in greenhouse gas emissions.

Capturing and storing CO_2 emissions (CCS):

Carbon can be captured prior- or post-fossil fuel combustion. Through this approach, the energy production process is not directly affected as an add-on component is installed instead. The carbon can then be stored in geological formations such as oil and gas fields, unminable coal beds or deep saline formations, in oceans, or through industrial fixation of CO_2 into inorganic carbonates [24]. This results in the removal of emissions which would have otherwise been emitted into the atmosphere.

The three flexible mechanisms of the Kyoto Protocol: Joint Implementation (JI), the Clean Development Mechanism (CDM) and Emissions Trading (ET) are supposed to lead to an efficient compliance with the Kyoto commitments. The first two allow Parties with emission targets to conduct emission reduction or sink enhancement projects in other countries and use the resulting emission credits for compliance with their commitments. Emission trading creates an international market on which emission allowances and credits can be traded.

The CDM is a project-based mechanism through which a developed country partner and a developing country partner jointly develop a project that reduces greenhouse gas emissions. In essence a CDM project would involve either reducing currently occurring emissions from a particular activity or ensuring the emissions from a future activity are less in the presence of the project than they would have been without the CDM project. It is also required that the CDM project shall assist the developing country in achieving sustainable development. This will require some form of criteria and approval confirming that the project does contribute to sustainable development in the country in which the project will occur. The greenhouse gas reductions are termed “certified emission reductions” (CERs) in the case of the CDM because they will need to be audited and certified by an independent third party. The CERs are the 'currency' of the mechanism and they have value to the developed country because they are less costly to produce than greenhouse gas reductions would be in the developed country. The CERs are valuable to developing country because they are the commodity which they sell to the developed country in return for technology, capital investment in projects, or direct financial returns [25,26,27].

The regional distribution of CDM projects is still rather uneven with two countries China and India accounting for 82 percent of the projects (Fig. 4). China completely dominated the CDM sell side in 2006, miles ahead of India, Brazil and Egypt.

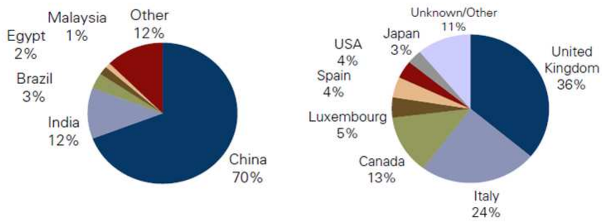

Fig. 4 The relative share of CDM country sellers (left) and buyers (right) in 2006
Source: (Point Carbon. "Carbon Market Insights 2007". Point Carbon’s 4th annual conference, Copenhagen, 13-15 March 2007.) [28]

D. Adapting to Unavoidable Climate Change

All countries, rich and poor, need to adapt to climate change and this will be costly. Developing countries (including Egypt), already the hardest hit by climate change, have little capacity (both in human capacity and financial resources) to adapt. An effective way to address the impacts of climate change is by integrating adaptation measures into sustainable development strategies so as to reduce the pressure on natural resources, improve environmental risk management, and increase the social well-being of the poor; looks at adaptation in the light of sustainable development, the integration of adaptation into policy and development planning, and the need for further capacity-building and training. Sustainable development and the Millennium Development Goals (MDG) constitute a necessary backdrop to integrating adaptation into development policy.

III. Energy Security Challenges

Before investigating the energy security challenges facing Egypt, a short overview of some perspectives and priorities on energy security are given.

A. Perspectives on Energy Security

1) Energy Security Indicators

Two quantitative approaches are commonly used by policy-makers and scholars to assess the energy security implications of resource concentration. The first focuses on measuring import dependence while the second focuses on the notion of diversity. In sum, a measure of import dependence may be considered as an indicator of the energy security implications of resource concentration when a distinction can be made between domestic and foreign resources. This is the case in regulated market environments where physical unavailability risks prevail but not in liberalized market environments [3].

Diversity is broadly thought of as a hedge against uncertainty and has attracted much policy attention in the context of energy security. Yet while it seems relatively self-explanatory that the more diversified an energy system is, the less it is likely to be vulnerable to the disruption of one of its elements, on closer inspection a number of issues make the concept of diversity difficult to apply for energy security analysis. First, it is unclear what aspect of the energy system should be diversified and to what extent. Second, while the concept of diversity is familiar to most, it is difficult to grasp in a formalized manner. For these reasons, the vast majority of references to diversity in relation to energy security have remained qualitative [3].

A hybrid approach which combines various energy security concerns into a single indicator: fuel mix diversity, import dependence, political stability of trade partners, and resource depletion was proposed [29]. While the proposed approach appears to be instructive, it inevitably raises the question of balance between the different parameters considered. Arguably, this depends on the country’s circumstances and should be fine-tuned on a case-by-case basis by experts.

2) Priorities on Energy Security

With regard to energy security policy, a distinction can be made between government actions to mitigate the short-term risks of physical unavailability occurring in case of a supply disruption and efforts to improve energy security in the long-term [3]. In the first case, actions include establishing strategic reserves, dialogue with producers, and determining contingency plans to curtail consumption in times of important supply disruptions. In the second case, policies tend to focus on tackling the root causes of energy insecurity

(a) ***Managing Short Term Volatility***

Supporting the most vulnerable: Governments may consider that some groups in the community need to be assisted in order to help them to manage the welfare impacts of adjusting to high energy prices. International assistance and programs and funds may also be appropriate to help the poorest countries manage and adjust to the impact of large oil price increases.

Not Subsidizing Consumption Generally: Attempts by governments to shield users in oil consuming countries from high international prices, have usually had adverse consequences. Such efforts have often proven to be unsustainable because of the high budgetary costs of doing so, especially when prices have remained high longer than might have been initially expected. Measures adopted by governments to protect users from increased prices will also tend to dampen the potential short term stabilizing impact of increased international prices on demand.

Applying Appropriate Macro-economic Policies: Governments need to apply appropriate macro economic policies that realistically account for the impact of high oil prices on their economies and use a variety of macro-economic approaches to try and ensure that the impact of sharp rises in oil prices is mitigated.

Greater Transparency: For both short term management and understanding of longer term oil markets and for helping setting a course for the longer term, reliable information about the oil market is important for analysis and policy making. In the short term, information about flows (production and consumption) and stocks of crude and products, and prices, is essential for assessing market developments. For the longer run, a good understanding of the resource base and potential production capability is vital in coming to reasonable views about ranges of possible outcomes in terms of supply, demand and pricing. Such views constitute a key input into decision making about energy choices with long term consequences [30].

(b) ***Enhancing Long Run Energy Security***

Improving Energy Efficiency: Improved energy efficiency is often the most economic and readily available means of improving energy security and reducing greenhouse gas emissions. Improved energy efficiency is a shared policy goal of many governments around the world. The benefits of more efficient use of energy are well known and include reduced investments in energy infrastructure, lower fossil fuel dependency, increased competitiveness and improved consumer welfare. Efficiency gains can also deliver environmental benefits by reducing greenhouse gas emissions and local air pollution [31].

Diversifying the energy portfolio: Renewable energies have great potential to contribute to improved energy security and reduced greenhouse gas emissions. The research, development and demonstration (RD&D) programmes of governments will play a vital role in enabling renewable technologies to deliver their potential [32]. There have been increasing calls for higher priority on nuclear energy mainly in industrialized countries. Based on the experience of some EU countries, as well as Japan and Korea, nuclear power plants can contribute to a country’s energy security through reducing its dependence on fossil fuels. However, concerns about waste disposal, nuclear proliferation and public perceptions about safety, have undermined public support for nuclear power. International cooperation focused on nuclear safety is warranted [30].

3) Interrelation between Energy Security and Climate Change

Energy lies at the heart of the climate change issue. The emergence of anthropogenic climate change as a new and important energy policy concern requires that greater attention be given to interactions between different policy efforts in the future. A sound understanding of these interactions is necessary to ensure the efficiency of government action.

Energy security and climate change interests sometimes conveniently align. There are many options having both positive climate and energy security characteristics. Like other efficiency options, improvements in energy efficiency have a unique combination of positive security and climate traits. Improvements in energy efficiency and reductions in energy demand provide a "double win". Increased efficiency has the potential to reduce GHG emissions throughout the economy by decreasing the amount of energy needed for society to function.

Depending on domestic resource endowment and disposal facilities, lower-carbon energy sources such as wind, solar, biofuels, and hydropower provide domestically produced energy and can substantially reduce emissions compared to fossil fuels. Nuclear power can also improve energy security while reducing emissions; however this is not always the case. Research and development to increase commercialization of current technologies and to create new clean energy technologies is an essential component of meeting energy security and climate goals.

On the other hand, there are some measures which present conflicts between energy security and climate goals. There are some options which have positive energy security but negative climate traits. A good example is utilizing the coal-to-liquids (CTL) technology. Using coal-to-liquids (CTL) technology will allow reduced oil imports. Pursuing this option will result in additional CO_2 emissions resulting from the conversion of coal to liquid fuel compared to traditional petroleum. This will impose significant negative impacts on global warming, even with carbon dioxide capture and sequestration (CCS). Domestic fuel options (e.g., oil shale, oil sands, and extra-heavy oil deposits) result in higher carbon emissions than traditional resources. Greater use of these fuels (without the ability to capture and sequester the carbon emissions at a large scale) would dramatically increase GHG emissions.

There are also some options having positive climate but negative energy security characteristics. Expanding imports of liquefied natural gas (LNG) may expose a country to greater risks of potential imported fuel supply disruption, but this fuel is less carbon-intensive. Climate change strategies that replace high-carbon fuels with lower-emitting energy sources can increase energy insecurity. For example, switching from coal combustion to natural gas in the power sector is an effective means to reduce GHG emissions, however, many regions rely on imported natural gas. Still remains an option having both negative energy security and climate implications; the expanded reliance on imported oil.

B. Egypt Energy Outlook

1) Energy Flow

Egypt's proven oil reserves stand at 3.7 billion barrels [33] (BP estimated 4.1 [34]). In 2007, Egypt produced 664,000 barrels of oil per day (bbl/d) continuing its fall from a high of 950,000 bbl/d in 1995. Yet having consumed 653,000 b/d in 2007, production was sufficient to prevent Egypt from becoming a net importer of oil as some had predicted [33].

Egypt's oil production in 2007 represented less than 1 percent of world production the same year. To monitor the high rate of depletion of oil resources in Egypt, it is important to notice that Egypt's proven oil reserves represents only 0.3 percent of world reserves [35].

Due to major recent discoveries, natural gas is likely to be the primary growth engine of Egypt's energy sector for the foreseeable future [34]. Egypt's natural gas sector is expanding rapidly with production having increased over 30 percent between 1999 and 2007. In 2006, Egypt produced roughly 1.9 trillion cubic feet (Tcf) and consumed 1.3 Tcf of natural gas, making Egypt a net gas exporter. With the continued expansion of the Arab Gas pipeline, which increased its exports to roughly 68 bcf during fiscal year (FY) 2006 from 8 bcf in 2003, Egypt is on its way to becoming a leading supplier of natural gas throughout the Mediterranean region [33]. According to the Oil and Gas Journal, Egypt's estimated proven gas reserves stand at 58.5 Tcf, or roughly 1 percent of world reserves (0.9%) [36].

Demand for petroleum products, after being relatively flat since 1999, is again rising rapidly [34]. It would be worth to mention that the driving forces of the ever increasing demand for primary energy resources are: meeting the needs of development plans in rural and urban areas, in addition to existing subsidies for energy prices, the continuous relatively high population growth, and the growing implementation of new intensive energy consuming industries [35].

TABLE II
EGYPT ENERGY FLOW

Parameter	Unit	Year	Amount
Proven Oil Reserves	billion barrels	1.1.2008	3.7
Oil Production	thousand barrels per day	2007E	664
Oil Consumption	thousand barrels per day	2006	653
Crude Oil Distillation Capacity	thousand barrels per day	2007E	726
Proven Natural Gas Reserves	trillion cubic feet	1.1.2008	58.5
Natural Gas Production	trillion cubic feet	2006E	1.9
Natural Gas Consumption	trillion cubic feet	2006E	1.3

Source: Adapted from EIA, 2008 [33]

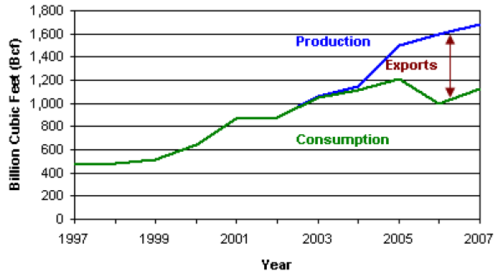

Fig. 5a Egypt's Annual Natural Gas Production and Consumption

Source: EIA, 2008 [33]

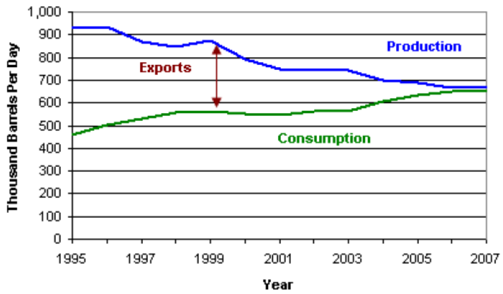

Fig. 5b Egypt's Annual Oil Production and Consumption

Source: EIA, 2008 [33]

The analysis of energy consumption and production for the last 25 years reveals that the average annual consumption growth rate (4.8%) is much higher than the production one (2.8%). This negative trend or gap entails the need for enhancing the contribution of RE in the production side and in the same time reducing the consumption through the RUE measures [11].

2) Energy Indicators

Energy indicators can play an important role in supporting energy efficiency policy development and evaluation [31]. It should be pointed out, however, that the same value for a given energy indicator might not mean the same thing for two different countries. The meaning will depend on the state of development of each country, the nature of its economy, its geography, the availability of indigenous energy resources and so on [37].

TABLE III
EGYPT ENERGY INDICATORS (2006)

Parameter	Unit	Amount
Population	million	74.17
GDP	billion 2000$	127.85
GDP (PPP - Purchasing Power Parity)	billion 2000$	303.93
Energy Production	mtoe	77.83
Net Imports	mtoe	-14.37
TPES (Total Primary Energy Supply)	mtoe	62.50
TPES/Pop	toe/capita	0.84
TPES/GDP	toe/000 2000$	0.49
TPES/GDP (PPP)	toe/000 2000$	0.21

Source: IEA, 2008 [4]

For the overall economy, energy use per capita (Overall Use) and energy use per unit of GDP (Overall Productivity) are the most commonly used aggregate indicators. The energy use per capita measures the amount of final energy "used" per person in a country, and is the energy use in terms of total primary energy supply (TPES), total final consumption (TFC) and final electricity use per capita. The energy use per unit of GDP measures how much energy is needed to produce one unit of economic output and is represented by the ratio of total primary energy supply (TPES), total final consumption (TFC) and electricity use to gross domestic product (GDP).

In Egypt, energy imports accounted for 16.3% of the total imports in 2006 (as against 5.2% in 2003) and claimed 24.5% of exports (9.2% in 2003). The energy bill in share of GDP reports a very strong growth and reaches significant percentages: 3.1% of GDP 2006 in Egypt (0.8% in 2003) [11].

C. Egypt Renewable Energy (RE) Potential

All renewable energy resources are unevenly distributed. They are effectively considered as domestic resources exploited within domestic boundaries. Egypt is generously endowed with productive land and valuable natural resources, including renewable and non-renewable resources.

1) Wind Resources Potential:

Wind resource measurements analysis and assessment have shown that the Gulf of Suez region enjoys considerable wind potential where wind speeds are ranging between 8.5-10.8 m/s with average yearly capacity factors ranging from 38% up to 60% or more than 5000 equivalent hours, making that region among the best world areas for wind power generation projects [35]. The Gulf of Suez is an arid desert area with no human activity except some tourist villages and oil fields along the coast. The estimated potential is in the order of 20000 MW installed capacities of grid-connected wind farms.

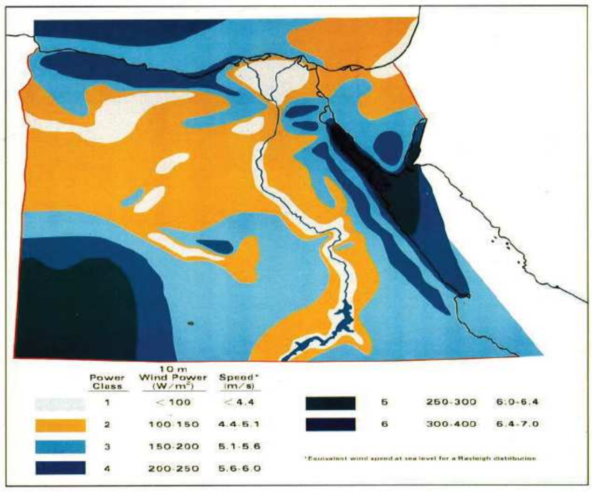

Fig. 6 Egypt Annual Average Wind Power Estimates

Source: Wind Atlas for Egypt, 2006 [38].

Other locations in the Eastern and Western Desert of Egypt as well as Sinai Peninsula having considerable wind potential, even though less than that of Gulf of Suez, with wind speeds between 6-7.5 m/s, in addition to some locations around the Nile Valley with speed 7-8 m/s. The overall wind potential in such areas could reach 60000 MW installed capacity [35].

The preliminary wind energy long term action plan was elaborated by NREA during January 2008. By 2020/21, the plan targets to install a total of 7210 MW installed capacity of wind power plants [13]. After their installation they are expected to generate about 31 billion KWh annually where the expected amount of corresponding GHG emission annual reductions is about 17 $mtCO_2eq$. It should be noted that the installed wind farms capacity for electricity generation has reached 310 MW by early 2008 [11].

Wind energy has attracted more attention reflected in future plans. This can be attributed to the impact of the tremendous worldwide technology development and economic maturity as well as the very favorable wind potential in some locations in the country; mainly Gulf of Suez. Another reason could be attributed to the willingness of the fund raisers and donors in the countries of advanced wind industry to get involved in such projects in Egypt, for the benefit of both sides [11].

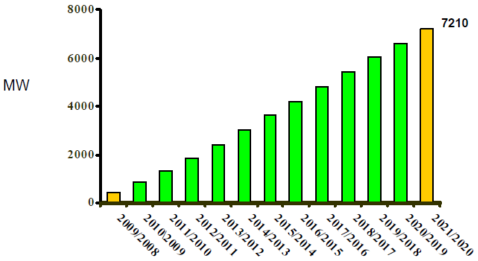

Fig. 7 Accumulated installed wind capacity planned until 2020/21
Source: UNEP/MAP/BP, 2008 [11].

2) Solar Resources Potential:

Egypt enjoys a considerable solar potential being located within the Sun Belt countries, with annual global solar insulation ranging from 1750 to 2680 $kwh/m^2/year$ from North to South and annual direct normal solar irradiance ranging from 1970 to 3200 $kwh/m^2/year$ also from North to South with relatively steady daily profile and small variations making it very favorable for utilization. Such conditions of favorable solar resource utilization are supported by other conditions of sunshine duration ranging from 9 – 11 hours with few cloudy days over the year [35].

Desert Areas with almost no inhabitants in Egypt exceed 90% of the country's area of one million km^2. Theoretically speaking, more than 900000 km^2 are available for solar collectors' installation. Even if we consider only 50% of the available desert land, the available potential would be very high reaching more than 3×10^5 TWh yearly. One should note that such huge figure is the theoretical available solar resource but usable potential is very much dependant on many practical factors such as both economic competitiveness and technological development at least, and thus, it would be very difficult to specify an exact usable potential, however, the Egyptian solar resources is one of the best worldwide [39].

Historically, solar thermal energy activities have been concentrated in the field of domestic solar water heating and have started as early as 1979. However, there has been a limited achievement in this area reflected in the implementation of an estimated total accumulated number of about 250000 installed systems (typical system: 2 m^2 of collectors and 150 liters storage tank) by 2007 resulting in GHG emissions reduction of about 0.25 $mtCO_2eq$ annually [11].

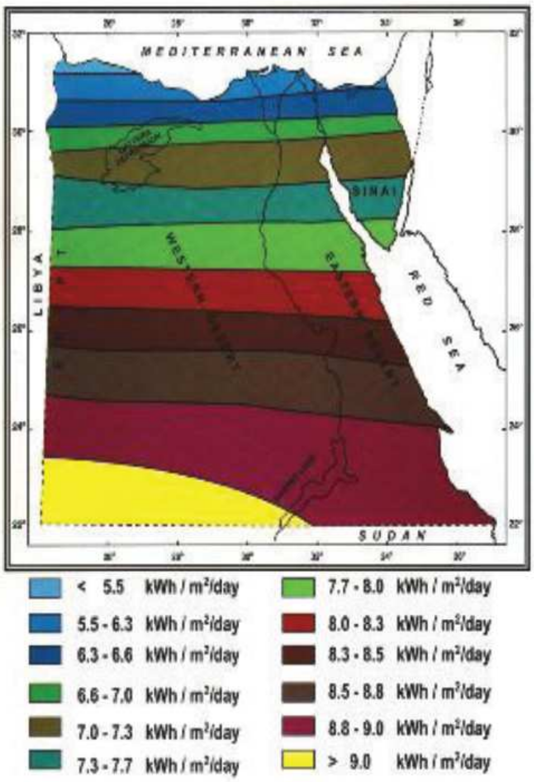

Fig. 8 Egypt Annual Average of Direct Solar Radiation
Source: UNEP/MAP/BP, 2008 [11].

3) Hydropower Potential

Most of the available hydropower energy resources in Egypt are mainly located on the River Nile. They were largely exploited with the construction of the Aswan Reservoir, the High Dam, and the Esna Barrage Hydropower Station, with installed capacity of 592 MW, 2100 MW, and 91 MW respectively and representing a total installed capacities of 2783 MW. There are 109 MW hydropower projects at Nagah Hamady and Assiut Barrages under construction on the main river. Small capacities of another 60 MW in total are also available at main canals and branches of the river. These capacities which sum up to a grand total of 2952 MW represent most of the available potential [35].

Most of Hydropower resources in Egypt have been so far exploited as the total installed capacity reached 2783 MW by 2007 with a limited expansion capacity for mini and micro-hydropower installations [11].

4) Nuclear Power Potential

During the year 2007, the government expressed its intention to start a program of building a series of nuclear power stations starting by the first one to be commissioned around the year 2017 [11].

Uranium, the fuel used in nuclear power plants, is also unevenly distributed and, like fossil fuels, is exploited within an international market structure. However, uranium is unlike fossil fuel markets on many accounts including two which are particularly pertinent to the energy security concerns of interest here. First, uranium has a higher energy density than fossil fuels. This means that uranium can more easily be stored and is less dependent on international trade and market infrastructures than fossil fuels. Storage of one year's worth of nuclear fuel is both economically and physically feasible. Second, fuel costs represent only approximately 10-15% of electricity generation costs from nuclear plants compared to much higher levels in the case of fossil fuel-based plants (approximately 30-40% for coal and 60-85% for gas). Nuclear generation is therefore much less affected by fuel price fluctuations than fossil fuel-based generation. For these reasons, nuclear power can be considered to be significantly less prone to energy security risks related to resource concentration than fossil fuels [3].

5) Biomass Potential

The biomass potential (mainly agricultural residuals, animal dung, sewage and municipal solid wastes) in Egypt is estimated to be about 16 mtoe annually out of which 5 mtoe are poorly exploited for energy purposes mainly due to the lack of appropriate technologies and market support as well as the absence of adequate institutional structure that should perform necessary planning and coordinate between the related diversified stakeholders, e.g. Ministry of Agricultural, Ministry of Electricity and Energy, Municipalities, Local Authorities and the Industry [11].

6) Biodiesel

Biodiesel industry is still in its infancy in Egypt. The new process technologies developed during the last years made it possible to produce biodiesel from recycled frying oils comparable in quality to that of virgin vegetable oil biodiesel with an added attractive advantage of being lower in price [40]. The annual consumption of vegetable oil in Egypt exceeds million MT/ year (1,248,000 MT in 2005 according to the official statistics of the Ministry of Internal trade in Egypt and the USDA). Consequently, millions of liters of oil used for frying foods are discarded each year into sewage systems [40]. From a waste management standpoint, producing biodiesel from used frying oil is environmentally beneficial, since it provides a cleaner way for disposing these products; meanwhile, it can yield valuable cuts in CO_2 as well as significant tail-pipe pollution gains.

D. Egypt Potential for Energy Saving from Rational Use of Energy (RUE)

Effort to develop a National Energy Efficiency Strategy (NEES) was exerted in the year 2000 as part of the Egyptian Environmental Policy Program (EEPP) to be jointly implemented by the Egyptian Environmental Affairs Agency (EEAA) in cooperation with all concerned stakeholders. However, the lack of political will and support of energy related governmental bodies have led to the bereavement of the targeted benefits of such an effort [11].

The WEC Report issued on 2008 focused on the evaluation of energy efficiency trends around the world and the interaction between energy efficiency policies and energy efficiency performance of economies [41] pointed out that in Egypt, only 10% of the recommended measures were really implemented. It has become almost imperative to develop the present energy regulatory framework and introduce new legislation in favor of both RUE and RE to support and promote their wide spread utilization as well as to diffuse their technologies in relevant applications.

It is recommended that policy makers would take into account such consequences, and formulate from now an alternative low carbon energy scenario adopting much greater use of RUE and RE in order to overweigh such high expected costs in the future. A study was conducted by the United Nations Environment Programme/Mediterranean Action Plan/Plan Blue (UNEP/MAP/BP) in 2008 [11] aiming to estimate the direct short-term economic cost of not engaging actions as described in the MSSD targeting the field of energy. The method used has consisted in coupling a standard economic channel in volume reconstructing the operating conditions of three countries from the Southern Mediterranean rim (accounting for nearly 45% of the population, a third of the energy consumption, and a quarter of the economic production Morocco, Tunisia and Egypt) and an energy channel which estimates the volume of energy necessary to the operation of the economies. This simulation was, initially, calibrated in such a way as to reconstruct the trends of the 3 economies over the past 15 years. Then, the operation is extended until 2015, that is an extra 10 years. This extension describes a trend, baseline, scenario which stands for non action in terms of national energy strategy.

Four (4) alternative scenarios inspired from the objectives of the MSSD, standing each for a certain type of actions in favor of rational energy use (REU) or of development of renewable energies (RE) were compared to the baseline scenario in order to calculate the potential direct economic gains generated by these types of action. These possible gains are then interpreted:

• either in terms of "cost of non action", since the cost of energy in the baseline scenario is higher than the same cost in the identical economic context of the alternative scenario, but the latter taking into account the behavioral changes with respect to energy;

• or in terms of financial room for maneuver elicited mainly for the financing of the described actions, assuming that, with an expenditure budget maintained, the price differential obtained can be invested in the field of energy efficiency.

The quantified illustration in the case of Egypt is given in Table IV. The quantified illustration tends to indicate that most of the possible actions generate an appreciable direct economic benefit under the form of non used and, hence, available resources for alternative uses. It helps visualize directly the strictly economic and immediate cost of not investing in a better energy management, which was described as the cost of non action.

For Egypt, to take actions of rational energy use on the demand side aimed at cutting down by 10%, for the time frame 2015, the energy intensity of households and industries (scenarios 1 and 2), while modestly developing renewable energies so that they account for 1% of consumption (scenario 3), would lead to the saving of 35015 thousand toe in 10 years. By combining the actions of rational energy use (REU) with a more ambitious development of renewable energies (RE) - which would reach 3% of consumption (scenario 4) -, the volume of energy saved would amount in 10 years to 38234 thousand toe.

The cost thus avoided for the last three years (2013-2015) would amount to 10.2 billion dollars if the oil price were to drop back to 75 $, 15.4 billion if the price of the barrel were to stabilize at 120 $, or it would amount to as much as 21.5 billion dollars if the oil price were to rise to 175 $ by 2015 That would generate, according to the evolution of oil prices, a saving in the range of 11.6 billion to 24.5 billion dollars.

TABLE IV
SUMMARY OF THE RESULTS OF THE STUDY CONDUCTED BY THE PLAN BLUE (UNEP/MAP/BP)

No	Alternative Scenarios	In volume (Thous -and toe)	Cost of "non-action" Price of barrel in 2015 (Million dollars)		
			Price of barrel in 2015		
			$75	$120	$175
1	Actions of Rational Energy Use targeted at households and transport (demand side) Leading to a decrease by -10% in 10 years of the energy consumed per GDP unit	-21381	- 6161	- 9129	12949
2	Actions of Rational Energy Use targeted at industrial sectors (demand side) Leading to a decrease by -10% in 10 years of the energy consumed per GDP unit	- 11650	- 3354	- 5058	7049
3	Diversification of the domestic energy supply by promoting renewable energies exclusive of biomass (Low hypothesis) Increase domestic production to reach 1% of the App. Consumption in 10 years (from 47 to787 Ktoe)	- 1984	- 724	- 1099	1540
4	Diversification of the domestic energy supply by promoting renewable energies exclusive of biomass (High hypothesis) Increase domestic production to reach 3.0% of the App. Consumption in 10 years (from 47 to 2360 Ktoe)	- 5203	- 2099	- 3200	4499

Source: UNEP/MAP/BP, 2008 [11].

E. *Egypt Energy Challenges*

1) *Energy Subsidies*

The continuous rise in energy demand is due partly to high domestic subsidies. According to official figures, the value of government subsidies to petroleum products has continued to rise, from 14.3 billion Egyptian pounds (EGP) in FY2004 to 62.7bn EGP in FY2008 - with the 2008 subsidy being 71.3% higher than that projected for the previous year at 36.6 bn EGP. Though the government hopes to reduce demand by gradually lifting subsidized prices and targeting subsidies more effectively, this is a politically sensitive issue that will take time to fully implement. The increased use of compressed natural gas (CNG) as a fuel for motor vehicles is one trend that may aid government efforts [33].

Subsidies place a particularly large burden on Egypt's finances: they accounted for 36.8 percent of spending in 2006/07, more than twice the LMI MENA median of 16.3 percent. The subsidies are often described as poverty alleviation measures, but they appear to be extremely inefficient for this purpose: the World Bank found that it takes $500 of Egypt's gasoline subsidies to deliver one dollar of resources to the poor and US$46 of bread subsidies to do the same [42] Government should have ample scope to improve fiscal performance and the success of poverty reduction efforts by eliminating energy subsidies to industry and improving the targeting of food subsidies [43]. The IMF also suggests that Egypt deemphasize in-kind subsidies in favor of more efficient cash transfer programs.

TABLE V
CONSUMPTION SUBSIDY AS PERCENTAGE OF FINAL ENERGY PRICES (2005)

Gasoline	65
Diesel	80
Kerosene	88
LPG	94
Light fuel oil	80
Heavy fuel oil	71
Natural Gas	76
Coal	0
Electricity	4

Source: IEA, 2006 [44]

Domestic energy subsidies accounted for 6.8 percent of GDP in FY2006, almost double the level three years ago as a result of higher international oil prices. While the fiscal cost of fuel subsidies has declined in FY2007 to 5.5 percent of GDP, owing partly to a hike in domestic fuel prices in summer 2006, Egypt still provides one of the highest domestic fuel price subsidies in the world [45].

The main focus of the reform should be on phasing out the system of fuel subsidization and in-kind social support. Reductions in subsidies on refined gasoline, which disproportionately benefit rich households, would secure savings for fiscal consolidation. The subsidy on kerosene could be reduced more gradually to insulate the regressive impact on the poor, especially given the relatively modest burden of this subsidy compared to the cost of other fuel subsidies such as natural gas, diesel, and fuel oil [45].

The effective resource transfer to the poor provided by food and energy subsidies is limited and highly expensive. Energy subsidies also distort production decisions and entail adverse externalities from excess energy consumption. The government has recently announced plans to phase out gas and electricity subsidies for industrial users; domestic fuel prices should be gradually moved closer to world prices. Social considerations suggest that the pace of price adjustments should be more rapid for products consumed intensively by higher-income households, while products consumed intensively by lower-income households should be adjusted more gradually. Subsidy reform should also be taken as an opportunity to redesign the structure of social safety nets with programs based on proxy means-testing and geographic targeting.

Despite 2007/08 energy subsidies increases by some 50% over previous year's allocations, it is important to note that a large content of the fuel subsidies bill is offset by higher tax and dividends receipts from EGPC (Egyptian General Petroleum Corporation); making such burden more affordable by the budget [46].

2) Barriers for the Promotion of RE in Egypt

Several institutional, regulatory, technical, and economic barriers are currently hampering the diffusion of RE technologies in Egypt:

Weak intersectoral coordination and communication: The fields of renewable energy and energy efficiency suffer from weak intersectoral coordination, which not only tends to slow down the promotion of such projects, but also leads to duplication of efforts and weak human capital buildup. Attaining broad stakeholder participation and coordination among different stakeholders and various sectors of government is indispensable [34].

Unbalanced market: The economics of some RE technologies are in an unfavorable competitive position because of energy subsides in the market, especially for natural gas, and oil industry.

Lack of dedicated finance: There are no financial or nonfinancial incentives, for both users and investors, or command and control regulations that would increase the adoption of RE technologies.

Lack of knowledge networks: Although some associations have been created to promote cooperation, a lack of common platforms seems to be an obstacle. According to some researchers, knowledge is often not disseminated, leading to duplication of efforts and delayed capacity building.

Awareness and information: Although improving, there is still a general lack of information about the potential and benefits of RE technologies among policymakers, energy planners, and potential users of the technology.

Quality and certification: The certification and the quality control of the products and services provided to the users are not always properly assured.

Reputation: There is a still general belief that RE technologies does not work properly and are unreliable. This belief stems mainly from some negative experiences in which poor technology standards combined with lack of maintenance and monitoring led many systems to stop functioning.

IV. Recommendations for an Integrated Energy and Climate Policy

A. Adapting to the Massive Challenge of Climate Change

Adaptation to climate change should be understood as a continuous process which addresses current climate variability and future climate risks. Egypt's challenge is to develop a framework and policies that ensure that resources are used efficiently and equitably, to maintain economic and developmental aspirations, and to be alert in responding to changes in the climate.

Egypt should enhance its efforts to adapt in the context of sustainable development and sustainable development must incorporate adaptation plans. Development partners must deliver on their commitments to support Egypt to adapt to the unavoidable effects of climate change. That includes scaling up efforts to improve and increase access to climate data; investment and transfer of technologies for adaptation in key sectors; developing and implementing best practice guidelines for screening and assessing climate change risk in their development projects and programs in climate sensitive sectors; mainstreaming climate factors into development planning and implementation; and providing significant additional investment in disaster prevention.

B. Legitimate Need to Improve Egypt's Energy Efficiency

- Applying consistent and comprehensive policies for achieving energy efficiency that use pricing (including consideration of externalities), taxation, regulation and other forms of support to effectively achieve long term efficiency objectives.
- Promote energy efficient transportation through more energy efficient individual vehicles, transport corridor planning and traffic management.
- Promote energy efficient urban management systems by spatial urban planning and improved building codes.
- Focus on efficiency improvement in energy production and transportation by promoting more efficient power plants and reduced transmission and distribution losses, or through reduction in gas flaring and methane leakages.
- Support technologies for fostering and realizing large potential energy efficiency improvements such as for example, end-use areas, such as lighting, appliances, transportation vehicles, and commercial and industrial equipment.

C. *Recourse to Renewable Energies*

Lower-carbon energy sources such as wind, solar, biomass, and hydropower provide domestically produced energy and can substantially reduce emissions compared to fossil fuels. To encourage the use of this type of energy, it is necessary, on the one hand, to build awareness among the population about these new resources and, on the other hand, to set up financial incentives both for users and investors.

D. *Stressing on Appropriate Energy Options*

Energy options that are compatible with existing infrastructure (e.g., pipelines, vehicles, power generation facilities, etc.) have a natural advantage over those energy sources that require new or altered infrastructure. This economic advantage can drive businesses and policymakers to choose energy sources that can be used in the existing infrastructure despite the trade-offs or undesirable consequences.

E. *Compromises in Energy Policy*

To find compromises between often contradictory targets (e.g. economic, environmentally friendly and secure energy supply), it has been necessary to develop cornerstones for a new integrated energy policy.

Egypt is currently a minor petroleum (mainly natural gas) exporter but will become a net importer (for mainly oil) in the near future. Hence there is a national drive to become a more energy efficient economy and to make greater use of Egypt's large RE potential. This will have the added benefit of putting the country on a less CO_2 intensive development path. Nevertheless, the energy price subsidies are currently constraining investment in RE and RUE resulting in limited GHG reduction outcomes in the energy sector [11].

F. *Governance*

One of the institutional specificities in Egypt is that energy affairs are managed by two independent ministries. One for oil and gas issues named “Ministry of Petroleum” (MOP), and the other one for electricity issues named “Ministry of Electricity and Energy” (MOEE). The Cabinet of Ministers is the main venue of coordination for energy strategies and policies. It operates through specific Ministerial committees and is responsible for pricing the petroleum products in the local market and setting electricity tariffs at different voltage levels for end-users [35]. The Ministry of State for Environmental Affairs (MSEA) is the government body responsible for environmental policy in Egypt. The Egyptian Environmental Affairs Agency (EEAA), as the executive arm of the Ministry of State for Environmental Affairs, is the main administrative body responsible for environmental protection in Egypt. MSEA/EEAA meets this challenge by continuously striving for the integration of the environmental dimension into national policies, plans and lines of action.

The top-down approach, which assumes that policies set explicit aims and objectives that are directly translated into action on the ground does not offer a complete picture of the potentially enabling or constraining effects of different policies on future adaptive planning. A complementary bottom-up approach which recognizes the importance of other actors in shaping policy implementation offers new perspectives [47]. Sectoral governance and government play complementary roles in the policy process. Government actors typically lack the specific knowledge about local conditions and the capacity to process information to flexibly adjust rules in a volatile environment. Governance mechanisms provide opportunities for information sharing, mutual learning processes and performance enhancing benchmarking processes that are crucial for developing sound policies. Moreover, the inclusion of sectoral governance actors is a source of legitimacy for policy results [48]. There could be three features of network governance: firstly, a form of sectoral governance; secondly, a shift of power from previously well-established levels to organizations or individuals whose main role is linking actors; and, thirdly, changes in the mode of governance, away from hierarchy towards more ‘ horizontal’ and co-operative forms of decision-making [49].

G. *Capacity Building*

Relevant governmental and non-governmental institutions and organizations at all levels should be strengthened by provision of adequate staff, equipment, infrastructure and financial resources to enable them to effectively implement the policy. A national environmental management system should be established to provide accurate and timely information for informed decision making as well as to ensure public access to environmental information.

Improvement in the state of the art depends on a variety of factors that embrace capacity building. Augmenting and improving human capital could be achieved through training programs. Short, medium and long-term programs should be designed and implemented after comprehensive training needs assessment.

H. *Bridging Science and Policy*

There will remain always a need for more research to inform the policymaking process. For scientific data to be successfully exchanged and used in policy formulation and decision making, it must meet a number of key criteria, namely: relevance, timeliness, clarity, integrity and visualization. Developing countries need to adapt and apply science and technology to attract efficient investment, improve competitiveness, and stimulate productivity.

1) *Promoting Research Programs*

Research and development to increase commercialization of current technologies and to create new clean energy technologies is an essential component of meeting energy security and climate goals. Renewable energies and environmental technologies are considered as growth sectors. It is assumed, that this range, which plays a subordinate role in Egypt so far but shows considerable growth potential, will play a substantial role in the future [50].

New renewable energy technologies become cheaper only if

R&D investments are undertaken. Egypt has poorly funded research and government institutions, which makes it difficult to build and retain capacity for research programs [10]. Expenditure on research and development in Egypt has been consistently low (just 0.2 percent of GDP) far less than the global high-five average of 3.7 percent. Although Egypt's R&D spending would not be expected to equal spending in richer countries, future economic growth strategies should consider stimulating investment in R&D [42].

2) Facilitating Access to Technology Transfer

Transfer of technology will be a key pillar in any agreement on a future regime to combat climate change. An important barrier to technology-transfer deals is the potential lack of commercial viability. In general, technology imported from industrialized countries is more efficient but also more expensive than technology manufactured locally, and it therefore requires higher initial investment costs [51]. While views on how to resolve this issue differ broadly, the private sector will play an important role, as it is the main source for the worldwide diffusion of technology. Including technology transfer within the Clean Development Mechanism (CDM) could serve the dual purposes of both reducing the emissions of developing countries and changing their course of development.

Whilst access to Intellectual Property Rights (IPRs) may sometimes be a necessary part of facilitating technology transfer, it is not likely to be sufficient by itself. Other factors such as absorptive capacity and risks associated with new technologies must also be addressed [52].

In the Global Competitiveness Index (GCI) rankings (2008), Egypt ranked 81 (out of 134) and scored 3.98 (1-7) [6]. Although Egypt's scores on the Transfer index and the Availability of Scientists and Engineers index were favorable (47^{th}), Egypt will need to upgrade its educational institutions, which continue to receive weak assessments (126^{th}) and Quality of scientific research institutions (96^{th}) [6].

I. Public-Private-Civil Society Partnership

1) Identifying and Involving Major Stakeholders

Stakeholders (e.g., business, unions, non-governmental organizations) consultation and involvement in the decision-making process is one of the cornerstones which should be taken into account in the early phases of setting the policy to ensure their active participation during the implementation stages. To address and solve tensions that emerge from diverse objectives and stakeholder needs, participatory decision processes and information tools are required [53].

2) Encouraging Private Sector Investment

It is imperative that the private sector be involved in both the formulation and implementation of the policy. The Egyptian government should continue to improve the environment for private sector investment.

3) Supporting the Role of Egypt's Civil Society Organizations

Both the natural and the built environment are areas where Egypt's civil society organizations (Non-Governmental Organizations - NGOs) can play an important role in their capacity to reach the poor and to identify specific local rather than general national needs more accurately [10]. A key element now missing is to integrate environmental policies under a national plan that would include the active participation of civil society and an enlightened private sector.

J. Facilitating Access to Credit

Egypt's legal and regulatory regime is also problematic. Although the country's score on the World Bank's Credit Financial Index improved from 2 (of a possible 6 points) in 2006 to 4 in 2007, its score on the Index of Legal Rights for Borrowers and Lenders remained a poor 1 (of 10 points). Egypt's poor score on this indicator signals the need for substantial reform to facilitate access to credit [45].

K. Informative Measures

1) Raising Public Awareness

Beside technical, legal and economic questions, however, broad public acceptance and a corresponding transfer of consciousness into every-day life are essential for reaching policy goals. Planning proceedings should always take perceived justice by the public into account. If people feel left out of the planning process and decision making, they will be more likely to oppose these processes [54].

It is important for decision-makers to recognize the range of different pressures and forces shaping the policy environment within which they must craft the pathway toward a stable climate and more energy-secure future.

2) Promoting Environmental Education

Environmental education should be integrated into all levels of curricula and syllabi from primary schools to university levels. In the 1980s, around fifteen public universities in Egypt adopted a new policy to insert the environmental agenda into their curricula. A Vice Dean was appointed in more than 300 faculties in charge of community development and environmental affairs, and a Vice President for each university became the person in charge of this new national higher education sector [10]. However, the current university pedagogical program is not designed to exploit partnerships, either with government or with civil society, so as to direct scientific research and its application to policy making or to the community level. The program has so far had little impact on guiding the environmental movement, although university staff in various related specializations have, themselves, created NGOs to produce, apply, and implement research results.

L. Promoting International and Regional Cooperation

1) Strong Commitment to International Agreements

The world's most developed countries are the leading producers of greenhouse gasses. Ambitious and binding commitments on reducing emissions by the developed countries should be a constant, justified call. Although there are still no commitments on reducing emissions by developing countries, including Egypt, yet measures have to be taken to cut emissions. By recognizing Egypt's legitimate development needs, incentives from developed countries should be expected.

Development partners and the Egyptian partner must review carbon finance mechanisms to make them more easily accessible to Egypt for climate adaptation and to help Egypt meet its energy requirements while moving to cleaner energy. This must be accompanied by efforts to raise awareness about the potential benefits of CDM in helping Egypt to develop new sectors such as renewable energy, and support by external partners for capacity development to elaborate and certify CDM projects.

2) Strengthening Regional Cooperation

Egypt should improve regional cooperation and promote the implementation of regional programmes of action with adequate means. The Mediterranean Strategy is a framework strategy. Its purpose is to adapt international commitments to regional conditions, to guide national sustainable development strategies and to initiate a dynamic partnership between countries at different levels of development. The EU and developed countries on the northern shore will have an important role to play, through vigorous aid policies, in promoting the co-development of the North and the South. Moreover, a strengthening of relations between the European Union and the Mediterranean region, within the framework of a cooperation on reforms of the energy sector - as a support for the development of effective energy policies, as well as for the promotion of renewable energies -, would allow the Southern Mediterranean countries to achieve significant gains in terms of energy saving [11].

M. Policy Coherence Issues

The policy is dealing with a “multi-aspect problem” which requires that the applied instrument mix should address the problem as broadly as possible. To increase the coherence of the instrument mix being applied different levels of policy co-ordination will be needed. In addition to co-ordination among environmental and energy policies, co-ordination with other related policies will also be needed, either to address possible negative interactions, or to develop reinforcement mechanisms [55].

V. Conclusion

Energy plays a crucial role in sustainable development. On the one hand, the consumption of energy is a necessary condition for human activities, and thus economic welfare, while on the other, the way energy is currently produced and consumed also causes various sustainability problems in terms of environmental impacts and energy security. Egypt’s challenge is to develop a framework and policies that ensure that resources are used efficiently and equitably, to maintain economic and developmental aspirations, and to be alert in responding to changes in the climate. Egypt’s capacity to respond to these challenges will be expanded by improving overall resilience, integrating climate change goals into sustainable development strategies, increasing the use of modern energy systems with reduced carbon intensity, and strengthening international initiatives. To find compromises between often contradictory targets (e.g. economic, environmentally friendly and secure energy supply), it is necessary to develop cornerstones for a new integrated energy and climate policy.

References

[1] IPCC (Intergovernmental Panel on Climate Change). "Climate Change 2007: Synthesis Report". IPCC, Cambridge University Press, Cambridge, UK, 2007.

[2] UNDP (United Nations Development Programme). “Human Development Report 2007/2008. Fighting climate change: Human solidarity in a divided world”. Palgrave McMillan, NY, USA, 2007.

[3] IEA (International Energy Agency). "Energy Security and Climate Policy: Assessing Interactions". OECD/IEA, Paris, France, 2007.

[4] IEA (International Energy Agency). "Key World Energy Statistics 2008". International Energy Agency, Paris, France, 2008.

[5] Esty, D.C.; Levy, M.A.; Kim, C.H.; de Sherbinin, A.; Srebotnjak, T. and Mara, V., "2008 Environmental Performance Index". Yale University, Yale Center for Environmental Law and Policy, New Haven, CT, USA, 2008.

[6] World Economic Forum. "The Global Competitiveness Report 2008-2009". World Economic Forum, Geneva, Switzerland, 2008.

[7] Risbey, J.S. "The new climate discourse: Alarmist or alarming?". Global Environmental Change, Vol.18, No.1, pp.26-37, 2008.

[8] OECD (Organisation for Economic Co-operation and Development). "OECD Environmental Outlook to 2030". OECD Publishing, Paris, France, 2008.

[9] Tol, R.S.J.; Downing, T.E.; Kuik, O.J. and Smith, J.B. "Distributional Aspects of Climate Change Impacts". Global Environmental Change, Vol.14, No.3, pp.259-272, 2004.

[10] UNDP (United Nations Development Programme). “Egypt Human Development Report 2008. Egypt’s Social Contract: The Role of Civil Society”. United Nations Development Programme, and The Institute of National Planning, Egypt, 2008.

[11] UNEP (United Nations Environment Programme). "Climate Change and Energy in the Mediterranean". UNEP, Mediterranean Action Plan (MAP), Blue Plan/Regional Activity Centre (BP/RAC), Sophia Antipolis, Valbonne, France, 2008.

[12] Dasgupta et al. "The Impact of Sea Level Rise on Developing Countries: A Comparative Analysis". Policy Research Working Paper No.4136, The World Bank. Washington, DC, USA, 2007.

[13] IBRD (The International Bank for Reconstruction and Development). *Global Monitoring Report 2008: MDGs and the Environment: Agenda for Inclusive and Sustainable Development". IBRD, The World Bank Group, Washington, DC, USA, 2008.

[14] UNFCCC (United Nations Framework Convention on Climate Change). "Climate Change: Impact, Vulnerabilities and Adaptation in Developing Countries". UNFCCC, Climate Change Secretariat, Bonn, Germany, 2007.

[15] UNEP (United Nations Environment Programme). "Water demand management, progress and policies: Proceedings of the 3rd Regional Workshop on Water and Sustainable Development in the Mediterranean, Zaragoza, Spain, 19 - 21 March 2007 ". UNEP, Mediterranean Action Plan (MAP), Blue Plan/Regional Activity Centre (BP/RAC), Sophia Antipolis, Valbonne, France, 2007.

[16] Mohamed, Y.A. and Loulseged, M. "The Nile Basin Water Resources: Overview of key research questions pertinent to the Nile Basin Initiative. IWMI Working Paper No.127, IWMI (International Water Management Institute), Colombo, Sri Lanka, 2008.

[17] UNEP (United Nations Environment Programme). “Hydropolitical Vulnerability and Resilience along International Waters: Africa”. UNEP, Nairobi, Kenya, 2005.

[18] Hoekstra, A.Y. "The global dimension of water governance: Nine reasons for global arrangements in order to cope with local water problems". UNESCO-IHE (United Nations Educational, Scientific and Cultural Organization/ The International Hydrological Programme), Delft, the Netherlands, 2006.

[19] Bates, B.C.; Kundzewicz, Z.W.; Wu, S. and Palutikof, J.P. (Eds.). "Climate Change and Water". IPCC Technical Paper VI. Technical

Paper of the Intergovernmental Panel on Climate Change, IPCC Secretariat, Geneva, Switzerland, 2008.
[20] Eid, H.; El-Marsafawy, S. and Ouda, S. "Assessing the Economic Impacts of Climate Change on Agriculture in Egypt: A Ricardian Approach". Discussion Paper No.16, CEEPA (Centre for Environmental Economics and Policy in Africa), University of Pretoria, South Africa, 2006.
[21] Strzepek, K. and McCluskey, A. "District level hydroclimatic time series and scenario analyses to assess the impacts of climate change on regional water resources and agriculture in Africa". Discussion Paper No.13, CEEPA (Centre for Environmental Economics and Policy in Africa), University of Pretoria, South Africa, 2006.
[22] Eid, H.; El-Marsafawy, S. and Ouda, S. "Assessing the impact of climate on crop water needs in Egypt: The cropwat analysis of three districts in Egypt". Discussion Paper No.29, CEEPA (Centre for Environmental Economics and Policy in Africa), University of Pretoria, South Africa, 2006.
[23] Strzepek, K. and McCluskey, A. "The Impacts of Climate Change on Regional Water Resources and Agriculture in Africa". Policy Research Working Paper No.4290, The World Bank. Washington, DC, USA, 2007.
[24] Klein, R.J.T.; Huq, S.; Denton, F.; Downing, T.E.; Richels, R.G.; Robinson, J.B. and Toth, F.L. "Inter-relationships between adaptation and mitigation. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, 2007.
[25] Olsen, K.H. and Fenhann, J. (Eds.). "A Reformed CDM – Including New Mechanisms for Sustainable Development". Capacity Development for CDM (CD4CDM) Project, UNEP Risø Centre, Roskilde, Denmark, 2008.
[26] Shrestha, R.M.; Sharma, S.; Timilsina, G.R. and Kumar, S. "Baseline Methodologies For Clean Development Mechanism Projects". Capacity Development for CDM (CD4CDM) Project, UNEP Risø Centre, Roskilde, Denmark, 2005.
[27] Lee, M. "CDM Information and Guidebook". Second edition. Capacity Development for CDM (CD4CDM) Project, UNEP Risø Centre, Roskilde, Denmark, 2004.
[28] Point Carbon. "Carbon Market Insights 2007". Point Carbon’s 4th annual conference, Copenhagen, 13-15 March 2007.
[29] Jansen, J.C.; van Arkel, W.G. and Boots, M.G. "Designing Indicators of Long-term Energy Supply Security". ECN (Energy Research Centre of the Netherlands), Petten, Netherlands, 2004.
[30] The World Bank Group. "Energy Security Issues". The World Bank, Washington, DC, USA, 2005.
[31] IEA (International Energy Agency). "Worldwide Trends in Energy Use and Efficiency: Key Insights from IEA Indicator Analysis". International Energy Agency, Paris, France, 2008.
[32] IEA (International Energy Agency). "Renewable Energy: RD&D Priorities. Insight from IEA Technology Programmes". OECD/IEA, Paris, France, 2006.
[33] EIA (Energy Information Administration). "Country Analysis Briefs: Egypt". EIA, Washington, DC, USA, August 2008.
[34] OME (Observatoire Méditerranéen de l’Energie). "The Mediterranean Energy Perspectives 2008". OME, Nanterre, France, 2008.
[35] UNEP (United Nations Environment Programme). "Energy and sustainable development in the Mediterranean: Proceedings of the Regional Workshop Monaco, 29 - 30 March 2007". UNEP, Mediterranean Action Plan (MAP), Blue Plan/Regional Activity Centre (BP/RAC), Sophia Antipolis, Valbonne, France, 2007.
[36] EIA (Energy Information Administration). "International Energy Outlook 2008". Office of Integrated Analysis and Forecasting, U.S. Department of Energy, Washington, DC, USA, 2008.
[37] IAEA (International Atomic Energy Agency). "Energy indicators for sustainable development: guidelines and methodologies". IAEA, Vienna, Austria, 2005.
[38] Mortensen et al. "Wind Atlas for Egypt: Measurements, micro- and mesoscale modelling". Risø Centre, Roskilde, Denmark, 2006.
[39] WEC (World Energy Council). "Assessment of Energy Policy and Practicies". WEC, London, UK, 2008.
[40] Refaat, A.A.; Attia, N.K.; Sibak, H.A.; El Sheltawy, S.T. and El Diwani, G.I. “Production Optimization and Quality Assessment of Biodiesel from Waste Vegetable Oil”. International Journal of Environmental Science and Technology, Vol.5, No.1, pp.75-82, 2008.
[41] WEC (World Energy Council). "Energy Efficiency: A Worldwide Review – Indicators, Policies, Evaluation". WEC, London, UK, 2004.
[42] Manring, R.; Reisman, M.; Allen, D. and James, M. "Egypt: Economic Performance Assessment". USAID (United States Agency for International Development), Washington, DC, USA, 2008.
[43] IMF (International Monetary Fund). "Arab Republic of Egypt: 2008 Article IV Consultation". IMF Country Report No.09/25, International Monetary Fund, Washington, DC, USA, 2009.
[44] IEA (International Energy Agency). "World Energy Outlook 2006". International Energy Agency, Paris, France, 2006.
[45] IMF (International Monetary Fund). "Arab Republic of Egypt: Selected Issues". IMF Country Report No.07/381, International Monetary Fund, Washington, DC, USA, 2007.
[46] Ministry of Finance. "Egypt Economic Outlook". Macro Fiscal Policy Unit, Ministry of Finance, Cairo, Egypt, 2008.
[47] Urwin, K. and Jordan, A. "Does public policy support or undermine climate change adaptation? Exploring policy interplay across different scales of governance". Global Environmental Change, Vol.18, No.1, pp.180-191, 2008.
[48] Eberlein, B. "The Making of the European Energy Market: The Interplay of Governance and Government". Journal of Public Policy, Vol.28, No.1, pp.73-92, 2008.
[49] Coen, D. and Thatcher, M. "Network Governance and Multi-level Delegation: European Networks of Regulatory Agencies". Journal of Public Policy, Vol.28, No.1, pp.49-71, 2008.
[50] Zimmermann E. "Market Analysis of the Environmental Sector in Egypt". Ministry of Foreign Trade and Industry, Small and Medium Enterprise Promotion Programme (SME Promotion Programme), German Technical Cooperation (GTZ) report, Egypt, 2005.
[51] Schneider, M.; Holzer, A. and Hoffmann, V.H. "Understanding the CDM’s contribution to technology transfer". Energy Policy, Vol.36, No.8, pp.2930– 2938, 2008.
[52] Ockwell., D.G.; Watson, J.; MacKerron, G.; Pal, P. and Yamin, F. "Key policy considerations for facilitating low carbon technology transfer to developing countries". Energy Policy, Vol.36, No.11, pp.4104-4115, 2008.
[53] Tschakert, P.; Huber-Sannwald, E.; Ojima, D.S.; Raupach, M.R. and Schienke, E. "Holistic, adaptive management of the terrestrial carbon cycle at local and regional scales". Global Environmental Change, Vol.18, No.1, pp.128-141, 2008.
[54] Zoellner, J.; Schweizer-Ries, P. and Wemheuer, C. "Public acceptance of renewable energies: Results from case studies in Germany". Energy Policy, Vol.36, No.11, pp.4136-4141, 2008.
[55] OECD (Organization for Economic Co-operation and Development). "Instrument Mixes for Environmental Policy". Secretary-General of the OECD, Bonn, Germany, 2007.